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ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE

ROYAL NEW ZEALAND INSTITUTE OF HORTICULTURE (INC.)

Dominion Secretary: Mr J. K. Lemmon, A.C.A., A.C.I.S., First Floor, British Sailors' Building, 10 Brandon Street, Wellington 1; Postal Address, P.O. Box 450, Wellington.

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Editor (Act.): Mr M. B. Thomas, M. Hort. Sc., N.D.H. (N.Z.) Dip. Hort. (Linc.)

Correspondence relating to the contents of the Journal, articles for publication, etc. should be sent to:— Professor T. M. Morrison, Horticulture Department, Lincoln College, Canterbury.

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COVER PICTURE

"A young apple tree bearing a good crop, Roxburgh, Otago."

[Otago Witness, December 1914]

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Contributors

Mr H. R. Sampson	Ex. Fruitgrower and Past Canterbury Director of N.Z. Fruitgrowers Federation.
Mr A. J. Dakin	Horticulturist, Auckland.
Mr E. M. Mearns	Horticulturist, Auckland.
Dr. S. M. Smith	Demonstrator in Horticulture Lincoln College
Miss M. Watling	Floral Art Lecturer Christchurch
Dr. K. Young	Scientist, Plant Diseases Div. DSIR, Auckland.
Mr L. J. Metcalf	
Mr R. B. Stevens	Assistant Lecturer in Horticulture Lincoln College
Mr M. B. Thomas	Lecturer in Horticulture Lincoln College
Mr M. Spurway	Technician in Horticulture Lincoln College
Mr D. Moon	DSIR, Lincoln.
Mr J. O. Taylor	Senior Lecturer in Horticulture Lincoln College.
Mr D. S. T. Collins	Tauranga Parks and Reserves
J. Hayes	Horticulturist, Canterbury.
Dr. D. I. Jackson	Reader in Horticulture Lincoln College.
Dr. N. C. Lambrechtsen	Scientist National Plant Materials Centre (MOW), Palmerston North.
Mr W. E. Turner	Director of Parks Tauranga
Mr N. A. Aitken	Landscape Architect Ministry of Works & Development, Christchurch
Mr H. Gill	Lecturer in Horticulture Lincoln College.
Prof. T. M. Morrison	Professor of Horticulture Lincoln College

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The History of Fruitgrowing in New Zealand

by
H. R. SAMPSON

(Mr Sampson was elected an Associate of Honour to the RNZIH in 1973 for his services to horticulture and fruitgrowing — ED.)

I have been asked to write a short history of fruit growing in New Zealand. There are several ways to do this — technically with graphs, tables of acreages, production, dates and with rise and fall of varieties — by districts or by the country as a whole. Any of these methods are open to a student who wishes to delve into those statistical records which are available in the N.Z. Year Books and the reports of the Department of Agriculture and he will come up with an indigestible mass of figures which will have to be regurgitated to find out what they really mean and what caused them. I have therefore decided to start at the North and work Southwards. This will mean a chronological jumble which may be easier to follow than jumping from Province to Province.

AUCKLAND

The first fruits here were planted by the early missionaries in the 1830s, near the Bay of Islands — the other European inhabitants were too busy carousing at Korararika to be bothered with agriculture in any form while they could harvest the sea. These first plantings were by seeds or cuttings stuck in potatoes or possibly some seedlings could survive the voyage from Sydney. These were just "home orchards" and not commercial blocks. With the growth of both civil and military population areas near Whangarei were developed quite extensively for apple growing — coastal shipping was quite good in those days. But with the growth of orcharding about Auckland these Northern areas gradually dwindled — one of the early proofs that given reasonable growing conditions it is more profitable to grow near consumers. Later citrus growing went off to an opmistimic start but earlier plantings this century were not altogether successful for several reasons (a) there was no basic experience in growing citrus in the conditions of soil and climate (b) it was difficult to obtain suitable rootstocks and varieties (c) most of the settlers were quite inexperienced in any form of agriculture (d) blocks were too small (e) too many varieties of sub-trophical fruits were attempted. These difficulties are gradually being overcome.

But a different story comes from the lower part of Auckland Province. Gisborne flats were very suitable for apples and pears and later, with new varieties being developed, citrus is a substantial part of the Poverty Bay fruit crop and the former isolation of the area has largely been overcome. In the Bay of Plenty a number of returned servicemen were assisted to grow at Te Puke under circumstances which gave them a better start than those beginners at Keri-keri. And now the rapid development of all varieties of fruit here will soon make New Zealand self-supporting in Citrus. It is a cause of wonder to visitors from other countries that apples, pears, peaches, plums, oranges, lemons, grapefruit and other forms of citrus can all be grown on the same orchard.

Some apricots (probably Mushmush) were grown in Thames for the Auckland market but disease — mainly brown-rot wiped them out. There seems to be an affinity apricots and gold cf. California and Central Otago.

In the Waikato peaches grew wild in several places — in fact they were fed to pigs, but again disease took its toll. Andreas Reitcheck, an Austrian naturalist who was the first European to penetrate deep into the King Country was offered peaches by the Maoris early in the 1860s.

Orcharding increased around the City of Auckland as the City grew and an additional impetus was given as the gum-fields gradually petered out. Many Dalmations had engaged in this search and when it no longer provided a living they turned to fruitgrowing as a livelihood could be made from a small holding. They have been very efficient growers of all fruits and in addition they have been able to cultivate grapes with the skill that many families brought with them from home.

TARANAKI

Because climate, and particularly salt-laden Westerlies, made fruitgrowing difficult no real commercial ventures were undertaken but some English plums were grown for home use. Over 60 years ago there was a jam factory at Lepperton Junction but what may have been a large undertaking in my childhood memory may have been only a boiler in the corner of a cow-shed. Some 10 acres were planted at Bell Block — peaches and citrus — but because of the Westerlies the area was divided into four 2½ acre blocks by very high shelter belts which made growing conditions impossible.

HAWKES BAY

The Heretaunga Plains have proved most suitable for fruit-growing and a number of blocks were planted late in last century. When irrigation became available the production of the area as a whole per acre became higher than any other district in N.Z. The heavy production of apples, pears and peaches led to the establishment of ancillary industries particularly valuable as the area was somewhat distant from consumers and export was not always a reliable outlet. This combination of very efficient production and competent processing has made the Hastings-Napier area one of the most prosperous in the country. I will not deal with this district in any detail as I understand that a local history is about to be published.

WELLINGTON

Several orchards were planted up the Whanganui River — apples being delivered to town by Maori canoe but the land on the South bank on much better soil are producing well as is the block at Turakina. There were a few orchards around Palmerston North but they have not thrived. The work being done at Massey University may be an encouragement to further plantings. In the Wairarapa orchards were planted in the boom of 1910-20. The ones on good land still thrive, but some of the boney areas have had difficulty to survive. There was a theory once (probably fostered by "developers" that apples would thrive on poor soil — "Good fruit, Sir Knight, said the yeoman in 'Ivanhoe' will sometimes grow on a sorry tree" but there were some bitter and costly disappointments here as in some other parts of N.Z.

The heavy soil of the Hutt Valley was suitable for fruit but no really commercial blocks were planted. Dr Mason, in his "Garden" had many varieties some of which were taken by one of his employees to Wainui-o-mata where he established an orchard in "Skull Gully". This is the site of a Boy Scout camp and perhaps some of the apples are still growing there.

NELSON

The very fertile areas of Stoke and Riwaka proved ideal and some very highly productive orchards were established and still flourish in the former place which provided the first export from Nelson — to Java, but Stoke has been overgrown with housing.

The boom in the first 2 decades of this century which caused a planting explosion not only here, Australia and South Africa but also in Argentine, Chile and Brazil where many of the orchards were planted on trees raised in New Zealand. Premier Seddon is credited with having promised growers a government guarantee of 1d per lb on export which would meet the cost of freight to Europe. This was an additional spur and planting covered most of the Moutere Hills-Mahana area which presented many difficulties because of the untried soil conditions and the fact that many planters were unskilled in horticulture (this of course applied elsewhere in New Zealand) and many young orchards were owned by absentees who hoped to take over from managers when the blocks came into bearing. The first world war followed by severe depressions caused the abandonment of many orchards but later improved soil management and less astringent sprays have led to a production per acre on these "poor" soils which now exceed the dreams of the original planters. One small corner of Nelson may yet come into its own — Karamea. This badly organised settlement was a failure although the climate may be the best in New Zealand but isolation and poverty made farming difficult but at one time apples were sent down to Westport by scow. With improved communications this may prove a bright star in the horticultural firmament.

MARLBOROUGH

Plantings here followed the same pattern as in other places — poor soil would do! But after some thin years growers now have the advantage of irrigation and here also production has improved considerably — trees which once looked downhearted now flourish. Stone fruit grows well and 20% of New Zealand's cherries are grown here. Years ago acres

Apple picking, Nelson 1920.

Apples for export leave by horse and cart from Mariri for Motueka in 1912.

"The Warrenheip gardens motor lorry for transporting fruit to the railway station. During the height of the fruit season 80 tons of fruit were transported from Roxburgh to the railway in one day – a record for the district. Had it not been for the motor lorries, which made two trips a day, many growers would not have been able to get their fruit away."
[Otago Witness, March 1916]

of cherries grew wild about the Sounds and although tedious to pick these small cherries made very good jam which children called "spit" jam for very good reasons.

CANTERBURY

This was really the home of fruitgrowing in New Zealand because the Canterbury settlement was organised and founded with the intention that a slice of English society from the wealthy to artisans, tradesmen and labourers should be established. Among them were gardeners and nurseries were soon established. When Mrs Godley visited the Deans farm at Riccarton in 1851 shortly after the arrival of the "first" four ships she was surprised to find apples and pears ripening. The Scots had beaten the English by 10 years. Woolston proved very suitable for pears — nearly all gone now, pushed out by housing and factories. This same fate has met most of the apple orchards near Papanui. It was from an orchard here — still in production — that the first export to Chile went in 1888 and shortly afterwards the 1st New Zealand export to London was sent. Christchurch was well known for pears and quince grown in many house gardens but fire blight in the thirties killed most of them.

In North Canterbury speculative planting was as elsewhere with much the same history. When the French arrived at Akaroa in 1840 they hoped to be able to make their own wine — they had brought grape cuttings with them but this disorganised and unsupported settlement never really got going and only walnut trees remain of French horticultural hopes. In South Canterbury several blocks were planted near Timaru and one at Fairview this year (1974) celebrates its centennial. The boom in planting and bright prospects encouraged Two Bays Nurseries of Melbourne to plant 250 acres at Waimate but difficult soil and climate made this an unprofitable venture except for the better patches where some trees remain.

OTAGO

The first plantings were on the Taieri plains where a number of orchards were established to supply Dunedin then the busiest town in New Zealand. With dwindling returns from gold in Central Otago many miners turned to fruitgrowing as they could establish themselves on small blocks without much capital. Where irrigation was available — mainly from races put in for mining — trees flourishing especially apricots and cherries. Then pears and apples with quite high production in some places. The ill-conceived "Fruitlands" block planted by Two Bays Nurseries of Melbourne between Alexandra and Roxburgh — the highest orchard ever planted in New Zealand — was so beset by almost blizzard conditions that the whole 350 acres was abandoned. On the South bank of the Waitaki River several blocks were established, apples did not do so well without irrigation but apricots and cherries thrive. I am not aware of any orchard in Southland but perhaps some day some of the more sheltered and warmer spots on the West side of Stewart Island may supply fruit for Invercargill.

I have not touched on the influence of growers co-operative organisations as they have been dealt with elsewhere but I must mention that when the New Zealand Fruitgrowers Federation Ltd., was formed in 1916 growers asked to be taxed both for research and for their own political organisation. Two "firsts" here — the first time a tax has been asked for and the first example of compulsory unionism. In fact one Nelson grower, an ex-soldier, refused to pay the tax and when the Court ruled against him he packed up all his medals and sent them to the King at Buckingham Palace. He did not suffer the fate of Tomasco Aniello commonly called "Masaniello" who was the leader to the revolt in Naples in 1647 against a tax on fruit. He was assinated three days after the tax was repealed.

The great influence of some very competent nurserymen, research bodies and Government Departments cannot be dealt with here nor can the effect of marketing organisations all of which have had great influence on fruitgrowing.

Although the prospects for several fruits grown in excess of New Zealand's own requirements are somewhat uncertain, the great need for food in many parts of the world must overcome the difficulties of profitable distribution.

Notes on the Vegetative Propagation of *Agathis Australis* (Kauri)

by
A. J. DAKIN and E. B. MEARNS

SUMMARY

Some past work on asexual propagation of kauri **(Agathis australis)** *is reviewed.*

A small scale trial is described in which cuttings from young nursery stock plants were induced to form adventitious roots. Cuttings were set in September, treated with a growth regulator (Seradix 3) and rooted under mist.

It was concluded that the age of the stock plants was probably the most important factor in rooting success, but that other factors such as nutritional state of stock plants were also beneficial.

Some possible uses of cuttings in nursery propagation of young plants are examined.

INTRODUCTION

At first sight the propagation of kauri by vegetative methods would appear to be of academic interest only. This is particularly so, when kauri rarely fails to produce adequate quantities of seed, and effective nursery techniques have been developed for seedling production (Morrison 1955) (Morrison and Lloyd 1972).

However, it is in relation to tree improvement and breeding that vegetative methods of propagation have considerable value. Thulin (1957) states "that some prospects for applied breeding are present in kauri, which can be established artificially, and has a reasonable rate of growth."

In any tree breeding programme vegetative propagation is of importance in reproducing special characteristics of superior trees, i.e. stem straightness, better growth rate, improved seed quality and quantity etc.

Therefore, any breeding and improvement work in kauri must first be preceded by the development of suitable methods for vegetative reproduction. In this regard kauri has proved generally amenable to a technique of cleft grafting (Thulin 1957), but has not responded to other vegetative propagation methods, such as air layering, or cuttings.

This article reviews briefly some aspects of past work in vegetative propagation of kauri and also describes results from a small scale trial with cuttings from young stock plants.

PREVIOUS WORK ON ASEXUAL PROPAGATION OF KAURI

Very little information has been published in New Zealand regarding attempts to asexually propagate *Agathis australis.*

The most notable published account is that by Thulin (1957) in which he described successful trials with cleft grafting of kauri. Scions were taken from one year shoots, on trees 70-100 years of age, and grafted on to four year old nursery stock plants. From the trial results, it appears that September was the best month to take and graft scions.

The aim of these grafting trials was to reproduce trees which were considered to be desirable seed parents, the grafts would them be planted in seed orchards in the expectation of a future harvest of high quality seed, which could be easily collected.

Some 350 graft specimens have been established in seed orchards at Waipoua Forest since 1956, but to date, only a small quantity of seed has been harvested (Morrison and Lloyd 1972). The grafting of kauri for this purpose is apparently not in use at the present time.

Experiments have also been undertaken with other methods of vegetative propagation (R. C. Lloyd pers. comm.) (Morrison & Lloyd 1972), these have included air layering (root grafting) and stem cuttings. However, it is reported (even though air layers formed callus), that all these trials failed to induce formation of adventitious roots. It should be emphasised that these trials were not pursued extensively, mainly because tip cleft grafting had proved successful, seed was readily available, and nursery germination satisfactory.

Recently it has been reported (R. C. Lloyd pers. comm.) that J. Bayer a nurseryman at Warkworth has rooted epicormic shoot cuttings of kauri, however, shoot growth after rooting has been very poor.

Several cutting trials at Hunua over the past few years have ended in failure, material used was from trees in the 60-100 year age range and even though cuttings looked healthy for a long period, the stems eventually rotted and collapsed, without any callus or root formation.

Despite such failures, it was felt that the propagation of kauri from cuttings was worth pursuing, and that better success might be achieved if material from young plants were used. This led to the small scale trial reported on in these notes.

METHODS AND RESULTS

A small number of cuttings were taken from 2½ year old nursery stock plants which had been grown in plastic containers in a sand-peat potting medium. Plants had been placed outside in autumn, in full light and consequently stems were quite hard at the time cuttings were taken.

Material for cuttings was selected in early September from plants which were double leadered. One leader was removed and cut to a length of 8-10 cm, these 'terminal' cuttings were then left to 'dry' in a shady place for about 4 hours before being trimmed back to just below a pair of leaves. Basal leaves were removed and the cut base treated with Seradix 3 (0.8% indolebutyric acid).

Cuttings were then set in a scoria-sand-peat medium in 5 cm plastic tubes and placed under intermittent mist on a well drained bench with polythene top and sides.

Air temperatures on the cutting bench were taken daily, and average monthly temperatures over the rooting period are summarised in Table 1. Relative humidity averaged 70-90% over the period.

TABLE 1
AIR TEMPERATURES BY MONTHS IN CUTTING BENCH

Months	AUG	SEP	OCT	NOV	DEC	JAN
MEAN MONTHLY TEMPERATURE °C	16.2	17.1	18.5	20.4	22.5	22.7
MEAN MAXIMUM TEMPERATURE °C	23.3	23.5	25.0	26.7	30.4	31.8
MEAN MINIMUM TEMPERATURE °C	8.9	11.0	12.0	14.1	14.6	13.6

It was noted that callus and roots had formed by early December, and cuttings were sufficiently well rooted to be potted on towards the end of December and in early January. A sand-peat potting compost was used at transplanting and cuttings were placed under glass for growing on.

Although no measurements were taken, shoot growth appeared to be at least equal to, if not slightly better than, seedling plants grown under the same conditions.

Figure 1 illustrates the condition of cuttings in April (8 months after setting), with one year old seedling plants shown as a comparison.

The differences in root form and origin are readily apparent. In the typical seedling plant a single taproot is formed with laterals arising in succession whereas the cutting produces 2-3 strong 'peg' like roots, these emerging through the cutting base.

DISCUSSION AND CONCLUSIONS

It is only fair to re-emphasise that this was a small scale trial, carried out at the time, with considerably

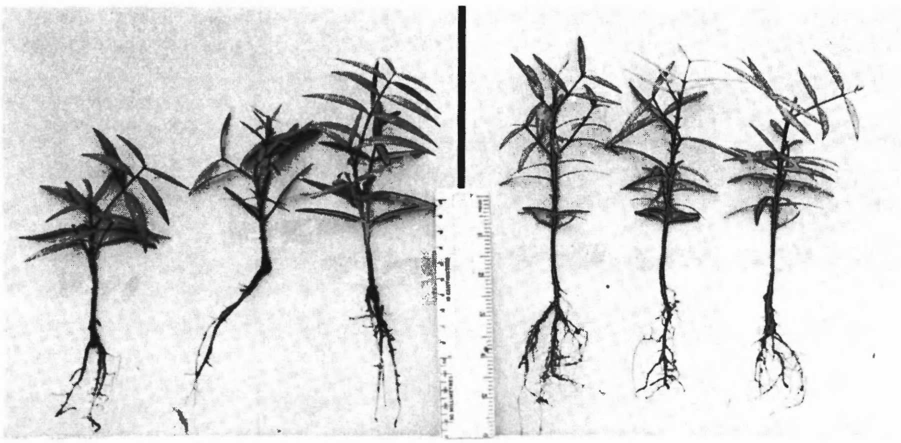

FIGURE 1:
Left—Cuttings lifted 8 months after setting.
Right—One year old seedlings

more faith than hope. However the important fact is that kauri cuttings have been induced to regenerate roots under this particular set of conditions, and this fact in itself opens the way to the conduct of further more extensive experiments.

Several factors no doubt played a part in root formation, but probably the single most important, was the age of the stock plants.

This juvenility factor as it is called, has been reported as being of particular importance in species which are difficult to root (Hartman and Kester 1968). They report on a study made on certain coniferous and deciduous species known to root only with extreme difficulty, and it was concluded that the most important factor affecting root initiation was the age of the tree from which cuttings were taken. Cuttings formed roots readily from one year old wood, but the ease with which roots formed, decreased steadily with increasing tree age.

In work with Rimu *(Dacrydium cupressinum)*, both Richards (1974), and Dakin (1974) found that cuttings from juvenile stock plants formed roots readily, but Richards reports that cuttings from an older tree rooted more slowly, and with slightly poorer results.

The 'age limit' up to which kauri cuttings can be readily rooted, can only be ascertained by experiments using material from plants of different known ages.

Another important factor in root formation may have been in the nutritional state of the stock plants when cuttings were taken. Stock plants were grown initially under shade, in a potting mixture containing a well balanced fertilizer base, and consequently growth was rapid during spring, summer and early autumn.

However, root restriction in containers, plus a slowing of shoot growth was apparent when plants were placed outside in mid-autumn. Plants remained in this condition and exposed to full light over winter until the following spring when cuttings were taken. Hartman and Kester (1968) indicate that this type of treatment with stock plants, favours a low nitrogen — high carbohydrate balance which in many cases seems to favour rooting. They further state that "cuttings taken from slow-growing stock plants in containers where root development is restricted, carbohydrates have accumulated and nitrogen is low, usually root more readily than cuttings taken from rank-growing field plants."

Time of year may not have been critical for rooting of kauri cuttings, but it is perhaps of some significance that September also proved to be the best month to make grafts.

What effect the period of 'drying' before setting had on ability to form roots is not at all clear, and this needs further investigation. However, it is likely that such a 'drying' period may be of some importance in cuttings from a species such as kauri which exudes copious 'gummy' sap from cut surfaces. It is conceivable that such a sap layer could easily prevent or impede root egress.

In conclusion we can only speculate as to the role cuttings might play in kauri improvement and nursery propagation, however some possible uses of cuttings from young plants spring to mind.

1. Cuttings provide a means of reproducing particularly strong growing plants in the nursery bed. Kauri, when sown from seed exhibits a wide variety of genetic seedling types, this is so prevalent that culling and grading of seedling lots is necessary. Cuttings could be taken to 'capture' the improved growth of better seedlings, and increase their numbers.
2. Seed orchard seed is available in small quantities, providing that it is of superior quality, and improved seedlings result, then cuttings provide a means by which the numbers in a batch could be readily increased.

Inevitably a number of problems remain to be solved in asexual propagation of kauri, these particularly in relation to older trees where cuttings would be of value in reproducing trees for their superior phenotype.

It seems that cuttings may have a role to play in tree improvement and nursery propagation of kauri, particularly if combined with the technique of grafting and seed orchard production.

ACKNOWLEDGEMENTS

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Radiation Frosts

by
K. YOUNG
Mt Albert Research Centre, DSIR, Auckland, New Zealand

INTRODUCTION

Each year horticulturalists in many parts of New Zealand are reminded of the dangers of frosts. Fortunately, methods for protecting sensitive crops from frost damage are well known and experience has taught most to cope adequately with this problem. However, the mechanism of frost formation and microclimatic conditions which arise during frosts are often not well understood. This article briefly examines some of these aspects.

In New Zealand, frosts are almost always of the radiation type which occur during clear calm nights. This type of weather is normally associated with the passage of high pressure anticyclones which move eastwards over New Zealand about once every week. Advection frosts, or those caused by freezing air masses of polar origin, seldom, if ever, occur during critical crop periods in New Zealand and will not be dealt with in this article.

HEAT EXCHANGE PROCESSES

Frost results when sufficient heat is removed from vegetation and soil to lower air temperature to 0° C. When a body loses or gains heat, 3 methods of heat transfer may be involved, namely conduction, convection and radiation. Conductive and convective transfer of heat are familiar processes to most people and probably require little explanation. Radiation however, is the ultimate process by which heat on earth is gained (from the sun) or lost (to space) and because of its importance to the frost problem, it warrants some discussion. Each of the heat transfer process will be described briefly below within the context of radiation frosts.

Conduction is the process where heat is transferred from one body to another without physical movement of the bodies. For instance, air in contact with a cold leaf or fruit will cool by conduction. This thin layer of cold air can then in turn cool surrounding air by conduction. Air, however, is in fact a very poor conductor of heat and it is this property which is an important factor in the formation of frosts. Generally solids and liquids are good heat conductors and gases are poor conductors.

Convection is the process where heat is transferred by mass transfer. That is there is actual physical movement of warm and cold bodies. For example, if the air around the cold fruit cools sufficiently, it will become more dense and will settle downwards. Relatively warm air will move in to take its place and a convection current is set up. In this example, conduction is the primary process by which heat is transferred from air to fruit and convection is the secondary process. Rising warm air from fires and during hot days are two other common examples of convection. All these are examples of free convection caused by density changes in the transfer medium, and it is necessary to distinguish this process from another type of convective heat transfer which occurs in nature. This type is called "forced convection" which essentially is the vertical mixing of warm and cold air layers by wind, often against natural air density gradients. It is frequently referred to as turbulent heat transfer and is related directly to wind speed. Both free convection and turbulent transfer are important processes during daytime but the former plays little part in heat transfer at night. As discussed later, heat from atmospheric turbulence is a major component of the nocturnal heat balance during frosts.

Radiation is the process where heat is transferred from one body to another without the need of a connecting medium. The most common example of radiative heat transfer is the heat radiated from the sun to earth across 93 million miles of space. While the sun is obvious to all as a radiator of heat, it is often not realised that objects on earth, including atmospheric gases and water vapour, are also good heat radiators. Of course the rate of radiation on earth is much lower than that of the sun. Radiation rate, or more correctly, radiation intensity from a body is dependent basically on its temperature and a fundamental physical law is that good heat radiators are also good absorbers of heat. If this was not so, then good radiators would continuously lose heat and get extremely cold, or conversely, if a body absorbed more heat than it emitted, it would get extremely hot.

Except for solar heat, humans are seldom aware of the fairly large amounts of heat continuously radiated to, from, and around them because their temperature is not so very different from those of surrounding objects. That is to say, humans emit heat at about the same rate as they absorb it and so feel neither hot or cold. Nevertheless, this radiant energy is present and can be readily detected by radiation measuring instruments.

In dealing with heat interchange at the earth's surface, radiation can be divided into 3 classes; solar radiation, terrestrial radiation and atmospheric radiation. Solar radiation from the sun is not directly related to frost but it is necessary to consider it in order to appreciate fully the process leading to frost. Terrestrial radiation as its name implies, is the radiation emitted by terrestrial objects such as soil and vegetation to space. Atmospheric radiation is the radiation emitted by atmospheric gases and water vapour back down to earth. Atmospheric radiation is often referred to as back-radiation or counter-radiation since it counteracts outgoing terrestrial radiation and effectively reduces terrestrial heat losses by 75%. Both terrestrial and atmospheric radiation rates are fairly similar during day and night.

The role of radiation in the daily heat balance of the earth during clear skies is illustrated in Fig. 1. In this diagram, the arrows represent the main heat components and their size indicates approximately their relative magnitude. Input heat during daytime from solar and atmospheric radiation is balanced by terrestrial radiation, by heat used in evaporation of water and evapotranspiration of plants, and by heat given to soil and air (heat content of vegetation is usually disregarded in the heat balance). It must be remembered here that conductive and convective heat transfer occur only in the lower atmosphere

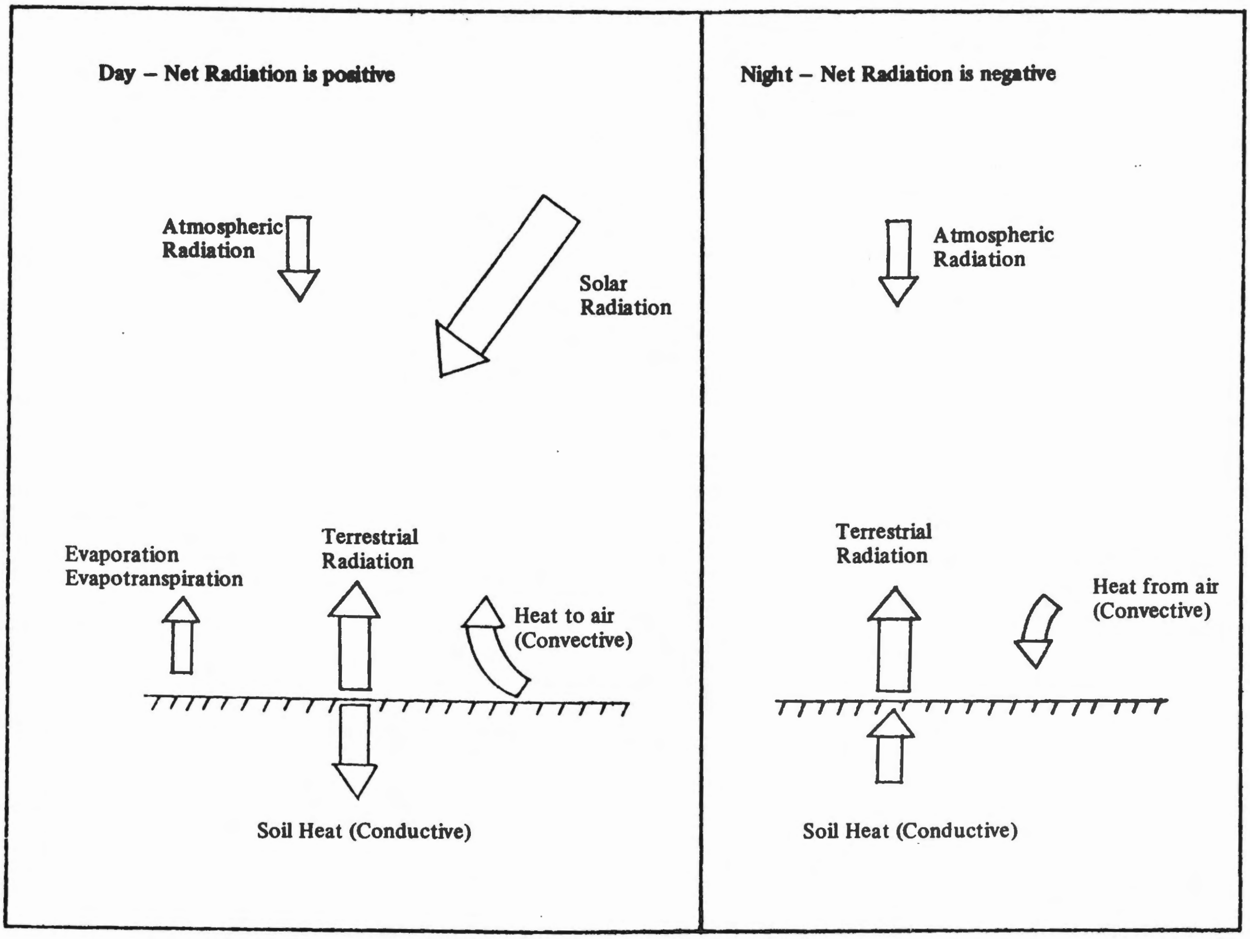


FIGURE 1 – Simplified heat exchange at the earth's surface during clear weather.

