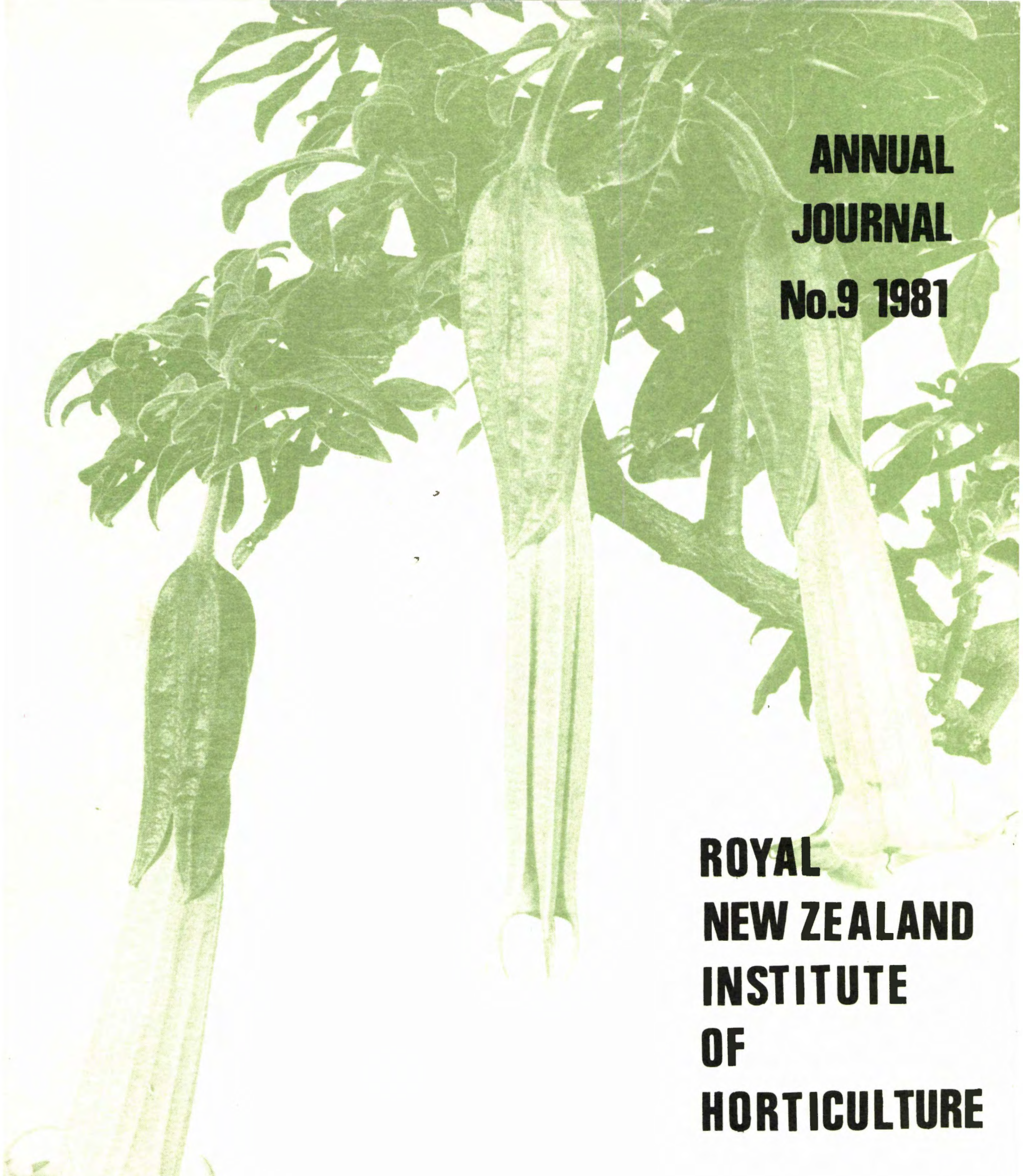

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COVER PICTURE - *Brugmansia sanguinea*

This has also been knwon as *Datura sanguinea* or *D. rosei* (Sykes 1976). A solanaceous shrub with pendulous yellow trumpets. The lobes of the trumpets can be red or yellow. The plant originates from the northern Andes and does not commonly fruit in New Zealand.

This species is poisonous and some problems have arisen in New Zealand: a child chewed or ate the flowers; another child had eaten some seeds, and a youth who experimented with this species became unconscious, but recovered after treatment (Connor, 1977).

(Refs: Connor, H.E. 1977: The poisonous plnats in New Zealand. Govt. Printer, Wellington. 247p.
Sykes, W.R. 1976: Shrubby *Datura* species in the South Pacific. R.N.Z.I.H. Annual Journal 4: 13-15.)

Photo by Diane C. Heslop

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Contents

The Banks Lecture, 1981
Poisonous Plants and Horticulture in N.Z.

by

H.E. Connor

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By good fortune the coincidence of this Banks Memorial Lecture on 2nd May, and Walpurgisnacht was avoided; on the night of 30th April Satan relaxes his guard over the enchanter's nightshade *Atropa bella-donna*. One could, on that night, gather some enchanter's nightshade and then make the devil do one's bidding, that is, change the mortal aspect of men, and reduce them to swine[1]. The cerebral depressant *l*-hyoscyamine, an alkaloid, occurs throughout that plant. I suppose it could cause such changes, though modern evidence on the point, is slight.

JOSEPH BANKS

This year, 1981, is the bicentenary of Banks' elevation to the barontetage; it seems a slight enough commemoration, but it does remind us that Banks, then under 40 years old, was a very public man, and was publically acknowledged by that appointment. Two of the sciences that he espoused, horticulture and botany, were similarly acknowledged.

POISONOUS PLANTS AND HORTICULTURE

Horticulture as a science is bounded only by the impossible; it may be that it is just impossible to grow a particular species in cultivation. For New Zealand, the impossible is already recognised for many taxa, but the research is continuous.

Before one can proceed very far, some perspectives are needed on the number of plant species in New Zealand: native species of ferns and their allies, conifers, and higher plants total about 2,000; about 1,800 species of the same plant groups are naturalised here; in horticulture in New Zealand there are already at least 12,000 species representing these same groups.

The component of the native flora that is toxic to man and his animals is, I believe, widely and accurately known[2]. Barring a major discovery, it seems unlikely that another native species will be added to the list of poisonous plants found in New Zealand. The realm of horticulture is likely to contribute new poisonous plants to the greater realm of agriculture, but horticulture alone will not be the sole source of such plants; the camp-followers of agriculture are like camp-followers everywhere, not always free of unwelcome qualities[3].

One would expect a toxic plant, ragwort for example, to be eradicated, but no one expects the toxic plant ngaio to be destroyed; the former is naturalised species, the latter indigenous. No one expects the yew trees cultivated in cemetries and parks to be destroyed because they are toxic. Are there ambivalences in these attitudes? Is the indigenous and toxic tutu (*Coriaria* spp.) favoured because it is not an alien weed? This topic is barely worth extended examination, but how often could one support demands for the destruction of toxic plants growing in gardens? It is different, however, to advise against planting in places of public recreation plants that are known to be toxic and also to be attractive to children. This must be one role of the Royal New Zealand Institute of Horticulture - the protection of public places. Another role is the educative one, a concern that buyers understand the risks in the plants that they are purchasing. To my eternal astonishment poison ivy, *Rhus radicans*, was grown in a Christchurch garden for some years; it caused typical poison ivy rashes annually. There was uncertainty over the cause of the dermatitis, for most medical practitioners have no experience of this plant. One of my colleagues identified the plant and disclosed the solution to the dermatitis problem simultaneously.

With the reasonable prediction that the number of species in cultivation in New Zealand will increase because of the national interest in horticulture, the risk of new toxic plants entering the country will increase. The characteristics of plants wanted in horticulture are determined by those in the industry. Information on the toxic potentialities of the plants being introduced is not always sought out, but it can be safely assumed that every member of the genus *Rhododendron* will produce the toxic diterpene andromedotoxin[2]. It can be safely assumed that every member of the genus *Myoporum*, or its relative *Eremophila*, will synthesis the toxic furanoid sesquiterpene ketone (-)ngaione[4].

THAT PLANTS SHOULD BE TOXIC

The green plant, capable of the most significant biochemical reaction in the world, photosynthesis, dominates the landscape: in trees and forests at low levels, in shrubs and scrublands higher upslope, in grasses and grasslands at very high altitudes; and at the apparent limits of life lichens may still be found. That plants, and the communities they form, have not just been totally consumed by herbivorous insects, birds, and animals is interpreted as indicating the significant presence in plants of compounds that protect them against these depredations[5].

The facts now being assembled show that plants have been under attack by herbivores during the whole of the co-evolution of plants and animals[6].

Plants and animals having evolved together had little option but to respond to each other. And one major response on the part of the plant has been the production of compounds that protect them from grazers, browsers, and thieves. Evidence that plants have evolved internal mechanisms to protect themselves from grazing, or to protect their seeds from being consumed comes largely from insect-plant studies[7]. The evidence for some responses to mammals is slighter, and in some cases toxicity to mammals, including man, is quite co-incidental[7].

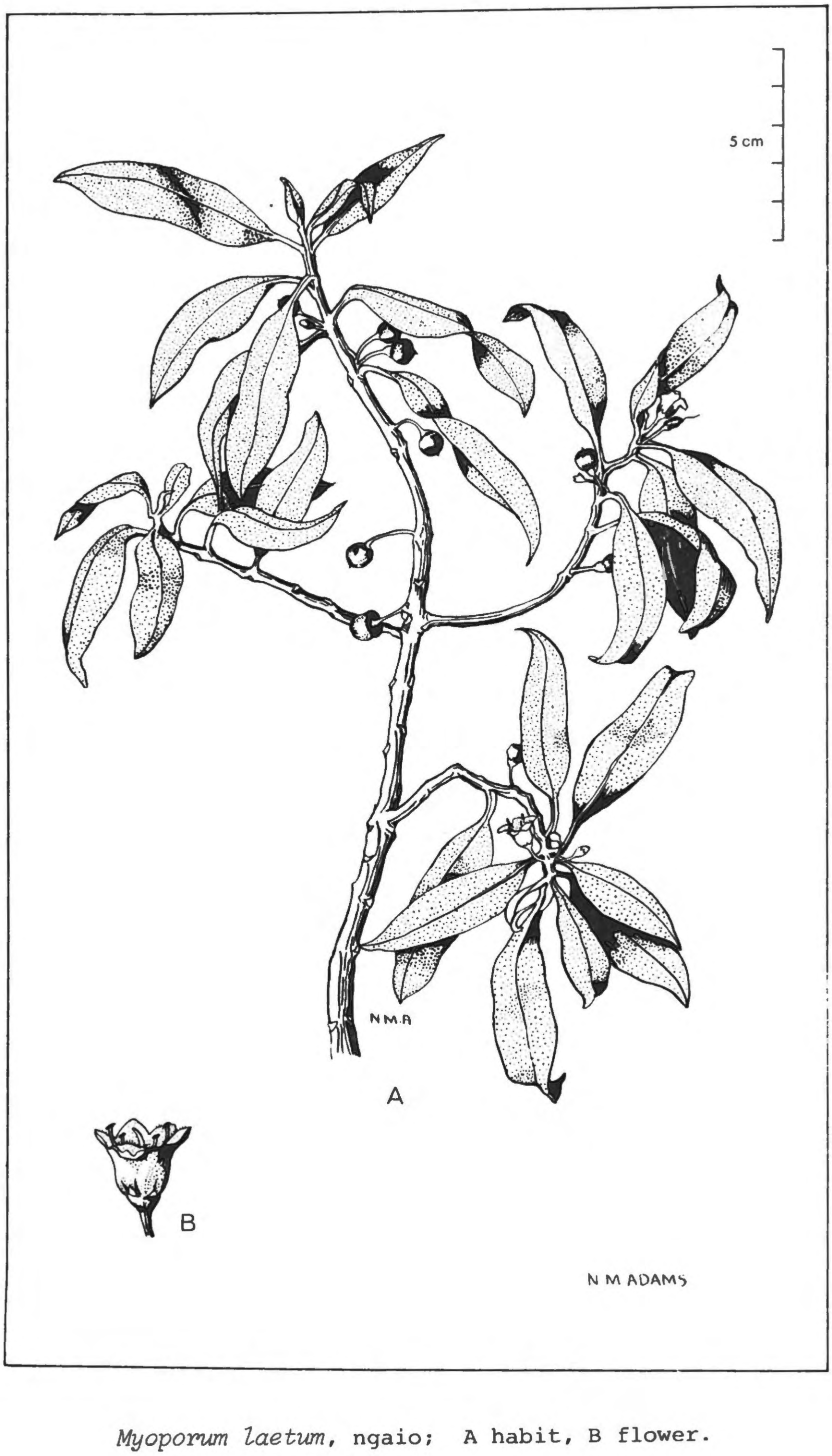
If we use New Zealand as an example, and we do know it best, we find that endemic plants like ngaio, *Myoporum laetum*, tutu, *Coriaria* spp., Strathmore weed, *Pimelea prostrata*, buttercups, *Ranunculus* spp. contain compounds toxic to mammals; Australian species of *Myoporum* and *Pimelea* produce either the identical toxin, or compounds of very similar structure[2]. Across the whole world *Coriaria* produces very similar toxic compounds, and *Ranunculus* produces the identical -lactone. Two points arise: (i) The domestic animal - plant interaction in 20th century New Zealand will reveal nothing of the selection pressures that induced buttercups, or ngaios, or pimeleas to produce their toxins; and (ii) there are no toxic compounds found in native New Zealand plants that are not known from elsewhere in the world[2]. The New Zealand flora may have an impressive level of endemism; the toxins in our plants are completely undistinguished.

Defence Mechanisms in Plants

Plants have responded to insects in several ways, for example, the seeds, leaves, buds, and even nectar may possess repellent odours, or produce antagonistic compounds. Other mechanisms are more obvious - spines, prickles, stinging hairs, matted hairs - and these may deter some insects, but more often they deter larger grazing animals. To the ravages of herbivores, plants must respond or not survive. For crops, plant survival may lie in external chemical control; for wild plants, internal chemical control is one option.

Secondary Metabolites

Some plants have responded to insect predators by producing the so-called secondary metabolites. These may be alkaloids which are characterised by bitter taste; or cyanogens that yield the bitter-almonds smell of the crime writer, and of fact; or glucosynolates that give the biting, brassica, isothiocyanate mustard-oil taste and odour. There are also volatile compounds, the oils found in the



Myoporum laetum, ngaio; A habit, B flower.

Labiatae, Compositae, and Umbelliferae; some of these certainly act as deterrents to larger animals, but must also to lower animals. In parts of the world with a longer history than ours it often seems that all that is left of a flora and vegetation is that which is spinescent, lanate, urticate, malodorous, bitter, or possesses digestibility-reducing compounds, or yet some other unattractive quality.

Until recently the secondary metabolites were considered to be end products of plant metabolic pathways - the remnants of biochemical reaction, excreta from the production of the essentials for the life of living plant[8,9]. That some of them were characteristic of plant groups was a proof of the naturalness of those plant groups. As they were considered to be secondary metabolites, any toxicity to insects or larger animals was also secondary.

Secondary metabolites are now being shown not just to be end points, and not left inertly in cells and of no further use to the plants; they are being shown to be active in metabolism[9]. The turnover of some of these compounds is now accurately measured. In horehound, *Marrubium vulgare*, so common on sheepcamps, the sesquiterpene marrubiin has a half-life of about a day[9]. The alkaloid tomatine in tomato fruits has a half-life of about 6 days, and disappears as the fruits ripen - a characteristic of many Solanaceous fruits[9]. Nicotine in tobacco has a half-life of about a day; and when nitrogen-labelled nicotines were fed to tobacco plants there was clear evidence that these alkaloids had been involved in other metabolic processes because amino acids, sugars, and organic acids were labelled[9]. In hemlock, alkaloid concentration rises and falls during the day and the alkaloids may be metabolised into non-alkaloidal compounds. Alkaloids there are translocated from the leaves to the fruits where the energy-rich alkaloid coniine is also recycled[10]. It is possible, too, that cellular cyanide metabolism and the formation of amino acids may be interpreted as either a detoxification mechanism, or as a pathway to the formation of toxic amino acids[2].

In *Ungnadia speciosa*, Mexican buckeye, for example, up to 15% of cyanolipids may be present in the seeds; but within three days of germination all will have disappeared. The suggestion is that the compounds with the cyano moiety were essential storage compounds. And as grasses like *Sorghum* and *Cortaderia* pass from seedlings towards maturity so too the cyanogenetic glycoside concentration decreases[9].

Secondary metabolite biosynthesis possesses all the pathways, spatial controls, and channelling of any metabolic pathway. No novel cellular compartments occur that affect the synthesis of secondary compounds, nor of the concentration of toxic products, nor their release from storage if they are needed[11].

The solutions to predation as seen in plants suggest that particular types of metabolite are favoured, or are more readily synthesized, or are the more readily efficient response to predators. For example: cyanogenic glycosides are known in at least 800 species of plants from 70-80 families; these occur among fungi, ferns, gynmosperms, and angiosperms[12]. On a much narrower front, fluoracetate is synthesized by *Dichapetalum*, a genus in a family of its own, the Dichapetalaceae, and by *Acacia*, Leguminoseae[2], a somewhat distant pair of families. Desoxyphorbol esters that are co-carcinogens, or irritants, are synthesized by *Euphorbia*, Euphorbiaceae, and *Pimelea*, Thymelaeaceae, equally distant families[2].

Secondary metabolites do have other roles - one should perhaps adopt the more recent convention and call them secondary plant compounds. Flavonoids for example are associated with pollination in that they determine flower colour. Honey guides on petals are characterised by secondary plant compounds-carotenoids or flavonoids. Plant scents where they are attractive or pleasant to man are mostly terpenoids; the unattractive scents - really odours or smells as in *Arum* - are mostly monoamines[8].

Secondary Plant Compounds and Toxicity

White clover, *Trifolium repens*, for example, consists of populations where some plants synthesize the cyanogenetic glycoside linamarin, and others do not. When enzymically hydrolysed the glycoside yields hydrocyanic acid (mostly known as prussic acid). Observations and experiments showed that slugs and snails preferentially ate the acyanogenic forms, leaving those that did produce the cyanogen to grow and flourish.

Coriaria arborea, tutu; A habit, B flower.

A-B: *Senecio jacobaea*, ragwort; A rosette, B flowering stem.
C: *Senecio mikanoides*, German ivy.

Sheep in New Zealand are known not to discriminate among clovers, but in the United Kingdom sheep do distinguish cyanogenic bracken from the non-cyanogenic form in Richmond Park[14].

Among central South American woody perennial legumes, Janzen[7] found that the seeds of *Mucuna* were protected from the attacks of seed-eating weevils by the non-protein amino acid *l*-dopa; in other leguminous trees which had no protecting compound, the seeds were heavily infested with weevils.

Secondary Plant Compounds Useful to Insects

The monarch butterfly is well known; its food plant *Asclepias curassavica*, the milkweed is as well known. The monarch lives happily on milkweed despite the several bitter tasting cardiac glycosides found there. These glycosides, though toxic to higher animals, are selectively gathered by the monarchs, and stored in their bodies. Birds - the blud-jay is the one in the published accounts - searching out the monarch butterfly as food, find themselves eating a butterfly full of bitter cardiac glycosides that causes them to vomit. No second attempts are made by the birds. And a second order effect is one of colour warning to the blue-jays; they avoid the monarch coloration and anything that mimics it even if it does not have a bitter taste. Other butterflies live on *Asclepias gurassavica* and benefit from the glycosides[8].

Aposematic, warningly coloured, butterflies also search and store the ragwort alkaloids found in species of *Senecio*. The monarch butterfly, too, sequesters and stores pyrrolizidine alkaloids from *Senecio*, and may even go to the extent of searching out members of the Boraginaceae which are alternative pyrrolizidine alkaloid sources. These searches are important because male monarch butterflies need pyrroles, the hydrolysis product of the pyrrolizidine alkaloids, for aphrodisiac substances in courtship displays towards females[8]. These pyrroles are liver toxins in mammals, and are usually produced from the alkaloids by microsomal enzymic dehydrogenation in the liver[15]. Moths, it could be noted, store the ragwort alkaloids unchanged.

Is this provision of protection for the butterflies by toxins produced seemingly against some other feeding agent, a loss of plant protection?

But specifically against whom or what are the numerous secondary plant compounds directed? At present there are many more compounds than there are answers: many are toxic to higher animals; many will be shown to have a clearly defined ecological role; and it will be inevitable that some explanations will be in keeping with the proposition that plants with heart-shaped leaves will be beneficial to suffers from heart-disease. The doctrine of signatures will never disappear.

A challenge to understand New Zealand's plants lies here. It is significant to know that New Zealand conifers and ferns produce ecdysones, insect moulting hormones - conifers and ferns actually do just that[8]. But there is an opportunity here to seek evolutionary and ecological interrelationship between plants and secondary compounds. And as Miriam Rothschild points out, the bird predator has been, until recently, neglected in plant-insect coevolution[16].

Secondary Plant Compounds and Their Detoxification

In the Bay of Plenty and the Coromandel Peninsula the Australian passion vine hopper, *Scolypopa australis*, sucks the juice of tutu plants, *Coriaria arborea*, and excretes a honey dew onto the leaves. This honey dew if collected by bees and incorporated into honey renders that honey poisonous to man[2]. This three step pathway towards poisonous honey does not reveal all the intricacies that actually occur there. In the body of the passion vine hopper the toxin tutin, a member of the picrotoxinin class, is oxidized to hydroxytutin[17]. Insects may detoxify some plant compounds in this way. Hydroxytutin is also known as hyenanchin, a name derived from the South African suphorbiaceous poisonous plant *Hyenanche globosa* whence it was isolated. For hyenanchin LD_{50} is about 0.1 mg/kg, and for tutin 0.01 mg/kg, when both are tested against mice[18]. In man the effects of the honey toxins are apparently more severe than in test animals. For the passion vine hopper, its action is a straight forward response: confronted with a mammalian toxin against which it had no known pre-experience, there being no *Coriaria* spp. in Australia, it metabolises the tutin in such a way that its toxicity, even to man, is diminished.

An old fashioned, but favourite way to prepare insect specimens for a collection, was to place them in a small jar with some leaves of cherry laurel, crush the leaves, cover the jar, and wait for the released hydrocyanic acid to kill the specimen. But detoxification of HCN by insects does occur through a metabolism that uses the enzyme rhodanese to convert the cyanide to thiocyanate; examples are found in the weevil *Hypera plantaginis*, and the butterfly *Polyommatus icarus*[13]. And some of the slugs and snails, referred to earlier, are able to detoxify HCN, too.

Rhodanese mediated liver-centred detoxification of the cyanide ion to thiocyanate also occurs in mammals[19]. In sheep it seems that hydrolysis of the cyanogenic glycoside is fairly rapid, and HCN is liberated quickly, and is equally rapidly absorbed from the rumen. Sheep can tolerate almost twice the minimum lethal dose of HCN for several hours on end. Yet sheep or cattle may very quickly consume sufficient cyanogenic forage, such as sudan grass or glyceria maxima, and die suddenly - sudden death is a typical clinical sign of HCN poisoning[2].

The ragwort alkaloids which are stored harmlessly and almost essentially in moths, that are utilised by some male butterflies in sex attraction, may be detoxified by sheep, but scarcely so by cattle. In the rumen of sheep a pyrrolizidine alkaloid may be hydrolysed into its acidic and basic moieties, both of which are non-toxic. An alkaloid may be oxidized into its N-oxide which is highly water-soluble and rapidly excreted. In sheep too, an enzymic demethylation of alkaloids may take place, rendering them rather less toxic[15,20].

Glycoalkaloids become concentrated in greened potatoes, especially around the "eyes"; death has resulted among people who have eaten greened potatoes, and the cause is identified as the glycoalkaloid solanine[2]. Although I shall return to solanum alkaloids later, the important point is that they, too, may be detoxified in the body [21]. Solanine is hydrolysed to solanidine; on the other hand the glycoalkaloids solasonine and solamargine, the most common alkaloids in solanums in New Zealand, are hydrolysed under acid conditions to the aglycone solasodine losing at the same time the sugar part of the compound. The sugar parts of these compounds are safety devices used within the plants to render them interceullarly safe. That apart, the aglycones are the pharamacologically active part of the compound. Solanine, has a low oral toxicity because it is poorly absorbed in the gastro-intestinal tract, where it is hydrolysed to the less toxic solanidine; solanidine is rapidly excreted in urine and the faeces[21]. The information available for the commonly found aglycone, solasodine, is very slight, but its fate is probably parallel to that of solanidine.

Differential Responses to One Kind of Secondary Plant Compound

It is unwise to associate safety for man of plants, fruits, or seeds that are consumed with safety by birds. The worst example, or the best depending on one's outlook, of the falsity of the correlation can be found in deadly nightshade berries. The large purplish-black berries of *Atropa bella-donna*, borne in leaf axils, or forks of the stem, are not toxic to birds but are toxic to man and mammals through the action of the alkaloid *l*-hyoscamine.

Some plants contain monofluoracetic acid, a compound which, on being converted to fluorotricarboxylic acid, inhibits the Krebs cycle, and ultimately leads to the eventual cessation of respiration. Fatal doses of fluroacetate in man is 2-5 mg/kg[8]. But some Australian marsupials can eat with immunity, plants that contain fluoracetate, and so can many birds[22].