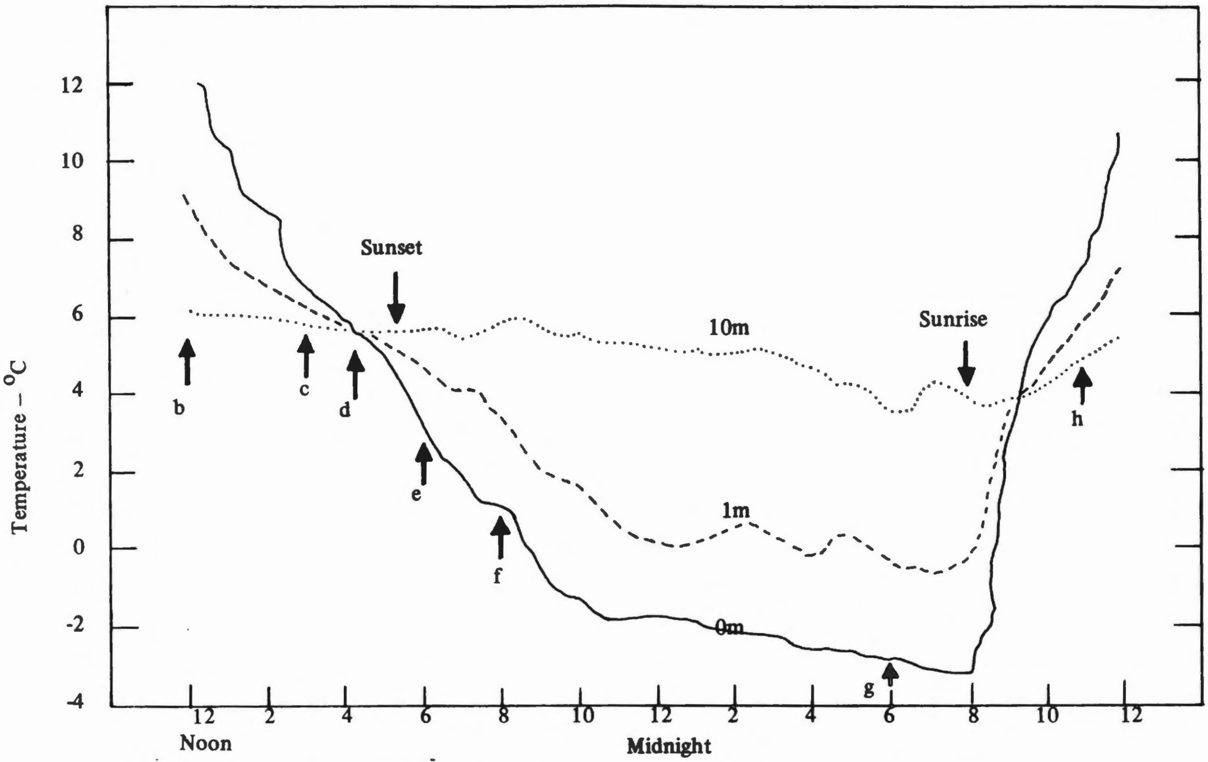


FIGURE 2a – Typical diurnal spring temperature patterns during clear skies and light winds.

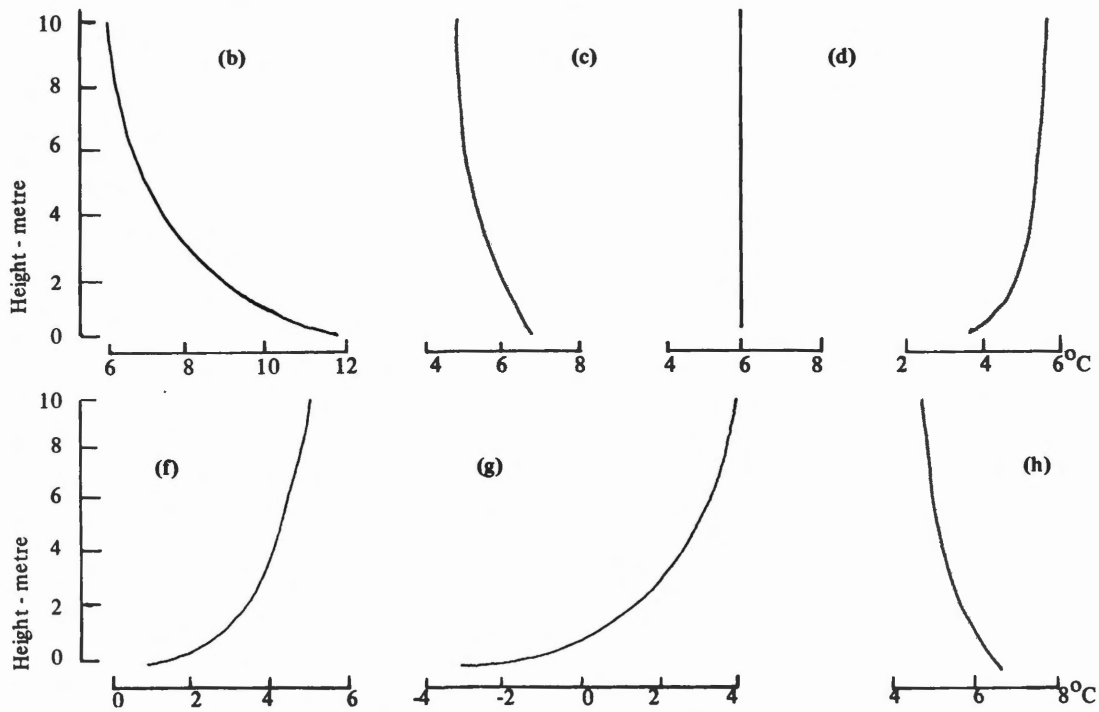


FIGURE 2b-h – Temperature profiles corresponding to times b-h respectively in Fig. 2a.

and radiation alone is the ultimate process whereby heat on earth is gained or lost. Net radiation, or the difference between incoming and outgoing radiation is clearly positive during the day due to the large influx of heat from solar radiation.

At night, without solar radiation, more heat is radiated outwards to space than returned from the atmosphere, and net radiation becomes negative. The net outgoing heat must be supplied from some source and in this case it is from the soil and from air by turbulent transfer (and a small amount from vegetation). This of course causes air layers near the ground to cool.

The rate of heat loss by radiation during clear nights may be of some interest. It has a fairly universal value around 70 watts/square metre or about 1 million BTU/acre/hour. This is equivalent to the heat from nearly 300 single bar electrical heaters per acre and is essentially the heat that has to be replaced when protecting plants from frost.

With a knowledge now of the fundamental heat exchange processes at the earth's surface we can examine how these influence the temperature microclimate to bring about frost.

FORMATION OF INVERSIONS

If during potential frost weather, air temperatures at several heights above ground were measured continuously, a temperature pattern similar to that shown in Fig. 2a would emerge. For purposes of clarity, only temperatures at ground level (0 metre — 0m), 1m and 10m are shown in this diagram but temperature at other levels can be interpolated by eye. Temperatures deyond 10m can be disregarded since they probably have little relevance to the frost problem in horticulture.

Two features of the temperature microclimate are obvious from Fig. 2a. First, day temperatures are highest at ground level, and second, the situation is reversed at night with ground temperatures being lowest. During the day solar radiation dominates the daytime heat exchange causing considerable heating of soil and vegetation. This heat is in turn transferred to the air by conduction and convection but clearly temperatures at ground level will remain relatively high.

The daytime vertical temperature structure is more readily visualised in profile form which is a graph of air temperature against height. The right curving line in Fig. 2b indicating increasing temperature towards the ground is a typical calm day temperature profile known as a "lapse profile".

As the day advances and solar radiation decrease, there is less surface heating and profiles now take on a more upright shape as shown in Fig. 2c. About half an hour before sunset, solar and atmospheric radiation is just sufficient to balance terrestrial heat losses (net radiation is zero) and a "neutral" condition represented by the vertical line in Fig. 2d arises. After the transitory neutral phase, net radiation becomes negative marking the onset of surface cooling. Note that cooling starts before sunset although the sun is so low at this stage that solar heat is almost negligible.

As soil and vegetation continue to lose heat to space, the surface air cools, because more dense and eventually settles down close to the ground. Since air is a very poor conductor, heat cannot be readily conducted from the relatively warm air layers above. Furthermore, heat cannot be readily transferred downwards by turbulence since a precondition for inversion/frost formation was that winds be very light or calm. Consequently more and more heat is withdrawn from the relatively shallow layer of air near the ground and the temperature profile now assumes the left curving slope of the well known temperature inversion. Fig. 2e, f and g show the progressive developement of the inversion during the night. As indicated by these diagrams, an "inversion" is literally an inversion of daytime lapse conditions.

Destruction of an inversion is fairly rapid after sunrise. Solar heating again takes over and a neutral phase occurs about an hour after sunrise followed by a rapid reversion to lapse conditions (Fig. 2h).

SOME PRACTICAL IMPLICATIONS

The maximum height to which temperatures increase during inversions, sometimes called the "inversion ceiling", varies greatly from less than 10m under certain conditions to hundreds of metres, and depends largely on location and topography. However, as a generalization the greatest difference in temperature occur within 2-3 metres from ground level with a smaller difference up to 10m or so and probably only 2-3°C from 10m to beyond 100m. Inversions in New Zealand are comparable with those of important horticultural locations overseas and generally range from 3-8°C (10m temperature minus 1m temperature) with an average around 4°C.

It should now be evident that frost is not a "uniform" phenomenon but tends to be more severe near the ground. Between early winter and late spring there is a downward shift in frost levels (the level below which air temperature is 0°C or lower) as indicated

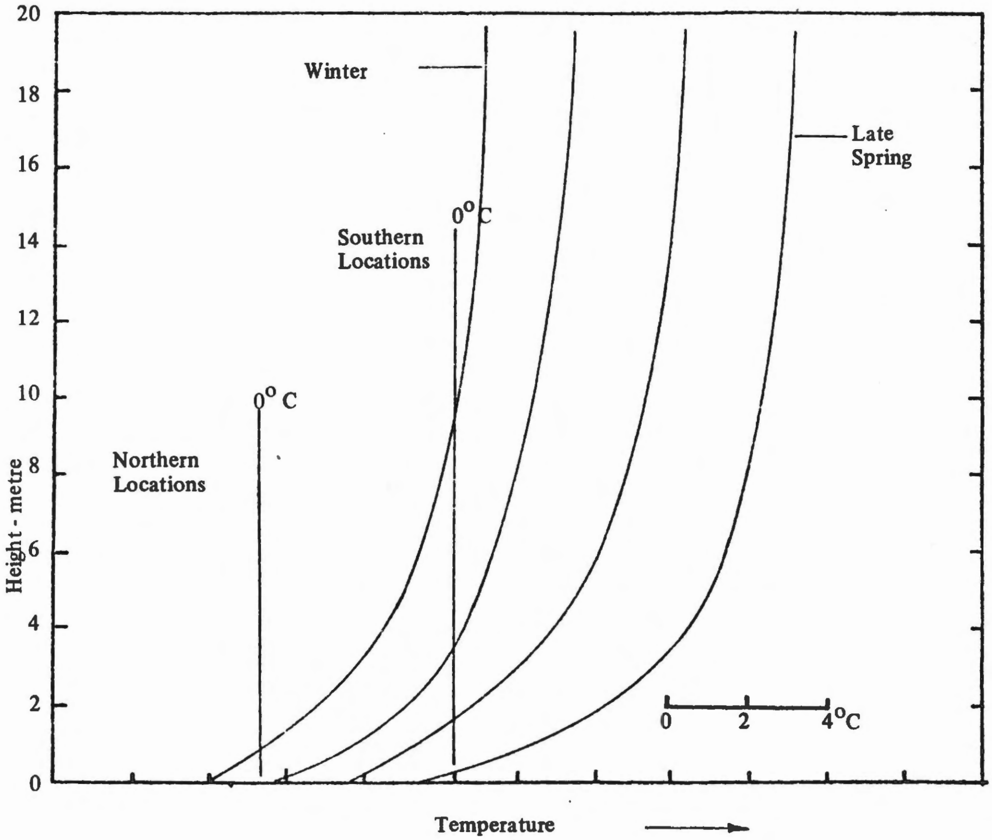


FIGURE 3. – Seasonal change in inversion profiles. Frost levels are indicated at the intersections of the vertical 0°C iines and the temperature profiles.

in Fig. 3. It should be pointed out here that the information in Fig. 3 is a generalization only and marked variations in profiles do occur within and between seasons. In this diagram, seasonal frost levels for northern (e.g. Auckland) and southern (e.g. Canterbury) locations in New Zealand are indicated where the 0°C vertical lines intersect the temperature profiles. In northern locations, frost seldom occurs above about 1m and then usually only during June and July. Note that as air temperatures increase as the season progresses, inversions tend to become more pronounced or stronger. This is because cooling periods get progressively shorter and relatively less and less heat is drawn from upper air layers.

From a grower's viewpoint, the most important implication of radiation frosts is that damaging temperatures are confined close to the ground. Even in more northern locations in New Zealand, such as Auckland and the Bay of Plenty, young citrus stock and sub-tropicals such as tamarillo are susceptible to frost damage when plants are small but the risk of damage decreases markedly as the crop grows. Frost sensitive ground crops such as tomato, bean, potato and strawberry are particularly prone to damage by late spring frosts which may only last for an hour or so. Training of vines to a height greater than normal is a method commonly used in marginal frost areas in U.S.A. to prevent damage to vines.

In many practical horticultural situations, temperature profiles during frosts are seldom of the form indicated in Fig. 3 except for those over ground crops such as mentioned above. During late spring, leaf growth in many crops is fairly rapid. In mature citrus, stone and pip fruit orchards for instance, and in dense growing ground crops such as tobacco, there is a marked discontinuity in the temperature profile at leaf canopy level (Fig. 4). Over very dense crops, temperatures are actually lowest at canopy level due to the fact that leaves, rather than the ground, act as the radiating surface. Very leafy crops are particularly susceptible to frost damage since

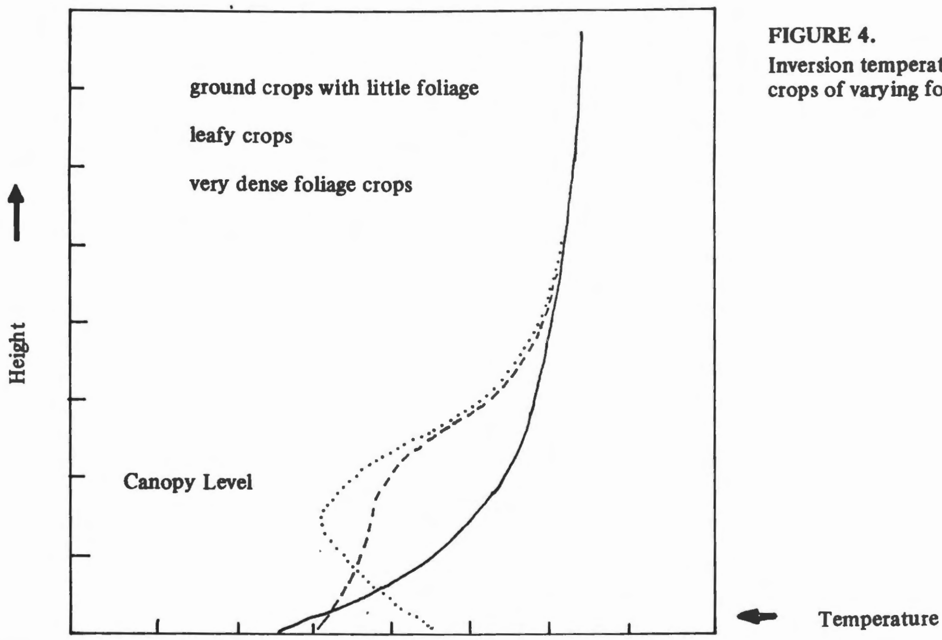


FIGURE 4.
Inversion temperature profiles for crops of varying foliage density.

canopy temperatures are often as low as ground temperatures in an open field.

Finally a word about soil heat and turbulent heat from air insofar as these components may be modified by cultural practices. With moist compact soil, soil heat can supply up to 60% of net radiation during frosts. This figure drops sharply to around 20% over short grass or thick weed, and reduces further to 5-10% over long grass and thick mulches of sawdust or straw. Heat flow through dry loose soil is about a half of that for moist compact soil. Cultural practices which increase the resistance of heat flow from soil to the radiating surface can be responsible for a 1°-3°C increase in frost severity. It is worth noting that such practices would not only reduce nocturnal heat outflow from the soil but also reduce heat inflow or storage during the day.

When winds drop to about 2m/sec (4.5 mph) during clear nights, natural mixing of air layers near the ground decreases markedly. 2m/sec is in fact the transitional windspread above which strong inversions will not form and severe frosts are rare. At 0.5m/sec (1mph) atmospheric turbulence virtually ceases and the air near the ground is said to be highly stable. It can be seen that if all other factors remain the same and turbulence is minimal or suppressed, heat cannot be readily transferred from upper air layers and surface temperatures must fall. It will be remembered that soil heat and turbulent heat are the 2 major components which balance nocturnal net radiation during clear nights. The practical implication here is that stable air near the ground is often artificially induced rather than caused by natural means. Shelter-belts and windbreaks are standard features wherever intensive crop production is practised and often their influence on frost severity is not appreciated. In marginal frost areas, induced air stability due to shelterbelts could mean the difference between significant frost damage to crops and no damage at all. Deciduous belts may be preferable to evergreen belts in many cases since leaves will not be fully developed until late spring. Induced stability therefore will be minimal until well into the frost season when the risk of frost damage is significantly reduced.

CONCLUSION

Frost will always be a perennial problem for many horticulturalists. While we cannot prevent frosts from occurring, we can at least be forearmed with a knowledge of why they occur and the microclimatic conditions which are likely to arise. Such knowledge should assist growers to avoid potential frost situations and to provide a more objective attitude towards protection of vital crops from frost damage. In this article, only the basic mechanism of radiation frost formation and frost characteristics have been covered. Those interested in frost protection or simply wishing to pursue the topic further are advised to read general bulletins on frost relevant to N.Z. horticulture such as "Preventing frost damage to fruit trees" by E. W. Hewett (N.Z. DSIR Information Series No. 86, 1971).

Floral Art: Influences of Design and Colour in the Selection of Plant Materials

by
M. WATLING

In accord with the allied arts of the painter, sculptor and ceramic craftsman, flower arranging is greatly influenced by trends of the current era. This in turn shows a desire for ornamentation, purposeful interior decoration, or more extensive experimentation to extend the scope of the art. This tendency to assume a general trend may also increase the popularity of certain plants distributed by the nursery and cut flower trade.

Fragrance was an attribute often associated with flowers popular in the 19th. Century and early 20th Century, in the era of nosegays, fresh flowers preserving under glass domes, and floral designs of rounded shape. In those very ornamental times of fluted glass and the epergne, emphasis was on colours in variety and abundance of materials placed in close proximity. Asparagus fern and lycopodium were widely used as foliage, and flowers such as fuchsia, rose, calendula, dahlia, single aster, hosta, nasturtiums, calceolaria, monbretia, *Reseda odorata* (mignonette) and convallaria (lily of the valley).

Today a feeling of nostalgia may still be conjured up by the use of these flowers, and also nigella, aquilegia, *Primula auricula*, salpiglossis, lavender and heliotrope, in appropriate symmetrical, semi-massed designs.

The intervening years have brought many changes in style, with a trend in the 1950's for rather two-dimensional designs with an inclination to mass material into compact form with a lack of voids, especially in the silhouette. Fan-shaped patterns of gladioli, for instance, absorbed a great deal of material because of their very shape. The use of gypsophylla with larger rounded forms such as carnations was an example of materials unrelated in scale. The advantageous use of foliage was often overlooked.

In the following fifteen years, sources of influence on New Zealand floral art have been the American and Japanese styles; changes in our immediate environment such as architectural trends and the shrinking of the domestic garden space, as well as the challenge of air conditioning and central heating. There is also a more general awareness of design potential in natural plant material. Some plants are proving timeless in this respect, such as the aspidistra, featured on grandmother's verandah, yet now widely sought for its innate sculptural qualities.

In this generally more design-conscious era, it is possible to assess the contribution any material may make to a design before actually removing it from the plant. The design elements of line, form, colour, texture and pattern, arranged in three-dimensional space, influence this choice. Linear forms such as branches, foliage of phormium, cordyline, aspidistra; curling euclyptus bark and flowers of kniphofia establish the main lines of a design.

The shape of materials denote their position, finer forms usually achieving better balance at the top and outline, and larger forms being incorporated near the base. A variety in types of material yield contrasts of form, the source of supply not being confined to the plots of annual and perennial flowers — ornamental corn and small gourds, a wide selection of seed-pods from all sectors of the garden and fruits such as *Persoonia pinifolia*, *Idesia polycarpa*, *Mahonia lomarifolia*, vitis and *Malus* 'Jack Humm', are typical of the extensive range.

An often overlooked quality is the surface structure or texture of the plant material, which can have great influence when used deliberately in contrast or harmony. The roughness of bark or wood, the wiryness of leucospermums, velvety appearance of roses, waxy surface of tulips, the leathery impression of *Magnolia grandiflora* leaves, all play a part. The amount of light reflected by the surface of the material will affect its dominance in the design, shiny surfaces making themselves very conspicuous.

Colour may either emphasize or detract from a design, and careful consideration should be given to its use when selecting plant materials. The total concept of colour is made up of all the component parts, including the container, foliage, flowers, seedpods, fruit etc., and the actual setting for the design. Generally, it is regarded as more successful to have one dominant colour, the others being subsidiary.

Novelty of new colours or forms influences fashion in materials — in colour, for example, the acceptance of green in various degrees in foliage may be contrasted with a marked stir of enthusiasm when this hue appears in a flower. There now exists a formidable array in this colour range, among the annuals being numerous gladioli such as Green Woodpecker; *Zinnia* 'Envy', *Amaranthus viridis*, mollucella, while perennials include *Eucomis comosa*, Zntedeschia 'Green Goddess' Helleborous corsicus, *Chrysanthemum* 'Madam E. Rodgers', and angelica. Shrubs offer a choice of green in *Phylica pubescens, Erica sessiliflora, Protea macrocephala, Rosa chinensis* 'Viridiflora', and the vibrant hue of *Crotolaria laburnifolia* (Queensland Bird Flower).

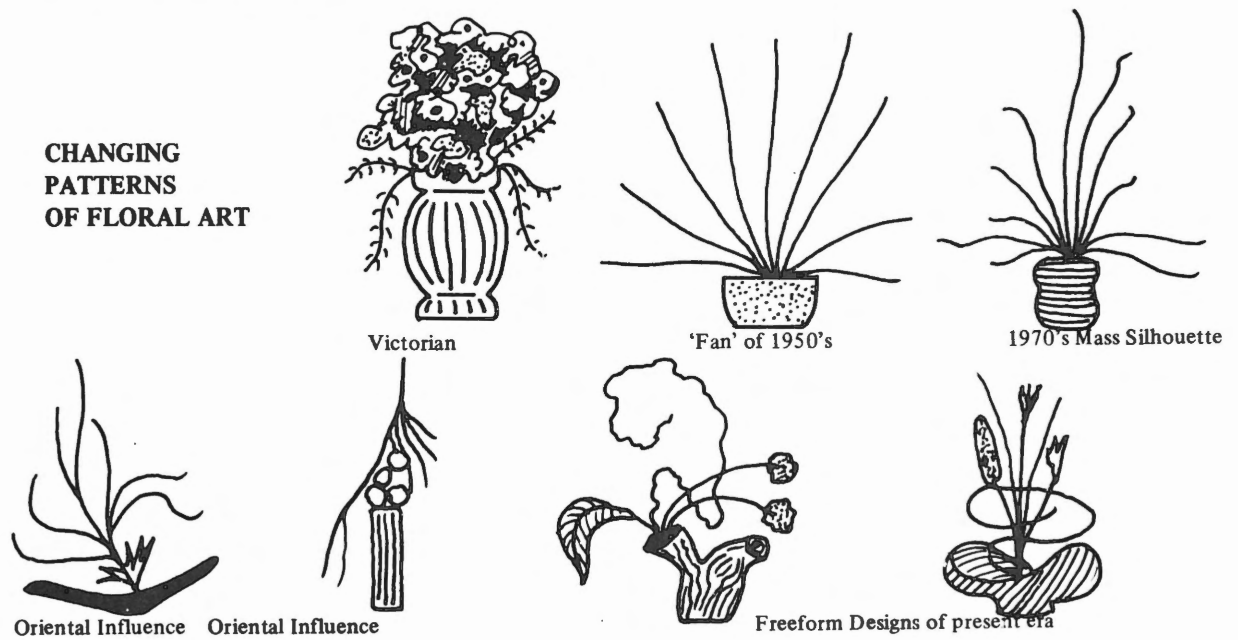
Rose hybridists are also recognizing the popularity of subtle hues in the mauve to brown range, of which Sterling Silver and Vesper are samples. Gladioli too, contribute such unusual tonings as Chocolate Chip and Crepe Paper.

The pattern created by the materials is closely related to form, and in this age of often minimal use of subjects, in bold effects with active voids, the growth habit of the plant itself may inititate the design. *Salix matsudana* 'Tortuosa', *Actinidia chinensis*, wistaria, or vitus pines; philodendron, *Fatsia japonica* and manipulated phormium leaves all set a pattern, giving rhythm and accenting voids. Interesting flower forms include *Strelitzia raginae; Leucospermum bolusii*, cannas in glowing colours; and the strong shapes of *Narcissus* 'Golden Ducat' and *N.* 'Baccarat'.

Plants having excellent lasting qualities when cut are always valuable, and this is aided by knowledge of the particular conditioning methods necessary. Chrysanthemums, proteas, arums, leucospermums and leucodendrons, aspidistra and fatsia foliage all last well. Generally most flowers react favourably to having the stems placed in about 15 to 20 cm of hot water up to 20°C, and then left till the water is cold, while foliage such as angelica is best submerged in cold water overnight.

Plant material which also dries and preserves well, is also an asset and examples are the flowers of *Beaufortia sparsa, Achillea filipendula* 'Gold Plate', and *Agonis juniperina*, while leaves of magnolia, fatsia, and photinia process well in the preserving method using one part glycerine to 2 parts warm water.

Thus the elements of design influence the choice of plants for the home garden, with the ultimate purpose of acquiring materials with which to convey the interior decoration characteristics of this present era.



Nitrogen in Container Mixes and a Simplified Method for Comparative Analysis

by
M. B. THOMAS and M. SPURWAY
Horticulture Dept., Lincoln College

ABSTRACT

The attention of nurserymen is drawn to the importance of nitrogen for plants. Nitrogen release in overseas and N.Z. potting mixes, and from individual fertilisers is examined. Nitrogen release patterns are simplified to allow a working method for comparing nitrogen levels at given times in different potting mixes.

1. INTRODUCTION

Decision making and examination of chemical ingredients of potting mixes is often based on very little background information. This article attempts to provide some of the guidelines needed for planning new mixes or appraising mixes in use.

Furuta (1969) states that a study of potting mixes requires an evaluation of physical, biological and chemical characteristics plus the quality, stability and cost of the ingredients. He points out that it is possible to establish tentative and minimum specifications for certain parameters of soil mixtures. The minimum requirement for fertilisation is given as 'slow release nitrogen incorporation, constant fertilisation with nitrogen and potassium, and phosphorus incorporated as single superphosphate'. The application of nitrogen is of high importance. Optimum growth of nursery plants depends on supplying nitrogen at the right levels and most nurserymen will have observed how too little gives deficiency while excess quickly leads to toxicity.

The nutrient supply characteristics of various fertilisers has been examined by various workers. Cochrane and Matkin (1967) found that the rate of nitrogen released from osmocote (N.P.K. 18-3.9-10.8), hoof and horn, and bone meal was roughly double that of magamp (fine grade) over the 14 week experiment. Prasad and Galagher (1972) used the same length experiment and found that the cumulative release of nitrogen from IBDU was 69%, and 30% from ureaformaldehyde at 14 weeks. Bridger et al (1961) found that the total nitrogen converted to nitrate was 58% for ureaformaldehyde and 65% for fine grade magamp after 11 weeks while with coarse grade magamp it was 34%. Allison (1973) points out that 87% of the nitrogen in urea is converted to nitrate in 20 days while it takes a further 40 days for an additional 1 or 2% more. Other workers like Bunt (1968) have looked at nutrient release and although the precise figures don't always agree because of the many variables effecting release, a general comparative picture can be drawn up. Figure 1 attempts to give the actual nitrogen release patterns based on the findings of these workers and estimates of probable release based on plant response in various nutrition trials.

Levels of other elements are comparatively much less critical and are less subject to loss by leaching, etc. Furthermore it has been found from nursery container research (Hocking & Thomas, 1974; Thomas, 1974) that nitrogen is often the dominant element for the growth of many container grown shrubs and that other major elements like phosphorus and potassium need only be supplied at moderate levels. Scott (1972) for example, found fast growing shrubs were tolerant to and responded strongly to high levels of liquid fed nitrogen.

This article closely examines levels of fertilisers and nitrogen supply in research and commercial potting mixes and attempts to make recommendations accordingly.

2. FERTILISER RELEASE PATTERNS

The large number of fast and slow or controlled release fertilisers available in New Zealand has meant that nurserymen have a wide range of materials to choose from. Richards (1969) (a) described the various fertilisers available and pointed out the importance of a knowledge of release characteristics in the light of the growing importance of slow release fertilisers in container growing in New Zealand. Amos (1973) discussed the chemical ingredients of NZ mixes based on slow and fast release fertilisers with reference to soil tests. Unfortunately these soil tests do not include nitrogen.

Nutrient release curves vary greatly in shape and in most cases the final few grams of nutrient may be very slowly released and the top of the curve levels off onto a plateau. In order to simplify analysis of the chemical ingredients of mixes at different times nitrogen release curves have been replaced by straight lines as shown in Figure 2. Osmocote (N.P.K. 18-2.6-10) is referred to as a slow release fertiliser releasing nutrients for 8-9 months. The nitrogen release from this fertiliser is shown in Figure 2 as a straight line with 100% release at 8½ months. This straight line representation of release rates therefore gives a broad, simplified basis for analysis which should be suitable until more detailed research has been done on this aspect.

3. RESEARCH RESULTS

The results of a trial using medium and short term fertilisers in various soils and soilless mixes using tomatoes is shown in Figure 3. The release of nitrogen at given times is tabulated below Figure 3 using the linear release rates shown in Figure 2. Tomatoes are often referred to as a 'gross feeder' and have been shown to respond strongly to added nitrogen particularly when adequate potassium and phosphorus levels are supplied, Bunt (1969).

The tomato trial summarised in Figure 3 illustrates the value of slow release materials. Plants grown in the soil mixes with perlite (PPS) and vermiculite (VS) with total nutrients of NPK 225-150-125 g/m³ were of similar size irrespective of the fact that one was with fast and one with slow release fertilisers. But when plants were given 450-300-250g NPK / m³, supplied from fast release fertilisers, their growth was significantly smaller in both the vermiculite mixes (V&VS) and the perlite mix (PP), than the plants supplied with slow release fertiliser and the same total nutrients (PP & PPS). All plants given the highest rate of fast release fertilisers in the three mixes were very severely stunted and contrasted with the again significantly larger plants supplied with the two slow release materials.

These results serve as a guide for looking at suitable levels of nitrogen release for container grown plants, particularly rapid growing subjects. The figures giving release of nitrogen in grams per month under Figure 3 indicate why the fast release materials were comparatively unsatisfactory even for a short term crop like tomatoes. The release of nitrogen from the fast release fertilisers in the first two months was obviously too high, and toxic. These excessive nitrogen levels probably carried on well past the first month. The 450g N/m³ rate supplied from the slow release osmocote fertilisers was probably close to the point of maximum response with 121 gN/m³ being released per month for the first two months. The interesting aspect was that the tomatoes grown with the 900g N/m³ from slow release osmocote in peat:perlite:soil were not significantly larger than with 450g total N/m³, indicating that increasing the rate from 121 to 250g N/m³ per month proved of no value. These plants at the 900g N/m³ rate were therefore in the luxury range of nutrient response, furthermore, when grown in peat:perlite at this high rate, these levels proved slightly toxic and the plants were significantly smaller than the corresponding mix with ⅓ soil. Soil acted as a good buffer with the highest fertiliser rates with the perlite and vermiculite mixes and also the vermiculite mix at the 225N-150P-125K level. Soil in the mix with both fertiliser types improved the growth of plants where nutrient levels were low. Plant growth was significantly greater when soil was added to the vermiculite and perlite mixes at the lowest fertiliser rate and in the vermiculite mix at the 225g N/m³ rate as compared to the corresponding light weight mixes. Soil can act as a nutrient supply or 'mop-up' toxic levels of fertiliser, although it is noticeable that peat:perlite was one of the three mixes with the largest plants.

Three additional and separate trials show further aspects on fertiliser response and nitrogen requirements of plants. These were 2³ factorial experiments with a total of 14 treatments in each. The five balanced or medium treatments for two woody species and tomatoes were taken out of these trials and are shown in Figure 4.

The nil and low rates of fertiliser were obviously inferior to the medium rates. The most important aspects of these results is that the medium nutrient rate supplied from the 8-9 month fertiliser was equal to the 3-4 month treatment with ericas. Growth was less for boronias and tomatoes than when supplied by the 3-4 month material. The differing growth from these treatments should be considered using the levels of nitrogen released on average per month and given in the table under Figure 4. It is reasonable to conclude that the 53 g N/month supplied from the 8-9 month osmocote (medium rate) is not adequate for optimum growth of shrubs. Probably 90-100g N/month from the slow release material would be a desirable level which is approximately the level of N supplied by the 3-4 month material for the first 4 months. The shrub crops were grown for 10-11 months and although nutrient release was relatively low in the first 4 months, with the 8-9 month fertiliser nutrient, release continued for most of the rest of the growing period. The short term materials would have ceased supply within 4-5 months. This was of course no problem for this second tomato trial which was grown for just under three months, although it was noticeable that the 900gN/m³ fertiliser rate was no significant advantage as was the case in the first trial (Figure 3). This high rate, released an average, 250gN/month over the first 2 months which caused severe toxicity for ericas and reduced growth in the boronias.

A rate of 90-100gN/m³ **per month** from slow release fertilisers would appear to be the requirement for tomatoes and shrubs from this data.

OTHER NUTRIENTS

Phosphorus supplied at 300gP/m³ using the fertiliser rates given under Figures 3 and 4 proved to be satisfactory in these and other shrub trials (except for proteaceae).

Potassium supplied at 250gK/m³ using the fertiliser rates given under Figures 3 and 4 proved to be satisfactory for shrubs. Tomatoes respond to higher rates.

Calcium is normally at adequate levels in potting mixes due to the standard use of lime. Magnesium is often supplied via dolomite or complete fertilisers. Trace elements especially iron, are often added especially to soilless mixes.

Research on nutrients for container mixes other than nitrogen will be published at a later date.

MANUFACTURERS' RECOMMENDATIONS FOR LONG TERM FERTILISERS

The rates with nutrient release and crops recommended for medium and long term slow release fertilisers are shown in Table 1 based on the simplified and theoretical release patterns in Figure 2.

The magamp recommendations for potted chrysanthemums and osmocote for shrubs, fall within the recommendations of approximately 100g N/m³ per month concluded at the end of the comments on research. The coarse magamp recommendation for shrubs appears too low and this rate should be supplemented with the fine grade material to give adequate monthly nitrogen release.

Floranid, osmocote (NPK 14-6-12) uramite and IBDU are shown at typical rates. Table 1 and also Figure 1 show that most of the nitrogen from these materials is released within **3-4 months** under warm (20°C) moist soil conditions.

In order to provide nitrogen over the same period as the 8-9 month osmocote a supplementary feeding will be necessary with medium term slow release fertilisers. For example, floranid used as part of the base fertiliser at 1.5 kg/m³ will need to be applied again at this rate 4-5 months after potting. The broken line labelled A in Figure 2 illustrates the theoretical use of a repeat application of medium term nitrogen.

A practical conversion chart (Table 1A) gives the approximate average nitrogen release per month from 1 kg/ m³ levels of various fertilisers. A nurseryman adding 1 kg of osmocote (NPK 14-6-12) plus 1 kg of floranid per cubic metre of mix can quickly see that this supplies 40 + 57 i.e. 97 g N/m³ each month for approximately 3½ months. This would be a good medium nitrogen supply for up to 4 months.

ANALYSIS OF COMMERCIAL MIXES

Birch (1970, a & b) reviewed and tabulated the ingredients and nutrient levels contained in the principal potting mixes used overseas. Some further analysis and conversion of these mixes to metric units is given in Table 2.

The basic mixes used overseas can be seen to be based on a relatively short term nitrogen supply. Birch (1970, b) pointed out the inherent danger of nitrogen starvation with U.C. mixes in Britain, and Richards (1969, a & b) points out some of the difficulties in trying to use U.C. mixes under New Zealand conditions. Naturally the John Innes mixes, which are based on soil, would not require feeding as early as the U.C. mixes. These mixes appear to have adequate nutrients for the first 4 months for most shrub crops, however supplementary feeding would

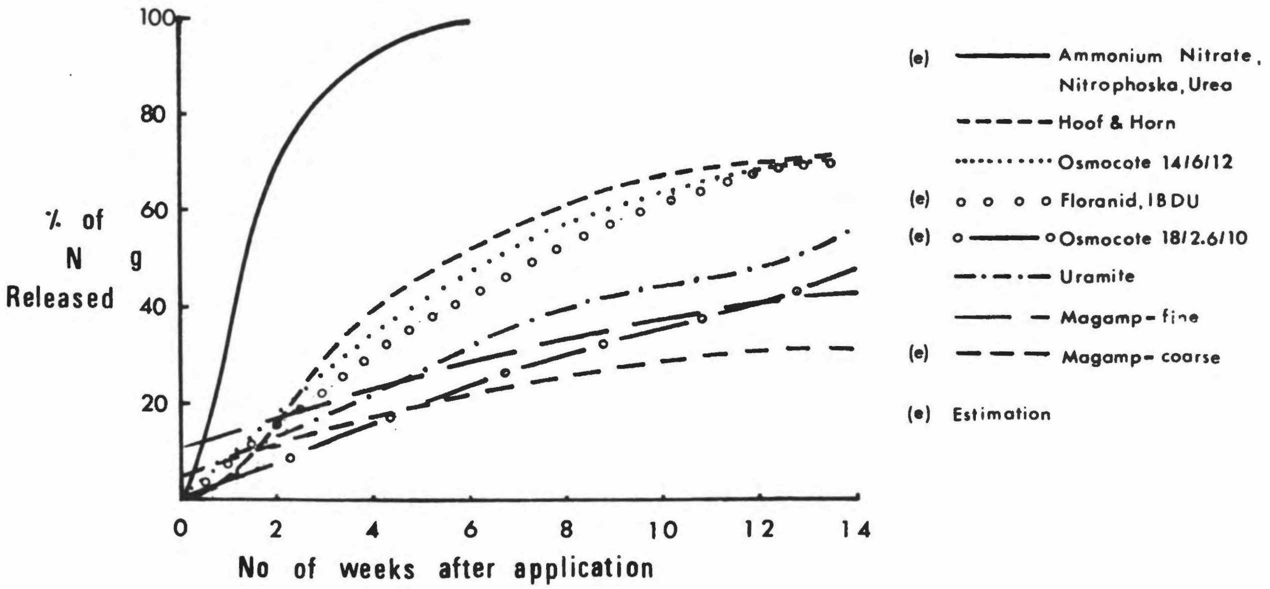


FIGURE 1: Diagram illustrating estimated and reported nitrogen release patterns from fertilisers.

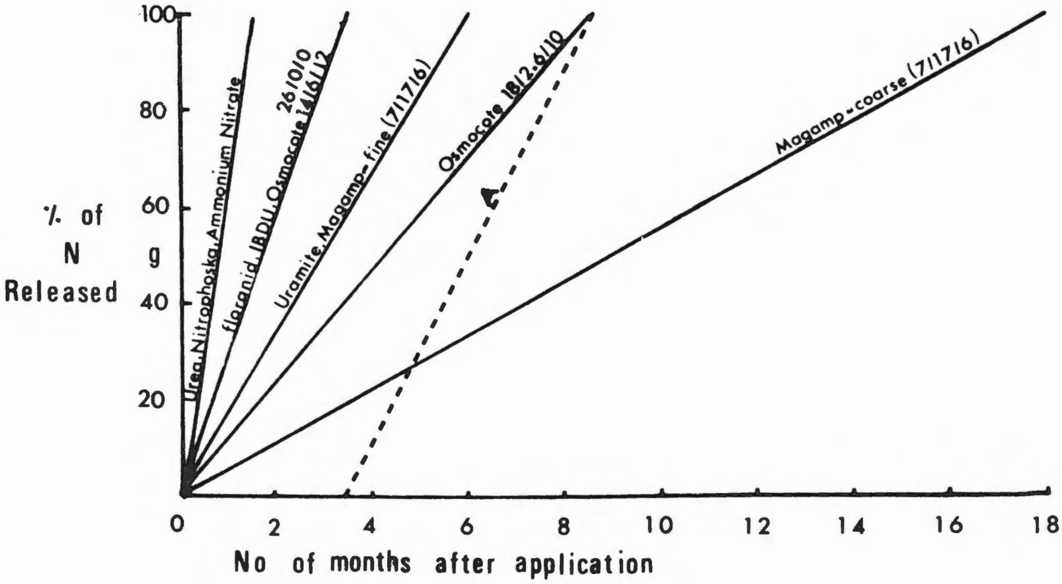


FIGURE 2: Diagram illustrating theoretical nitrogen release patterns from fertilizers assuming 100% efficiency.

TABLE 1

The monthly nitrogen release from certain commercial slow release fertilisers (using Figure 2) based on commercial or common application rates.

		AVERAGE GRAMS OF N RELEASED PER M^3 /MONTH				
Fertiliser	**Rate of Application**	**First 2 months**	**3-4 months**	**5-6 months**	**7,8,9 months**	**10-18 months**
Magamp (medium) – for potted chrysanthemums NPK (7-17.8-5)	10.38 kg/m^3 (17½ lbs/yd^3) (727gN/m^3)	121	121	121	–	–
Magamp (coarse) – for shrubs (7-17.8-5)	8.01 kg/m^3 (13½ lbs/yd^3) (561 gN/m^3)	31	31	31	31	31
Osmocote (18-2.6-10) low rate	2.37 kg/m^3 (4 lbs/yd^3) (427gN/m^3)	50	50	50	42	–
Osmocote (18-2.6-10) medium rate	4.15 kg/m^3 (7 lbs/yd^3) (747gN/m^3)	88	88	88	73	–
Osmocote (18-2.6-10) high rate	5.60 kg/m^3 (9½ lbs/yd^3) (1008gN/m^3)	119	119	119	98	–
Floranid (20-2-7)	1.5 kg/m^3 (2½ lbs/yd^3) (297gN/m^3)	86	64	–	–	–
Uramite (38-0-0)	0.89 kg/m^3 (1½ lbs/yd^3) (338gN/m^3)	56	56	56	–	–
IBDU (31-0-0)	1.04 kg/m^3 (1¾ lbs/yd^3) (322gN/m^3)	93	68	–	–	–

TABLE 1A

Basic Conversion chart for nurserymen showing approximate supply of nitrogen per month provided by 1 kg (1¾ lb) of specific fertilizers and release periods.

Fertiliser	**gN released/ month**	**Approx. duration of supply (months)**
Magamp (coarse)	4	18
Osmocote 18-2.6-10	21	8½
Magamp (fine)	12	6
Uramite	63	
Osmocote 14-6-12	40	3½
Osmocote 26-0-0	74	
Floranid	57	
IBDU	89	
Ammonium Nitrate	227	1½
Ammonium Sulphate	140	
Nitrophoska Blue Extra	80	
Urea	307	

TABLE 2

The monthly nitrogen release rate of various standard overseas potting mixes (based on Figure 2).

Mixes		Average N release/month (gN/m^3) First 2 months	3rd & 4th months	5th & 6th months	Total Nutrients (g/m^3) N	P	K
John Innes Potting Composts	JI1	40	30		141	94	237
	JI2	82	61		285	186	474
	JI3	122	91		426	280	711
University of California Composts (U.C. Composts)	1	17	–		33	117	142
	2	68	38		211	117	142
	3	119	76		389	117	142
Glasshouse Crops Research Institute (G.C.R.I. Mixes)	seed	28	–		56	58	139
Potting on high N reserve	1	97	37	37	342	117	292
	2	116	56	56	456	117	292
	3	134	74	74	564	117	292
Pricking out low N reserve		91	–		182	117	292
Kinsealy Composts	Tomato	140	47	47	468	105	308
	General	185	–		371	53	308
Peat-lite Mixes	seed	102	–		204	93	–
	growing on	45	–		89	93	222
Valentines Composts	seed	45	33		156	94	237
	potting	94	49		286	139	492

be necessary at approximately 6 months, depending on the season. It is noticeable that for the first 2 months the second level for most mixes, such as John Innes Potting No. 2, approximate to the guideline of 100g N/month recommended in this article. However the GCRI and Kinsealy mixes with 150-190g N/ m^3 per month for the first 2 months show that 100g N/ month is a safe level.

The nutrient release from potting mixes used by a selection of nurseries in New Zealand are listed in Table 3. The principal fertilisers and type of production are also given. One of these mixes (G) is first looked at in more detail by examining the total amounts of nutrients released from this soil based mix and the average monthly nitrogen levels.

Mix G is a soil mix used for pot plants. It contains the following:

	N (g/m^3)	P	K
.24 kg/m^3 (.4 lb/yd) Uramite	90.2		
.48 kg/m^3 (.8 lb/yd) Serp. Superphosphate		33.2	
.24 kg/m^3 (.4 lb/yd) Sulphate of Potash			92.5
1.48 kg/m^3 (2½ lb) Osmocote 14-6-12	207.6	90.5	172.0
1.48 kg/m^3 (2½ lb) Osmocote 18-2.6-10	267.0	38.6	148.3
(Plus lime) Total	564.8	162.3	412.8

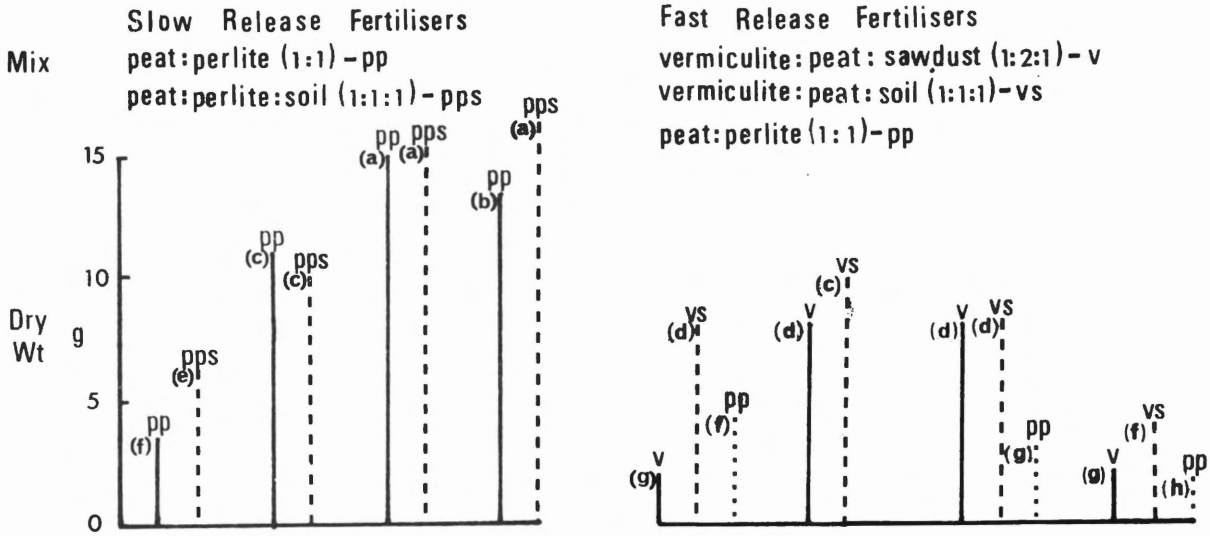
Examining the nitrogen part of the mix by looking at the average monthly N release rate gives:

	Average release of N/month g/m^3 First 2 months	3rd & 4th months	5th & 6th months	7th — 9th month
Uramite	15.0	15.0	15.0	–
Osmocote 14-6-12	59.4	44.5	–	–
Osmocote 18-2.6-10	31.5	31.5	31.5	26.0
Total (as per table 3)	105.9	91.0	46.5	26.0
			Total N g/m^3	564.8

Mixes D and H will require side dressing after 6-7 months of warm conditions although feeding of mix H need only be in small increments since it is a soil based mix and nitrogen will be gradually released from magamp (coarse) for approximately 18 months. Mixes G and E would last an additional 1-2 months before available nitrogen becomes lacking. Nitrogen levels in mix E are higher than other mixes and are best suited to maintaining the growth of large shrubs and pot plants and could be toxic to small or fertiliser sensitive plants.

Some general observations can be made about the mixes listed in Table 3. Mixes I, C, and F appear to have an adequate supply of nitrogen for each of the first 4 months. Side dressing with equivalent N levels

FIGURE 3: A summary diagram depicting the growth response of tomatoes to fast and slow release fertilisers and in various media. (Levels of significance are shown by small letters in brackets above the columns – where small letters are common there is no significant difference at the 5% level using Duncan's test).



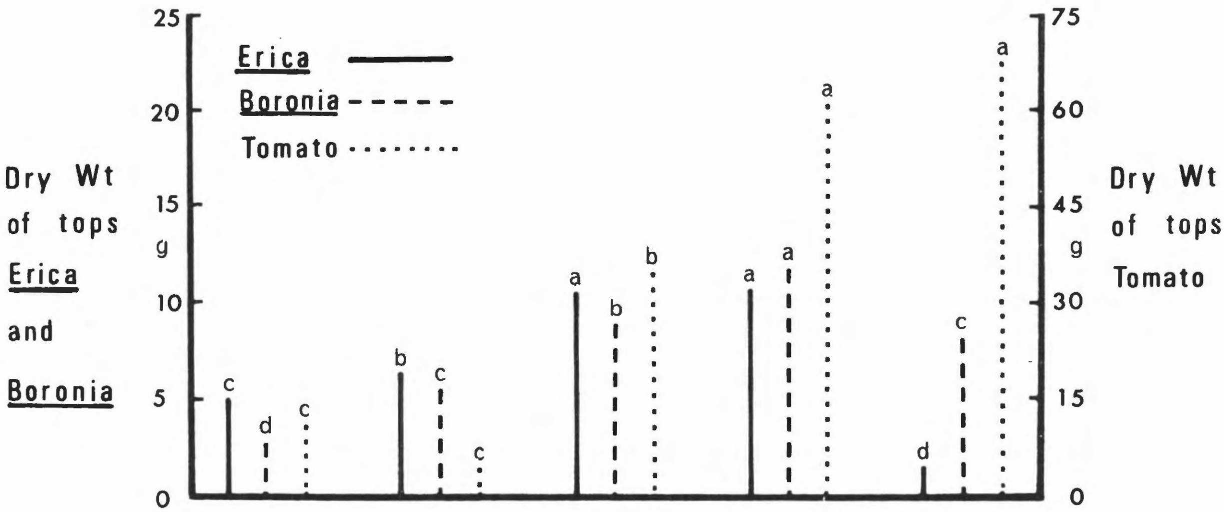
		Slow				Fast			
Nutrients g/m^3	N	45	225	450	900	45	225	450	900
	P	30	150	300	600	30	150	300	600
	K	25	125	250	500	25	125	250	500
g N/m^3 Av/mth	1st mth	5	57	121	250	18	138	288	587
	2nd mth	5	57	121	250	15	75	150	301
	3 & 4 mth	5	44	92	188	6	6	6	6

Fertilisers kg/m^3 (1 kg/m^3 = 1lb 11oz/cu. yd)

Osmocote 18-2.6-10	0.25	0.25	0.25	0.25	Floranid	0.12	0.12	0.12	0.12
					Nitrophoska Blue Sp.	0.12	0.12	0.12	0.12
Osmocote 26-0-0	–	0.69	1.56	3.29	Bone Flour	0.20	0.20	0.20	0.20
					Sulph. of Amm.	–	0.86	1.93	4.06
Superphos-phate	0.26	1.60	3.26	6.60	Super	–	1.33	3.00	6.33
Sulph of Potash	–	0.26	0.58	1.22	Sulph. of Potash	–	0.26	0.58	1.22

All mixes received 6 kg/m^3 lime + trace elements.

FIGURE 4: A summary diagram depicting the growth of *Erica carnea* 'Springwood White', *Boronia megastigma* and tomato at different fertilizer rates and from 3 separate factorial trials. (Levels of significance can only be compared within one species – with small letters in common shown in brackets above the columns, there is no significant difference at the 5% level using Duncan's test).



Main Fertilizer		Nil	8-9 month Osmocote	8-9 month Osmocote	3-4 month Osmocote	3-4 month Osmocote
		Nil	Low	Medium		High
g per m^3	N	0	45	450	450	900
	P	0	30	300	300	600
	K	0	25	250	250	500
Average gN released per m^3 /month.	First 2 mths	0	5.3	53	121	250
	3 & 4 mths	0	5.3	53	.92	188
	5 & 6 mths	0	5.3	53	5.3	5.3
	7,8,9 mths	0	4.4	44	4.4	4.4

Fertilisers kg/m^3 (1 kg/m^3 = 1lb 1oz/ cu.yd)

Osmocote 18 2.6 10	0	.25	2.50	.25	.25
Osmocote 26 0 0	0	0	0	1.56	3.29
Super	0	.26	2.60	3.26	6.59
Potash	0	0	0	.58	1.22

Mix: Peat:perlite (1:1) + fertilisers + 6 kg/m^3 lime + trace elements.

TABLE 3

The monthly nitrogen release rate of various N.Z. commercial mixes (using Figure 2) grouped under the crops grown.

Mix	Average release of N/month in g/m^3: First 2 months	3rd & 4th months	5th & 6th months	7th – 9th month	10th-18th month	Total g/m^3: N	P	K	
Trees and Shrubs									
A	63	63	63	52	–	534	211	297	Mainly long term osmocote with superphosphate.
B	126	126	126	73	–	975	108	415	Long term osmocote with some uramite.
C	135	102	–	–	–	474	131	421	Mainly floranid with some serp. super and sulphate of potash.
Trees, Shrubs and Pot Plants									
D	75	75	75	–	–	450	107	463	Equal amounts of uramite, superphosphate and sulphate of potash.
E	150	150	150	–	–	900	427	925	Based on large applications of uramite, superphosphate and sulphate of potash.
F	131	98	–	–	–	458	224	334	Mainly based on short term osmocote.
Pot Plants									
G	106	91	47	26	–	565	162	413	Based mainly on short & long term osmocote.
H	78	73	56	5	5	474	498	234	Mainly based on long and shorter term magamp.
I	156	80	–	–	–	472	147	245	Based on floranid, nitrophoska blue extra, bone dust and superphosphate.
Bedding Plants									
J	118	42	–	–	–	320	83	231	Based on nitrolime, IBDU, serp. super & sulphate of potash.
K	43	9	–	–	–	104	148	231	Based on superphosphate, sulphate of potash nitrolime & blood and bone.
L	38	38	38	–	–	228	107	231	Based on uramite,superphosphate & sulphate of potash.

as in the base dressing will be required at 5 or 6 months or as the growing season dictates (broken line Figure 3). For example pot plants grown in heated glasshouses may have an extended growing season.

Mix A is a relatively low nutrition mix which could be used for initial potting into small containers. Mix B will last an equal period (10 months) without sidedressing being required. In this latter mix nutrient levels are more than adequate and in fact care would be needed with small plants of difficult subjects like waratahs or proteas. Mixes J, K and L are used for bedding plants. Mix J is probably closest to the optimum nitrogen content while rapidly growing plants in mixes K and L will need sidedressing for optimum growth. Recent work indicates that bedding plants are much more responsive to balanced NPK levels than are shrubs. For example recent research with marigolds indicated that they grew best with 120 gN/m^3 per month from slow release fertiliser plus a base dressing of 300 gP/m^3 and 250 gK/m^3. The phosphate levels in Mix E and H appear to be excessive while the amount of potassium in mixes C, E and D is unnecessarily high and could potentially initiate nutritional problems since the potash fertilisers are relatively short term. Potassium levels in mixes J, K and L appear to be at a good level for bedding plants and in fact the amount of P & K does not appear to be too low in any of the N.Z. commercial mixes listed in Table 3.

ECONOMIC ASPECTS

Minard (1968) and Harre (1973) reviewed general plant nutrition and the types of fertilisers used in horticulture, including prices and unit costs of nutrients supplied. Van den Broek (1972) looked at the costing of container production based on a total of 100,000 units and including all aspects from capital, labour and materials to sales expenses. He found that the compost was one of the largest cost items apart from raising the plants ready for potting. The initial phase of a study into the economic aspects of container mixes with cost benefit analysis

TABLE 4

The cost of materials to make up two soilless potting mixes each with the same physical ingredients.