Karakin, the toxin isolated from karaka fruits by Easterfield and Aston[23], is hydrolysed in *B*-nitropropanoic acid[24], but may be detoxified by rumen micro-organisms. In non-ruminants, like birds, karakin is more likely to be toxic[25]; in man it is toxic[2].

The ragwort alkaloids have been included several times in this discussion; in mammals they affect the liver in horses and cattle, but the lungs in pigs[2]. Another marked difference may be seen where pregnant ewes grazing goitrogenic brassicas do not show clinical goitre themselves, but their lambs do[26].

Corynocarpus laevigatus, karaka.

Multiple Responses By Plants

Acacia, albeit a large genus, produces toxins as varied as: digestibility-reducing tannins which fundamentally precipitate proteins and cause starvation[27]; cyanoglycosides that yield HCN[28]; alkaloids[29]; the earlier mentioned fluoracetic acid[22], and non-protein amino acids[30]. An extensive range for a genus, but all compounds do not occur in any one species.

Bracken, *Pteridium esculentum*, causes stomach cancer in man, two major syndromes in cattle - a chronic neoplastic urinary bladder condition, and an acute haemorrhagic disease. It also causes a nervous disease in horses, and bright blindness in sheep[2]. The nervous disease of horses results from the action of the enzyme thiaminase 1 which inactivates vitamin B1. What exactly causes cancer of the bladder in cattle is vigorously debated, but not resolved; it certainly is not thiaminase. The cause of the acute haemorrhagic diseases, too, is unknown. The cyanogenetic glycoside prunasin is present in a polymorphic state, but is so far not known to be associated with any of the syndromes that I have described[2]. Ferns are rarely the food of insects[6]; are these reactions in mammals responses to defence systems that are of old?

The yew tree contains a mixture of alkaloids, a cyanogenic glycoside, oil of yew, and perhaps some other compounds. After eating yew leaves, cattle often suddenly drop dead, a normal clinical sign of HCN poisoning, but the main effects are attributed to the non-irritant alkaloids[2]. Gymnosperms are not favoured food of insects either.

Amino Acids, Proteins, and Peptides

I have so far avoided discussing the toxins in poisonous fungi - even mentioning fungi and mycotoxins at all. Toxins in fungi are often peptides as in the yellowish-olive death cap fungus *Amanita phalloides*[31]. It is rare for a patient to recover from the hepatic coma that is preceded by loss of strength, marked thirst, violent seizures of abdominal pain, bloody vomit and diarrhoea, that result from eating *Amanita phalloides*. Two separate set of peptide toxins, the phallotoxins which act specifically on the liver, and the amatoxins which act on the liver and kidneys, are present. The amatoxins are 20 times as active as the phallotoxins and are the more important in death cap. Peptides may also occur in toxic algal blooms[2].

Proteins are the staff of life, but the castor oil plant produces in its seeds the very toxic protein, ricin; ricin, itself, inhibits protein synthesis[2]. The toxic dose is 0.01 ug/kg. Abrin, found in *Abrus precatorius*, the precatory bean, Leguminosae, is another toxic protein; one seed well chewed, is one seed too many well chewed[2]. And to finish this list of lesser known toxins there are some toxic non-protein amino acids found especially, but not exclusively in the Leguminosae[30].

Janzen, Juster & Bell[32] determined the toxicity for the brucid beetle *Callosobrachus maculatus*, southern cowpea weevil, against alkaloids, e.g. gramine, strychnine, atropine; against protein amino acids, e.g. alanine, cysteine, methionine; and against non-protein amino acids, e.g. canavinine, *l*-dopa, 5-methoxy-N, N-dimethyltryptamine; and finally against itmes such as ginger, paprika, and nutmeg. Their test was a diet-added test; in essence it showed that alkaloids are always likely to be more toxic than non-protein amino acids, and these latter more toxic than protein, amino acids. All of which is substantially reassuring to those of us who eat food!

A Modern Interpretation

Many secondary plant compounds are toxic to insects, and to this is attributed one of the world's "most conspicuous non-events" - the desctructive potentialities of herbivorous insects have not prevented higher plants from dominating the earth[5]. Many insects have become highly specialised in feeding habit, and many have adjusted to toxic secondary compounds and evolved to use them beneficially. Plants of very different families have evolved identical or similar secondary compounds as defence mechanisms. Ferns and gymnosperms are rarely fed upon by insects, but produce some toxins; ecdysone production is common to both[8].

That many secondary compounds are also toxic to higher animals which are never as selective as insects in their feeding patterns, may lie in a continuation of the evolutionary trend for self-defence, or these compounds are accidentally toxic to higher animals, or because invertebrates and vertebrates behave similarly.

Plants in horticulture here are, for the greatest part, plants that have evolved outside New Zealand and have responded to insect selection pressures from elsewhere. These insect predators did not, in many cases, accompany the host plants here; such plants, with particular defence systems, have arrived in New Zealand where these systems may never be called upon against their primary predators. Are there examples in New Zealand horticulture and agriculture of new insect responses to old insect repelling metabolites?

One may wonder, too, if there have been any changes in insect pollinators for those plants that possessed attractants for specific insect pollinators? Because of their secondary compounds do a significant number of plants in horticulture do better in New Zealand than they do in their homelands.

HORTICULTURE AND POISONOUS PLANTS

Among the plants in horticulture in New Zealand, poisonous properties may be found in nectar, the fruits, the leaves and stems, and the wood.

Earlier, I referred to poisonous honey from native species of tutu; but the most famous case of honey poisoning ever reported was that where in Asia Minor, Xenophon's soldiers died from, or were intoxicated by, honey incorporating nectar from *Rhododendron ponticum*. The account is in the "Anabasis" published in 400 B.C. Toxic nectar in New Zealand is known in karaka[33] and kowhai[34], and bees are primarily affected; there is no suggestion so far of karaka toxins in honey. Nectar from the strawberry tree *Arbutus unedo* is also apparently toxic to bees[8]; the fruit is harmless but not very palatable[35].

In the nectars of rhododendron, karaka, and kowhai, the same toxins that affect man and his animals poison the honey bees. There are no special nectar toxins as far as one can judge.

It might be simpler for my purposes to divide horticulture in two, the comestible and the admirable, and deal firstly with the things we eat.

Fruit and Vegetables

Cabbage and other brassicas are no longer the root cause of goitre in man in New Zealand that they once were. The solution lay in iodine and education, and not in breeding plants free from goitrins.

It seems of interest nowadays to know the extent of nitrate in such foods as silver beet, spinach, and in their health - addict substitutes. Nitrate in plants may be reduced to toxic nitrites, but this reduction does not occur in the stomach of man. The condition of nitrite poisoning is recognised by methaemoglobinaemia, the presence of brownish discoloration of the blood, and by bluish-purple discoloration of the lips and skin[2]. Children under 3 months are liable to methaemoglobinaemia especially from drinking waters where nitrate levels are high. Vegetables confer no risk of nitrate-nitrite poisoning in man even though spinach petioles in particular have higher levels of nitrate than in many other plants[36].

More serious problems arise from errors such as: the confusion of foxglove for comfrey; the inclusion of the leaves of rhubarb with the leaf-stalk; the use of very greened potatoes; the confusion of two kinds of chestnuts.

In 1968, 120 hospital inmates suffered nausea, violent vomitting, diarrhoea, and bleeding from the nose. All had eaten new seasons rhubarb, and it can be assumed all ate a share of leaves. All the symptoms were typical of rhubarb intoxication; none of them is typical of oxalate poisoning not even of acute oxalate poisoning[2]. The toxin in rhubarb is not known for certain; it is very, very unlikely to be oxalic acid or free oxalates[37].

Comfrey, a popular culinary plant but one now known to synthesise the pyrrolozidine alkaloids very familiar in the ragworts[38], was to be gathered by a Christchurch man for inclusion in a salad. He and his two companions ate in fact a salad that included foxglove, *Digitalis purpurea*, harvested by mistake. All three were digitalised, hospitalised, and very ill; all survived[2].

It is quite a long time since we have heard of solanine poisoning from greened potatoes because I think everyone knows about

Digitalis purpurea, foxglove.

it, and because the bitter taste acts as a warning. Solanine and its behaviour in the gut is discussed above.

Quite frequently, huckleberries are promoted on the New Zealand market[2]. These are for use in confitures and by crustularians. The huckleberry plant is *Solanum nigrum* var. *guineense*, one of the many varieties of black nightshade, that very common weed of gardens. The ripe fruits of black nightshade are not poisonous; the green berries contain solamargine and solasonine, both of which decrease in concentration as the fruits ripen.

From time to time a packet of frozen peas may contain some green fruits of one of the black nightshades. What should one do? If there are only a few, one should not worry even if they are eaten; if the proportion is high and this is unlikely, return the packet to your retailer. He will take the next steps.

Caper spurge, the biennial *Euphorbia lathyris*, bears fruits about 10 mm long. A Christchurch man mistook them for the true capers of *Capparis spinosa*, and was made severely ill[2]; a very distressing error on his part.

Horse chestnuts and sweet chestnuts are sometimes confused; the irresistible conkers of the horse chestnut usually contain one large, flat nut, in contrast the three small conical nuts from the sweet chestnut. Horse chestnuts get into commerce from time to time but should not be eaten; they are toxic, but the toxin has not with certainty, been determined. It could be a non-protein amino acid[2].

Laetrile, extract of apricot kernels, is newsworthy at present. Apricot kernels, peach kernels, plum kernels, apple pips are all cyanogenic - on hydrolysis they yield hydrocyanic acid[2]. Not that the yield per kernel is high, and not that many people eat a lot of them; but there is a risk, and risks should just not be taken. The flesh of apricots, peaches and plums is never dangerous.

Although I have never experienced the most extreme bitterness that occurs from time to time in cucumbers, it is asserted that "the most bitter and more distasteful triterpenoids are the cucurbitacins"[8]; these are tetracyclic triterpenes found in cucumber and other members of the cucurbitaceae. They are unpleasant rather than toxic.

From the comestible let us turn to the admirable.

Herbs, Shrubs and Trees

The plant family that includes buttercup, hellebore, and clematis is not considered by many taxonomists to be a very advanced family. It may then be easy to start there. Aconite, *Aconitum napellus*, also known as wolfsbane, or monkshood, was considered by the Greeks "to have arisen from the foam of the mouths of Cerberus while he was under the influence of Hecate, goddess of the underworld and magic"[1]. Aconite, chiefly through the action of the alkaloid aconitine causes respiratory paralysis and a disaffection of the heart[2]. It, and deadly nightshade, were, and perhaps still are, the essential ingredients of witches flying ointments[1].

The black hellebore, *Helleborus niger*, among several cultivated in New Zealand as winter roses, has a reputation and a use seemingly little practised now. Rooted up, dried, and powdered, and thrown in the air it renders men and witches invisible; it is of special merit for witches as they then cannot be seen flying in the air[1]. John Gerard in his Herbal of 1636[39] found another use: "A purgation of hellebore is good for mad and furious men, for melancholy, dull and heavie persons, and briefly for all those that are troubled with blacke choler, and molested with melancholy".

This plant is seemingly underutilised in New Zealand, and has potentialities for export to countries where there are large numbers of mad and furious men, or many people troubled with "blacke choler". Hellebores contain the buttercup irritant, ranunculin, and a toxic bufadienolide, hellibrigenin[2].

Delphinium poisoning of livestock has occurred in New Zealand, but it is much more common in U.S.A. The seeds when drunk are "...good against the stingings of scorpions"[39].

Long, white, trumpet flowers, and a heavy scent during twilight, are simple associates of *Datura candida* (*Brugmansia* if you prefer that generic name). *Datura candida* is but one species among perhaps a dozen in the genus; one species was used in commercial robbery; others have been used in materia medica; and some species have

A: *Solanum dulcamara*, bittersweet. B: *Solanum pseudocapsicum*, Jerusalem cherry. C: *Lycium ferocissimum*, boxthorn.

been smoked, or infused, often in experiments by the young in the hope of a lift from the "black choler". *Datura* is a genus in the family Solanaceae, a family that contains many poisonous, and many useful plants. The daturas include the weedy species *D. stramonium*, thorn apple; *D. meteloides*, *D. rosei*, and *D. tatula* are in cultivation. All are potentially dangerous in the wrong hands, i.e. children, and the young looking for kicks. Scopolamine and hyoscyamine are the main alkaloids; and the seeds are no less dangerous than the leaves[2].

Other members of the Solanaceae attract attention because of their fruits.