Physical Components of both mixes

1 pt peat at $15/m³

1 pt sand at $6/m³ ∴total cost per m³ = $10.50

Osmocote Mix (8 - 9 month release)

A. Fertilizers	Rate	Cost	Actual Cost	N	P	K
				g nutrient/m³		
Osmocote 18-2.6-10	4.15 kg/m³	$19.75/22.7 kg	$3.61	747	108	415
Superphosphate	2 kg/m³	$2.15/50 kg	.09		180	
Lime	6 kg/m³	$0.50/50 kg	.06			
		Total	$3.76	747	288	415

(average release of N/m³ per month = 83g)

∴ total cost of mix $/m³ = $14.26

Assuming 1 m³ fills 352 PB5's (2.85 litre bag) ∴ cost per plant:

Fertilizers	1.07 cents
Physical compon.	2.98
Total	4.05 cents/plant

Floranid Mix (3 - 4 month release)

B. Fertilizers	Rate	Cost	Actual Cost	N	P	K
				g nutrient/m³		
Floranid	1.54 kg/m³	$12.87/25 kg	$0.79	308	31	123
Superphosphate	2.86 kg/m³	$2.15/50 kg	0.12		257	
Lime	6 kg/m³	$0.50/50 kg	0.06			
		Total	$0.97	308	288	123
	+ Floranid sidedressing		$0.79 (average release of N/m³ per month = 77 g)			
			= $1.76 ∴ total cost = $12.26			

Assuming 1 m³ fills 352 PB5's (2.85 litre bag)

∴ Cost per plant:		
	Base fertilisers	.28 cents
	Floranid sidedressing	.22
	Physical component	2.98
	Total	3.48 cents/plant

on the chemical and physical aspects has been completed at Lincoln College (Stevens 1973). Stevens (1974) reports that subsequent studies on 25 representative container mixes have shown that fertiliser costs comprise between 0.8 and 35% of all costs (including materials, labour, machinery depreciation etc)., of preparing a commercial potting mix. However, it should not be inferred that higher fertiliser costs automatically mean greater benefits in plant growth.

The cost of materials (only) to make up a soilless mix based on 8-9 month osmocote and one for floranid are shown in Table 4. In the osmocote mix the cost of materials in the mix is close to 4 cents per plant in a PB5 (2.85 l) bag. With the floranid one side dressing would need to be carried out to give a release of nitrogen equal to that of the osmocote at 88.3g N/m³ per month (288 gP/m³ is contained equally in each mix). Allowing for the base + sidedressing the material costs of the floranid mix comes to 3.48 cents per plant or .57 cents per plant less than the alternative mix. Therefore the nurserymen must consider whether the labour involved in sidedressing, the efficiency of sidedressing (possibility of poor fertiliser distribution) and other factors such as the availability of labour make one of these types of mixes more suitable to his operation than the other.

CONCLUSIONS

Nitrogen nutrition is of major importance in container culture. Given actual nutrient levels of 200-300g P/m^3, 150-250g K/m^3 plus a base dressing of 3-6 kg lime/m^3, magnesium and a supply of trace elements the nitrogen release should be approximately **100 gN/m^3 per month.** For small sensitive or slow growing plants this level could be reduced to 60-70g N/m^3 while large fast growing plants being potted prior to a growth period could be supplied with approximately 120 g N/m^3 per month. Sidedressings of nitrogen may be required supplement base dressings of short term slow release fertilisers.

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Horticultural Applications of Tissue Culture

by
S. M. SMITH

ABSTRACT

Developments in aseptic tissue culture techniques in the last fifteen years have led to a number of important applications in horticulture. This paper discusses the value of callus and meristem culture for elimination of virus diseases and for micro-propagation of orchids and other crops.

Looking to the future, the potential of tissue culture techniques for the plant breeder is assessed with reference to embryo culture and "pollen plants".

INTRODUCTION

Tissue culture is a term which encompasses a whole range of techniques for growing plant organs and tissues in aseptic conditions on nutrient media. Early workers in this field were inspired by the desire to understand the nutritional requirements for growth and development of isolated cells and tissues, but such studies have led to the discovery and development of techniques of applied significance for horticulture and plant breeding. Mostly these techniques have involved the regeneration of **new plants** from small pieces of stem or root or from meristems, embryos or anthers.

The development of embryo plants in cultures of carrot is a classic example (see Plate 1). This phenomenon was discovered by Steward, Mapes and Mears (1958) who claimed to have stimulated in finely dispersed suspension cultures of carrot, the development of "embryoids" from free cells. Although it has not been firmly established that single cells in culture can develop directly and independently into embryos, this work did raise the possibility that any living cell in the plant body could be stimulated to behave like a fertlilized egg cell and regenerate a new plant. The possibilities for plant propagation were immense, and in the last fifteen years examples of the development of new plants from cultured tissues of a large number of different species have been published.

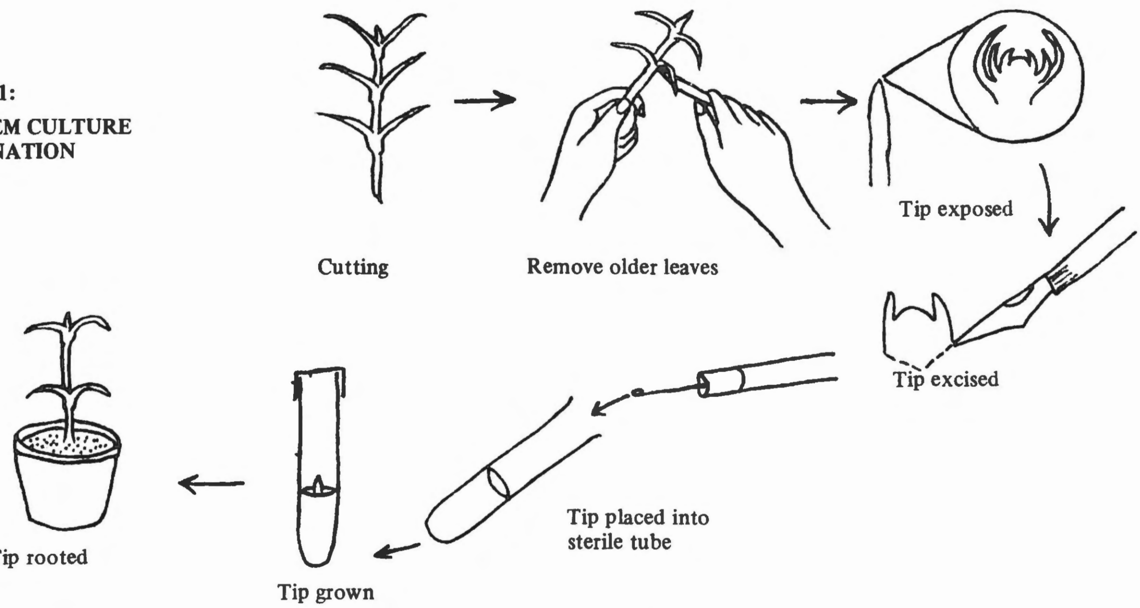
MERISTEM CULTURE FOR VIRUS ELIMINATION

Vigour and yields of many crop plants can be greatly reduced by systemic infection with virus. In some cases the infection can be removed by growing the plants for some weeks at 35°C followed by removal of a small apical shoot which is grafted on to a healthy stock. However, in many cases it is necessary to resort to the technically more difficult technique of meristem culture. Morel and Martin (1952) found that by taking the minute growing-tips or meristems from the shoots of virus-infected Dahlia plants and placing them on a simple nutrient medium containing mineral salts and sucrose, they grew into new normal plants showing no virus symptoms. Morel later demonstrated a similar technique for virus-infected potatoes and for orchids.

The meristem technique is based upon the assumption that, in a virus-infected plant, the rapidly-dividing cells in the shoot apex do not contain the virus particles but only become infected as these cells start to differentiate behind the meristem. Thus it is essential that the explant taken consist of only the meristem itself together with not more than 2-3 microscopic leaf primodia (see Fig. 1). The size of the explant is only 0.1-0.5 mm^3 and the necessity for careful excision and culture on a balanced nutrient medium free from microbes is obvious, in order to nurture such a tiny fragment of tissue into a new plant.

Meristem culture has now become a well-established technique for eliminating virus from a number of crop plants including carnation, chrysanthemum, hops, gooseberry, blackcurrant and strawberry. Elliott (1969) at the Plant Diseases Division in Auckland has also developed a method for growing meristem tips of kumara in culture. The list of successful cultures continues to grow, but some species have resisted all attempts at meristemming;

FIGURE 1:
MERISTEM CULTURE OF CARNATION



After removal of the older leaves, the cutting is sterilized in hypochlorite solution (domestic bleach). The meristem is then excised under a dissecting microscope, and placed on the surface of nutruent medium.

Roses are one example, and research continues to be carried out in New Zealand where most cultivated roses are heavily infected (Marcussen, 1974).

In Great Britain, the production and certification of virus-free material is carried out by the Nuclear Stock Association and plants are sent all over the world. There is at present no organisation in New Zealand which carried out meristem culture on a commercial scale and we have to import nuclear stocks of such crops as carnation and chrysanthemum from either the U.K. or Australia. Whilst the success of meristem culture is now well-proven, it must be remembered that it cannot control virus diseases in the absence of effective hygiene in the field and glasshouse.

ORCHID CULTURE

Normally, excision and growth of a meristem results in only one new plant. However Morel (1959) whilst attempting to grow meristem-tips of Cymbidium noticed that the explant swelled-up and developed a number of projections or "protocorms" (see Plate 2) resembling the structures which are formed when orchid seeds germinate. Morel noted that other mature parts of the plant did not respond in this way in culture, and considered that tissue near the shoot meristem was unique in that it remains "embryonic" throughout the life of the plant (Morel 1971).

Once formed, these protocorms retain the capacity to form new protocorms since, if the clump is cut up and each piece transferred to new medium, further proliferation occurs; thus from one original meristem, many new embryo plants can be formed. The process of dividing up the culture stimulates proliferation of new protocorms but inhibits their further development; on ceasing this operation, the protocorms stop proliferating and each develops root and shoot and grows into a new plantlet (see Plate 3). On reaching about 3 cm in height, the young plantlet can easily be transferred to soil.

The vast potential of this technique for propagation of orchids was quite obvious to the early workers and over the last ten years it has revolutionised the orchid world. Not only can virus diseases be controlled to a large extent, but by cutting up each culture into four parts and subculturing at monthly intervals, literally thousands of cultures can be obtained in less than a year, from a single meristem. Growers in U.S.A. and Europe are now producing thousands of carbon copies of superior *Cymbidium* hybrids for sale as pot plants or cut flowers and the only limit is on the number of plantlets that can be handled in the laboratory and greenhouse. It has also been possible to build up clones from unique but sterile hybrids which could not otherwise have been duplicated except by the very slow division of parent plants.

Reliable methods have now been developed for rapid proliferation in culture of *Cymbidium, Cattleya, Dendrobium, Miltonia, Odontoglossum, Vanda, Phalaenopsis* and several other genera. The genus *Paphiopedilum* has not as yet yielded to meristem culture despite extensive research. There is no doubt about the potential of meristemming for orchid growers, but the question which has to be asked is — will meristemming, by reducing the rarity value of orchids, eventually erode the market for orchids and reduce demand?

TISSUE CULTURE AND MICRO-PROPAGATION

The term 'micropropagation' has been used to decribe tissue culture techniques which result in the production of new plants, and implies regeneration from very small explants or from microscopic cell clumps within the culture. The orchids are a prime example of the commercial success of micropropagation and, although similar techniques have been developed for some other horticultural crops, none has yet been adopted widely on a commercial scale. The reasons for this are complex, but it may safely be said that the success of orchid meristem culture has **not** been entirely due to their prolific multiplicative capacities in culture. A number of other factors all contributed to the rapid acceptance of the technique by the orchid world. Firstly, the orchid culturist was already familiar with sterile techniques since methods were in use from the 1930's for the asymbiotic germination of orchid seeds on nutrient agar medium. Also, the high value of orchids justified the expense of the specialised techniques. Finally, the highly heterozygous nature of the plants meant that propagation from seed, especially in the case of hybrids, rarely produced plants similar to, or even as good as, the parent.

Thus, one type of situation where tissue culture can be of great advantage to the horticulturist is **where desirable hybrids are highly heterozygous, therefore making it impossible to obtain large numbers of uniform plants from seed, and where existing asexual techniques yield only a few plants per year.** Apart from the orchids a number of other crops

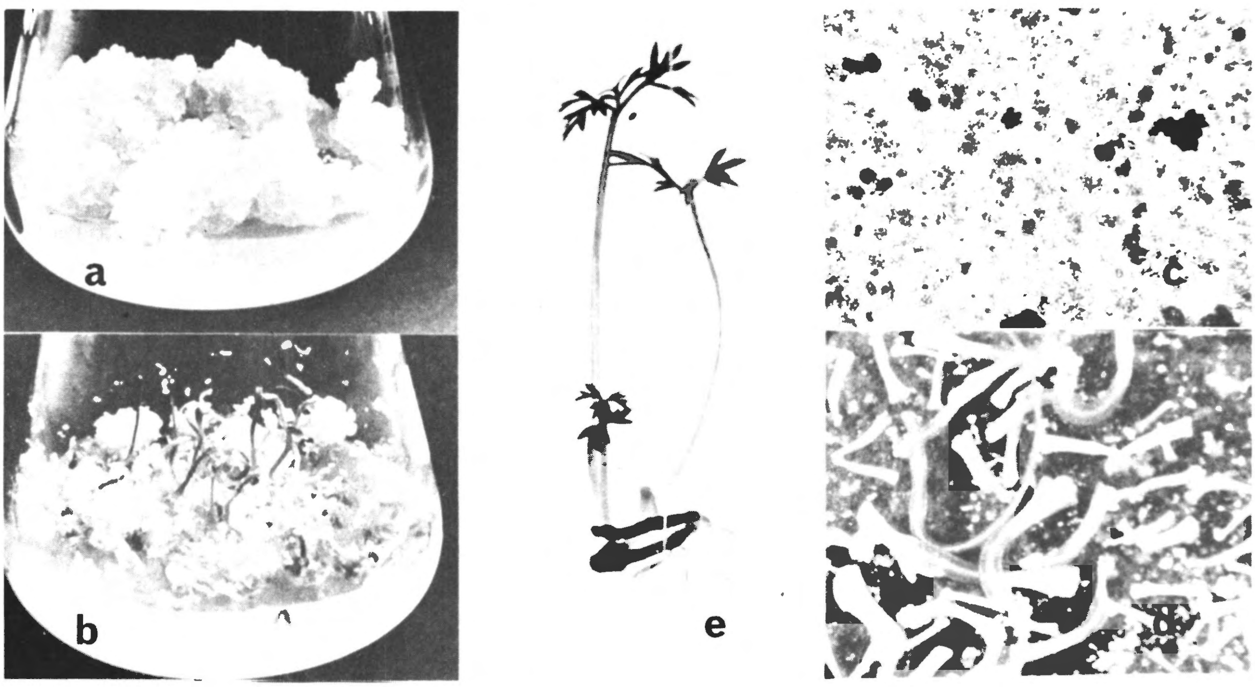


PLATE 1. Embryogenesis in carrot cultures.

(a) Callus growing on MS[1] medium with auxin.
(b) Callus transferred to MS medium lacking auxin, produces embryos in 2-3 weeks.
(c) Suspension culture maintained on MS medium with auxin.
(d) Suspension transferred to liquid MS medium lacking auxin produces embryos.
(e) Embryos from b) or d) can develop into new carrot plants.

1. MS = Murashige and Skoog (1962) medium. Physiol. Plant. 15 : 473-497

come into this category e.g. asparagus, some brassicas and also Oil-Palm, Rubber and *Eucalyptus* spp.

A great deal of work has gone into trying to develop a reliable micropropagation techinque for asparagus which would be of immense benefit to breeders trying to develop better strains in this notoriously non-uniform crop. It was realised that if all the apical and lateral meristems from young spears could be cultured into new plantlets, then one original high quality plant could be multiplied up fairly rapidly. Murashige et al (1972) also achieved rapid multiplication by division of the plantlets produced in culture, or by taking the apical tips from them. Although apparently normal asparagus plants were formed, their establishment in soil brought problems in many cases. Aynsley (1974) argues that one reason for death of plantlets on transfer to soil may be that shoot and root development have not become fully integrated; anatomical studies showed that in some cases, vascular bundles from the root did not link up with those of the shoot.

The importance of the asparagus work is linked with the need for a uniform crop of high quality. A similar need exists with the breeding of many tree crops but here, the time scale involved in breeding programmes multiplies the breeders' problems. Much work has gone into development of micropropagation techniques for oil and coconut palms, but little success has been achieved as yet. The importance of such work is indicated by the fact that an average plantation of coconut may yield 800 kg/ha. of copra, but selected plants can yield at an equivalent rate of 4-5,000 kg/ha. A rapid vegetative propagation method for such trees would obviously be of great value (Abbott, 1971). Finally, *Eucalyptus* is a genus which has considerable ornamental value in this country, yet propagation by seed does not yield uniform results and cuttings are difficult to root. Studies are in progress at Lincoln to try to define the conditions necessary for regeneration of roots and shoots in cultures of *Eucalyptus* spp.

A slightly different type of situation where tissue culture could be of great commercial value, is to **speed up the conventional propagation method for a particular crop.** For example, bulb flowers are normally propagated by division of bulbs or corms which may give a multiplication rate of x5 or 6 per year. This is very slow when one is trying to build up numbers of a new variety for marketing. Speed in getting the variety on to the market may mean the difference between success and failure for the competitive grower.

Davies (1972) has developed a rapid tissue culture propagation method for Freesias. The method does not involve meristem culture, instead large numbers of new plantlets are regenerated from *callus.* The mature parts of many plants e.g. small portions of stem or leaf can be made to undergo a process of "dedifferentiation", when excised and cultured on suitable medium. Cells in the explant may be said to exhibit a wound reaction and undergo rapid cell division to produce a disorganised *callus* tissue (see Plate la). Under appropriate conditions, portions of this callus can be induced to differentiate new roots and shoots or embryoids which develop into plants. Skoog and Miller (1957) showed that the type of organ produced by tobacco pith callus was dependent upon the relative proportions of two hormones — auxin and kinetin. High auxin with low kinetin levels induced root production, whereas high kinetin relative to auxin stimulated shoot production.

In the case of Freesias, plantlets initiated on a suitable medium are transferred to another medium to form vigorous plants, before being established in soil. This tissue culture technique has the double advantage of rapid propagation of uniform plants, **and** virus freedom, and consequently, it had already become routine procedure for at least one freesia nursery in the U.K. Similar techniques have been developed for a number of other bulb crops e.g. *Gladiolus* (Ziv, Halevy and Shilo, 1970).

Tissue culture has been adopted by Freesia growers because of the slow natural multiplication rate of the corms. However, even when the conventional propagation method for a crop is relatively easy and rapid, tissue culture may still be potentially valuable when it is desired to have a very rapid build up of numbers as in the case of bringing a new variety on to the market.

In hyacinth for example, it is possible to obtain a high rate of multiplication by the technique of "scooping" mature bulbs. One bulb may produce 60 tiny bulblets, but they require 4-5 years to reach flowering size, when the scooping can be repeated. Thus, the multiplication capacity of one bulb is high, but "generation time" is long. When large amounts of material are available, then this technique is adequate. However, in a breeding programme, when a single promising plant has been selected for propagation, then the multiplication rate from one bulb would be at least 60 in 4 years, 3,600 in 9 years etc.

The advantage of a tissue culture technique would be in the first multiplication stage to bulk up the

PLATE 2. Protocorm development in cultures of Cattleya.
Left: early stage Right: three weeks later.

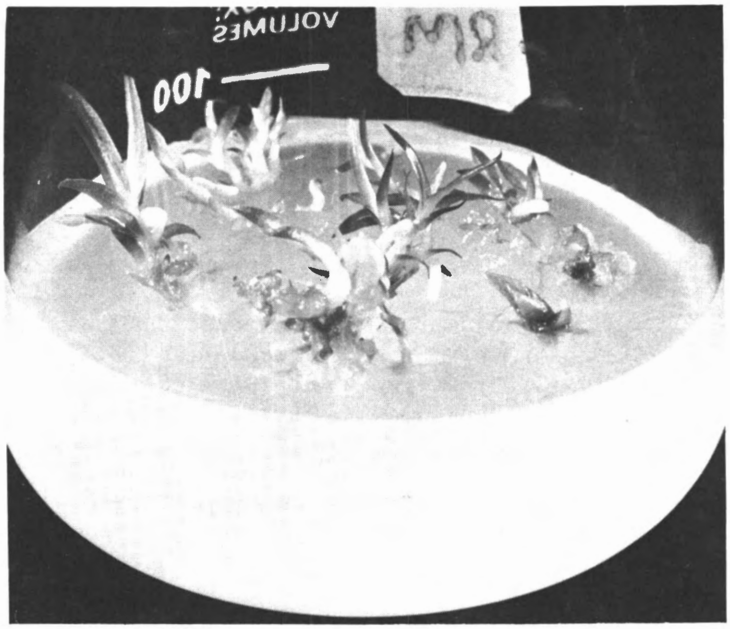


PLATE 3. Cattleya plantlets developing roots and shoot.

PLATE 4. Bulblet formation on cultured Hyacinth bulb scale segment.

number of initial bulblets produced in the first year. Pierik and Woets (1971) studied the factors required for bulblet regeneration from isolated bulb scale segments of hyacinth in culture. Similar experiments carried out by the author have indicated that the regeneration potential of a single scale segment approximately 2 cm x 1 cm may be six or more bulblets initially (see Plate 4). The possibility for further proliferation of these bulblets when excised from the initial segment is under investigation, so that perhaps 500 bulblets might be produced in the first year as compared to 60 by the conventional technique. This would cut down the time taken to reach marketable numbers by several years.

The advantage of tissue culture lies in the capacity for successful propagation from very small fragments of tissue which would not survive under normal greenhouse conditions, and so its application lies in such situations where very limited amounts of plant material are available for propagation. Whether or not tissue culture will ever become feasible for production of plants on a field scale is arguable, but large scale continuous culture techniques are being developed on the lines of the microbial fermenter (Street, 1973).

It has been shown that a four litre suspension culture of carrot tissue, if kept constantly supplied with fresh medium, has the capacity to produce more than a million embryo plants per day every day! (Smith, 1973).

TISSUE CULTURE IN PLANT BREEDING

Before looking too far into the future, one old-established culture technique which has been somewhat neglected by plant breeders should be examined. Hannig (1904) first discovered that immature embryos of Crucifers may be excised and brought to maturity by artificial culture. Then in 1934 a paper was published on "Artificial Cultural Methods for Isolated Embryos of Deciduous Fruits". (Tukey, 1934). As well as providing an effective technique for shortening the breeding cycle of deciduous trees, especially peach, it also increased the percentage germination of hybrid seed.

Plant breeders sometimes find that potentially valuable hybrids fail to produce seed or show a very low percentage germination. As pointed out by Lammerts (1962) the most desirable combination of characteristics may be found in that percentage of seeds which do not germinate. In some cases, seed failure is due to embryo abortion, resulting from somatic incompatibility between maternal and hybrid tissue. This in turn results in non-development of the triploid endosperm so that the embryo develops to a certain critical stage and then dies through lack of nourishment. If however, the embryo is excised before this stage, and cultured under sterile conditions on a suitable nutrient medium, then the embryo can often be induced to develop into a viable and fertile plant.

Lammerts used embryo culture routinely in his breeding programmes for apricot, peach and nectarine. He obtained 70-80% success rate and cultured several thousand embryos. Other successes have been obtained with interspecific hybrids of *Lilium* (Laibach, 1925). This is a simple techniques which could receive a great deal more attention from plant breeders in the future.

Whilst some artificial crosses may not produce viable seed, others may not "take" at all since pollen placed on the stigma of an incompatible mother plant may fail to germinate altogether or the pollen tube may not reach the embryo sac. In these cases, it may be possible to culture **isolated ovules,** thus removing the barrier of the stigma, fertilization being achieved in vitro by means of pollen introduced into the culture tube. Kanta, Ranga Swamy and P. Maheshwari (1962) cultured in the same vial, ripe pollens and ovules of *Papaver somniferum* (opium poppy) and observed all the stages from germination of pollen to double fertilization to development of mature seed.

Both the techniques described above are of considerable interest since they may enable plant breeders to combine desirable genetic characteristics from distantly related plants, which might otherwise be impossible. A third technique, pollen culture, may enable breeders to produce pure-breeding lines of new hybrids, more rapidly than has hitherto been possible. Nitsch and Nitsch (1969) working with tobacco, showed that the pollen grains could be induced to change their normal course of development and become embryonic, if anthers were excised and cultured at a precise stage during the development of the flower bud. After a few weeks, the anthers burst open to reveal hundreds of embryo-like structures which were later shown to be haploid and to have developed from pollen grains. These embryoids could be grown into plantlets by pricking them out in new medium and subsequently transferring them to soil. The plants were haploid and therefore sterile, but colchicine, if used at an early stage, caused the doubling up of the chromosomes to produce a diploid plant. The "doubled haploids" were of course homozygous in all characters and therefore, any desirable plants subsequently selected would breed true from seed, thus greatly reducing the time normally required for production of pure lines. (Sunderland 1970).

CONCLUSION

It can be seen that tissue culture embraces a whole range of techniques, all of which could make or already have made contributions to horticulture especially in the fields of propagation of disease-free plants, and in the breeding of improved lines. However, one drawback which has not so far been mentioned has prevented the widespread acceptance of tissue culture in horticultural practice. This is the problem of **variation** in plants produced from culture. In a number of instances, gene mutations or chromosomal abnormalities such as polyploidy or aneuploidy have been detected in plants derived from tissue culture, especially callus cultures. (Ben-Jaacov and Longhans, 1972; Murashige and Nakano, 1966). However, although a widespread problem, chromosomal instability is by no means universal in cultured tissues. Few problems have been met with in the Orchidaceae, and also the Freesia plants produced by Davies (1972) appeared to be normal in all respects. Investigation of the requirements for maintaining stability in cultured tissues should put tissue culture on a more stable footing as a horticultural technique.

A good deal of interest has been expressed by the N.Z. Nurserymens' Association in tissue culture, with particular reference to the need for rapid propagation methods for certain valuable Southern Hemisphere plants for which propagation techniques are at present very slow, e.g. *Phormium* spp. (N.Z. flax), *Cordyline* spp. (Cabbage Tree) and *Eucalyptus* spp.

The horticultural industry in New Zealand is likely in the future to exploit more fully its climatic advantages and the difference in seasons between Northern and Southern hemispheres for export purposes. Tissue culture could play a part in the development and propagation of high quality disease-free nursery plants and other horticultural crops in this country.

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BOOK REVIEW

NEW ZEALAND ALPINE PLANTS

by

A F. MARK and M. ADAMS

262pp. Illustrated 1973. (A. H. & A. W. Reed Ltd., Wellington)
Bound with hard cover $19.50, soft cover $13.50.

Apart from Dr Salmon's Field Guide to New Zealand Alpine Plants, there is no one comprehensive book to which one may turn for information concerning New Zealand's alpine flora.

The authors are Dr Alan Mark who is Associate Professor in Botany at the University of Otago and Nancy Adams who works in the Dominion Museum, Wellington. Dr Mark has done a great deal of research on the alpine vegetation in the mountains of Otago while Miss Adam is well known for her illustrative work in other botanical publications.

In this book Dr Mark has described over 640 species and varieties of alpine plants, most of which have been illustrated by Miss Adams.

The book is divided into two parts; the first containing some brief but concise chapters dealing with the alpine zone and its vegetation.

These chapters adequately convey, to the reader, details of the origin and structure of our mountains, the limits of the alpine zone; the environment and the plants. In the latter chapters, for example, Dr Mark discusses the probable reasons for the predominantly white and yellow flowers of our alpine plants and also a little about some of the influences which govern the flowering of alpine plants. Regrettably this part of the book is rather brief.

The second part of the book contains the illustrations and the text pertaining to them.

In the introduction it is stated that common names are included only where they are in general use, or where they seem particularly appropriate. However, *Ranunculus lyallii* is too firmly established as the "mountain lily" of "Mt Cook lily" to permit the obviously coined "great mountain buttercup" being substituted as a common name.

All too often the text of books such as this appears to be written in support of the coloured reproductions without much thought for the reader's depth of understanding. However, in this work Dr Mark has generally struck a balance with the significance of the text. Possibly the main criticism, although a minor one, would be that more details concerning the habitats of the individual plants could have been provided.

The illustrations are adequate and some are very good, but generally they lack definition and detail. In too many instances the essential detail has been ignored and the colour applied simply as a wash. The plate of *Ranunculus lyallii*, in particular, illustrates this criticism. With few exceptions the white flowers have been painted without using any grey, which makes them quite flat and featureless.

However, in spite of the above criticisms it is a fine, well produced book which should be of great use to the professional botanist and the layman alike.

L. J. Metcalf

New Zealand Gardening–An Historical Letter

introduced by J. O. TAYLOR

The following article was written in England in 1864 by the late Mr. A. L. Taylor prior to his coming to New Zealand in 1879 to take up the position as Curator of the Christchurch Botanic Gardens, a position which he held for 28 years.

Mr. Taylor received his early training at the Royal Botanic Gardens, Kew, and became head gardener and estate manager to Baron Rothschild. At the time he accepted the challenge to emigrate to New Zealand, he was head gardener at Chatsworth, which was the estate home of the Duke of Devonshire.

The article was passed on to Mr. J. O. Taylor (no relationship) by Mr. A. L. Taylor's son, Mr. Edgar Taylor A.H.R.I.H. (N.Z.). Mr. Edgar Taylor, who is now in his 87th year, retired from the position as Landscape Architect to the Christchurch City Council some years ago after giving long and outstanding service not only to the City of Christchurch but to horticulture and the landscape profession of New Zealand as a whole.

Mr. 'Cabbage' Wilson (in reference to the hats he wore which were made of cabbage tree leaves) about whose nursery the article is written, was the first Mayor of Christchurch and his main nursery was on the block of land now occupied by the New Zealand Farmers Co-op. between Cashel Steet and Beford Row.

We have received a file of Lyttelton papers, in which occur some interesting sketches of antipodal gardens, which we shall transfer to our columns. We commence with Mr Wilsons nursery gardens, which date their origin from the founding of the City of Christchurch, some 14 years ago, and are not only the oldest established, but by far the most extensive nursery gardens in Canterbury, and the largest and best stocked in New Zealand. They are three in number, and comprise about 19 acres, all in the highest state of cultivation. The gardens contain very many thousands of fruit-trees, English forest-trees evergreen and deciduous flowering shrubs and plants, and are the source whence has been derived a very large proportion of the fruit-trees which now fill the gardens of the Province with a profusion of fine fruit, and of the forest-trees which ornament Christchurch, The nursery garden in Cashel Street is securely enclosed by a very lofty and well-kept gorse fence, within which there is a closely planted line of lofty, Australian Blue Gums and Lombardy Poplars, whose dense foliage and branching arms completely intertwined, afford the most complete shelter from all winds. Immediately in front of this screen there is a broad belt of fruit trees running round the whole of the garden consisting mainly of apples, pears, plums, cherries, peaches, nectarines, figs, filberts, medlars, quinces and almonds, besides immense quantities of gooseberries, black, red and white currants, raspberries, strawberries and other small fruit. A spacious grass walk 726 feet long stretches from the entrance gate to the eastern end of the garden. At right angles to this walk and at distances of 132 feet apart, the garden is intersected with lofty and well-kept Cape broom fences, thereby forming convenient nursery compartments; these consist of beds 18 feet in width with 4 feet intervening footpaths. The beds in some of the compartments are all densely filled with a most luxuriant growth of from one to six years old fruit trees, of the kind which we have already enumerated.

Other beds are filled with forest trees, such as English and mossy-cupped oaks, English ash including some very tall-stemmed ash trees, upon the summit of which some weeping ash are growing gracefully pendent. There are also quantities of the Scotch and English elm and also the weeping and American lime trees. With mountain ash, horse chestnuts, and sweet or Spanish chestnuts, besides hornbeams, common and purple leaved beech trees with lombardy and black Italian poplars, the former mainly remarkable for their handsome upright habit of growth, and the latter recommending itself by its rapidity of growth and the large size to which it speedily attains, rapidly yielding timber, well suited for very many purposes of utility. Side by side with some of these will also be formed quantities of the Norway and other maples, besides the well-known and handsome foliaged English sycamore and the noble-leaved *Platanus orientalis* some four feet high, and the first, so far as we know, which have yet been grown in New Zealand We also noticed some beautiful birch trees about seven feet in height with quantities of English laburnum and locust trees of all ages and sizes. The latter not only makes a very impenetrable hedge, but when thinly planted, rapidly becomes a lofty tree and yields fine timber of an excessively hard and most enduring character and largely used in the States of America for the purpose of shipbuilding. Amongst coniferous trees were considerable quantities of the pinaster and still more of the hardy *Pinus maritima*, which will yet clothe with luxuriant green the slopes and summits of our driesh and evershifting sandhills, for which this highly ornamental tree seems to possess an especial preference. There were hundreds of walnut trees, from 5-12 feet in height. These have all been raised from the well known French walnuts grown and fruited so abundantly at Akaroa.

Of hedge plants large quantities of thorns, privets, sweet briars, thorn acacia, English, Cape and Portugal white brooms were grown, having their respective uses for the purposes of protection, ornament or shelter. First amongst ornamental evergreens and deciduous flowering plants we noticed quantities of the handsome English holly, besides some dozens of the still more beautiful variegated hollies, budded or grafted upon the common green form and presenting the well known varieties of gold and silver-edged; the hedgehog and broad leaved Dahoon holly, these being respectively the much admired ornaments of all well kept ornamental grass lawns. Also some hundreds of the noblest of all beautiful evergreens the *Rhododendron ponticum* and similar other varieties of this handsome flowering occupant of all English shrubberies. In close proximity to these were many hundreds of fine large plants of the common English laurel, a familiar and well known evergreen. Asserting its right to a place in all shrubberies and ornamental grounds by its large and handsome shining green leaves; a quantity of fine plants of the *Laurus tinus*, esteemed not more for its handsome evergreen foliage than for its admired peculiarity of blooming profusely throughout the whole of the winter; and some plants of the well known Portugal laurel, and equally familiar bay laurel or sweet bay and near to them plants of the *Aucuba japonica* or gold japon tree. In addition to these were the handsome flowering *Weigelia rosea*. The still more ornamental snow-ball guelder rose, with plants of the early spring-flowering scarlet *Pyrus japonica*, many hundreds of the *Spiraea corymbosa*, the New South Wales may, besides other varieties of the spiraea recently introduced from England. Among climbing plants were *Rhus toxicodendron* or poison oak; three varieties of the English ivy; besides several sorts of climbing roses. There were also handsome Chinese arbor-vitae, and still more handsome evergreen cypress, besides the most beautiful of all cypress, the *Cypressus lambertiana*, and handsome specimens of *Pinus insignis* and of the equally ornamental and lofty *Pinus excelsa*. Amongst coniferous plants in pots were quantities of pinasters, scotch and spruce firs. *Pinus maritima,* stone pinus and many other handsome sorts of pines, cedar, cypress, juniper and other similar plants and trees, precarious to transport unless established in pots which ensures their being removed with the most perfect certainty of growth. We further observed plants of the American osage orange, of the evergreen and deciduous fruit-bearing barberry, of the pomegranate, of the handsome rose acacia, of the sweet smelling *Buddlea globosa,* of the *Salisburia adiantifolia* or maiden-hair tree, with quantities of boxtrees, and Siberian, Persian and white lilacs, broad-leaved American thorns, besides a large number of budded plants of the double scarlet, double white and single scarlet thorns, the latter especially for its grèat profusion of brilliant scarlet bloom, forming one of the most handsome flowering trees for a grass lawn.

Time and space however would fail us to enumerate all the trees and plants here cultivated. The garden fronting on Madras Street is surrounded with a sweet briar fence, immediately within which a lofty row of blue gums and poplars afford excellent shelter. The border in front of these is planted all round with some 400 of the newest and best sorts of pears and plum trees, the pears comprise over 400 varieties of the choicest new French varieties. Many in full bearing, the remainder of this nursery ground is mostly filled with young grafted or budded fruit trees, with large quantities of damson and mussel plums, with some thousands of lombardy and black Italian poplars, common willows, weeping willows and the lofty timber-growing variety known by the name of the Huntington willow, mainly remarkable for rapidity of growth, the lightness and whiteness of its timber, and the numerous purposes of utility to which it can be applied. Prominently noticeable, however, amongst all the production of this garden are some 25,000 English ash trees, in remarkable health and vigour, and standing from 3 to 10 feet high. These we hope will soon be distributed and planted over the country to afford in after years a supply of ash timber, so indespensable in all the ordinary farming operations of every community, from its extreme toughness and remarkable elastically. So necessary is it that we are obliged to import annually from England and America many hundreds of pounds worth of this timber, for handles of implements and other agricultural purposes.

Passing over many other interesting plants in this garden, we proceed to the more recently formed nursery garden of 10 acres on the Ferry Road, this is bounded by a gorse fence, and planted with a broad border of forest trees and evergreen shrubs; shelter in all cases being one of the first considerations in Mr Wilson's gardening. The land is also divided into compartments with Cape broom fences, and each of these compartments is filled with forest trees, comprising ash, oak, elm, beech, lime, acacia, maple and sycamore, besides many thousand seedling pines. We were also glad to notice about a thousand young trees of two years growth of the *Ailanthus glandulosa* or silkworm trees, so much used as a handsome avenue tree, on the sides of the streets of towns in America, and which, we doubt not, will also be largely used in Canterbury, when it merits as a hardy ornamental tree are better known. Near these a large quantity of the *Gleditschia triacanthos,* or three spined acacia, were growing luxuriantly. This is a hardy tree with a handsome small green foliage, which secures for it a position on planted lawns as an ornamental tree. Portions of this ground are also devoted to the growth of vegetable seeds and especially to the growth of thorns for hedges.

Some Special Aspects of Plant Protection in Tauranga Parks and Reserves

(Extracts from a thesis for the National Diploma of Horticulture (NZ), submitted by D. S. T. COLLINS)

FUNGOUS DISEASES

1. DAMPING-OFF OF SEEDLINGS

Damping-off of seedlings has been one of the greatest problems. Not so much the disease itself, but the incorrect use of chemicals to combat the disease.

Athough there are several fungous species causing damping-off the main species infecting ornamental seedlings are:—
Pythium, Rhizoctonia and Phytophthora.

captan 80% W.P. ("Flit 406")
From observations, captan has been the most effective, for the following reasons:—

(1) Extremely effective against the damping-off organisms of Pythium, Phytopthora and Rhizoctonia.

(2) In all observations, completely non-phytotoxic to seedlings.

At normal dose rates:

(3) No unpleasant reactions to human beings (as is the case with thiram and captafol 80, which cause irritation to the nose, throat and bronchial tubes.

thiram (Thiro spray 80%W.P.)
(1) On observations this chemical is almost as efficient as captan against the damping-off organisms.

(2) This material can be extremely phytotoxic against seedlings, unless the application rates are absolutely adhered to. During some observations some seedlings were discovered which had such badly burnt roots, that the plants could be blown off the surface of the trays. Almost all seedlings were susceptible to this damage including:—
Begonia semperflorens, nemesia, calendula, stocks, pansies, celosia, exacum, gloxinia, petunia, tuberous begonia.

DAMPING-OFF EXPERIMENT

Controlled experiments using captan, thiram, fenaminosulf 70, captafol 80, benomyl 50, methylmercuric dicyandiamide were carried out. Lobelia "Mrs Clibran" and french marigold "Petite Yellow" seed were used, as lobelia is very susceptible to damping-off, and marigold only slightly so. They both produce almost 100% germination under normal conditions.

CHART SHOWING AVERAGE GERMINATION PERCENTAGE BETWEEN LOBELIA AND MARIGOLD EXPERIMENTS

Therapeutant applied		Percentage	Germination
captan	90%	65%	77½%
fenaminosulf 70	60%	90%	75%
benomyl 50	65%	70%	67½%
methylmercuric dicuandiamide	80%	25%	52½%
captafol 80	80%	5%	42½%
thiram	50%	10%	30%
control average	71%	36%	53½%
	Marigold	Lobelia	Average

Captan was the most successful, and this agrees with observations made, under normal growing conditions. Fenaminosulf 70 was surprising, as in observations it seemed unsatisfactory. Methylmercuric dicyandiamide seemed promising at first but the lobelia was struck down rapidly with damping-off.

Captafol 80 and thiram performed exactly as expected, proving extremely phytotoxic to the germinating seedlings.

The results from benomyl 50 were fairly promising and further experimenting with this therapeutant would be worthwhile.

Under normal use, the averages would be higher, as it is not normal to inoculate seedling trays with damping-off fungus or increase dose rates. A further application of therapeutant would be given at 7 days after germination, or when damping-off occurs and every 14 days until pricking-out.

To give doses at closer periods than this, is inadvisable, even if damping-off occurs, as damage by phytotoxicity is inevitable.

2. BOTRYTIS OF GREY MOULD *(Botrytis cinerea)*

Next to damping-off, this is the most prevalent disease we have had to contend with in the Tauranga Parks Nursery, and showhouses. It caused the most damage.

The main control for botrylis is good management.

(1) A good circulation of air should be maintained around each plant. This can be achieved by giving the plants concerned **sufficient spacing** and keeping ventilation to the maximum, without dropping the temperature below the ideal for the particular variety of plants.

(2) All spent flowers, dead and diseased leaves should be regularly removed as part of the daily routine.

(3) **Avoid overhead watering** as Botrytis thrives in wet conditions.

(4) A regular spray programme should be followed and a 10-day programme is probably too optimum. For simplicity a 14-day programme may be adopted because the cycle falls on the same day each time e.g. every second Thursday. This programme is more easily adhered to by employees, particularly apprentices.

Therapeutants Used for Botrytis on Ornamentals:

Dithane Z78	zineb 75
Benlate	benomyl 50
Topsin M	thiophanate-methyl 80
Dithane M22	maneb 80
Copper Oxychloride	

COPPER OXYCHLORIDE

Copper Oxychloride has been used a great deal in the past for botrytis, as have other copper sprays. They are undesirable for ornamentals under glass as they are extremely phytotoxic, burning leaves and blooms. They also leave unsightly leaf residues spoiling appearance of plants on show.

thiophanate-methyl and benomyl 50
These have proved the most suitable therapeutants for controlling botrytis on ornamentals, for the following reasons:—

(1) After experimenting with them on every species of plant in our Nursery, no phytotoxicity was produced with these therapeutants (even with application rates triple the recommended dose).

(2) The application rate is 50-60g/100l (8 to 10 ozs per 100 gallons) and if correctly applied, practically no leaf residue is visible.

(3) Both these therapeutants are systemic and are therefore taken into the plant and cannot be washed-off.

(4) As well as giving protection against attack, they both will eradicate botrytis providing it has not gained too great a hold on the plant.

Under observation there were no marked difference in the performance of the two therapeutants. Occasionally the application rate may need to be doubled to gain control of the disease.

3. POWDERY MILDEW

Powdery Mildew is predominately a disease of dry, hot conditions. As glasshouse conditions are usually humid, there has not been much trouble with this disease in the Nursery or showhouses. However, occasionally severe attacks have occurred on all varieties of begonias.

This fungus belongs to the class Ascomycetes and the order Erysiphales. There are many different species, but the main species affecting nursery plants are:—

(a) *Oidium begoniae and Erisiphe cichoracearum*
Infecting all species of begonias.

(b) *Sphaerotheca pannosa*
Infecting most species and varieties of roses.

(c) *Erisyphe polygoni*
Infecting many annual and perennial ornamental plants.

With the advent of benomyl 50 and later thiophanatemethyl this disease is no longer a problem to control. *Begonia semperflorens* seedlings have been observed, white with powdery mildew before treatment with benomyl 50. After treatment, the fungus has not only been brought under control, but completely eradicated, almost all trace of the disease having disappeared, except where observed under a magnifying glass, when small light depressions can be seen on the leaves and stems.

There is no doubt that good management cannot be too greatly stressed as without it, control of fungus diseases will not be obtained.

PESTS

The following are the problem pests in the Tauranga Parks Nursery:—

1. Mites
2. Mealy Bug
3. Aphis and Whitefly
4. Caterpillar
5. Black Vine Weevil
6. Scale

LEAF RESIDUES

One of the greatest problems with the application of insecticides and acaracides to ornamental plants on show, is the residue left on the leaves.

This problem is greatly accentuated on glossy-leaved plants (e.g. *Brassaia actinophylla, Ficus elastica* 'Decora', *Monstera deliceosa, Philodendron* spp. etc).

Also to a lesser extent on slightly less glossy-leaved plants (e.g. crotons, aphelandra, cyclamen, jacobinias etc). Provided applications are not too heavy, spray residues do not show to any extent on coleus, plectranthus, cineraria and other rough or hairy-leaved plants, and the problem is not great on plants with cream or white variegations.

Fortunately glossy-leaved plants, do not suffer to any extent with fungus diseases, but they are attacked by pests such as mealybug, mite, aphis, whitefly, scale and to a lesser extent caterpillar. Although these can be kept in check by oil emulsions, diluted with water and wiped on to leaves (spraying of glossy-leaved plants on show, amongst non-glossy-leaved plants is not possible with oil emulsions as they will burn the leaves and blooms of these plants). This cannot be used on the underside of leaves as it blocks the stomata and will not reach into all crevisses and leaf axils. If large quantities of glossy-leaved plants are to be treated this method would not be practicable owing to labour costs.

With insecticides and miticides two types of sprays can be used, but present difficulties:

(a) Wettable powders, which are as a general rule not highly phytotoxic, provided they are kept off the flowers, but leave an unsightly residue on the leaves especially if used at rates of 100g/100 l (1lb per 100 gallons) or over.

(b) Emulsifiable concentrates, which don't leave leaf residues, but can be extremely phytotoxic to many ornamentals. Glossy-leaved plants do not usually burn easily with emulsifiable concentrates, but to set up suitable decorative arrangements these plants must be used amongst non-glossy and soft-leaved susceptible plants.

1. Mites — Class Arachnida — Order Acarina

Of all the pests contended with, mites are the most difficult to control because of their ability to gain resistance to therapeutants very rapidly.

Although there are many species of mites, the species causing by far the most damage to ornamental plants in Tauranga is:—

TWO SPOTTED OR RED MITE *(Tetranychus telarius)*

This species is found on a wide range of ornamentals and persists in the active stage throughout the year under glass. It can cause severe stunting, damage and if left unchecked death to plants. It can be found on almost every species and variety of house plants, shrubs, trees, perennials and annuals in the Nursery.

The following are the therapeutants used:

Plictran 50w	tricyclohexyltin-hydroxide 50
Folimat	omethoate 58% w/v
Orthodibrom	naled 87% w/v EC
Malathion 25% W.P.	maldison 25
Tedion V18 W.P.	tetradifon 20
Ethion 25 W.P.	ethion 25

tricyclohexyltin — hydroxide 50 (Plictran 50W)

Of the miticides I have observed and experimented with, this therapeutant (which I have used for 8 months) is the most promising to date. There has been no return of mite on treated plants while plants left untreated, as a control, were covered with mite this chemical is deceptive as it works by paralysing the mouthparts. The mites seem just as active, sometimes for up to two weeks but they cannot feed and soon die. They cause no further damage after application.

It has proved non-phytotoxic to most ornamentals.

Petunias and Asters may show signs of chlorosis, but this is not serious and soon passes off.

At application rate of 25-38g/100 l (4 to 6oz per 100 gallons) it leaves no unsightly residues.

omethoate 58% W/V A.C. (Folimat)
This is a systemic miticide which gives effective control of mites. So far they do not seem to have gained resistance to this chemical.

I have experimented with omethoate 58% on all forms of ornamental plants without any sign of phytotoxicity. Even blooms were unharmed, providing treatment was not carried out during the heat of day.

There is no residue left on leaves after application.

This seems to be one of the most promising therapeutants on the market, for the control of sucking insects on ornamental plants.

2. MEALYBUG

The Grape Mealybug *Pseudococcus maritimus* is the species most commonly found on ornamental plants. Although the **Long-tailed Mealybug** *Pseudococcus adonidum* is also often found.

Mealybug can become a considerable problem, especially when it occurs in difficult to reach situations. Such as, crevisses in bark, axils of leaves, the most difficult situation of all to eradicate mealybug from is the roots.

The therapeutants experimented with are:–

Matacil W.P. 75% W/W	aminocarb
Folimat 58% W/V	omethoate
Rogor E 40% A/C	dimethoate
Malathion 25% W/P	maldison

aminocarb 75 (Matacil W.P.)
This is one of the most effective therapeutants for controlling mealybug, giving almost 100% control.

DISADVANTAGES

1. It does not reach and kill mealybug in the roots unless a thorough soil drenching is given.
2. Mealybug seems to have a particular liking for glossy-leaved plants such as *Phormium* spp., *Brassaia actinophylla*, Fatsia Japonica etc. As it is applied at 150g/100 l (1½lbs per 100 gallons) to give effective control, an unsightly residue is left on leaves. This makes it unsuitable for glossy-leaved plants on show in showhouses, public buildings, although not to the same extent as some other insecticides.

Mealybug seems to go into the plant roots, more in the winter than in summer. Therefore aminocarb 75 is suitable for use in summer on glossy-leaved plants not on show or on rough-leaved plants.

Aminocarb 75 does not have any phytotoxic tendencies, provided it is not applied directly on to blooms, during the heat of the day.

omethoate 58% W/V (Folimat) — Systemic
I carried out experiments, as to whether omethoate 58% would control mealybug feeding on the roots of potted polyanthus. Although 100% control was not established, 90% of the mealybug were killed, which is far in excess of the control gained by any other therapeutant. Of the therapeutants I have used I feel that omethoate 58% is the most efficient for the overall control of mealybug on ornamentals.

BLACK VINE WEEVIL *(Otiorhynchus sulcatus)*

From experience in Tauranga Parks and Reserves, black vine weevil larvae has only caused serious damage to Cyclamen, severe losses often occuring.

The biggest disadvantage is that the attack is not visible until severe damage has been done.

Usually a liquid feed is applied every 21 days to cyclamen with the addition of carbaryl 80W at 150g/100 l (1½lbs per 100 gallons) to the water with the feed (liquiphos), this pest can be completely controlled.

APHIS, WHITEFLY, CATERPILLAR, SCALE

Are reasonably easy to control and have not been covered to any extent.

The following are the controls found the most efficient:

Aphis Whitefly	omethoate, maldison, diazinon 50, dichlorvous 50
Scale	Volk Supreme, maldison, omethoate
Caterpillar	Trichlorfon 60, methomyl 90, carbaryl, maldison.

Of the pesticides for caterpillar, trichlorfon 60 proved the most efficient. Athough it was phytotoxic to blooms it proved practically non-phytotoxic to leaves, and was by far the most efficient in regards to the % kill. It left absolutely no residue on leaves.

Methomyl, carbaryl and maldison, all leave residues on leaves but are reasonably effective as controls.

Methomyl and carbaryl produce approximately the same phytotoxicity as trichorfon 60.

Maldison can be very phytotoxic to young plants and immature leaves.

Juvenility — its Importance in Horticulture

by
R. B. STEVENS

Juvenility is not simply an interesting but exceptional phenomenon, but rather it is very common and probably a univeral occurrence in woody plants. Within horiticulture, manipulation of the juvenile phase to common place. Plant breeders seek to shorten the juvenile phase, plant propagators to prolong it. It is essential therefore, that juvenility be put into perspective and the horticulturalist appreciate it as a natural growth phase in the development of many plants.

INTRODUCTION

All plants undergo a series of growth phases during their development from seeds. These phases can be defined as; embryonic differentiation, juvenility, maturity and old age — with more or less gradual transitions.

As early as 1889, Goebel in "Organographie de Pflanzen" was the first to formulate concepts of distinct growth phases in plants.

The juvenile phase is the period from seed germination during which no flower initiation can take place, under conditions such as photoperiod (day length) and temperature, which may be favourable at a later stage. The attainment of the ability to flower indicates the end of the juvenile phase: the production of flowers is the first indication of the adult phase, although the end of the juvenile phase and the first appearance of flowers may not coincide.

The juvenile phase often differs in morphological as well as physiological factors. Juvenile plants may or may not exhibit differences from the mature phase such as leaf shape and size, leaf abscission, phyllotaxy (leaf-stem arrangement), thorniness, ease of rooting in cuttings, growth habit — and flowering.

Leaf shape, to a certain extent indicates the physiological state of the seedling at the time of leaf formation, and is an indication of the changing physiology of the plant. Apple and pear seedlings for instance have small leaves and horizontal, thorny branches as compared with the adult phase of large leaves and upright branches without thorns. In many woody plants such as *Fagus sylvatica* and *Quercus robur*, juvenile forms may retain their leaves throughout the winter while adult forms are fully deciduous. Juvenile citrus plants are thorny but as they mature, the upward and outward shoots loose their thorny condition. The New Zealand native plant *Pseudopanax crassifolium* in the juvenile phase exhibits long, drooping, swordlike leaves — leathery with marginal teeth. Mature lance wood plants have shorter, wider and more deeply lobed leaves. The juvenile form of the native rata, *Metrosideros carminea* is a self supporting climber with small round leaves, while the adult form is more shrubby in habit.

In *Hedera helix*, the English ivy, the subject of much research work on juvenility, the differences between the juvenile and adult forms are well recognised; juvenile—creeping or climbing shoots, lobed leaves, somewhat flattened stems and *no* flowers, and adult — more upright growth entire leaves and flowers.

Distinct juvenile and adult phases have also been distinguished in many other plants including apricots, larch and many other conifers, hornbeam, ash, elm, lilac, maple, poplar and forsythia.

The most noticeable cases of juvenility occur in woody plants, in which the above morphological characteristics are obvious. In herbaceous plants juvenile forms may exist, although these are usually less obvious than in woody plants.

Kronenberg (1970) found that brussel sprouts grown from cuttings of adult plants remained in the adult phase of development and flowered when given the flower inducing conditions of low temperature. Juvenile seedlings did not flower given these same conditions, and no morphological differences were evident between the juvenile and adult plants.

Plants of brussel sprout must reach a certain age, usually about 11 weeks before they become sensitive to low temperatures.

The juvenile phase varies in duration, even between varieties of the same species. In annuals this phase may last a few weeks, perhaps months, after germination. In biennials a period of several months may be required while woody trees and shrubs and bulbs usually require a longer period.

In the early nineteenth century, it was noted that a period existed in the growth of plants before "ripeness to flower" occurred — for raspberries 2 years, vines 3-4 years, apples 5-12 years, pears 12-18 years, citrus 5-6 years. *Hedera helix* is thought to have a period of 10 years between germination and the first appearance of flowers, given optimum growing conditions.

Some juvenile forms exist throughout the life of the trees. For example, juvenile forms of *Chamaecyparis* spp. and *Thuja* spp. are so different from the adult forms of the genus that early botanists once classified them under a new genus *Retinospora*. Transitions to the adult form may occur in some branches of these "*Retinospora*" as the trees become older, but in *C. pisifera* "Squarrosa", the juvenile form is maintained completely, even in trees more than seventy years old. Permanent juvenile forms also exist in *Picea* spp. where *P. glauca* "Conica" (syn. *P. albertiana* "Conica"), a seedling from the 10-15m high *P. glauca* seldom exceeds 1.5-2m high even at seventy years of age.

In 1932, Leonard Cockayne, a New Zealand botanist, stated that no less than 200 species of spermatophytes in New Zealand go through a juvenile phase markedly different from the adult, and cited kauri, *Agathis australis*, as remaining in the juvenile phase for more than 100 years.

FACTORS INFLUENCING THE DURATION OF THE JUVENILE PHASE

Although the juvenile phase cannot be eliminated, it can be shortened considerably, by breeding, controlling the environment in which the seedlings are grown and by various cultural practices.

The length of the juvenile phase is a genotypic expression from the parents and, athough inherited, it can be influenced by various factors. Johnsson (1949) crossed two precocious individuals amongst a seedling group of *Betula pendula* and obtained progeny, 70% of which flowered up to two years earlier than the normal five to ten year juvenile phase. In another experiment, the self pollination of a precocious pine species, *Pinus eliotii*, resulted in the initiation of cones at the cotyledon stage — an extreme example.

Plant growth rates, and factors influencing the growth rates, also have a major effect on the duration of the juvenile phase. Faster growing and therefore larger plants generally have a shorter juvenile phase. Heath and Holdworth (1948) stated that for onion, the minimum required leaf number for "ripeness to flower" occured was thirteen. In onion the effect of age on inflorescence initiation would seem to operate mainly through size attained, and possibly leaf area. This is a factor which can be influenced by the stimulation of vegetable growth, through favourable environmental conditions and adequate fertilisation.

The environment, through its effect on growth rate is a major determinant of juvenility duration. Camellia seedlings grown under continuous light with a minimum temperature of 18°C and "well fertilised", flowered in 2 years compared with the normal 4-5 years. *Betula pendula* seedlings grown under continuous long day photoperiods, initiated catkins on the upper part of the tree in less than a year from seed. Jonkers (1971) grew the same apple variety in six locations from Finland to Italy — the plants flowered first in the southern most point (and the warmest) Italy, and progressively later northwards to Finland. Research work in Europe has indicated that by the stimulation of grape seedling growth immediately after germination, fruit could be harvested within 9 months, when normally it requires 3-6 years.

Various methods of grafting also affect the juvenile phase. When apple seedlings were budded on Malling IX, a dwarfing rootstock, 44% flowered in 6 years, compared with 5% when on their own roots. However, the reduction in the juvenile phase is small and may not be economically justifiable.

Campbell (1961) illustrated that by budding apple seedlings on to apomictic seedlings of a related species, *Malus sikkimensis*, flowering of 15% in 3 years and 53% in 4 years occurred, while at the same stage none of the control seedlings had flowered.

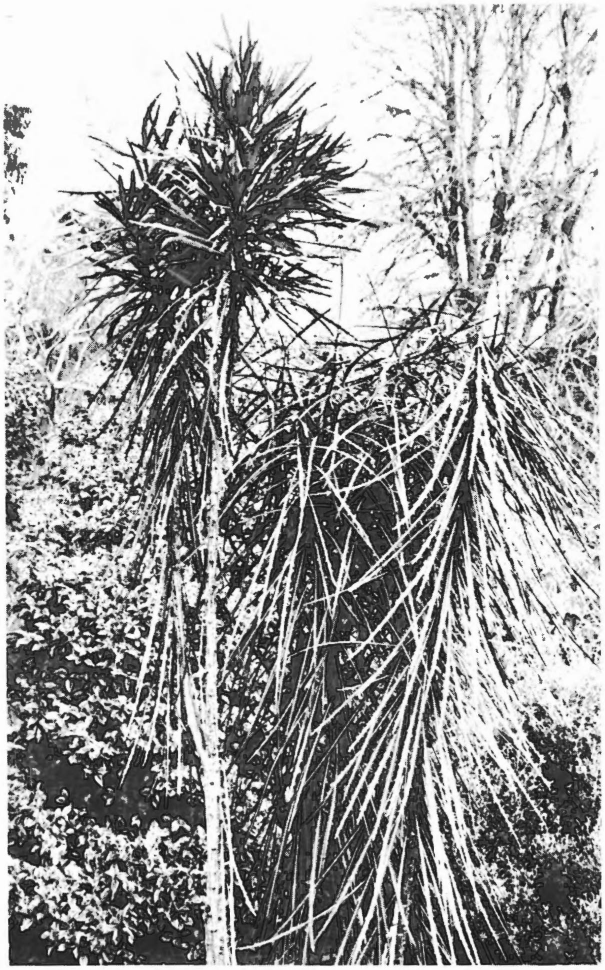
Scions of apple seedlings grafted on to old trees were observed by Hendrick and Wellington (1912) to start fruiting 4-5 years from germination while seedlings on their own roots did not start for 6-9 years. Similar results have been recorded on grapes, citrus, larch and some coniferous evergreens.