The fruits of *Solanum dulcamara*, bittersweet, are red ovoid berries and these berries, if hung around the neck, ward off the evil eye[1]. But these berries can cause headache and nausea, and if eaten in large numbers, paralysis of the central nervous system[2]. Glycoalkaloids are found throughout the plant. But the climber, bittersweet, causes less trouble in New Zealand than the two small indoor and garden shrubs, *S. pseudocopsicum*, Jerusalem cherry, and *S. diflorum*, false Jerusalem cherry. The orange-coloured fruits are attractive, and in New Zealand have fatally poisoned one child, and been responsible for sickness in many others. Solanum fruits usually decline in glycoalkaloid concentration as they ripen; the fruits of native poroporos, *S. aviculare* and *S. laciniatum*, clearly follow this pattern, because the green fruits are toxic but the ripe fruits are suitable for jam making[2]. In *S. pseudocapsicum* and *S. diflorum*, however, the alkaloids are not bonded to sugars as in glycoalkaloids[40], and may not follow the generalisation of a reduction in alkaloid concentration during ripening.

No one would grow henbane for pleasure; it is smelly and toxic. *Cestrum* is different, and the berries are just attractive enough to cause concern[2]. Species of *Cestrum* are among the few plants where saponins are clearly identified as the toxin; usually saponins are toxic to cold blooded animals but in *Cestrum* they are toxic to mammals[41].

The Solanaceae is a family, all the members of which should be treated circumspectly, the fruits in particular and especially when green.

Hard seeds seem, at first glance, to be unlikely causes of poisoning, yet laburnum seeds and castor beens have both caused sickness in New Zealand, once again more commonly in children[2]. *Laburnum anagyroides*, Leguminosae, contains typical leguminous alkaloids especially in the seeds[29]. Castor beans, are found in the soft spiney capsules of *Ricinus communis*, Euphorbiaceae. Castor beans contain one of the most poisonous compounds produced by plants - the glycoprotein ricin[2]. Castor beans must never ever be used as a substitute for castor oil. Laburnum is considered the cause of most plant poisoning in man in Great Britain[42].

Other members of the Leguminosae in cultivation seem to be a potential source of danger because of the level of dangerous alkaloids they produce[2]. The feeding pattern of the broom aphid, *Acyrthrosiphon spartii*, is stimulated by the alkaloid spartiene in broom plants, *Cytisus scoparius*; the aphid starts feeding on young shoots, moves on until it is feeding on peduncles, flowers, and then pods; it follows the varying site of greatest alkaloid concentration[8]. This example serves to let me make two points: (i) concentrations of alkaloids may change with stage of development; (ii) seeds and pods in the Leguminosae can harbour quantities of dangerous alkaloids such as cytisine, sparteine, and lupanine. As a result of the work of Dr E.P. White, formerly of the Ministry of Agriculture & Fisheries at Ruakura, The kinds of alkaloids and their concentrations are known for all leguminous plants in cultivation here[2].

I have no ambition to list all the poisonous plants found in New Zealand. I want to mention the exotic because everything else I have discussed so far has been fairly orthodox.

In the plant family Apocynaceae there are several, even many, toxic plants. The most interesting is the arrow poison *Acokanthera*; the most abaundant in New Zealand oleander, *Nerium oleander*; the most important *Rauvolfia* for the relaxant reserpine; and *Vinca rosea*, usually known now as *Catharanthus roseus*, as a source of new medicinal compounds.

Oleander is very poisonous but no poisoning is reported in man here although there have been livestock losses[2]. Cardiac glycosides in the plant cause a digitalis-like action on the heart. I have a fear that children will be poisoned at the Auckland beaches where oleander is frequently planted.

The yellow oleander, *Thevetia peruviana*, also contains cardiac glycosides, and is poisonous to man and to animals[40].

Acokanthera spectabilis is a shrub up to 1 m tall; the sweet-scented pale-pink flowers are succeeded by rounded blue-black berries; it is frequent in North Island. It, and other species, are the source of the African arrow poisons, based on cardiac glycosides, the chief among which is oubain[40]. These plants are poisonous, but I have never heard anything against *A. spectabilis* in New Zealand.

There is yet a much wider range of poisonous plants, including *Kalmia* and *Pieris*, Ericaceae; *Daphne* spp. Thymelaeaceae, where the red or black drupes are very dangerous for children; and *Melia azedrach*, Meliaceae, where the toxin is not known with certainty. Among herbaceous plants: lily of the valley, *Convallaria majalis*, is a very toxic plant but no-one has been poisoned by it as far as I know, even though it is common, and the berries are colourful; *Colchicum autumnale* and *Gloriosa superba* are both dangerous members of the Liliaceae. *Homeria collina*, Cape tulip, where heart damaging cardiac glycosides are present has caused death in man and animals in New Zealand[2]. I think that the very dangerous plant, Cape tulip, must be almost eradicated from gardens, though it still occurs as a naturalised plant in Marlborough[3].

Irritants

Everyone in horticulture worries about the rashes and irritations they may get from the plants they handle. Mitchell and Rook[43] wrote a book of almost 800 pages on this topic.

When celery crops are infected with *Sclerotinia sclerotiorum* two furanocoumarins, xanthotoxin and 4, 5, 8-trimethoxypsoralen, are produced; these possess the characteristic of being excited by light, and under light with wavelength of 320-360 mm they induce bullous dermatitis - blistering of the skin[44]. There must be diseased celery, in contact with a moist skin exposed to sunlight. The blistering agents, furanocoumarins, are synthesized, as a response to the fungus attack. Celery dermatitis occurs in New Zealand, but was only recently reported to Botany Division in Auckland by a local medical practitioner.

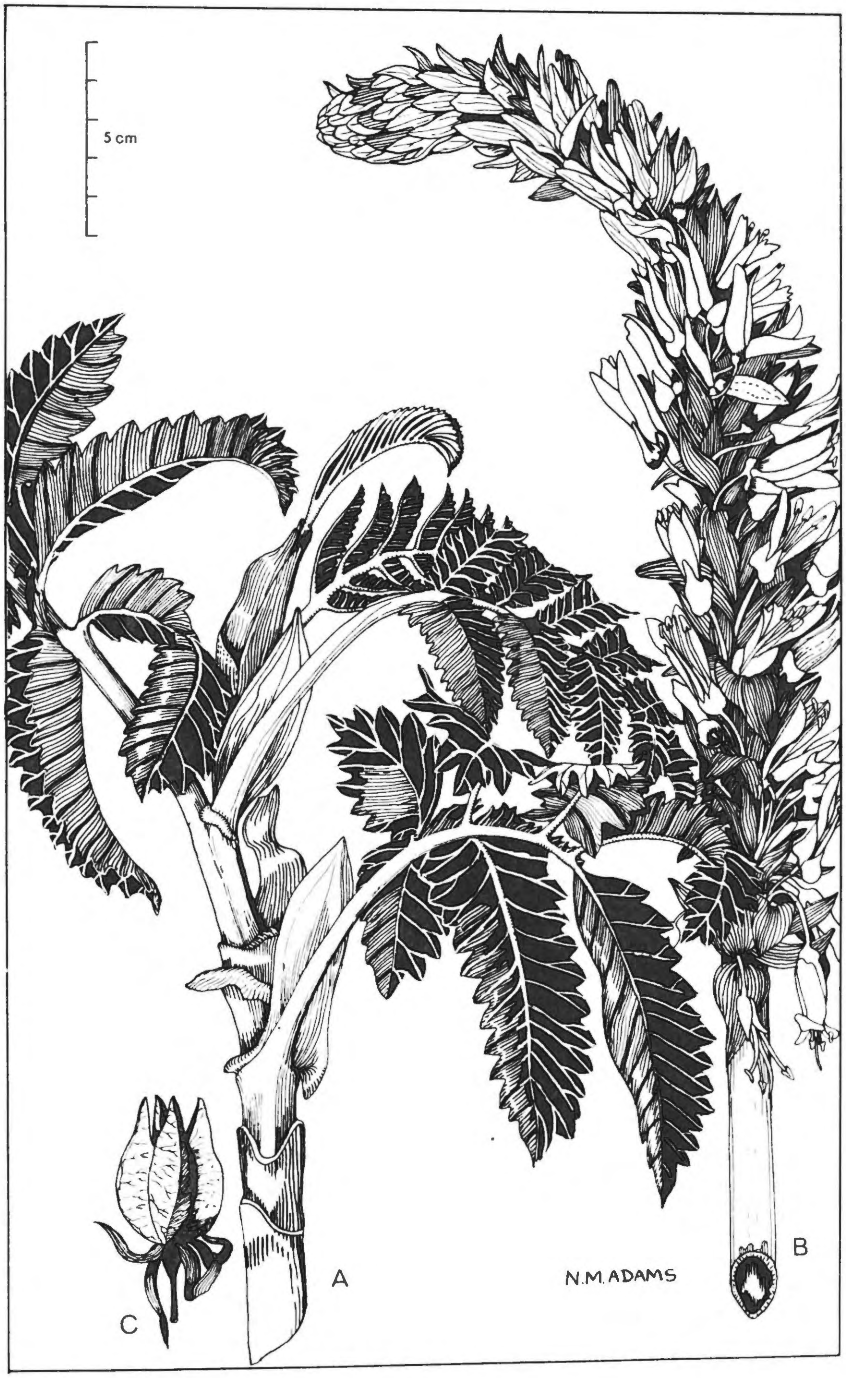
Blistering by these kinds of photosensitisers is well known in members of the family Umbelliferae[2]. Parsnip, *Pastinaca sativa*, synthesizes the furanocoumarins bergapten and 8-methoxypsoralen, and causes the same bulbous dermatitis as the diseased celery. This kind of dermatitis is frequently misdiagnosed as contact dermatitis; photodermatitis of this kind can be induced by carrots, fennel, angelica, and parsley among the Umberlliferae, and by members of the Rutaceae, e.g. citrus, or *Ruta graveolens*. The hogweed, *Heracleum*, which one can see often enough, is a serious offender; hemlock is much less so.

Primula obconica is a well-known irritant, the glandular hairs on the leaf secreting the toxic quinone, primin. Many species, including *P. malacoides*, *P. elatior*, *P. veris*, produce primin. The face, neck, eyelids, fingers and arms are most affected. *Primula* irritants cause contact dermatitis; exposure to light is not essential to the reaction[43].

Earlier, I mentioned poison ivy grown in a Christchurch garden, and the effect it had on the family. *Rhus succedana* is a common garden subject and it also causes skin irriation; *R. typhina*, the sumac, may do the same. In all these plants the irritant is "urishiol", a name accounting for several compounds[3].

Urtica, is one of three genera in the Urticaceae with stinging hairs; *Urera tenax* is described as having "ferocious stinging hairs"[40]. Two of my friends have been stung by Australian species of *Laportea* - neither wants to be stung a second time. One New Zealand native stinging nettle, the tree nettle or ongaonga, *Urtica ferox*, is a particularly dangerous plant to man and animals[2]. The toxins include the common agents acetylcholine and 5-hydroxytryptamine, and a new but unidentified compound that Fastier & Laws have called "triffidin"[45] after those plants of science fiction.

Sir Joseph Banks did not find any reason to comment on *Urtica ferox*, and it was not collected on his voyage to New Zealand, but on the second journey. Banks did



Melianthus major, Cape honey flower; A young shoot, B raceme of flowers, C capsule.

not comment, as far as I can ascertain, on any poisonous plant in New Zealand, but then the number of toxic plants known to the Maoris was few - tutu and karaka, at best. Banks would be aware of the poisonous plants of Britain, as were the learned men of his day. He also knew the physic garden. I am not well enough aware of the philosophical arguments of the times, other than that in this pre-Darwinian era the phlogiston theory still held sway in chemistry, that Isaac Newton's life and work were over, but that the French Revolution was taking place; I am not really able to do more than to hazard the quess that Banks would have thought little about poisonous plants except that they were created poisonous. Poisonous stings and venoms in animals must have been understood as devices of defence; that toxic qualities in plants could be parallel devices of defence was unlikely because plants contributed to materia medica and to health.

Banks would have enriched the current discussions with the vigor he brought to botany and to horticulture. Explanations for the roles of secondary plant compounds will continue to entertain men's minds just as the use of secondary plant compounds entertained the minds of the men in the times of Sir Joseph Banks.

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Impact of New Technology on Horticulture

by

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Over the period of my career I have been asked many times, by various people, to explain what I believe horticulture is and what makes it different from other forms of agricultural crop production. To the 'green thumb' practising horticulturist the question may seem trivial and the answer so obvious that it hardly seems worth putting into words. However, I believe that the question is a valid one. As new technologies are applied in horticulture the boundaries between what is horticultural production and what is agricultural crop production become extremely blurred. Changes which are happening now and will occur in the future, will have a major impact on how others view the horticultural industries, how the traditional horticultural industries view themselves, and how such industries organize themselves for research marketing and political purposes.

It is my belief that any segment of industry whether it be agricultural or manufacturing, organize themselves because of common interest in three areas:

1. The commodity,
2. the technologies employed to produce and distribute the commodity, and
3. the system or pathway through which the commodity passes to the market or consumer.

A major change in any one of these factors can severely strain historic alliances and organizations unless such changes are adopted and accepted universally.

To anticipate the likely impact of changes in technology on horticulture it is necessary to understand the historic circumstances and environment which lead to the present segmentation into agricultural and horticultural crop production and even into further sub-segments within horticulture.

Horticulture, unlike agriculture has two faces; one in which activities are directed towards man's leisure and aesthetic needs and commonly referred to as ornamental or amenities horticulture and the other directed to food production. It is the second face of horticulture which has much more in common with agriculture than the first. Even where horticultural products are grown for food, their place in the dietary habits of consumers are different from the mainline agricultural crop products. Horticultural commodities are consumed not only for their nutritive value but because they add variety to the diet and therefore add to the general quality of life. As an example, the quality criteria generally applied to horticultural products, particularly those consumed in the fresh state, include factors such as flavour, texture, freshness and things which affect eye appeal such as size, colour and freedom from blemish; requirements which are less stringently demanded in cereal crops.

Because of these quality requirements and the place of horticultural commodities in human diet, the crops covered by horticulture are extremely diverse, generally highly perishable and they require high levels of technological input to reach the quality demanded by the market. Many of the plant types used for fruit production are long lived perennial cane or woody plants of a shrub or tree type. The form and nature of the plant type dictates the management and technologies applied to the production of these crops.

Fortunately, the market place in general has recognized the high inputs required in horticultural production and western society in particular, has accepted that such products need to command relatively high prices if they are to continue to be produced.

Unlike the highly portable cereal crops which from ancient times have featured largely in international trade, horticultural products are relatively new comers to world-trade, particularly in the fresh form. The traditional methods of preserving horticultural products such as drying, juicing, pickling, canning and preserving in sugar are not only expensive but produce a commodity which, while it may be acceptable in the market place, is no real substitute for the fresh article. As a consequence, historically, horticultural products have tended to be grown close to the markets where they are consumed. Virtually every city of any size throughout the western world has developed its own regional horticultural industries in close association. Horticulture is one area of agriculture which has grown in close and intimate association with urbanized man. It is a form of agriculture which he not only sees around him but it is often the only form of agriculture in which many city people can and do involve themselves personally. Often this leisure activity develops into commercial interest.

The development of horticulture in close proximity to cities has another side effect. It has established an expectation that horticultural land prices will be high. It has become accepted that entry into horticulture will require relatively large capital costs per unit of land as land in close proximity to cities tends to suffer from competing land use demands. Thus the combination of commodity quality demands and high land prices has tended to enforce horticulture to develop on the basis of small land area units, intensively cultivated, with single properties often growing a range of crops. (Mixed cropping farms in New Zealand are the closest analogy with horticulture that exists in agriculture.) Marketing has tended to focus very much on the regional or local centres of population in relatively close proximity and growers are often very much personally involved with the sale of the product, if not direct to the consumers, at least to the retailer level.

However, at the turn of the century, particularly in America, this historic development of horticulture began to be challenged; influenced largely by two technological developments indirectly associated with horticulture. These were the development of faster and more reliable transport systems in the form of rail and steam driven ships, and the advent of refrigeration. The tyranny of distance from markets for horticultural products was removed and we began to see decisions about horticultural development being made more on factors such as the suitability of climate and soils for particular crops and the relative value of land.

The incredible growth of horticulture in California was made possible by these innovations and that state developed its horticulture with a strong outward looking view of itself as exporters of fruit to the centres of population on the eastern seaboard of the United States some 2-3,000 miles away. The essential nature of the horticultural development in California was that it was extensive rather than intensive and the technologies which have developed in that State reflect this emphasis. It also saw a change in the marketing system for horticultural products which was much more complex than the older systems that it replaced as it involved shippers, agents and other middle men between the grower and the consumer. Californian horticultural development in the early part of this century right up until after the second world war contrasted sharply with the older European system of horticulture which was largely regional and intensive in character.

Food production horticulture throughout the world has over the last fifty years effectively developed in two directions; one based on the American extensive horticulture model and the other on the European intensive system. The first has become more and more closely allied with other forms of agricultural crop production with its emphasis on specialization, mechanization, fast and efficient transport of commodities over long distances catering for the lower priced bulk horticultural commodity markets. The second was based on highly intensive systems of production with high labour inputs, concentrating on high quality commodities commanding high prices. The extensive systems see processing as a major and integral part of its marketing strategy catering for large populations, while the intensive system sees processing as secondary to its activities mainly to remove inferior fruit which does not meet the quality demands of the fresh market or to iron out periodic fluctuations in over supply situations.

The continued revolution in faster systems of transport, notably air and road transport, and more effective systems for cool-storing perishable commodities such as rapid temperature pull-down and controlled atmosphere storage has brought about a major change in the outlook of horticulture throughout the world. The advantages of close proximity to market that in earlier times conferred almost propriety right to a given market for some growers, is now under strong challenge. Horticultural products grown more efficiently in more distant areas, because of more favourable climates or soil conditions, lower land prices or the application of more advanced growing methods, can now compete favourably on such markets provided artificial trade barriers are not erected. The use of quarantine regulations as a non-tariff barrier has been used with great effect in preventing the free flow of horticultural crops throughout the world (a noble concept used for sinister purposes some might say).

In the western world in particular, we have seen vast changes in the retail system with the emergence of supermarket chains with their immense concentrated buying power and ability to by-pass the traditional marketing system. Such chains do not recognize the restraints of regional, state or national boundaries if they can avoid it when applying this buying power. The traditional marketing systems are still trying to come to grips with the reality of this new form of merchandizing.

In New Zealand the pattern of horticultural crop production with the conspicuous exception of apples and more recently, Kiwifruit, has been along the more traditional lines of the intensive European pattern with its view very firmly focused on the local regional markets. While such limited objectives remain there is little hope or incentive to expand as the local markets by and large are well served with horticultural products. Future expansion will only occur if this view is changed in the direction of export. Import substitution in horticulture is a very slender argument for the expansion of any horticultural industry.

The question which needs to be asked however, is what pattern of development and technology will be appropriate for an export oriented industry. Should it be based on the Californian extensive model or along the more traditional intensive European lines or is there some other alternative. New Zealand is in some ways fortunate because of its relatively late entry into the horticultural export field. We have the opportunity to learn from the mistakes of others and the chance to select the best features of both systems.

The first opportunities I believe New Zealand should consider seriously are systems, particularly with tree fruits, which recognize that markets and commodity fashions are ephemeral. What we need to develop are technologies which allow maximum flexibility to allow rapid change in direction as market opportunities change. Short term rotations are now possible with a number of tree crops which have in the past been considered to be long term crops with long establishment periods. This is particularly so with stone fruit. This can be achieved by using high plant populations and minimum pruning during the early phases of plant growth. New techniques involving root growth control also hold promise as a tool for increasing the fruitfulness of tree crops early in their life. New rooted cutting techniques for peaches and possibly tissue culture have recently been developed which should considerably reduce the time required to produce large plant numbers at a reasonable cost required by these high density planting systems. The other advantage of these short rotation systems is that they allow more rapid introduction of new varieties and fruit types which meet the contemporary market demands.

The second technological innovation of great importance is that of mechanization. Early developments in this field were directed to the more extensive American systems of horticultural production where processing was an important outlet for fruit. Unfortunately, these systems while sophisticated in the purely engineering sense, tend to be rather brutal on the fruit. This has lead to a well entrenched myth among horticulturists that mechanical harvesting and high fruit quality are not compatible. I would seriously challenge this myth as the Americans handed the whole problem to the engineer and the horticulturist stood back unprepared to change the tree management systems he had become so accustomed to. Recent developments at last are beginning to see the engineer and the horticulturist co-operate, and some interesting new concepts have emerged which result in high quality fruit being picked by machines. The Tatura trellis and the Lincoln Canopy are examples of what can be done where this co-operation occurs. However, I believe that the ultimate in mechanical harvesting will not be achieved until the plant breeder is also co-opted into the partnership. Mechanical harvesting if it is introduced however, will pose some social problems.

Mechanization, wherever it has been introduced into agriculture, usually is only economically viable where the size of individual holdings is relatively large or some form of co-operative harvesting arrangement can be organized. Secondly, mechanization is seen as a threat by many to their livelihood and a threat to the popularly held belief that expansion of horticulture along more traditional lines will create much needed employment. However, in my view, expansion of horticulture will inevitably require mechanical harvesting. It is predicted that if the projected production of Kiwifruit alone is achieved by 1985 that industry will require 40,000 pickers to harvest the crop. Without harvesting machines the present expansion in black-currants would have been virtually impossible even with unemployment figures as high as they are now.

The third area of technology which needs to improve is in the area of post-harvest handling of fruit. In the early stages of export where quantities of fruit are small and fruit is being sold on a seller market, air-freight can be used effectively. However, as production expands and transport costs become more significant in the overall profitability of a crop, slower sea transport is often the only viable means of transport. More sophisticated methods will be required to preserve the quality characteristics of fruit for longer periods. More accurate maturity indices will need to be developed so that fruit will store and transport well. Varieties with better handling characteristics will need to be introduced and varieties which extend the harvesting season will be required to allow more efficient handling and transporting of fruit.

Major difficulties will be met in the future regarding disease control as the range of chemicals which are acceptable as residues on fresh fruit and vegetables has become much narrower. Unfortunately, climates which tend to favour high yield and crop growth are often those which favour disease. It is my prediction that in the long run, drier climates will be more favoured for horticultural production for this reason alone.

Finally, I believe that we will see in New Zealand, over the next 20 years, the development of two groups of grower of horticultural products - one group will follow the more traditional intensive systems having long-term loyalty to a particular crop or group of crops. The other group will be less committed to the long-term crop loyalty and they will embrace the new short-term relations and mechanical harvesting systems. Holdings are likely to be larger in size, located further from major centres of populations and growing horticultural crops as just another crop alternative in their overall operations. One level of the industry will provide long-term stability in supplying horticultural products and the other will cater for the shorter term export opportunities.

The attitudes and objectives of both groups are likely to be different in major ways and will need to be understood if effective research, extension and education and industry associations are to be provided for both groups.

Growing Stonefruits Intensively — A New Look Stonefruit Industry

by

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In recent years there has been a marked swing away from the traditional extensive stonefruit orchard of around 250 trees per hectare to more intensive orchards ranging upwards from 500 trees per hectare. The upper limit in some experimental plantings has been in excess of 10 000 trees per hectare. With this trend a number of differing planting systems have been developed. They are all aimed at minimising the non-bearing establishment period of the orchard. Full production occurs 2-5 years from planting and if necessary stonefruit can become a short term crop. Initial capital outlay, particularly in trees is high but this is counteracted by early cash flows which limit the period that high orchard overheads are carried without the income to support them.

These early returns also give greater flexibility to change the variety mix and thus enable the intensive stonefruit grower to capitalise on new market opportunities which arise from the introduction of new varieties which extend the harvest season. The rewards of being first with a high demand variety on a bare market have sometimes paid the orchard establishment cost in the first harvest season.

In New Zealand tree decline diseases of Silver Leaf (Chondrosterium purpureum) and Stonefruit blast (Pseudomonas syringae) often decimate standard extensively planted stonefruit orchards before they reach economic cropping levels. Intensive orchards through shortening the orchard life cycle enables full production to be achieved before Silver Leaf takes its toll.

Tree Management

As there are no dwarfing rootstocks available for stonefruits the long term success of the intensive stonefruit orchard depends on the ability of the grower to maintain the potentially large and vigorous stonefruit tree within the confined space he has elected to grow it. Compared to the traditional extensive stonefruit orchard a radical approach to tree training and pruning is required.

Right from planting the objective is to minimise the development of heavy structural wood which pushes the fruiting zones to the outer periphery of the tree. The main emphasis is, therefore, to develop and maintain viable fruiting wood close to the centre of the tree within easy reach of the ground.

The training systems generally have one or two leaders per tree, all other strong shoots which have the potential to become substantial branches are removed in favour of weaker, fruitful wood which is left to crop. As fruit bud development is very sensitive to excessive shading and when this occurs fruiting laterals will dieback summer pruning to restrict tree height and shading is an essential part of tree management. Summer pruning and heavy regular cropping are the main dwarfing agents in the intensive stonefruit orchard.

Indications are that mechanical shearing of the tops and sides of the trees is a suitable technique for summer pruning provided that it is followed up with selective thinning out of the remaining growth later. Varieties with open growth habits such as Armking nectarine are particularly suited to mechanised summer topping.

Cultivar Vigour

Weaker growing precocious varieties such as Redgold, Fantasia and Favortop nectarines are particularly suited to intensive planting systems. Early ripening varieties also lend themselves to intensive planting systems becuase most of their new growth is made after harvest so summer pruning operations are simplified and can be carried out without affecting fruit size in the maturing crop.

Strong growing late harvested varieties such as O'Henry and Golden Queen which are not particularly fruitful when young appear more suited to semi-intensive than intensive systems of growing.