Although the removal of bark in fruit trees, particularly citrus, has been observed to hasten flowering in seedlings, and root pruning to promote cone production in some coniferous evergreens such as *Picea*, otherwise contradictory reports as to the effectiveness of such treatments means no firm conclusions can be drawn.

Research as to the effect of growth substances on

Hedera helix L. juvenile R. adult.

Seedling *Monstera deliciosa* showing commencement of adult phase



Three *Pseudopanax crassifolium* plants at different stages of juvenility

Thorns on Meyer lemon (Citrusx)

Leaf retention on juvenile *Fagus sylvatica* the duration of the juvenile phase appears inconclusive. However, De Zeeuw and Leopold (1955), found N.A.A. application to juvenile brussel spouts plants induced flowering and it was suggested that the completion of the juvenile phase may be, in part, the accumulation of a sufficient auxin level at the apical meristem to bring about the condition receptive to cold temperatures.

Flowering was induced in very young conifer seedlings by the application of various gibberellins (Pharis et al, 1967) — strobilli appeared in 3-12 months from germination, compared with the normal 10-20 years. However, gibberellin sprays have been found to cause reversion to the juvenile forms of growth in acacia, pear, almond, and apricot. No growth regulator has yet been found which will induce flowering on the vast majority of juvenile seedlings from woody plants.

JUVENILITY IN HORTICULTURE

The importance of juvenility in horticulture covers two basic and similar fields — breeding and propagation. However both fields require opposite effects from the plants. Plant breeders want to *hasten* the onset of the adult phase to obtain earlier flowering and in so doing, reduce the length of the breeding cycle. Plant propagators are interested in *prolonging* the juvenile phase to retain the easy rooting of cuttings.

PLANT BREEDING

The breeding of woody plants, especially fruit and forest trees is generally slow and therefore very expensive and has been passed over in favour of more readily controllable crops where juvenility is not a problem. Most of the work so far has been done on fruit and forest trees, by European scientists usually in conjunction with breeding programs. Economically, these trees are of much value to a country, but it could be argued that the breeding of ornamental trees and shrubs, at present vast and relatively untapped, could be of major economic significance as well.

The duration of the juvenile phase is genetically controlled and it is possible to speed breeding programs of woody plants by selecting for precocious flowering and by using parents which transmit this to their progeny Further influences on the duration of the phase can be affected by environmental factors. Attainment of a large size as rapidly as possible is most effective in reducing juvenility. Grafting, pruning, fertilisers and growth retardents all may affect the length of the juvenile phase to varying degrees, depending on the species concerned.

PLANT PROPAGATION

Ease of propagation, delays in fruiting and, in some cases, enhanced ornamental characters of leaf shape and growth habit are associated with the juvenile phase in many trees and shrubs. These are of theoretical interest and practical value to the horticulturalist.

The basal portion of a woody plant, is termed the juvenile zone and is characterised either by still showing features of the juvenile phase, or by the ability to produce juvenile characteristics by pruning or stooling. Generally, seed grown woody plants remain juvenile for many years. Peripheral growth becomes adult and as a result the tree is made up of a cone of juvenile material enclosed by a zone of adult material, depending on the pattern of growth.

Gardiner (1921) studied 21 different species of woody plant and found the cuttings from 1 year old seedlings of many fruit trees, elms, pines and spruces rooted easily but that rooting ability declined rapidly with the age of the cutting wood.

A forsythia originating at the Arnold Arboretum shows the effect of juvenility in distinctly opposite ways. From a nuserymans point of view, *Forsythia* cv "Arnold Dwarf" roots readily from cuttings but gardeners are not as pleased since this plant has a very long juvenile phase (the original plant did not flower for 8 years) and consequently it is poor in flower. Pruning this plant after flowering, as with most other cultivars of this genus,in effect stools the plant and keeps it in a juvenile condition.

A cutting or scion taken from the juvenile portion of the plant produces a plant with juvenile characters which will eventually pass to the adult. But if adult tissue is taken, the plant will possess solely adult features. This leads to another important aspect of juvenility "cuttings-topophysis". This term is used to describe cuttings preserving the individual characteristics of the part of the plant from which they originated. For example, *Araucaria auricana*, when produced from terminal cuttings, produces an upright growing plant, while a sprawling horizontal plant results if produced from a lateral cutting. Maintenance of a suitable form is important, especially in conifers, and plant propagators should understand this process in the choice and use of propagating material.

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A Study of the Potassium Requirements of an Autumn Crop of Tomatoes

(A review of a Thesis for the National Diploma in Horticulture (N.Z.) submitted by J. Hayes in 1973)

Summarised by T. M. MORRISON

The author attempted to relate fruit quality to fertiliser potassium level in an autumn crop of tomatoes. Fruit quality was assessed by the frequency of several common disorders — greenback, green blotch, yellow blotch, waxy patch, graining, poor colour, dry scar, hollow fruits, infected fruits.

Potassium sulphate was applied at 0, 4, 8, 12, 16, 24 oz/sq. yd to 4 tomato varieties in a commercial house and the crop was grown as part of normal commercial production.

Although tests showed that soil K levels more or less followed fertiliser additions, leaf K remained constant for all varieties under all treatments although the method of K analysis was not given. Similarly, although Super X and Eurocross BB consistently outcropped Potentate and Growers Pride varieties, no effect of applied K on fruit production was recorded. No consistent effect of K could be detected on fruit disorders, acidity, pH, refractive index, % dry matter on conductance.

A variation in fertiliser application was to dig out 12" of soil,deposit a layer of potassium sulphate 24 oz/sq. yd and replace the topsoil. This so-called "saline barrier" had a significant effect on fruit quality in increasing dessert grade from 47% to 73% although the toal yield was down. Leaf potassium levels remained normal.

The author discussed reasons for the apparently general low level of plant K even in treatments receiving high fertiliser additions and the lack of a range of K contents that reflected soil applications. Plant phosphorus levels appeared to be normal.

He suggests that K uptake is affected more by light levels than any other factor and that the marked effect of the "saline barrier" is linked somehow to root growth.

Hormones in Horticulture

by
D. I. JACKSON
Department of Horticulture, Lincoln College

In the 1920's and 1930's there were two discoveries of great significance to botanists, agriculturists and horticulturists. In the West a substance was discovered which, when applied to plants in minute concentrations, had dramatic effects on growth. For example, when scientists took the tops off the coleoptiles which emerge after an oat seed germinates, the growth of the coleoptile was greatly reduced, but when is was replaced by a small amount of this compound, it began to grow again. The substance was indolylacetic acid (IAA), which belongs to a category of materials known as auxins which in turn are a type of plant hormone. Hormones in animals and plants are materials produced in very small amounts and vitally affect animal and plant growth and action. When we get a shock the adrenal glands attached to the kidneys pump the hormone adrenalin into the bloodstream and this produces typical shock reaction of paleness of the skin and increased heart beat. This results in increases of blood supply to the muscles and prepares the body for any action that might be necessary. In the oat coleptile the tip produces the hormone auxin and this moves downwards to cause elongation below.

One characteristic of a hormone is that it is usually moved from the site of its production to the site of its action. In animals hormones are produced in glands and move in the blood stream to the part of the body where their effect is required. In plants hormones are usually produced at site of active cell division such as the shoot tips, young leaves, seeds, root tips and the cambial tissue, and move to their sites of action.

When these auxins were discovered and were able to be synthesised the botanical world became very excited. Here were compounds which were obviously the native factors controlling growth. All we needed to do therefore was to apply them to plants which would then show enhanced growth. Increased yields, monster carrots, turnips and roses were forecast. Unfortunately hopes were soon dashed to the ground. Auxin did increase growth but first one usually had to take away the natural sources — such as coleoptile tips or the seeds of fruits — before the applied auxin would replace the natural effect. Auxin might reproduce the natural effect but it would not usually supplement it. In fact one of the first big commercial uses of auxins were as weed killers where we gave plants overdoses of synthetic auxins, High concentrations plus the plant's inability to break down the unnatural auxin meant that we provided it with too much of a good thing and it died. These hormones, of which perhaps 2,4-D and 2,4,5-T are the best known, are used widely for such things as weed control in lawns (2,4-D), and control of gorse (2,4,5-T). You might remember the recent controversy over 2,4,5-T which suspected to cause malformations in the foetus in cattle and perhaps humans. The danger is not due to 2,4,5-T but an impurity dioxin which is very difficult to get rid of. For most purposes 2,4,5-T is now banned.

Now let's return to the second major discovery earlier this century. In Japan a common disease known as Bakanae causes elongation of the stems of the rice and these become so weak that they are easily broken by wind. It is caused by a fungus called *Gibberella fujikuroi* and Japanese scientists were able to demonstrate that a specific substance was being produced by the fungus which was responsible for stem elongation. It was gibberellic acid and represents another family of hormones called gibberellins. In the West, however, due to our ignorance of the Japanese language and its scientific literature, we did not become aware of this discovery until the 1950's. Again botanists hailed this as the answer to all our problems. I remember my lecturer in botany at the time breaking the news to us with awe, and telling us stories of cabbages growing up to 9ft tall. Whereas auxins usually had effects on growth in **non-intact** plants or plant parts, gibberellin had dramatic effects on **intact** plants.

You spray gibberellin on a plant and it does indeed grow bigger, but unfortunately, as with rice, bigger does not necessarily imply better. Again hopes were not fulfilled and there are few instances where we have increased crop size and yield with gibberellin.

Also in the 1950's another group of compounds were discovered called the cell-division factors or cytokinins and it was a New Zealander working in Auckland who first isolated the first natural cytokinin in plants, 'Zeatin'. A fourth major group of plant hormones are called inhibitors which generally have the effect of restricting growth of plants.

As a horticulturist it is strange to contemplate that now we have isolated probably the major compounds controlling growth of plants and yet, but for a very few instances, we do not seem to be able to use them for that purpose. When however one thinks more deeply it is perhaps not really all that peculiar. Plants have evolved over millions of years and each plant will have selected the most suitable balance of hormones to achieve healthy and strong growth. It is thus presumptous of us to think that we can improve on nature and you will see later that generally it is only when we ask of a plant something which is not normally required to give that hormones are of value. Let's now look at some of the uses of hormones to horticulture.

CUTTINGS

All nurserymen know of the value of the auxin IBA as an aid to rooting of cuttings. Auxins tend to be produced in the tops of plants and move downwards. Cytokinins, on the other hand, tend to be produced in root tips and move upwards. Auxins stimulate the production of roots and cytokinins stimulate the growth of buds. This seems ironic but perhaps it is the plant's way of ensuring that too many buds and roots do not grow, since this would dissipate the energy of the plant into a large number of directions. Plants can be divided into those that root easily from cuttings and those which don't. One could postulate that those which root easily are those where there is some evolutionary advantage for broken branches to take root on moist soil. By providing additional auxin we can increase the range and ability of many plants to propagate from cuttings.

FRUIT THINNING

If we spray the auxin NAA on an apple tree shortly after blossoming it will tend to cause many flowers to fall. We don't know how this works but as with weed killers it may be that a plant cannot cope with too much of a good thing. Orchardists use NAA to reduce flower numbers and thus reduce expensive hand thinning later. Oddly enough if we spray the same hormone just before fruit maturity it has the opposite effect. It stops fruit drop. Again this has advantages for us but not the tree. By this time the seeds are mature and there is no advantage in staying on the tree any longer. It will ripen on the ground, birds will still eat the fruit and some of the seeds and these will be spread over the country. For us however, once a fruit falls on the ground it is bruised and useless and we want it to stay on the tree until it suits us to pick it.

GROWTH OF GRAPES

The grapes which produce our sultanas and currants are seedless varieties. They obviously only survive because man has found seedless sports or mutants and increased their numbers by vegetative propagation. As grapes they are not very large but if we spray them with gibberellin we can greatly increase their size. Presumably what we do is to supply the grape with hormone that might normally come from the seeds. Confectioners don't always like extra large sultanas and currants but many sultanas are eaten as fresh fruit and for this purpose gibberellin is very valuable.

STORAGE OF VEGETABLES

In U.S.A. fresh leafy vegetables are trucked long distances from production areas in California to the Eastern States. Leaves of these vegetables often start yellowing before they are sold and consequently do not fetch highest prices. One property of cytokinin is to prevent the breakdown of green chlorophyll in leaves and it has been found useful to spray the vegetables before trucking with a solution of a cytokinin to prevent excessive yellowing.

DWARFING TREES AND POT PLANTS

We all know that seeds and buds become dormant in the winter. This is to ensure that if, in the middle of winter we get a sudden warm spell, the seeds and buds will not burst into growth and be killed by subsequent frosts. Dormancy is probably caused by a build-up of inhibitors and a reduction of the level of promotors, especially gibberellin. During the cold weather inhibitor levels gradually decrease and promotors increase so that by spring they are in the right balance to grow when temperatures rise; this is known as stratification. The correct growth of plant stems is probably similarly controlled by the correct balance between promotors and inhibitors. As horticulturists we sometimes would prefer more stunted plants than occur in nature. Glasshouse-grown pot-plants such as chrysanthemums or pointsettias are often too leggy and flower stalks tend to get broken. If we spray these with growth inhibitors such as Alar (B-995), CCC or Phosphon we can reduce the internode length and obtain more compact plants which are more acceptable to the buying public. Vegetative growth of fruit trees can also be reduced by spraying with Alar and in addition the amount of blossoms formed the following season is also increased. (by contrast gibberellin increases growth and reduces flowering.)

RIPENING BANANAS

There is one hormone which does'nt fit neatly into any of the categories mentioned above, this is ethylene. Unlike the other hormones ethylene is a gas which is produced by plants and probably moves around in the air spaces between cells before being released to the air and lost. It has been known for some time that fruit held in an atmosphere containing ethylene will ripen earlier. Apples give off ethylene and cool stores must be well ventilated otherwise build up of ethylene will ripen the apples too quickly. An unripe Chinese Gooseberry put into a plastic bag with apples will ripen much more quickly than normal. Ethylene is sometimes called the ripening hormone though in fact it has many other roles in plants, one of which is to counteract the effects of auxin.

Commercially ethylene is used to ripen bananas. When received from overseas bananas are green and can be held in this situation for some time. When they are required for sale Produce Merchants simply add a specified amount of ethylene to the rooms in which they are held and within a very short time the bananas turn yellow and ripen.

The growth of plants is organised by a balance of hormones acting in its best interests. We understand a great deal about these hormones and in some cases, as horticulturists, we have been able to use this knowledge to grow better plants and produce better crops. More knowledge will probably reveal new methods for their use and new synthetic compounds, but a revolution should not be expected.

FURTHER READING

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HILL, T. A. (1973), Endogenous Plant Growth Substances, Studies and Biology, No. 40. Edward Arnold (London).

Citation for Loder Cup Award, 1974

Mr Alexander Walter Anderson N.D.H. (N.Z.)

Alexander Walter Anderson, now aged 74, was born in Scotland and has had a lifetime interest in plants. He became a student at Kew Gardens, London in 1923, after he had spent four years at Littlewood Park in Aberdeen.

Mr Anderson became the first person to receive a Kew Guild assisted passage to New Zealand, where he obtained a position at the Dunedin Botanical Gardens, under the direction of the late Mr David Tannock.

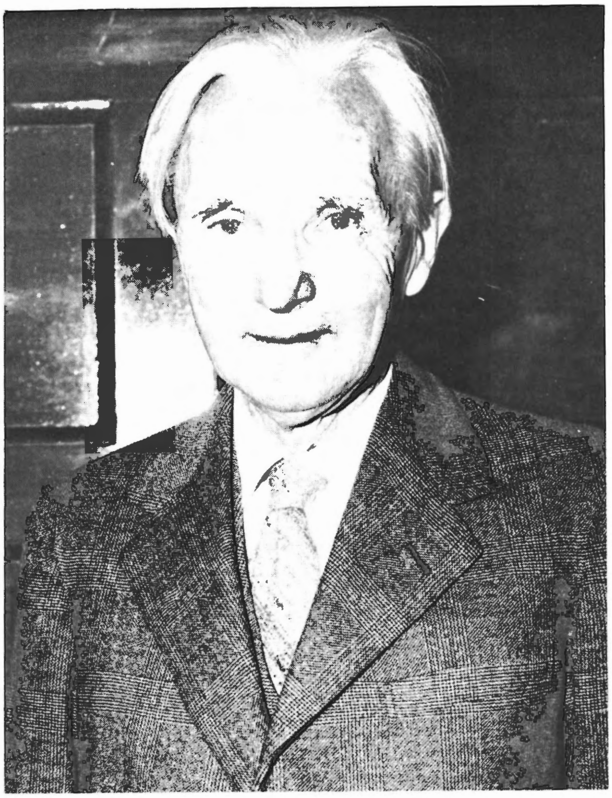
After many botanical excursions into the mountains of Central Otago and Fiordland, he was elected president of the Dunedin Naturalist's Field Club, and assumed executive positions with the Royal Forest and Bird protection Society and the New Zealand Alpine Club.

While in Dunedin he gained his National Diploma in Horticulture.

In 1932 Mr Anderson became director of Parks and Reserves in Timaru, where he was able to continue his growing interest in the New Zealand flora.

To encourage gardeners to grow and so perpetuate our native plants, he spent much of his own time writing articles about them for publication in periodicals and newspapers, not only in New Zealand, but in Britain and America.

His writings reached fruition in 1950 when he



Alexander Walter Anderson
N.D.H. (N.Z.)

published "The Coming of the Flowers", which sold several editions and is still in print. It was recently released in the United States of America as a paperback. At the time it was the first modern book to cover the origin of plants, and it was chosen as the British Broadcasting Corporation's garden Christmas Book of the Year. The book has since been accepted into the United States Congressional Library.

A second book, "Plants of the Bible," with British, American and Australian editions, was published in 1956.

Besides writing about native plants for New Zealand magazines for many years, Mr Anderson wrote weekly garden columns in "The Timaru Herald" and "Ashburton Guardian". He has also prepared articles on New Zealand natives for N.Z.B.C. presentation.

Mr Anderson has used all media to popularise and preserve the plants of New Zealand and he has furthered this aim by lecturing many organisations throughout South Canterbury, and in 1959 gave the Banks Lecture, "Plant Hunters of Canterbury."

Because of his wide knowledge of plant propagation, especially of the natives, he has been able to successfully grow and distribute some of our relatively rare New Zealand alpine plants. One such plant which he has popularised is *Ranunculus godleyanus,* the beautiful yellow counterpart of the familiar *R. lyallii* (Mt Cook lily) *R. godleyanus,* once thought to be extinct in the Mt Cook area, is now growing in many South Island Rock gardens. From two ailing seedlings found in the Whitcombe Pass area, Mr Anderson coaxed one to maturity and then over several seasons obtained seed from which he grew plants which now have pride of place in many rock gardens.

His seedlings of the beautiful *R. lyallii* and many other choice alpines and natives have found their way into gardens throughout New Zealand and Britain. His action in making these plants available does much to protect those growing in their natural environment.

He has been honoured with life membership by the South Canterbury Rose Society, Horticultural Society, the New Zealand Institute of Park and Recreation Administration and is or has been a member of the Royal Horticultural Society of Great Britain, British Rose and Fuchsia Societies and the Scottish Rock Garden Society.

Since his retirement, Mr Anderson has established a showpiece New Zealand alpine garden at Lake Tekapo. Over the years many gardeners, botanists and scientists have viewed in it, some for the first time, the distinctive flora of the New Zealand mountain tops, screes and lowlands.

Mr Anderson has also been instrumental in having grazing stopped on areas where colonies of rare New Zealand flora have been in danger of being eaten out by sheep. He has also helped with the discovery, collection and identification of specimens for the Department of Scientific and Industrial Research.

One plant he located in the Mackenzie Country, *Convolvulus verecundus,* is now, thanks to him, quite widely grown among gardeners and grows strongly in his Tekapo garden for all to see.

His botanical work was recently highlighted when he was asked to join the botanists "Hall of Fame". Due to his international reputation in the field of seed and grass distribution, plant exchange, papers, articles and books, the Hunt Botanical Library of Pittsburgh, Pennsylvania, approached him to supply them with biographical information about himself for their files of the world's most prominent and distinguished botanists.

Landscape Architecture and Ornamental Horticulture in New Zealand

by
N. A. AITKEN

GENERAL:

The recent emergence of the profession of landscape architecture in New Zealand has highlighted an area of grey which has its origin far beyond the shores of this country. This area is the indeterminate line that divides the professions of landscape architecture and ornamental horticulture, if, in fact, it can be regarded as a line at all. The situation is complicated by the international and universal environmental movement, which although hard to define, does aspire to take all the design and biologically oriented disciplines under its very broad umbrella. Obviously, both ornamental horticulture and landscape architecture fall within these rather nebulous requirements — but how and where?

The author of this article through his earlier training and experience in ornamental horticulture seeks to define the roles of these two very important and complementary professions. However, to take an objective view of the wide-ranging and complex issues in the contemporary scene, it is necessary to look briefly at history, and how this has influenced the evolution of ornamental horticulture and landscape architecture in New Zealand.

HISTORICAL INFLUENCES:

Garden design, if it can be termed as such, certainly dates back to antiquity, where it was first recorded in Egypt as the oasis garden, geometric in structure, enclosed, and providing a multipurpose environment for the various phases of living — an antithesis of the desert. The Assyrian garden which followed was bold and positive in appearance, due to its use of wooden hills, quite distinct from the flat desert landscape. The Persian garden which exploited the lavish use of flowers and trees, had a greater, more subtle reverence for nature and for water than either of its predecessors, and developed a tradition of great influence in the East, and subsequently, Spain. Initially, this tradition moved to India, which had already influenced first China, then Japan through Buddhism, expressing the art of garden design in controlled informality, epitomising natūral forms and materials in a fine but stylised way.

When the Moors invaded Spain, the Arabian tradition of garden design was introduced to southern Europe. Again there was the enclosure, the reverence and sheer delight in the presence of water, contained within an architecturally defined space, which was the basis of the patio and evolved from the Roman atrium.

This influence was carried to the New World with the Conquistadores in South America and later, the missionaries along the coast of California.

In Classical Greece, garden design was considered as an integral segment of the total built environment — typically reflected a philosophy which is equally as valid today, because the concept of integration is one of the principles of modern planning.

The Dark Ages delayed development in all cultural activities including garden design, when the emphasis was on defence against marauding hordes outside the battlements. Horticultural learning was nurtured and developed within the protective walls of monasteries, where the gardens were simple, introspective, providing herbs for culinary use and flowers for the altar. Its secular counterpart, the medieval castle garden, provided a quiet retreat from the debauchery of the banqueting hall.

Gradually, however, the preoccupation with conquest and defence softened, and this change in attitude expressed itself in garden design — the desire to go beyond the confining ramparts. Within these external gardens mounts were built for observation and their enclosing elements became less defensive and more ornamental, culminating in the Tudor garden. Here, the ornate balustrade and gazebo replaced the grim battlements.

In France, the aristocracy emerged as pre-eminent and garden design paralleled the supremacy of the Royal Court over the common people as the supremacy of civilised man over nature, in the vast, formal gardens hewn from the dense forest. For a time, this concept was also imposed, somewhat unhappily, upon the gently undulating landscape of England.

In Italy, the renaissance garden combined the richness of sculpture and ornate structural elements with massed, but visually simple planting design and intricate water features idealising the steep hillsides and unity with nature.

However, in England, the subtle, muted landscape influenced the whole concept of garden design, emerging finally in the perfection, simplicity and uniqueness of the English landscape garden — a conscious but passive revolt against the political structure and trappings of Britain's arch-rival and enemy — France. In its pure form, the English school was all too short-lived. The rapidly-expanding frontiers of the British Empire, led to a vast influx of showy tropical plants from foreign lands. Then followed the Industrial Revolution which had an irrevocable and devastating impact on stable rural communities. Traditional country estates were dismembered: there was a great exodus of farm workers to the cities to service the factories, Where they were housed in insanitary and anti-social conditions — the interminable rows of terrace houses which typify English industrial cities of that era.

In Victorian Britain, garden design reflected the extravagance of the time. In today's terms there were excesses in all design elements, and the wealth of plant material available suited the occasion only too well. Tropical plants were coaxed into lush activity in countless stove — or greenhouses, and imposed in profusion upon the cool English gardenscape. Gardens were also compartmentalised rigidly into such things as rose garden, rock garden and bog garden, etc.

This Victorian tradition is essentially what we inherited in colonial New Zealand and it undoubtedly has had a profound and lasting influence in this country. Also, there was a great pioneer spirit here and seemingly unlimited space in which to express one's individualism after the confines of Great Britain.

This superficial look at history is intended to show that garden design has expressed the social and cultural climate of the day. At times, these factors over-ruled biological and climatic constraints; for example, a traditional French garden in England or the use of showy tropical plants in a temperate/cool zone. However, on other occasions these human considerations would blend with natural influence, expressed in such things as the oasis garden or the English landscape garden.

Contemporary New Zealand is no exception to this tradition of change, and from our Victorian heritage we have not yet produced an "authentic" humanised landscape of our own. In today's complex society this will be no mean task, but there exists a sound ornamental horticulural base on which to build, if this can be interpreted in terms of today's needs rather than yesterday's. In essence, the problem we now face is one of interpretation, and it is here that the roles of ornamental horticulture and landscape architecture will have to be defined.

A LOOK AT THE CONTEMPORARY SCENE:

While the basic or fundamental principles of ornamental horticulture have remained relatively unchanged, ornamental horticulture, as a whole, has certainly responded to change in terms of the dramatic increase in the range of plants now available, accelerated through hybridisation and the emergence of countless garden cultivars; sophisticated propagation techniques; improved pest and disease control; complex herbicides; mass production methods, and innumerable other technical advances. This has given people the tools to "do their own thing" in domestic garden design, which is a logical continuation of the pioneer ethic of clearing the bush, and establishing a cottage garden with plants from home — nurtured and cherished throughout the long sailing ship journey. This nostalgia was quite understandable, but it did lay the basis for the very Anglo-Saxon or northern hemispheric "feel" of the New Zealand landscape.

In addition to the necessity for a humble cottage garden to provide vegetables, fruit and flowers, larger tracts of land were cleared for pasture, using proven introduced seed mixtures. Pastoral expansion, in turn, led to the necessity to provide shelter for stock and more recently, timber for the thriving building industry. From this very simple pioneer framework of resources utilisation, there has evolved what could be described as a "naturalised landscape" which, although not indigenous, is based (sometimes inadvertently) on sound, if somewhat modified, ecologic principles. Typical examples are exotic coniferous shelterbelts, fulfilling a role no native could fulfil; naturalised tussock grassland looking "just right" in the Mackenzie Basin; Monterey pine crowning a rocky knoll above the sea; the verticality of Lombardy poplar in a plains landscape, or a grove of gums shielding a farmstead from the wind.

In realistic terms we must now accept these modified landscapes as representative of a large part of New Zealand, because visually, they play a far greater everyday role than natural landscapes which are now limited to our diminishing wilderness areas.

However, from the Victorian tradition we have also inherited the "gardenesque" approach typified by the all-too-familiar rigidity in some municipal parks; elaborate plantings of a domestic scale in a rural landscape; massed shrubs and bedding plants in an urban landscape, or a tiresome repetitiveness and fear of trees in domestic gardenscape.

While the following criticism relates to English gardens, it readily fits the New Zealand scene:

> *"The diversity of plant material now available to us is often blamed for the lack of design in the majority of English gardens. But the real fault lies in the lack of discrimination and restraint."* (1)

In visual terms these examples are obviously quite distinct from a naturalised landscape, but in addition to this, they are not self-supporting or self-sustaining. To "manage" them and keep them orderly, man's input has to be constant and heavy, whether it is fertilizing, watering, spraying, mowing, clipping or pruning. Without this, they would not survive, meaning in many instances, that they are coaxed and cajoled into growing in conditions far beyond their natural ecological range of tolerance.

> *"Because plants are generally regarded — quite rightly — as intrinsically beautiful things, it is popularly supposed that it is enough to plant them, whether trees or flowers, anywhere, in the hope of a beautiful result. And so one finds some old garden where all was once greenness and shade, cut and defaced with beds of garnish flowers; or a great traffic roundabout, where one would expect smoothness and simplicity, incongruously decked with garnish suburban shrubs; or the great sweep of an arterial road, whose majestic verges should be part of the countryside, littered and vulgarised by puny pink trees. In all these and a thousand more, it is not the plants which are ugly, but their incongruous use."* (2)

It would be quite unrealistic and ludicrous to suggest that we impose a naturalistic order in the suburbs through a contrived re-creation of natural ecologic relationships. The result would be as incongruous as purple plums and forsythia beside a rural highway. It would also be grossly undemocratic to dictate planting design to those who obviously wish to "do their own thing". It is however, basically this philosophy which has contributed to an urban sameness in New Zealand, in situations where we have not allowed a naturalised landscape to emerge as it has with such clarity in much of our countryside.

Our urban open space has apparently not been large enough to accommodate "coarse" landscape, or able to provide a strong enough pattern to subjugate this sameness. We have got enmeshed in our present methods and consequently frightened by the maintenance bogey of systematically mowing all grass. Or perhaps, we thought in a humanised landscape, catering for the ordered and the orderly, that this approach just "wouldn't be right."

But can we afford to perpetuate a situation which largely fails to recognise New Zealand's inherent diversity in landscape and fails to respond to the forces and influences which shaped that landscape? Can we afford to perpetuate a system that is becoming increasingly costly and complex to manage — a system that will never be self-sustaining?

TOWARDS A NEW LANDSCAPE?