Soil Types

Although stonefruits, particularly peaches and nectarines, require well drained soils, experience in Hawkes Bay shows that intensive stonefruits become very difficult to manage when planted on deep fertile soils due to problems with excessive vigour. The best soil types appear to be lighter well drained soils which produce weak to moderate growth. This type of growth is more fruitful and much easier to control.

On these lighter soils irrigation over the final fruit swell stage is essential to produce fruit of satisfactory size.

The Systems

1. The Free Standing Intensive Central Leader

This is the simplest and most widely used intensive system. It seems to have been developed spontaneously in many places including Hawkes Bay.

Trees trained as a single leader 2.5m high are planted intensively along the row at 1.0 to 2.0m spacings. Between row spacing depends on orchard equipment but is usually 4.0 to 5.0m. Between row spacings as low as 3.0m have been tried in Hawkes Bay but unless a very narrow hedge is maintained this distance is far too close.

French recommendations for tree spacing on this system are 1.25m x 4.0m giving 2000 trees per hectare. Their research has shown adverse inter tree competition to occur when tree density exceeds 2800 trees per hectare.

2. The Ultra-high Density Replacement Leader System

This system was developed in Israel using densities of 6600 to 13 000 trees per hectare. It consists of growing a tree with two main fruiting arms or leaders, each of which is pruned down to a stump about 10cm high each alternate year. The tree consists of a bearing arm which is removed immediately after harvest and a growing arm to carry next year's crop. As the leaders which are grown in a Y configuration at right angles to the row direction are removed completely after two seasons growth has occurred tree containment is a much easier task than where the leader is permanent for the entire life of the tree. This practice makes higher densities possible. Comments from Israel suggest that a density of 13 000 trees per hectare is too high. Under New Zealand conditions with moderately vigorous cultivars planting distances of 0.75 into 1m by 3.5 to 4m giving tree densities of 2500 to 3800 trees per hectare may be more practical than the higher densities advocated in Israel.

Even wider spacings may be possible if the life of the temporary leaders can be extended to two or three crops instead of one.

3. Tatura Trellis

Developed at Tatura Research Station, Victoria, Australia, the Tatura Trellis high density mechanised growing system for pip and stonefruits has received wide interest in other countries.

It is based on high density hedgerows in which the trees are trained to a V shaped trellis. The trees are spaces at 0.75 to 1.0m in the row with 6m between the rows for mechanical harvesting or 4.5 to 5m between the rows for hand harvesting. The closer row spacing for hand harvesting enables the whole trellis to be serviced without ladders. Each arm of the trellis is inclined at 60^{o} above the horizontal and when fully developed should have a 2m gap between the canopy of each row to allow access for machinery to the inside of the V and to allow light into the undersides of the canopy. The central area between the two leaders must be kept free of growth. This is accomplished by two or more summer prunings. Detailed winter pruning is necessary to maintain a regular supply of good fruiting wood.

As each arm of the V is inclined at 60^{o} the Tatura Trellis enables a very high effective bearing surface per unit area of orchard and is claimed to out produce more conventional plantings which do not utilise the canopy area as effectively.

It is also claimed that the Tatura Trellis gives a management system which makes long term growth control of intensively planted vigorous trees possible.

The trellis itself is of light construction and is mainly a training aid but in the early stages of development is also expected to support crop load until the tree leaders stiffen sufficiently to support their crop.

The full range of stonefruit types appear adaptable to the Tatura Trellis. In New Zealand it is already being used quite widely for apricots in Central Otago and processing peaches in Hawkes Bay. In South Africa it is reported to be very successful for plums.

Under our conditions tree loss through leaf infection could become a limiting factor to this system.

4. Filler Trees

The concept behind filler trees is to solve the overcrowding problems of intensive plantings by periodic removal of the alternate trees in the hedgerow as trees become overcrowded. Because each thinning involves a change in direction of the tree rows it is only practical with large blocks of a single cultivar. Generally it is incompatible with solid set irrigation systems.

On this concept an orchard may be planted at 3m x 2m then as overcrowding begins alternate trees in the 2m row are removed to turn the block into a 3m x 4m spacing. With subsequent thinnings the spacing becomes 6m x 4m and then 6m x 8m.

Providing fruiting arms on "filler" trees extending towards the next trees in the row are trimmed hard back to allow unimpeded development of the adjacent "permanent" tree a year or two before removal the temporary tree can be removed with minimum reduction in overall orchard yield.

5. Semi-intensive

This is a compromise system between the old conventional extensive stonefruit orchard and the newer intensive systems.

Tree density is around 450 to 600 trees per hectare on spacings of 3m to 3.5m x 5 to 6m.

Full canopy is achieved in 4-5 years from planting and with it full production.

The semi-intensive orchard is free of tree containment and overcrowding problems in the early years but once full canopy is achieved overcrowding and shade out of the lower fruiting wood can become a problem.

The central leader tree is very suited to this system. Defined tiers of fruiting arms, and ladder bays as in the semi-intensive apple tree are necessary to retain healthy fruiting wood low in the tree. Summer removal of vertical water shoot growth along the fruiting arms helps keep shading down as the trees age careful thinning and shortening of higher branches is necessary to maintain the pyramid shape.

The system is well suited to more vigorous varieties which are slow to begin cropping such as Golden Queen and O'Henry.

Yields

Details of production for the various systems under New Zealand conditions have not been fully documented.

In general the intensive systems produce high yields early in the life of the orchard but in many instances may not necessarily out yield the mature standard orchard. However as cropping commences early in the life of the orchard cumulative yields over the life of the orchard will be much greater.

The following are examples of yields obtained with the various systems:

Free Standing Intensive	cumulative yield at 2yrs from planting - 19 to 69 t/ha
Central Leader (France)	depending on cultivar
Ultra-high density	13 000 trees/ha - 26 to 67 t/ha/year
Replacement Leader System (Israel)	depending on year and cultivar

Tatura Trellis - Australia t/ha

	2nd leaf	3rd leaf	4th leaf	5th leaf
Golden Queen Peaches at 6.0 x 0.75m = 2222 trees/ha	22	37	61	54
Semi-Intensive Hawkes Bay Golden Queen 5.5 x 3.5m Estimated yields t/ha	5	30	50	50

Average Hawkes Bay Production - 1978 Orchard Survey - trees 5yrs age and over 26 t/ha.

Conclusion

The concept of the intensive stonefruit orchard has become widely adopted. A number of different systems of orchard layout and management have been developed and only time will tell which ones are the most successful. High tree densities are the common feature and the objective is to develop a full fruiting canopy quickly, then with judicious orchard management maintain its productive efficiency.

Some of the features of intensive orchards are:

- High capital outlay in trees.
- Best suited to precocious, early cropping cultivars.
- Requires a radical approach to training, pruning and thinning.
- Instant canopy development gives high yields early in the life of the orchard but unless the standard of tree management is high later orchard performance could be poor.
- Potential annual yield per hectare may not be greater than a full bearing standard orchard, but it comes sooner consequently cumulative yields over the orchard life are much greater.
- Possible mechanisation of some operations.
- High initial yields gives great flexibility in the orchard variety mix making it easier to keep abreast of market requirements as variety preferences change.

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Growing 'Pomatoes': Tomato Scions Grafted onto Potato Rootstocks

by

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ABSTRACT

A simple technique, suitable for the home gardener, is described for grafting tomato (*Lycopersicon lycopersicum* (Linn.) Karst. ex Farw. cv. 'Money Maker') shoots onto potato (*Solanum tuberosum* Linn. cv. 'Ilam Hardy') rootstocks. The subsequent growth of the resulting "pomato" (or "topato") plants and their yields are discussed, along with the possibility of alkaloid translocation across the graft union.

INTRODUCTION

Grafting involves the joining together of plant parts in such a manner that they unite and continue to grow as one plant (Hartmann and Kester 1975). Although grafting has many uses, an important aspect involves the joining of plants and selected properties (Garner 1979). Such an objective is especially important in numerous woody horticultural plants where cultivars selected for desirable fruit or ornamental qualities are grafted onto rootstocks capable of tolerating unfavourable conditions or resisting soil borne pests and diseases (Hartmann and Kester 1975). However, another advantage, which is frequently not considered, is the grafting of two plants in such a manner that both the scion and rootstocks yield useful crops. For example, the grafting of tomato shoots onto potato stocks may yield both tomato berries and potato tubers. The aim of this paper is to describe a simple technique for producing such grafted plants ("pomatoes" or "topatoes") and to outline their subsueqent growth and yields.

GRAFTING PROCEDURE

Potato tubers (*Solanum tuberosum* Linn. cv. 'Ilam Hardy') were planted in garden soil in PB 5 (2.5 *l*) planterbags and allowed to grow outdoors until their shoots had reached 15-20cm above the soil. Using the wedge (or cleft) technique, recommended for grafting herbaceous stems (Garner 1979) lateral shoots from garden grown tomatoes (*Lycopersicon lycopersicum* (Linn.) Karst. ex Farw. cv. 'Money Maker') were then grafted onto the potato shoots. The grafting procedure is summarised in Fig. 1. Tomato shoots were cut into nodal segments and those with lateral shoots just beginning to develop were chosen for grafting. The stem above the lateral bud and the leaf petiole were trimmed to approximately 1 cm. Removal of the leaf lamina prevents excessive transpiration after grafting. After cutting a 1-2 cm long wedge just beneath the lateral bud, it was inserted into a complementary incision in the potato shoot. Once completed, the graft was held in position with a peg (see Fig. 2). The potential "pomato" (or "topato") plants were then thoroughly watered, enclosed in a large plastic bag and placed under low light (interal sill of a south facing window).

GROWTH OF THE POMATOS/TOPATOS

Growth in the tomato shoots was usually evident within one week of grafting. The enclosing plastic bag should be opened after one week (even if the tomato shoot shows no elongation), as the high humidity also promotes fungal growth which may lead to disease (especially damping-off). The

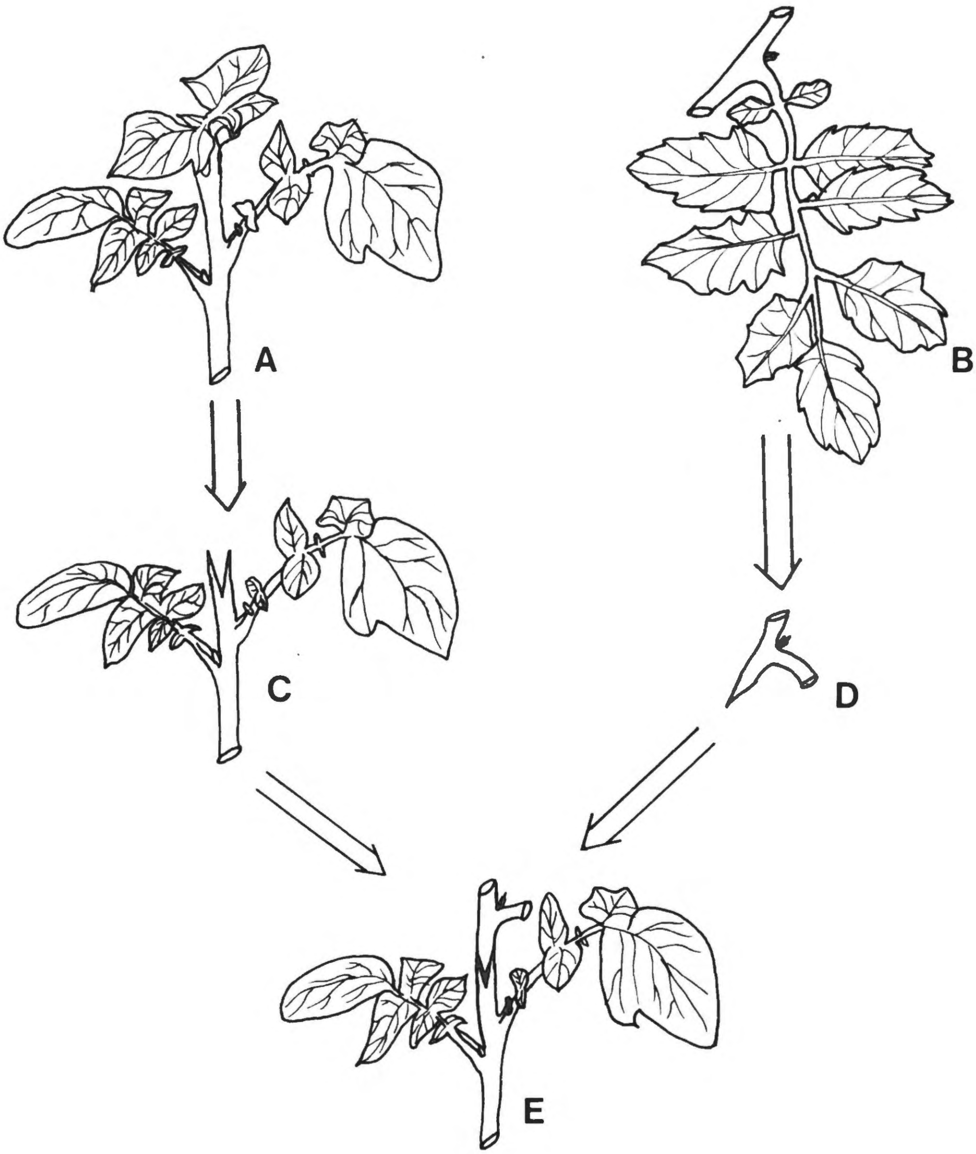

Figure 1: Summary of the procedure for wedge grafting tomato scions onto potato rootstocks. (A) Potato shoot. (B) Segment of tomato lateral shoot with axillary bud. (C) A wedge cut out of the potato stock with a razor blade. (D) Leaf lamina removed from nodal segment and base of tomato scion formed into a wedge with razor blade. (E) The shaped tomato shoot fitted into the complementary wedge in the potato shoot.

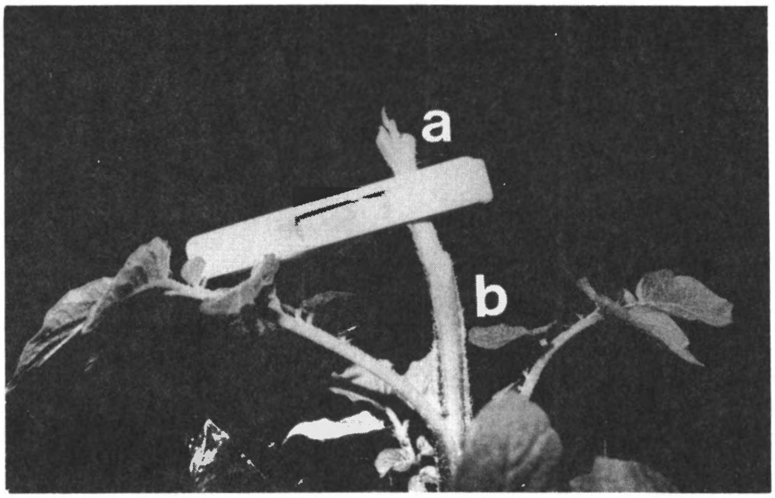

Figure 2: Tomato nodal segment with axillary bud grafted onto potato shoots and held by a peg. (a) tomato shoot, (b) potato shoot.

Figure 3: Two weeks after grafting the union had healed and considerable growth in the tomato bud had occurred. (a) graft union.

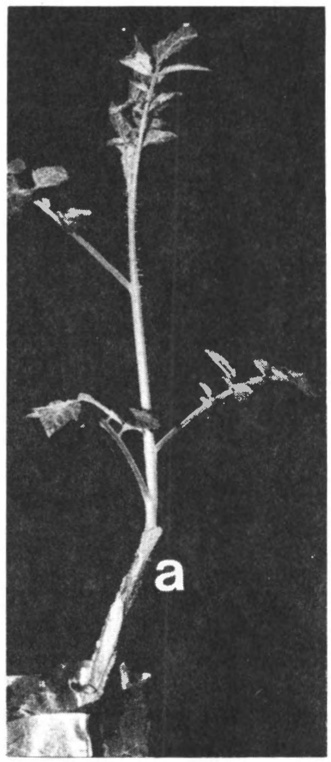

Figure 4: Four weeks after grafting the tomato shoots had reached up to 25cm high. The grafted plants were transplanted outdoors at this stage. (a) graft union.

plastic bags were gradually removed over the second week. After two weeks the graft unions had healed and the pegs were removed (see Fig. 3). At this stage the "pomatoes" (or "topatoes") were placed in full sunlight (although remaining indoors) and watered as required. A further two weeks later the tomato shoots had reached 15-25cm long (see Fig. 4) and transplanted outdoors. Just prior to transplanting, the graft was "bandaged" with raffia to help prevent possible breakage at the graft junction due to wind stress.

Four weeks after transplanting (a total of eight after grafting) substantial growth had occurred. The tomato shoots had reached 50-70cm high with 10-15 leaves and had set several bunches of berries (see Fig. 5). The bases of the "pomatoes" were then healed up with soil to just beneath the graft union to prevent exposure of the developing tubers to light.

One "pomato" plant was dug up four months after grafting to examine for tuber formation. Even at this early stage, seven potato tubers had already developed (4-8cm diameter), in addition to several bunches of ripening tomato berries (see Fig. 6). By the end of the growing season (May), after which numerous berries had been picked from the plants, the potato tubers were harvested. The number of tubers greater than 5cm diameter per plant ranged from 2-9 (mean = 4.6, n = 10).

COMMENTS ON THE TECHNIQUE

When preparing the plant tissue for grafting it is important that all cuts are made with a razor blade, scapel or a thin, sharp knife so as to avoid bruising of the delicate herbaceous stems. To facilitate healing of the graft union, it is important to maximise cambial contact between the tomato and potato shoots. This is promoted by grafting at a point where the tomato and potato stems are equal in diameter. When creating "pomatoes", several tomato shoots can be grafted onto the same potato plant. It is important that all the grafts are made at least 15-20cm up the potato stems. This helps to prevent scion rooting and the covering of the graft union with soil on healing up of the "pomato" plants.

Whilst securing the graft, the tomato shoots occasionally tend to be forced from the wedge in the potato shoots. If this occurs, it can be overcome by tying a thread over the base of the leaf petiole on the tomato shoot and anchoring it to a leaf petiole on the potato shoot. In addition to using a peg to hold the graft in place, the graft may be secured with raffia, self-sealing crepe rubber, plastic strips, electricians tape etc. Sealing the graft with petroleum jelly or grafting wax is unnecessary.

As soon as the graft has been completed, it should be placed in a moist atmosphere to minimise wilting while the graft is healing. To prevent excessive transpiration the leaf lamina of the tomato shoots are removed and only nodal segments with small lateral buds are used.

If the graft union becomes covered with soil, the potential for pathogen entry at this vulnerable site is increased. Consequently, when healing soil up around the stem base of the "pomatos" the graft itself should not be covered.

During the growth of the "pomato", there is a continual tendency for the potato to sprout shoots. To create a "true pomato" these should be removed as soon as they develop. Their development increases the yield of potatos, but tends to suppress the growth of the tomato shoots. In addition, they may induce problems with the translocation of poisonous alkaloids across the graft union into the tomatos.

ALKALOID LEVELS

It is well known that many solanaceous plants contain poisonous alkaloids. Potatos are no exception and contain solanine, a bitter-tasting glycoalkaloid which, if consumed, can cause severe illness and may even cause death (Jadhav and Salunkhe 1975). The majority of solanine in potatoes is found in the leaf buds, young shoots and flowers, with only traces present in potato tubers, although greening of potato tubers is associated with increasing levels of solanine (Jadhav and Salunkhe 1975). Therefore, when growing "pomatos" the possibility of such glycoalkaloids being produced in the potato shoots and translocated across the graft union into the tomato fruits should be considered. This is important, especially when alkaloids are known to be translocated into tomato plants

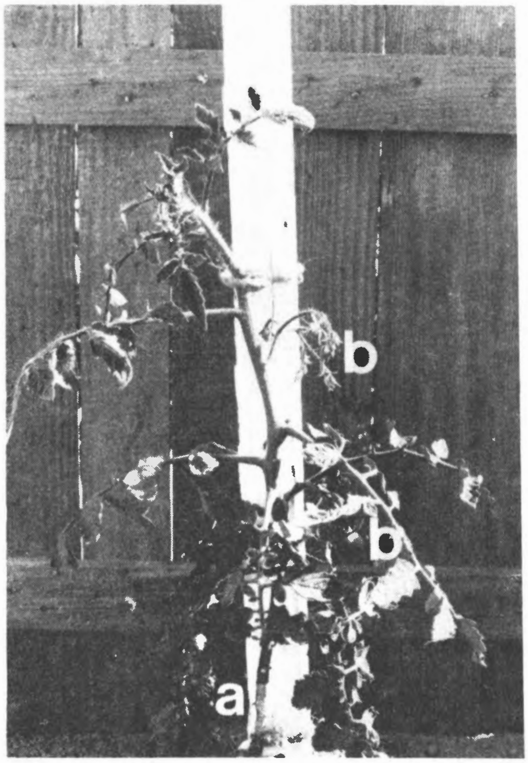

Figure 5: A grafted plant four weeks after transplantation outdoors. (a) graft union 'bandaged' with raffia, (b) developing fruit.

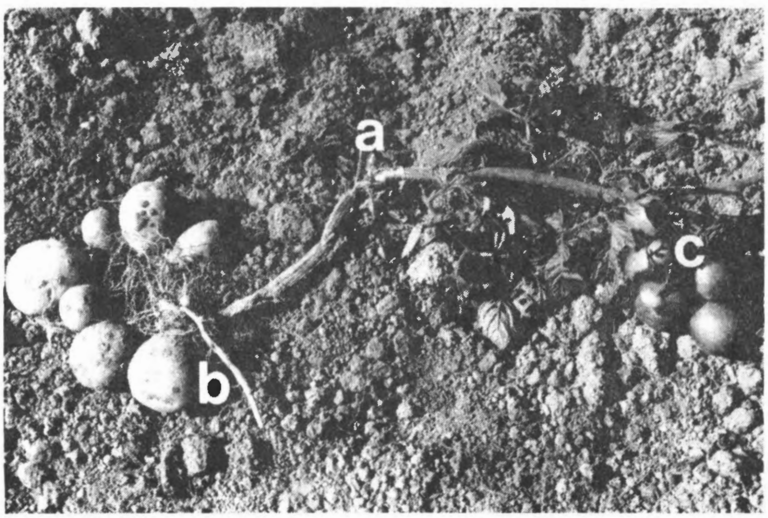

Figure 6: A grafted plant four months after grafting showing both tomato berry and potato tuber formation. (a) graft union 'bandaged' with raffia, (b) potato tubers, (c) tomato berries.

grafted onto apple thorn (*Datura stramonium*) rootstocks and accumulate in the tomato fruit (Lowman and Kelly 1946). Poisonous substances are also reported to be translocated into tomato plants grown on tobacco (*Nicotiana tabacum*), deadly nightshade (*Atropa belladonna*), *Duboisia myoporoides* and henbane (*Hyoscyamus niger*) rootstocks (see review in Lowman and Kelly 1946).

Although consuming small quantities of alkaloids may not prove fatal, the possibility of serious illness from eating small amounts over a long period should not be dismissed. Nevertheless, there is considered to be no evidence for illness resulting from eating tomato fruits produced on "pomato" plants (Garner 1979). Since solanine in potatos is primarily found in the leaf buds, young shoots and flowers (Jadhav and Salunkhe 1975) the possibility of its translocation across the graft union into tomatos can probably be eliminated by removal of all potato shoots as they appear on the "pomato" plants. Provided this is done there is no fear of poisoning as solanine levels in the tomato berries would not exceed those in normal potato tubers.

CONCLUSION

The prospect of developing plants that yield useful crops from both their roots and shoots has fascinated applied botanists for many years. Although "pomato" plants yield a number of potato tubers and several bunches of tomato berries, their yields are less than those of normal potato and tomato plants. It is therefore unlikely that these "pomato" plants would ever become a commercial crop, especially when the grafting procedure is labour intensive. However, for the home gardener they may be considered as novelty plants and certainly provide a sufficient curiosity to gain "one-up" on the neighbours! The possibility of developing plants yielding both edible tubers and berries on a commercial scale awaits the exciting work of Melchers *et al.* (1978) in which somatic hybrid plants have been regenerated from fused protoplasts of potatos and tomatos.

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The Influence of Slow-release Nitrogen, Liquid Fertilization and Media on the Growth of *Fatsia japonica*

by

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ABSTRACT

The influence of four nitrogen (N) fertilisers (Osmocote, 26% N; IBDU, 31% N; Gold N, 32% N and Nitrolime, 26% N), six levels of N from Osmocote, nine media and a liquid N fertilisation programme on *Fatsia japonica* growth were examined in a preliminary study. Generally, fatsia was tolerant of moderate N levels, although above 600g N m^{-3} growth was depressed. The N source had no effect on plants while liquid fertilisation above or combined with a base-dressing of Osmocote proved to be superior to a base-dressing alone. The different media only mildly influenced fatsia growth while tissue analysis for N concentration and yield moderately supported the results.

Optimum production of fatsia appeared to be in a peat:sand:sawdust (1:2:1; v.v.) or sand:sawdust (1:1; v.v.) medium with a base-dressing of 150 and 300g N m^{-3} respectively plus liquid feeding of a 100 ppm N solution at 250ml P m^{-3} respectively were adequate while liming to pH 6.0 and 7.0 respectively (6kg lime m^{-3}) was required.