While ornamental horticulture embraces a vast range of plant material, it is still a specialised field, with infinitely greater degrees of specialisation within its overall framework. Even with rapid technological advances, ornamental horticulture deals with one basic biological unit — the plant. On the other hand, landscape architecture is essentially a generalised field working in close association with many other skills. A landscape architect has to handle a broad range of raw materials, both organic and inorganic, under widely differing conditions. However, within this overall framework there are numerous and increasing areas of specialisation, but, however great the degree of specialisation, landscape architecture, to fulfill its true role, cannot work in isolation from other professions. However, working with other professions is not enough in itself, because all too frequently a landscape architect is at the end of the professional chain and is issued with neatly wrapped segments labelled "for landscaping".

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(1) Sylvia Crowe (1958) *Garden Design.* Hearthside Press Inc. New York. p.106.

(2) Peter Shepheard (1953) *Modern Gardens.* The Architectural Press, London. p.18.

To achieve its full impact, landscape architecture must be a fundamental component right from the inception of any study or project, working with a varied range of other disciplines, depending on the nature of a particular project. In situations where detailed investigations are called for, these may well be geologists, hydrologists, biological scientists or engineers. Or, in the case of a regional project where the emphasis is on planning and design, geographers, sociologists, planners and architects should be involved. At some point during the process of working from the general to the specific, all these skills must converge.

In New Zealand, the comprehensive approach to land use planning, whether national, regional or local, is still very much a recent thing, although it is being increasingly accepted as the only real answer to tackling the complex, and at times, dire problems facing us today. With continuing urbanisation, it is inevitable that more emphasis will be placed on recreation and open space planning as well as development and construction of utilities and services, such as transportation systems, within urban areas.

To counterbalance the sheer weight and inorganic dominance of these architectural and engineering structures, the organic component must be used with a sure and strong hand, as illustrated so superbly by Central Park in New York City, or on a local level, by Hagley Park in Christchurch. The organic component is, of course, the horticultural input, and in the past it has all too frequently been regarded in remedial and cosmetic terms — used as green and coloured project padding or cottonwool. Its inherent strength has been suppressed, and the result is often an apology, overwhelmed by the forces and forms surrounding it. This is the inevitable out-come of using plants as garden subjects in the sense of individuals for display purposes. On the other hand, with architecture and civil engineering, all the structural elements interrelate and are interdependent, reading quite positively as components of the whole. From this readily perceived unity a structure gains its visual strength.

These same basic principles apply to planting design, where unity and strength will only be achieved if the component is regarded in a structural sense. The landscape architect intuitively applies these principles to planting design in all situations. This always means "bridging the gap" between the "hard" landscape and the "soft" landscape — the inorganic materials and forms of architecture and engineering, and the organic materials and forms of ornamental horticulture. Traditionally, this has been a notoriously wide and deep chasm to bridge — but bridge it we must, and this, in real terms, is the major task of landscape architecture today. However, it would be futile to attempt this without the strong and meaningful backing of ornamental horticulture as a basic component.

From this unity, there would emerge a "new landscape" expressing itself as an entity, while functioning as an integral part of modern society.

Hybrid Production

by
D. M. MOON

INTRODUCTION

Hybrid varieties have become an increasingly important category of cultivated plants within recent years. F1 hybrids are progeny produced by the repetitive crossing of two or more parental lines that are maintained sexually or asexually. The effect of heterosis is greatest in the F1 generation and declines sharply in succeeding generations. Such seed if fertile would be unreliable for propagation purposes. A characteristic of F1 hybrid plants is that they are heterozygous and will not breed true. This means that in crops perpetuated by seeds such as vegetables, hand emasculation of parents may be necessary unless self-incompatability mechanisms can be exploited. However, propagation is often by vegetative means with many ornamental species and so seed that does not breed true (if fertile) is less of a limitation. This paper will examine a spectrum of horticultural crops where interesting hybridization developments have taken place.

CROSS POLLINATION

To produce commercial hybrid seed, the parental lines must be grown side by side so that cross pollination takes place between them. The seed produced (the F1 progeny of the cross) is the seed used to grow commercial crops. This cross must be repeated every time that the seeds are produced.

The limiting factor in most cases in hybrid production is development of methods whereby the hybrid variety can be produced on a large scale at moderate cost.

The mating system of some crops species encourage but do not enforce cross-pollination. Examples are systems involving monoecy, protandry and protogyny. Some degree of self-fertility is usual with these systems with the result that artificial selfing can be used to develop inbred lines. Since self-pollination is permissable and may be frequent, some form of artificial control of pollination may be required when selected inbred lines are recombined into hybrid varieties. For the production of hybrid seed, complete cross-fertilization is essential.

VEGETABLE CROPS

Several of the vegetable crops illustrate methods of obtaining cross-fertilization for hybrid seed production. Use has been made of male sterility (e.g. in onion and carrot), self incompatibility (Brassica crops), dioecism (spinach), and in the case of some monoecious crops, specially bred female lines (cucurbits). With a few crops (tomato, cucumber), cross pollination is sometimes done by hand. Van der Meer and Nieuhof (1968) note that compared with the propagation of a normal variety, all these procedures increase the production costs of the seed, for they require more labour while the seed yield is often lower.

HYBRID VEGETABLE PRODUCTION

1. **Use of Self-Incompatibility**
   Brassicas illustrate the use of self-incompatibility to control cross-pollination for hybrid production. Hybrid vigour is most effectively utilized in the F1 progeny of a cross between lines or varieties with high combining ability and in cabbages, appears to offer certain advantages in comparison with open pollinated varieties among which are larger and more uniform heads, earlier maturity and a better stand of plants.

   The basis of a method developed by Odland and Noll (1950) is selection of foundation material from parent stock with subsequent development of inbred lines using bud-pollination, pseudo-compatible lines or vegetative propagation methods. A double cross is then developed. The first cross permits multiplication of inbred material and the second cross results in the commercial F1 hybrid seed.

2. **Male Sterility**
   Using as the seed parent male-sterile lines of plants characterized by their inability to produce viable pollen, has become an important method in producing seed of several kinds of plants. The procedure used to develop and maintain such lines depends upon the breeding

behaviour of that character in the particular kind of plant in which it is found (Hartman and Kester 1960). The inheritance of male sterility takes place in different ways and is well illustrated in certain vegetable crops.

Allard (1960) emphasises that unlike incompatibility, male sterility is not a regular mechanism for controlling hybridity in natural populations. Rather, male sterile plants appear only sporadically in populations of both self and cross-pollinated species, presumably as a result of mutation at any one of the many loci that govern different vital steps in the formation of pollen. Although such mutants are deleterious in natural populations they are useful to plant breeders because they provide a means of emasculating plants genetically. This simplifies the production of hybrids to the point where hybrid varieties are now possible in some species in which the cost of hybrid seed was previously prohibitive.

Gabelman (1956) has listed several types of male-sterile vegetables in Table 1.

(a) Genetic Male Sterility (pollen, nuclear sterility). This is found in tomatoes and beans and male sterility is related to a single recessive gene. The male-sterile stock is maintained by crossing male-sterile plants with heterozygous fertile plants. Half of the progeny are sterile and half are fertile heterozygote. In making crosses, the male-sterile line is planted in alternate rows with the intended male parent. The fertile plants in the male-sterile rows are rogued as soon as they can be recognised. However, where flowers must be examined carefully to identify the male-sterile plants, it is not always possible to remove the fertile siblings of male-steriles before they shed pollen. In both tomatoes and beans, pollen dispersal is poor and seed set is likely to be low on male-sterile plants. However Allard (1960) notes that in tomatoes there are some indications that production of hybrid seed in commercial quantities may be possible when better pollinators become available and when the areas where environmental conditions most conductive to crossing have been identified. For the time being hand pollination therefore is still necessary even though hand emasculation is no longer necessary.

(b) Cytoplasmic male sterility (cytoplasmic pollen sterility). This is found in corn and as no evidence has been found in other vegetable crops by the author, will be dealt with summarily. The factor here is entirely cytoplasmic. All offspring of such plants would consequently be male sterile since the male parent would have no influence upon this character in the offspring. Since any pollen source could be used, this type of sterility could be readily used to produce hybrid seed (Hartman & Kester, 1960).

(c) Cytoplasmic-Genetic Male Sterility. This differs from cytoplasmic male sterility in that the off-spring of male-sterile plants are not necessarily male sterile but can be made fertile when certain stocks are used as pollinators. Those male parents that sire male-fertile F1 progeny have been found to carry genes having the power to restore the pollen-producing ability of the male-sterility cytoplasm. Thus cases of type B male sterility are converted to the C type merely by the discovery of "restorer genes." The best documented account is by Jones and Clark (1943) who discovered the C type of male sterility in onions.

Gabelman (1956) has looked at staminal sterility (cf. pollen sterility) due to both cytoplasmic and genetic factors. He has also looked at functional pollen sterility (genetic) and these three groups can be considered as additional to Allard's classification of genetic, cytoplasmic and genetic-cytoplasmic sterility. Thus:

(d) Staminal sterility (genetic). Many male steriles modify anther or male flowers severely. Although not as common as pollen sterility genes, several types are being incorporated into breeding programmes. A gynoecious character which according to Peterson (1960) is inherited with few genes involved has been found in the oriental cucumber variety Shogoin. Normally cucumbers produce 10-20 male flowers to one female flower. The gynoecious plant produces only female flowers. This has been exploited in the production of F1 gynoecious cucumber hybrids through the use of growth regulators, namely gibberellin and ethylene (ethrel) (Robinson et al, 1969; Pike & Mulkey, 1971; Augustine et al, 1973).

(e) Staminal sterility (cytoplasmic). Found in *Nicotiana* sp. and can be used in hybridization as easily as onion steriles inherited cytoplasmically. None of the steriles found in vegetables is of this type.

TABLE 1

Abnormalities associated with unfruitfulness in vegetable crops.

	Description	Crop	Classification	Inheritance
1.	Self-incompatibility	Cabbage	Incompatibility	Gene
2.	Positional sterile	Tomato	Functional pollen sterility	Gene
3.	Male sterility	Tomato	Pollen sterility	Gene
4.	Male sterility	Lima Bean	Pollen sterility	Gene
5.	Male sterility	Onion	Pollen sterility	Plasmid and gene
6.	Stamenless	Tomato	Staminal sterility	Gene
7.	Gynecious	Cucumber	Staminal sterility	Gene

Ref: Gabelman (1956)

Sears (1947) has summarized (Fig. 1) methods of inheritance of the three types of male sterility.

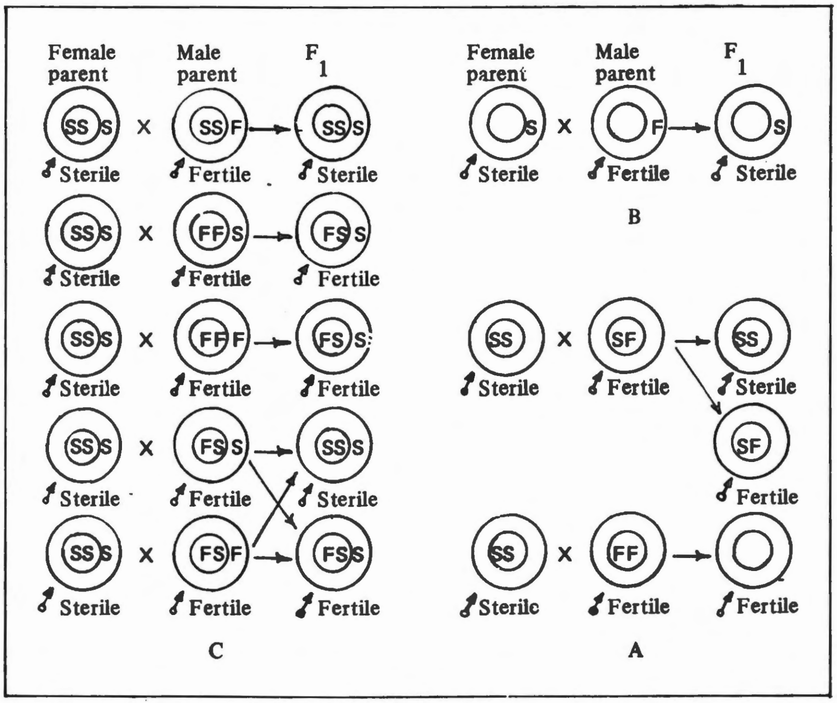


FIGURE 1: Method of inheritance of three different types of male sterility: A, genetic; B, cytoplasmic; and C. cytoplasmic-genetic. Letters in the inner circles represent genetic factors; letters in the outer circles show cytoplasmic factors. The S means male sterile, the F male fertile. The gene F is dominant to gene S. The cytoplasmic factors are transmitted only by the female parent. (After Sears, 1947.)

Ref; Allard (1960)

(f) Functional pollen sterility (genetic). The postional sterile tomato gene (ps) forms viable pollen. However, the stomia of the tomato anthers fail to open, and thereby the pollen is prevented from reaching the stigmatic surfaces. This mutant does not prevent manual self-pollination. Inbred lines, which do not segregate for this sterile character can be maintained.

3. **Hand pollination following emasculation of the pollen-producing stamens**
   This is time consuming making the seed expensive. With most plants it would not be practical on a large scale but it has been used to obtain hybrids of some ornamental flower crops such as petunias and tuberous begonias.
4. **Monoecious Species**
   May be readily adapted to hybrid seed production. This is seen in the classical example of corn and success with cucumber hybrids has been noted in this paper.

DETERMINATION OF CROSS-POLLINATION METHOD

It is generally accepted that self-fertilized species have evolved from cross-fertilized ones and rarely, if ever, the reverse (Rowlands, 1964; Stebbins, 1950). This suggests that in the ancestry of self-fertilized crops mechanisms assuring cross-fertilization were, and may still be present. Some workers are of the opinion that one of the major factors in the rapid evolution and proliferation of angiosperm species was the coevolution of self-incompatibility in the group. Accepting this, it would seem to follow that such an evolutionary important mechanism should still be common in flowering plants. There are few families which lack self-incompatible species, and there are many families in which self-incompatibility is common. The possibility of finding self-incompatibility among the relatives of presently self-fertilized crops should be good according to Denna (1971) and he mentions specific examples involving tomatoes, beans and lettuce. A brief review of the literature indicates that the potential heterosis for yield in self-fertilized crops is similar to that currently utilized in cross-fertilized crops.

ORNAMENTALS

Allard (1960) stresses that cytoplasmic male sterility has real advantages in certain ornamental species. This is because the offspring of all male-sterile plants are also male sterile. See Fig. 1 (b). This is regardless of the pollen parent used and so will remain fruitless in the presence of pollinators. These non fruitful plants tend to bloom longer than their seeded counterparts, and the flowers remain fresh longer — obviously advantageous features in ornamentals. However, generally, little work has been done on exploiting self-sterility factors in ornamentals as many can be reproduced vegetatively. Annuals and perennials which are perpetuated by seed are named species and varieties with little hybrid production.

Two ornamentals which have received much attention are azaleas and *Camellias* and hybrid developments in these specimens will be reviewed.

AZALEAS *(Rhododendron* spp.*)*

If an individual plant within a species is selected as being desirable, it can be preserved absolutely by vegetative propagation by cuttings, grafts, divisions or layers. The original selected plant and the aggregate of the plants descended from it by actual propagation constitute a clone. It is not known whether a clone is potentially immortal or whether there is some over-all limit to its longevity as a whole, and not just of individual members.

Hybrid Groups

The majority of azaleas grown today in gardens are hybrids, the result of crosses between parents from different species or between parents from different hybrid groups. The individuals grown from seed of any such cross are not identical as are individuals composing a clone. Repetition of a cross, or interbreeding of individuals derived from it, may give rise to additional variation within the group. Furthermore as often happens, according to Lee (1958) individuals of more than two species are in the background heredity of one of these hybrid groups. These polyhybrids (abbreviated to polybrids) are common among garden azaleas. Technically such a group is called grex hybrida.

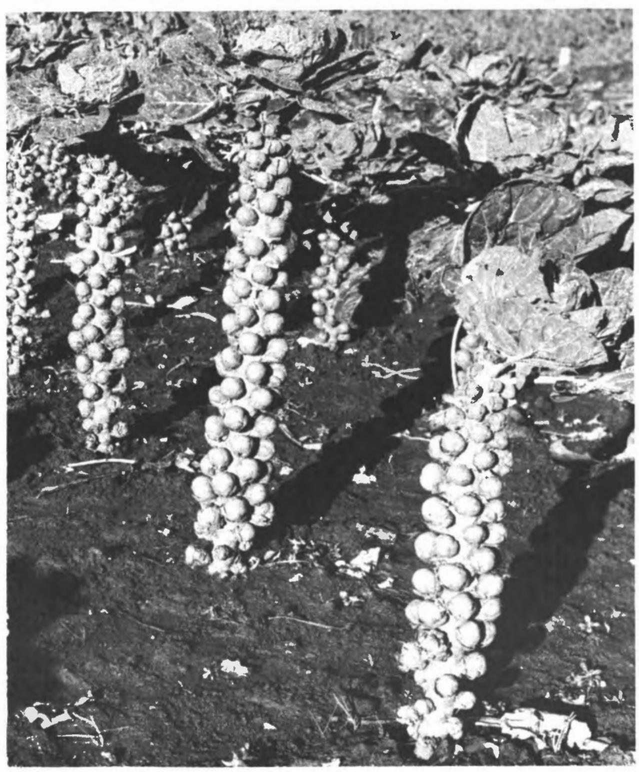
Especially desirable individuals of a hybrid group may be selected and propagated vegetatively and so give rise to a clone. Thus a clone may be of either hybrid or species origin.

Theoretically, all species within each subseries of the azalea series will interbreed. Characteristically, as with most ornamentals, practically all that is good today in azalea hybrid clones has come not from the geneticist but from the amateur gardener or professional horticulturalist whose work is carried out as an art rather than as a science.

Cross-Fertilization

In general azaleas are usually self-sterile, but readily

F_1 hybrid green sprouting broccoli developed for mechanical harvesting. The improved variety has less foliage, protruding heads and uniform maturity.



F_1 hybrid Brussel sprout (defoliated) developed for improved yield and mechanical harvesting.

cross-fertile. In nature, seeds most often result from the mating of separate individuals although selfing sometimes may occur. Most hybrids are the result of combinations within a subseries of azaleas. The most extreme examples of crosses beyond the limits of a single azalea subseries are the azaleodendrons. Several of these clones have one parent which is a "true" *Rhododendron* and so outside all azalea subseries. There is evidence that crosses can be accomplished between parents of different azalea subseries, but the records are few, for example a cross of the deciduous *casescens* (series Lutem) and the evergreen *mucronatum* (series Obtusum). The hybrid is evergreen. Its flowers are 5 cm wide and tubular, flushed lavender and have approximately 10 mm long sepals. The plant however is chlorotic, only 25 cm high after 8 years and the flowers are completely sterile.

Apomixis

Apomixis is a major problem in the hybridization of many ornamentals including azaleas and camellias where much breeding work has been done. Lee (1958) and others have emphasized the difficulty in ascertaining whether a cross has actually occurred lies in the possibility of apomixis. This is where reproduction without fertilization occurs with viable seeds being formed. Particularly in wide crosses, unless the characteristics of both parents are clearly apparent in the off-spring, there is this likelihood. Seeds are produced from accessory cells within the embryo sac and not from the egg cell itself. Therefore, these apomictic seeds (except in the case of haploid apomixis) give rise to plants called apomicts, which are identical with the mother plant. Apomixis is, in substance, another form of vegetative reproduction.

With inter-subseries çrosses, attempts to cross between the Obtusum and Luteum subseries have given seeds of low germination, the resulting progeny consisting of a high percentage of albinos which die, and a few plants which also die without flowering or at least without setting viable seed.

CAMELLIAS

Camellia belongs to the Tea family (Theaceae). In the western world, the *Camellia* is primarily known as an attractive ornamental. Sealy (1958) recognised 82 species of *Camellia* and and 16 others too. imperfectly known to establish their status. There is a wide variation in floral and vegetative characters reflecting a great diversity between species.

As with azaleas, an upsurge of interest in breeding has been apparent over the last 20 years especially in U.S.A. It would appear that the U.S. Plant Introduction Station, Glen Dale, Maryland, U.S.A. is the focal point for this work (Lee, 1958; Tourje, 1958).

Interspecific Hybridization

In 1960, a programme of interspecific hybridization of *Camellia* spp. at Glen Dale was initiated. The purpose of this project was to investigate the compatibility relationship of various species and cultivars and to determine the chromosome numbers of species and hybrids. A total of 7,289 controlled pollinations were made representing 206 interspecific combinations including reciprocal crosses. A total of 220 hybrid plants from 3, 682 pollinations in 63 combinations were obtained (Ackerman, 1970).

The flowers of many cultivated varieties are frequently almost sterile due to distorted non-functional styles and aborted pollen. Consequently selection of parents was very important. The following is a summary of rȩsults obtained:

1. Seed capsule development following pollination is no assurance of eventually obtaining hybrid plants. In many of the crosses, seed capsules developed to apparent maturity but contained either no seed or seeds with partially developed embryos. Poor seed is very common among interspecific and intergeneric crosses because compatibility factors frequently exist where large differences are involved in the genetic complexes of the parental species.
2. Large differences were observed in the percentage of hybrids developed per pollination between reciprocal interspecific crosses. The outcome of the cross was significantly influenced by the ploidy of either parent.
3. The percentages of aborted pollen produced by the hybrids generally exceeded those of the parents.
4. Success in the interspecific transfer of desirable genes in hybridization programs requires some degree of fertility in the F1 hybrids.
5. Observation of the pollen showed that the production of large grains with presumably unreduced chromosome numbers is very common in the genus. Large pollen in the parental species was of particular significance in regard to chromosome numbers in the hybrids.

Thus reduced fertility of polyploid hybrids is probably due to irregular meiotic distribution of chromosomes and aborted pollen (among diploid clones) and egg fertility suggests presence of chromosome structural changes or segregation of genes affecting fertility in *Camellia*. Therefore attempts to cross one hybrid of low fertility with another hybrid of similar low fertility may be futile. In instances where the desired genetic characteristic (e.g. floral fragrance) has been secured in the hybrid, a far more productive procedure would be to use low fertility hybrids as male parents in crosses with highly fertile female species possessing other desirable floral characteristics.

Intergeneric Hybridization

The first reported intergeneric cross was by J. H. Asper obtaining two hybrid plants of *Camellia pitardii* var. pitardii x *Tutcheria spectabilis* (Ackerman, 1970).

In 1960, attempts were made to hybridize several *Camellia* spp. with related genera at Glen Dale. A total of 1,064 controlled pollinations were made. These represented 24 intergeneric combinations, including reciprocal crosses. Intergeneric hybrids were secured from:

1. *Tutcheria virgata x Camellia granthamiana*
2. *Tutcheria virgata x Camellia miyagii*
3. *Camellia pitardii* var. pitardii x *Tutcheria spectabilis*

In 1968, further attempts were made to hybridize *Camellia* spp. with other genera:

1. *Franklinia alatamaha* x *Camellia hongkongensis*
2. *Franklinia alatamaha* x *Camellia miyagii*
3. *Camellia miyagii* x *Tutcheria virgata*

Any hybrids resulting from the *Franklinia* crosses would be of special interest as *Franklinia* is deciduous. Deciduous habit in camellias would make possible the extension of camellia growing.

Validity of Hybrid Plants

Apomixis is also a common phenomenon in *Camellia* spp. One of the first indications of validity of a young hybrid plant is the comparison of its vegetative morphological characteristics with those of its parents. Since most seedlings do not flower before they are 2-4 years old, it is necessary to rely heavily on vegetative characteristics rather than floral and seed characteristics.

GENERAL COMMENTS ON VIABILITY OF F1 SEEDS

The F1 seeds in many interspecific and intervarietal crosses are found to be partially developed. The seeds may look normal and there may not be any external indication of the internal defects. If such defective seeds are sown, usually no plant is obtained. In such cases, prior information about the internal details of every individual seed is very important as by providing requisite care, every one of them may be made to grow into a normal plant. Banerjee (1971) has used X-ray photograph technique and found this promising in isolating the under-developed seeds within short time, thus improving the chances of survival for more hybrid seeds.

Laibach (1929) studied methods of propagating embryos which otherwise may die in the seed. He was the first to demonstrate the possibility of using embryo culture technique in order to attain seedling development from inter-specific crosses in *Linum*. Immature seed are taken from fruit/capsule and incubated in nutrient solution and then germinated on a germinating pad.

These two techniques used together would permit obtaining as many viable seeds as possible from F1 hybrids where this is desirable.

CONCLUSION

True F1 hybrid production is based on the crossing of two inbred (homozygous) lines so that the off-spring are more or less identical. Most crop plants are maintained by seed because often asexual means are unavailable or are far too slow or inconvenient for commercial quantities required. Because of the economic importance of crop plants much emphasis has been placed on exploiting self-sterility factors present or incorporated into crops to facilitate hybrid production. Hybrid production is important for improving hybrid vigour of the crop and incorporation of other desirable characteristics. However, with ornamentals the objective is usually to generate maximum variability and then select from the progeny those with potenial consumer appeal.

Many ornamental plants are propagated asexually. As seeds from hybrids will segregate out in subsequent generations, repetitive crossing of parents is necessary to ensure uniform crop production. But in ornamentals, vegetative reproduction of the hybrid will perpetuate it indefinitely although there is the problem of clone "die-off" as there is no genetic variability within the clone and so resistance is low to viral attack. Little work has been done on isolating self-sterile mechanisms in ornamentals. Cytoplasmic male sterility is also useful in producing single-cross or double-cross hybrids in crop species in which some vegetable part of the plant is the commercial product. It is obviously unsuitable for production of hybrid seed in crops where the fruit or seed is the commercial product, except where some satisfactory provision can be made to provide pollinators.

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Labour Relations in New Zealand Horticulture

by
H. GILL

1. INTRODUCTION

The use of labour is a significant feature distinguishing horticulture from agriculture. Horticultural production requires a greater labour input and greater emphasis on physical rather than machine power.

In New Zealand study of the use of labour in agriculture and horticulture is only just beginning. In the past both study and advice given to growers have been piece-meal. Underlying much of this has been the idea of universally applicable principles. This is now being superseded by a more careful approach, whereby every business is seen as having its own problems which must be solved within the particular circumstances. Thus stress is placed on the choice of practise best fitting the unique combination of technical, economic and social conditions in the particular enterprise.

This paper reviews recent work carried out by the author at Lincoln College. The objective of this work is to widen the theoretical base of labour relations and to develop practical techniques to assist the manager of agricultural and horticultural businesses.

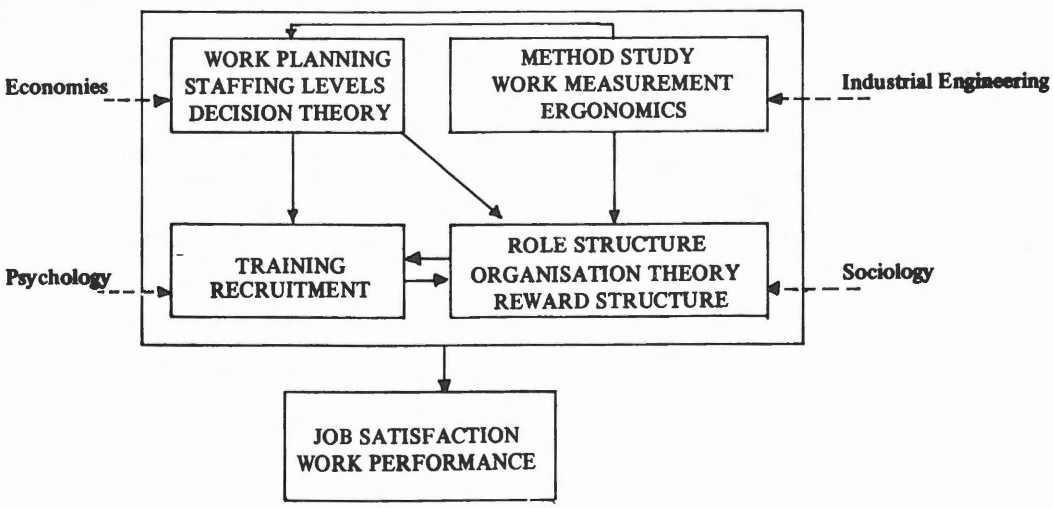
2. THE AREAS OF LABOUR RELATIONS

Figure 1 provides a schematic breakdown of the content of courses in labour studies developed by the author. From figure 1 the topics within the subject and their underlying academic disciplines can be seen. Such courses are concerned with four major areas:

1. The measurement of efficiency of work systems.
2. The inter-relationship of technology, organisation pattern, and social factors in determining job behaviour and work performance.
3. The techniques for examining and improving work systems.
4. The tneories and methods for studying job behaviour.

Figure 1 also shows two measures of the effectiveness of labour relations, work performance and job behaviour. There are two main reasons for this distinction. Firstly the factors which affect performance are not necessarily those which affect individual's attitudes to their job. Secondly an enterprise can be economically effective while being

FIGURE 1: The subject of labour management.



ineffective in social terms. Thus productivity and labour turnover can simultaneously be high.

This idea can be clarified by envisaging two dimensions to the study of labour relations; that of **work** and that of **job.** In studying work attention is focussed on the level and efficiency of task performance and the effectiveness with which physical and mental effort are expanded. Pertinent measures of this are those of productivity, such as output/man-hour or labour cost/unit of output. From an employee's point of view the economic effectiveness of employment is likely to be wages/unit of effort exerted. In studying the job, or the more social aspect of employment, concern is with the just as real, though less tangible, idea of the quality of the work experience. In taking a job an individual is committed to perform certain tasks, use certain skills, and to take part in various relationships. The job is also a major determinant of the social status of the individual. The individual's physical, psychological and social well being is likely to be substantially dependent on the employment. In turn the collection of tasks and relationships that constitute the job may affect labour turnover, recruitment, and industrial relations patterns.

There is however a complex inter-relationship between job and work. For instance actions taken to improve the economic performance of work, which may benefit both employer and employee, can cause job problems. Assembly line work, which has reduced labour cost/unit of production and placed such workers in a high earnings bracket, is an example of this. With the economic efficiency has come industrial conflict, quality control problems, and labour turnover. To some extent these must be seen as a reaction to the reduced quality of the job experience. Underlying these ideas is a 'systems' view of management. Management has to make decisions in three inter-related areas, the technical, the economic, and the social. Action in any one of them will have consequences in the others. For instance introduction of mechanised harvesting to vegetable or fruit crops goes far wider than the design of the equipment. Major changes in crop production methods and in the scale of production may be required. This will alter work methods and introduce new features into the jobs of individuals. These can include a shift from individual to group work, or a change from self to mechanical pacing of work rate. Frequently these factors are not considered in the evaluation of the system. Likewise the manager cannot explain the resignation of experienced staff or collective action against the change.

3. THE STUDY OF WORK PERFORMANCE

Possibly the study of work performance is more concerned with procedures, layouts, machines and equipment than with people. This is because variations in efficiency more often lie with these than in conscious action by the operator.

This is examplified by a study of the efficiency of grass mowing at Lincoln College. The total annual cost of using pedestrian controlled machines was estimated at $6,000. Using a spot sampling technique it was found that the mean proportion of working time actually cutting grass was 55%. More importantly there was a 12% difference in this between two makes of machine. This was statistically significant and represents a potential cost saving of $720 per annum.[1]

In a study of greenhouse vegetable cropping in Auckland the mean labour usage for tomatoes was compared to that calculated from work measurement data available from Guernsey. It was found that the Auckland level was 51% higher than indicated by these standards. It was also shown possible to reduce labour requirements with lower plant densities, without any loss in total yield.[2]

Such studies illustrate the identification and quantification of problems. Properly conducted such examinations also provide information for a preliminary cost-benefit assessment. This is an essential step as it is never worth spending more in designing and implementing movements than can be gained in cost savings or increases in returns. In the mowing example the cost of improving the efficiency of the poorer machine, to the level of the better one, should not cost more than $720 per annum.

Small changes in work methods can often lead to large increases in performance. One example was a study of the partial mechanisation of bedding plant production. It was found possible to avoid covering the seed after sowing by the simple expediant of changing the transparent polythene cover of the germination chamber to an opaque one. Similarly a number of small alterations in method meant that both hands could be used simultaneously in the planting of seedlings. This meant a potential 45% increase in output per hour.[3] In a similar vein a

1. Smith A. W., McFadden G. A., Lyford P. B. (1974), *A Study of the Efficiency of Grass Mowing at Lincoln College. (mimeo).*

2. Gill H. (1974), *The Profitability of Glasshouse Vegetables.* Bull 17 Lincoln College Hort. Dept.

3. Gill H., Smith A. W., Lyford P. B. (1974), *The Mechanisation of Bedding Plant Production.* Lincoln College (mimeo).

study of mushroom picking led to the suggestion that increases in work rate would follow from widening the space between stacked trays. This would give the picker better visibility of the mushrooms and allow picking with both hands.[4]

These particular findings are part of the results from studies on the feasibility of major changes in production methods. It must be stressed that they apply to the particular set of conditions of the study area.

Changes in production method can also lead to reductions in work efficiency. For instance it is known that some varieties of tomatoes and strawberries are substantially easier to pick than others. Yet in horticultural experimental work and in the evaluation of varieties the majority of results are still given in technical terms. Economic evaluation of the results is still rare; even rarer is assessment of the effect on work content.

A similar situation applies to the design of amenity features. Excessive maintenance costs are frequently made inevitable by such factors as the poor placement of kerbs and signs, too narrow pathways, and unfunctional shapes. While aesthetics and economics may well be incompatible the stage to comprise is in design, not after construction.

A technique called 'Predetermined Time and Motion Study' offers a potent tool for measuring the work content of new designs and in evaluating varieties and production methods. This technique was used in the bedding plant study discussed above. In the case of large amenity areas and major production and work systems it is feasible to use operations research techniques and computer simulation to improve efficiency. In designing a harvesting system for field tomatoes a computer model was used to examine the effects of organisation, number of pickers, the use of transport and the circulation of containers, on total cost.[5] An advantage of this procedure is that it provides experience of the results of possible actions before the system is used.

4. THE SOCIAL AREA OF EMPLOYMENT

An adequate theory of job behaviour must allow the identification of factors inside and outside the workplace that are linked to actions and attitudes. Individual employers and employees will evaluate their relationship according to their perception of the employment situation and the attitudes and expectancies they bring to it. It is thus necessary to document the social facts of the work situation and the orientation of the parties to this. The full derivation and description of this theory is available in a previous paper by the author.[6]

In a study of New Zealand National Park Rangers differences in work performance and job attitudes were related to the extent to which individuals were vocationally orientated to Park employment and to the perceived level of conflict between preservation and tourism. It was suggested that because of this alternative and mutually exclusive management policies were available; one that would favour economic efficiency and one that would encourage creative work.[7]

The phrase 'job satisfaction' is frequently used in discussions of attitudes towards employment. Athough it is in common use it is somewhat spurious. This is because of the tendancy to use it as an absolute measure rather than a comparative one. Using an attitude scale, or similar device, presuming that this is valid and reliable, it is possible to show that one group of people are more satisfied than another. However it is not possible to conclude that either group is satisfied or dissatisfied in isolation. A further problem is that there is no single measure of job satisfaction. Usually the situation is broken down to four areas, job content, supervision, work mates and earnings. However the four are not necessarily additive as individuals rank or weight the individual dimensions in deciding to take or retain particular employment.

It is generally accepted that job satisfaction is correlated with labour turnover, accident rates and absenteeism. The relationship with work performance is much more problematic; instances have been recorded where both high and low satisfaction have been linked in turn to high and low performance.

Significant differences in attitudes can be found on the basis of occupation, age, sex, and various social parameters. Table 2 presents some comparative

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4 Smith A. W. & Gill H. (1974). *Factors Affecting the Efficiency of Mushroom Picking.* MAF Canterbury (mimeo).

5. So far the results of the work on field tomatoes has only been privately circulated. It is intended that a joint research report by Crowder R. A. & Gill H., will be published.

6. Gill H. (1973). *Agriculture Labour Management; A Revision of Concepts.* British Journal of Agriculture Labour Science 2; ppl-18.

7. Gill H. (1974). *The Work Environment of the National Park in National Parks Seminar;* Bull 16 Hort. Dept. Lincoln College.

data from studies on horticultural workers and meat inspectors.[8]

TABLE 2

The Percentage of respondants reporting high satisfaction with

	Horticultural regular staff	Meat Inspectors
Job content	77	23
Supervisors	72	43
Work mates	90	50
Earnings	47	60

It can be seen that horticultural staff were more satisfied than meat inspectors with everything except their earnings. Such findings suggest that horticulture, as an occupation will retain individuals who put a high weight on the intrinsic rewards of work. That is who are concerned about what they do, how they do it and who they do it with. On the contrary meat inspection will suit individuals more concerned with economic reward. That is who regard work as obtaining the means to enjoyment outside it. The idea underlying this is that few jobs are both highly interesting and well rewarded. The majority of people who cannot enter such occupations must settle for either interest or high pay. In other words in a world of limited resources everybody cannot have everything.

Differences within the occupational group are also important. It was found that workers on glasshouse properties were generally more satisfied than those on outdoor cropping farms. As a group, women were generally more satisfied than men, despite lower earnings and less responsible jobs. Likewise in horticulture dissatisfaction increased with the level of job content; that is there was a gap between the expectancies of individuals with more responsible jobs and the rewards they perceived themselves obtaining.

An essential step in the understanding and solution of job related problems is that of definition and documentation of the situation. Berryfruit growers have faced rapidly increasing costs and relatively static returns; to this has been added an apparent shortage of pickers. However a study on one Canterbury property showed that this was not the only, and perhaps not the main problem. Information collated from wages books showed that 40% of pickers stayed less than three days on the property and 50% less than five. In comparing between properties it was found that at best 60% of pickers had worked at least one year previously while at worst only 22% had.[9]

To trace the causes of this, worker attitudes towards the job, supervision, work-mates and earnings were correlated with the level of earnings. This is also a test of the relationship between job satisfaction and work performance because of the piece-work payment system. The trends found were, firstly no relationship between level of earnings and the various measures of job satisfaction. Secondly individuals satisfied with their earnings, whatever the level, were less likely to leave than those dissatisfied. Thirdly no relationship was found between the other measures of satisfaction and duration on the property.

These type of studies allow the development of management strategies. This was briefly discussed in the National Parks example. In the case of berryfruit harvesting the grower was faced with the inter-related problems of shortage of pickers, increasing wage rates, and short duration of pickers on the property. The three factors re-inforce each other in a typical 'vicious circle'. Duration on the property is linked to satisfaction with earnings, however because of the piece-rate method of payment 'experience' is necessary before reasonable earnings are made. At the same time the declining margins make the grower less willing to increase pay rates or change to a time based payment method. So the shortage of pickers becomes worse.

One means of breaking this circle is to improve the methods of work and so increase the productivity of pickers to enable them to increase earnings. Among other things this includes instruction in the best method of picking, less wasted time in weighing fruit, and changing the method of supervision. The latter it was suggested should be work or efficiency centred rather than the text-book 'person centred'. The traditional theory of supervision states that to be most effective supervision should aim at increasing the individual's identification with the business. In the case of this berryfruit property the study suggested that this was not the best strategy for the grower to adopt. Once again however this is not

8 Gill H. *Job Attitudes in the Primary Sector.* Forthcoming paper.

9 Full documentation of the use of labour in berryfruit harvesting was presented at the Labour Management Seminar N.Z. Berryfruit Growers Association, July 1974. A version of this will be published by Gill & Smith as a Labour Management Case Study.

advanced as a universal principle but rather an example of fitting the solution to the situation.

The problem of the lower satisfaction of the staff with more responsible jobs suggests an opposite approach. In this case the manager must consider whether sufficient responsibility and involvement is being given. A case study on a large nursery showed that it was quite possible for large differences to exist between the level of responsibility the employer thought he was giving, and what senior staff felt they had. In cases such as these the use of job descriptions and management by objectives techniques can be useful.

5. PAYMENT METHOD

The system of payment, or the basis of the pay-effort bargain, overlaps and links the two areas of job and work. Changes in the basis of payment such as those aimed at increasing productivity or overcoming existing anomolies, can often have consequences in the social area of the job.

An example of this occurred in development of field tomato production. The adoption of bulk handling meant that the traditional individual piece-work system was infeasible. Also work measurement studies showed that the use of a fixed piece-rate across all areas of the crop was unfair to both growers and employees. It was found that for the same level of effort there was a 65% variation in picking rate per hour between areas of the same variety and a 133% variation between different varieties. With a fixed rate of $11.20 per tonne this would cause a range of earnings from $0.90 to $1.90 per hour for the same level of effort. Likewise the grower with the easiest crop to pick would be over-paying and the one with the hardest under-paying. A group based incentive scheme, based on the work measurement studies was introduced. This overcame both the organisational and the inequity problems. However it introduced new difficulties resulting from conflict between work groups.

A detailed study of the effects of changing the payment system was made in United Kingdom Local Authority Parks and Reserves Departments.[10] For a number of reasons, primarily economic, Local Authorities have been introducing work measurement based incentive schemes. These have led to increases in earnings and savings in labour costs. However they have also led to other changes which can be summarised:

1. Intensification of arguments about the allocation of work.
2. Systematic attempts to bend the incentive scheme.
3. Intensification of arguments about other wage differentials.
4. Demands for the consolidation of bonuses into holiday and sick pay.
5. Increased stress on the supervisors from both management and employees.
6. Re-arrangement of work-groups to match the level of bonus earnings.

These two studies of payment method both show the range of factors which must be considered. Once again no single best system can be propounded, it depends on the prevailing technical, economic and social situation.

6. CONCLUSION

This paper has reviewed part of recent work at Lincoln College which it is thought offers some new directions in the study of labour relations in horticulture. No claim is implied that we have a monopoly of the truth. However we believe that we are in the vanguard of a movement from universal panaceas and recipes to the study of the situation of the individual business. Each of the studies reviewed illustrates the value of detailed analysis.

Many of the techniques used in the studies reviewed are time consuming and require facilities beyond the scope of the individual business. This raises the question of who will provide these services to the New Zealand primary sector. There appears to be a place for the study of labour relations problems within existing advisory facilities. This could serve growers directly, and also indirectly by evaluating the output of research stations. The role of the Ministry of Agriculture is critical in the development of this approach. The present author is thus very pleased to acknowledge the assistance of staff of the Ministry who completed some of the studies reviewed while studying with him at Lincoln in 1974.

10 A fuller discussion of this is provided in Gill H. (1972), *The Uses of Incentive Schemes and Work Study in Local Authority Horticultural Service.* Lincoln College Hort. Bull. 14. Ed. J. O. Taylor, pp15-24.

Book Review

"Sicherungsarbeiten im Landschaftsbau", Callwey Verlag, Munchen, W. Germany
244 pages, 134 drawings, 172 photos and tables. DM 150,000 (Approx. NZ$40).

by
Dr H. M. SCHIECHTL, 1973

This book "Protection works in Landscape Development" with subtitles "Principles — Live Building Materials — Methods" is a very much enlarged version of Dr Schiechtl's earlier book "Grundlagen der Grunverbauung" published in 1958. The new publication is a manual for soil conservators, environmental foresters, and landscape architects who work on the revegetation and restoration of eroded landscapes, whether at high or low altitudes with mainly vegetative means.

Dr Schiechtl is one of the leading exponents on the building of vegetative barriers to control mountain torrents, slips, slumps and avalanches in the alpine regions of Central and Southern Europe. His choice of plants, based on ecological principles, relates to those regions but the biological engineering methods described in this manual have worldwide application. Some of the techniques have been applied for several years in New Zealand.

The book is divided into the following sections:

A. Selection of species for building vegetative barriers.

B. Choice of the most suitable biological engineering methods

C. Cultivation and maintenance of vegetative barriers

D. Costs of building vegetative barriers

E. Descriptions of biological engineering techniques

F. Bibliography

G. Glossary

H. Index

I. Plant index

Section A covers 72 pages. Many selected species are readily available in this country. The suitability of the plants for erosion control projects; and the descriptions of growth habit, strength of the roots, ease of multiplication are all based on practical experience. Clear line diagrams of the plants complement the descriptions.

Section E, covering 108 pages, describes 58 techniques with live materials in detailed "case histories". Non-living materials such as stones and plastics are dealt with in 24 pages. All techniques are clearly illustrated.

An English translation is in preparation and will contain many examples from non-European countries of Dr Schiechtl's restoration techniques. Some readers may wish to wait for the publication of the English edition, but those with even a limited knowledge of the German language would be well advised to obtain this comprehensive manual on biological engineering.

reviewed by N. C. Lambrechtsen

Podocarpus in New Zealand

by
L. J. METCALF

The endemic species of *Podocarpus* are some of the commonest and most noticeable of the large trees in New Zealand. Some make exceedingly fine specimen trees in gardens of parklands and it is surprising that, horticulturally, they do not figure more prominently. Many of the exotic species also grow well in New Zealand and it is equally surprising that they are not more widely planted.

The genus comprises some 65 species which are mainly confined to the Southern Hemisphere, but with some occurring in China, Japan, India, Malaysia and the Philippines. The majority of the species are trees, but a few are shrubs. The seven New Zealand species are endemic.

Although one or two of the native podocarps are fairly readily available from some nurseries, it would not be untrue to say that, as a group, they have been largely ignored. Duncan and Davies Limited list 5 species and one cultivar, but there would probably be few other nurseries in the country that would catalogue more than two.

Perhaps the most commonly grown species would be the totara *(Podocarpus totara)* and although inclined to be rather slow of growth, it eventually makes a very handsome specimen. Isolated specimens, which give a park-like appearance to the landscape, are a prominent feature of farmlands in some parts of the country and give a clue to the one of the most effective ways in which the totara can be used. These is no doubt that its use as a specimen, in parklands and similar areas, should be encouraged.

The golden totara *(P. totara 'Aureus')* is available from some nurseries, but it is rare to see it figuring in suburban gardens and yet, particularly during winter, its colouring is equal to many exotic conifers. Its habit of growth is different and is a break from the ubiquitous golden *Chamaecyparis.*

Even less well known is the weeping totara *(P. totara* 'Pendulous') which does not appear to be available from any nurseries and is only to be seen in a few private gardens. The parent tree is at "Sundrum" near Geraldine in South Canterbury. As a young plant it may require a little patience with training in order to induce it to grow into a well shaped specimen, but eventually it grows into a most attractive tree.

The kahikatea *(P. dacydioides)* has a rather unattractive juvenile habit, but semi-mature trees have a fine shape which makes them very useful for specimen planting. *Podocarpus dacrydioides* is available from some nurseries, but only as seedling plants so that the would be grower is forced to wait for quite a number of years before the tree assumes a pleasing shape. This problem could be overcome if nurserymen could be persuaded to vegetavely propagate their plants from semi-mature trees. Cuttings strike fairly readily and there is no reason why suitable plants should not be available from nurseries.

Similarly both the matai *(P. spicatus)* and the miro *(P. ferrugineus)* are less attractive in their juvenile stages and should be vegetatively propagated from more mature plants. The miro, in particular, can be a most attractive specimen and should be far more widely used. It has yew-like foliage but with a more graceful habit of growth.

Of the exotic species of *Podocarpus,* the most widely grown in New Zealand is probably *P. andinus* which comes from the Andean region of Chile where it grows at altitudes of from 1200-1800m. It eventually forms a round headed tree from 9 to 12m in height and in foliage and general appearance it is not too dissimilar to *P. spicatus. Podocarpus Andinus* is quite an amenable tree which should be more widely grown.

In Christchurch *P. elatus* has been grown for many years, but it is not known whether specimens exist in other parts of the country. It is a most handsome tree with large leaves 10-15 cm long by 6-12 mm wide. In its natural habitat of New South Wales and Queensland it attains heights of up to 30m, but in Christchurch growth is slower and the tallest specimen is only about 7.5m tall. It appears to thrive in quite dry soils, although growth is slower, and grows into a well-shaped tree.

Trees L. to R. *Cordyline australis, Podocarpus totara* 'Aurea' *P. totara* var. hallii

More recently *P. macrophyllus* has appeared in nursery catalogues and it has promise of being a worthwhile plant. It is native to China and Japan and has proved to be quite hardy. It is another large-leaved species with narrow leaves up to 13 cm in length and grows as a large shrub or small tree from 7-13m in height. It stands clipping well and in Japan is commonly used as a hedge plant. Another use to which it can by put is as a tub plant. In fact a number of *Podocarpus* are eminently suitable for growing in tubs.

Another recent addition is *P. alpinus* which is listed as *P. lawrencii* in the catalogues. It comes from the alpine and subalpine regions of Victoria and Tasmania where it ascends to an altitude of 1800m. It is said to grow up to about 3.5m tall, but it appears that in cultivation it only grows to about half of that height. In general appearance it is rather similar to our own native *P. nivalis* except that its foliage is a much darker, almost bluish green. The branchlets have a slight drooping habit which gives the bush a pleasing appearance. Accounts of it growing in England indicate that it is rather slow of growth.

In the Christchurch Botanic Gardens several other species of *Podocarpus* are being grown with a view to assessing their horticultural merits and hardiness. They are *P. montanus, P. pilgeri, P. milanjianus, P. polystachyus* and *P. nagi.*

Podocarpus montanus has yew-like foliage and appears to be rather closely related to the miro. It comes from the Cordilleras of Peru and Colombia where it grows at altitudes of from 2,600 to 3,000m. In nature it grows into a tree up to about 18m in height with wide-spreading branches. So far it has only been over-wintered outdoors for one season, but appears as though it might be quite hardy. From the young plants being grown the impression is that it makes an attractive small tree.

Podocarpus pilgeri comes from the Philippines and appears to be an interesting species. Little information concerning it is available. It has rather broad leaves from 1.5 to 4 cm in length and one of its most attractive features is the young foliage which has a glaucous bloom which contrasts against the dark green of the mature leaves. So far it has not been thoroughly tested out doors, but it may possibly be frost tender in Christchurch.

One of the other species being grown *(P. polystachyus)* is also likely to be frost tender. Similarly there is very little information concerning it. It comes from Malaysia and has narrow, sharply-pointed leaves up to 10 cm long.

With *P. milanjianus* there is a much greater chance that it will be hardy in Christchurch. This species comes from Uganda, Tanzania and Kenya where it ascends to an altitude of 3,350m. It grows up to 30m tall, but at high altitudes becomes a low, dense bush. The leaves are from 1 to 1.5 cm wide and up to 18cm long on young plants. *Podocarpus milanjianus* has not yet been tried outdoors in Christchurch.

Podocarpus nagi is native to Japan, China and Taiwan. It is another of the large-leaved species; the leaves measuring about 7 x 2cm. It grows into a tree from 18 to 24m tall and in Japan is highly regarded as a specimen tree. The Japanese also use it a great deal for bonsai work. It has proved to be hardy in Christchurch and should make a handsome specimen.

From the foregoing it will be seen that the genus *Podocarpus* has a great deal to offer in the garden and it is to be hoped that local horticulturists will make much greater use of this very worthwhile group of plants.

Weed Control in Parks and Reserves in the Tauranga District

(Extracts from a thesis for the National Diploma in Horticulture (N.Z.) submitted by W. E. TURNER)

WEED CONTROL IN TREE AND SHRUB BORDERS

With the frequent disturbance of soil by cultivation between trees and shrubs, further germination of weed seeds is encouraged, therefore in Tauranga's fine loam soil a never ending task faces the gardener. Unfortunately most of the information on selective herbicides is given out for agricultural species rather than for ornamentals.

There is a risk of damaging many species by applying herbicides to shrubberies. Knowledge at the time of experimentation (spring 1968) of herbicides in tree and shrub borders was that Paraquat could be safely used between plants provided it was kept back from foliage and young green bark. The contact translocated herbicide used was Phytazol "A" and the pre-emergence herbicide Simazine. There was on the market in granular form another pre-emergent "Casoron 7.5G"; dichlobenil was the chemical active ingredient. Men were first sent into the nursery to hoe through and clear away the herbage (this would make it safer for the plants to be treated). One-eighth of the nursery (about .4 ha or 1 acre) was portioned off. The part chosen was divided into two equal portions each containing as near as possible the same species of shrub or tree.

RESULTS

Plot 1

Gesatop (Simazine) 50% WP 1 kg of material in 135 l (30 gals) of water to .25 ha (1lb/¼ acre).

There was some noticeable reaction on certain plants in the late spring. These were: *Acer* spp. — killed; *Deutzia* spp. — killed; *Populus nigra* 'Italica' — retarded; *Prunus* spp. — several species killed. The poplars recovered later. There was good control of annual weeds but it was necessary to treat some seedlings and perennials in early summer.

Plot 2

Casoron G 7.5% (Dichlobenil) granules. The applicator was adjusted to deliver 339 kg/ha. (1 oz to the sq yd). (The applicator was supplied free with the granules). At this rate there was a reasonable control of all weeds except *Oxalis cernua* (Bermuda Buttercup) and there was no apparent ill effect on any of the trees and shrubs.

NOTE

After applying Gesatop and Casoron it was necessary to irrigate the area in order to incorporate the material into the soil.

Casoron had a better effect than Gesatop, for the latter did not control any of the perennial weeds and it did affect some trees mentioned. It would be possible if there was no alternative to Gesatop (Simazine) to isolate the planting of these susceptible species into one corner of the nursery to treat them with contact herbicides only. It was decided to use Casoron (Dichlobenil) on the whole nursery. An application at 339 kg/ha (1 oz per sq. yd) was put on in the late autumn of 1969 over the whole nursery, after lining out operations were completed and planting finished. This gave good weed control until late summer 1969 when it was necessary to apply a knockdown herbicide Phytazol "A". Since then the practice has been to apply at 678 kg/ha Casoron (2oz per sq. yd), in the early spring. This increased dosage is giving good control of the weeds in our nursery and tree and shrub borders throughout town. On isolated patches of *Oxalis* spp. the dose has been as heavy as 1356 kg/ha (4oz per sq. yard) with no apparent ill effects on the trees and shrubs and the *Oxalis* spp. has been eradicated.

SPECTRUM OF USE, CASORON GRANULES *(Dichlobenil)*

The following lists give an indication of those weeds that were controlled easily by "Casoron" G. (Dichlobenil) and those which were more difficult.

1. **Highly Susceptible** — Controlled at 339 kg/ha (1 oz per square yard) (Casoron 7.5%):
   Germinating seedlings of most annual and perennial weed seeds. Some established weeds will be checked and may even die if conditions following application are optimum.

2. **Moderately Susceptible** — Controlled at 339-678 kg/ha. (1-2 ozs per square yard) (Casoron 7.5%):
   Poa annua (Annual Poa)
   Urtica urens (Nettle)
   Sinapis arvensis (Charlock)
   Cerastium glomeratum (Mouse-eared Chickweed)
   Lavatera arborea (Tree Mallow)
   Ranunculus sceleratus (Celery Leaved Buttercup)
   Spergula arvensis (Spurry)
   Chenopodium album (Fat hen)
   Senecio vulgaris (Groundsel)
   Sisymbrium officinale (Hedge Mustard)
   Anthemis cotula (Mayweed)
   Taraxacum officinale (Dandelion)
   Rumex spp. (Docks)
   Plantain spp. (Plantains)

3. **Slightly Tolerant**
   Polygonum convulvulus (Cornbind)
   Polygonum aviculare (Wireweed)
   Capsella bursa-pastoris (Shepherd's purse)
   Lolium perenne (Perennial Rye grass)
   Cardara draba (Hoary cress)
   Galium aparine (Cleavers)
   Epilobium spp. (Willow weed)
   Veronica persica (Speedwell)
   Agropyron repens (Couch)

4. **Moderately Resistant**
   Convulvulus arvensis (Bindweed)
   Juncus spp. (Rushes)
   Trifolium spp. (Clovers)
   Ranunculus repens (Creeping Buttercup)
   Medicago lupilina (Black Medlick)
   Fumaria officinalis (Fumitory)
   Oxalis spp. several species
   Anthoxanthum odoratum (Sweet Vernal)

New Zealand Theses recently presented of Interest to Horticulturists

NDH Theses

Collins, D. S. T. (1973)	Some special aspects of plant protection in Tauranga Parks and Reserves 98p.	(3)
Cowan, J. M. (1970)	The commercial export of trees and shrubs, NDH thesis 16p.	LL (2)
Estcourt, D. E. (1971)	The influence of snagging methods of the growth of roses in a trial. NDH thesis 16p.	LL (2)
Hayes, J. (1973)	The effect of potash in the base dressing on the incidence of simple fruit ripening disorders. A specific study of an autumn crop of tomatoes on an old glasshouse soil at a high phosphate level NDH (Veg) thesis 41p.	LL (3)
Jensen, G. V. (1972)	A study of bird damage in a commercial orchard in the Auckland district. NDH (fruit) thesis 47p.	LL (2)
Mullholland, R. I. (1963)	Control of the aphid vectors of plant virus diseases by the use of systemic insecticides. NDH thesis. 55p.	LL
Nind, G. P. (1973)	Landscape and aesthetics of motorways NDH thesis 70p.	LL
Turner, W. E. (1973)	Weed control in Parks and Reserves in the Tauranga district. NDH Thesis 70p.	(3)
Walton, G. M. (1972)	The economics of the two-queen and single queen systems of colony management. N.D. Ap thesis 32p.	LL (2)

(1)—Appears in RNZIH Ann. Jl. 1973, No. 1.
(2)—Appears in RNZIH Ann. Jl. 1974, No. 2.
(3)—Appears in RNZIH Ann. Jl. 1975, No. 3.

LL — Copy deposited at Lincoln Library and available to students.

THESES PRESENTED AT UNIVERSITIES IN N.Z.
(Taken from 1974 University Calendars)

Cornford, L. H	Methods of Assessing the Effects of Herbicides. Dip. Agr. Sc. (Linc).
Edmonds, A. S.	Nitrogen Nutriment of Mycorrhizal Pines. Ph.D (Linc).
Edwards, W. R. N.	Water status and growth in populus M. Hort. Sc. (Mass)
Gardner, P. C.	Some factors affecting the establishment and growth of bud grafts of roses M. Sc. (Mass).
Harvey, P. W.	Measurement of Plant Water Status. M. Hort. Sc. (Linc).
Lunn, D. W.	Virus diseases of chrysanthemum in the Manawatu M. Hort. Sc. (Mass).
Mackintosh, B. L.	Studies on black scurf of potato caused by *Rhizoctonia solani* Kuhn M. Hort. Sc. (Mass).
McGlone, M. S.	The Pollen Morphology of the New Zealand Epacridaceae M. Sc. (Vic).
Singh, G.	Flower blight of chrysanthemums: the causal fungi and their control M. Hort. Sc. (Mass).
Smith, G. J. S.	Pollen Morphology of the New Zealand Species of Araliaceae M. Sc. (Vic).
Tantivanith, Miss V.	The role of young leaves in controlling lateral growth in *Phaseolus vulgaris* L. Dip. Agr. Sc. (Linc).
Warrington, I. J.	Artificial light spectra and plant growth M. Hort. Sc. (Mass).

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