INTRODUCTION

Fatsia japonica (F. Araliaceae) unlike other foliage plants is relatively tolerant of infertile conditions (Thomas, 1981). Seager (1973) found that other Araliaceae (*Hedera canariensis* 'Mugo') were less responsive to Megamp (7/17/5) than *Ficus elastica* 'Decora'. However, Poole *et al.* (1968) reported that the grade and growth of *Nothopanax guilfoylei* grown at 800, 350, and 664g N, P, and K m^{-3} respectively was better than those grown with 400, 176, and 332g N, P, and K m^{-3}, while Rochford and Gorer (1961) found that satisfactory Araliaceae growth occurred in the J.I.P. potting mix or a loam and manure medium supplemented with superphosphate. Generally, it would appear that satisfactory growth of *F. japonica* will occur in a medium with moderate N levels and low to moderate levels of other nutrients (Thomas, 1981).

The objectives of this experiment were to study the effects of:

1. Different levels of N from Osmocote (26% N) fertiliser.
2. Various N sources; Osmocote, IBDU, Gold N and Nitrolime.
3. Different media at moderate and high levels of N.
4. Liquid feeding compared to slow-release fertilisers.

MATERIALS AND METHODS

Plant Material and Growing Conditions

Size graded cuttings of *Fatsia japonica* were potted into 2.5l (PB 5) planterbags on 11.4.80. These were housed in a glasshouse equipped with fan ventilation and automatic heating so that the temperature was approximately 5^{o}C above ambient. Hand watering was carried out as required while the final harvest was on 26.11.80.

Experiment Design, Media and Fertilisers

A non-factorial design with 4 replicates involving 6 rates of N, 4 commercial N fertilisers, 9 media and a liquid fertilisation programme was set up. The rates of N used are shown in Figure 1 and were supplied from Osmocote (26% N) while the N sources were Osmocote (26% N), IBDU (31% N), Gold N (32% N) and Nitrolime (26% N) applied at 450g N m^{-3}. All fertilisers were mixed into the peat:sand (1:1 v.v) medium prior to potting-up of the plants.

The media used were based on peat, manufactured sand, sawdust, soil (Wakanui silt loam) and polystyrene (4mm diameter). The proportions of the media constituents and N levels are shown in Figure 3.

The liquid fertilisation programme used involved a water solution of ammonium nitrate (34% N) applied at 250ml per planterbag per week of 100, 400, or 700 ppm N giving total N levels of 320g N m^{-3}, 1.3kg N m^{-3} and 2.24kg N m^{-3} over the 32 weeks of the experiment. Liquid fertiliser treatments also involved applying 100 ppm N at 250ml per bag per week with three rates of Osmocote (26% N) added at the start of the experiment. The Osmocote supplied 150, 300, and 450g N m^{-3} to the medium so that total N applied was 470, 620, and 770g N m^{-3} respectively. The medium consisted of equal parts of peat and sand.

In addition all treatments, except the four different N sources, received a base-dressing of 200g P m^{-3} (superphosphate; 8% P), 166g K m^{-3} (potassium sulphate; 34% K), 75g m^{-3} iron chelate (Na EDTA; 12% Fe), 150g m^{-3} 'Sporumix A' (trace elements), 4.5kg m^{-3} dolomite and 1.5kg m^{-3} agricultural lime

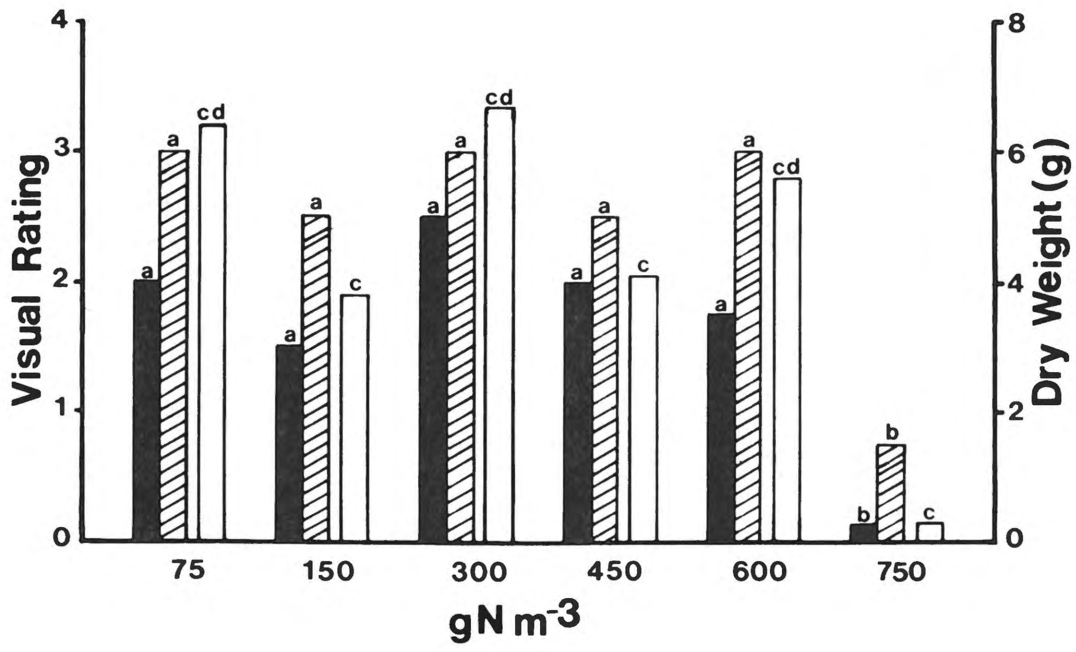

Fig. 1 The influence of N on *Fatsia japonica* dry weight and visual appearance. (Figures 1, 3 and 4: means without a letter in common for columns of equal shading differ significantly at the 5% level. Solid columns = rating at 18 weeks; hatched = rating at 23 weeks; shaded = dry weight.)

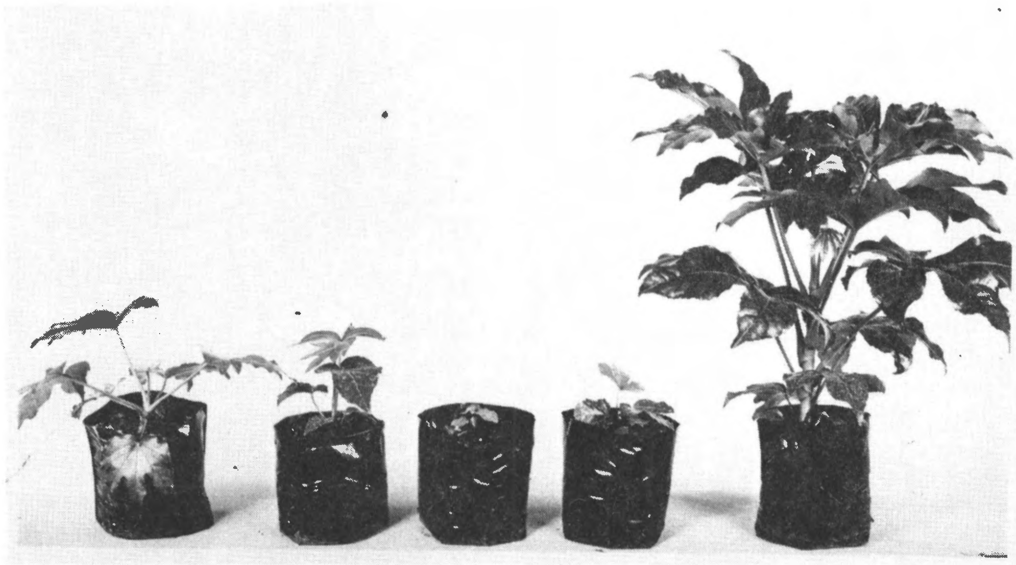

Figure 2: The influence of N source and liquid feeding.
<u>Left to right</u>:

Osmocote	IBDU	Control	Nitrolime	100 ppm N
450g N m^{-3}	450g N m^{-3}		450g N m^{-3}	+75g N m^{-3}

Figure 5: The influence of media.
<u>Left to right</u>:

Peat:Sand	Peat:Sand:Sawdust	Sand:Sawdust	Sand:Sawdust	Peat:Soil
1:1	1:2:1	1:1	1:1	1:1
600g N m^{-3}	600g N m^{-3}	600g N m^{-3}	750g N m^{-3}	450g N m^{-3}

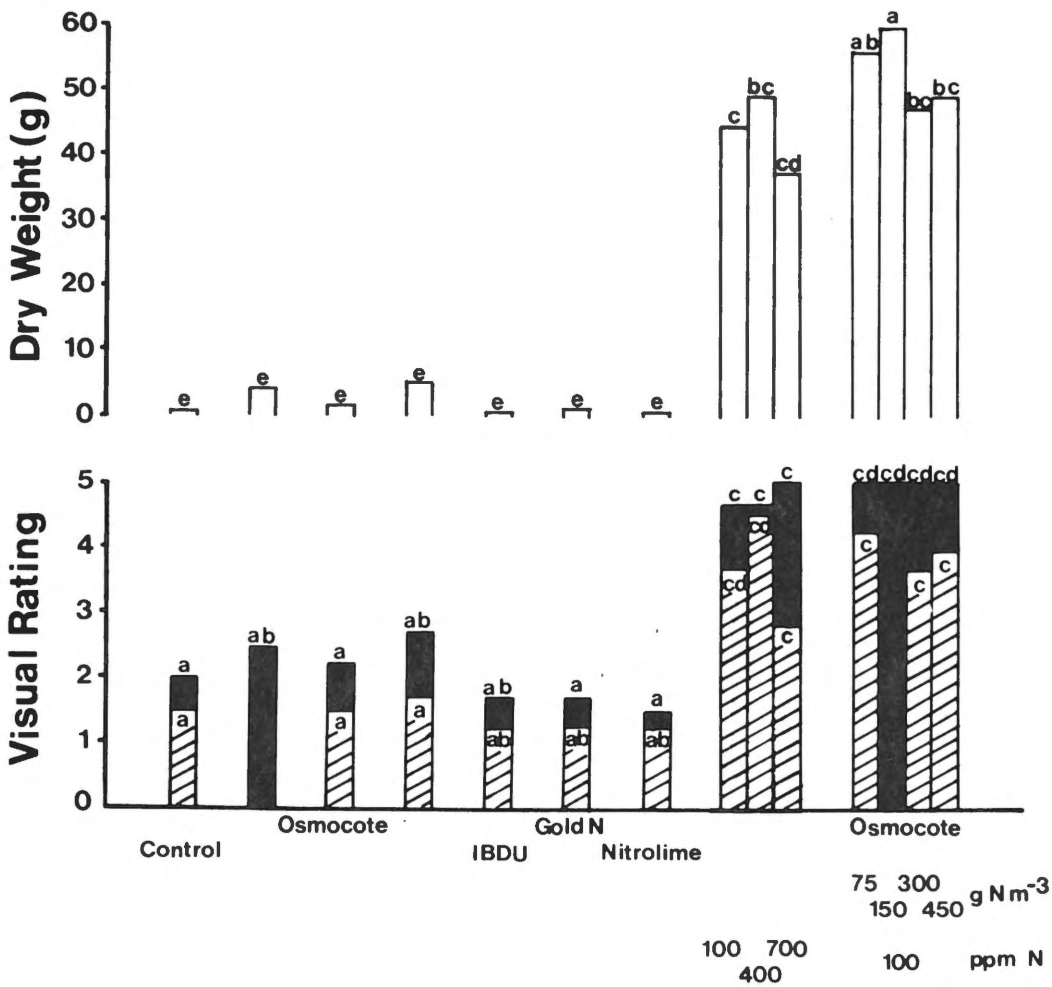

Fig. 3 The influence of N source and type of fertilisation on dry weight and visual rating of *Fatsia japonica*.

($CaCO_3$). The treatments with the commercial fertilisers received only dolomite and agricultural lime at the rates above. Physical and chemical characteristics of the various media have been reported previously (Goh and Haynes, 1977).

Data Collection and Analysis

Visual grading of the plants was carried out at 18 and 28 weeks (0 = dead plants; 5 = healthy, vigorously growing plants) while media pH (medium:water ratio = 2.5:1), plant dry weight, total N (Kjeldahl; % oven dry weight) and N yield (g per plant) were determined at termination of the experiment using methods described elswhere (Goh and Haynes, 1977). Data were statistically analysed by Duncan's New Multiple Range tests.

RESULTS

Generally, increasing the rate of added N supplied from Osmocote (26% N) had no effect on plant growth (Figure 1) although above 600g N m^{-3} plant growth was depressed. The maximum growth appeared to be at low N or 300g N m^{-3}. However, it was noticeable that the way in which fertilisers were applied strongly affected growth. The four types of commercial N fertilisers did not differ in their effect on fatsia growth while N supplied in a liquid form each week of the experiment produced better looking and heavier plants than with N supplied from a granular fertiliser (Figures 2 and 3). With Osmocote supplied as a base-dressing and supplemented with liquid fertilisation, plant

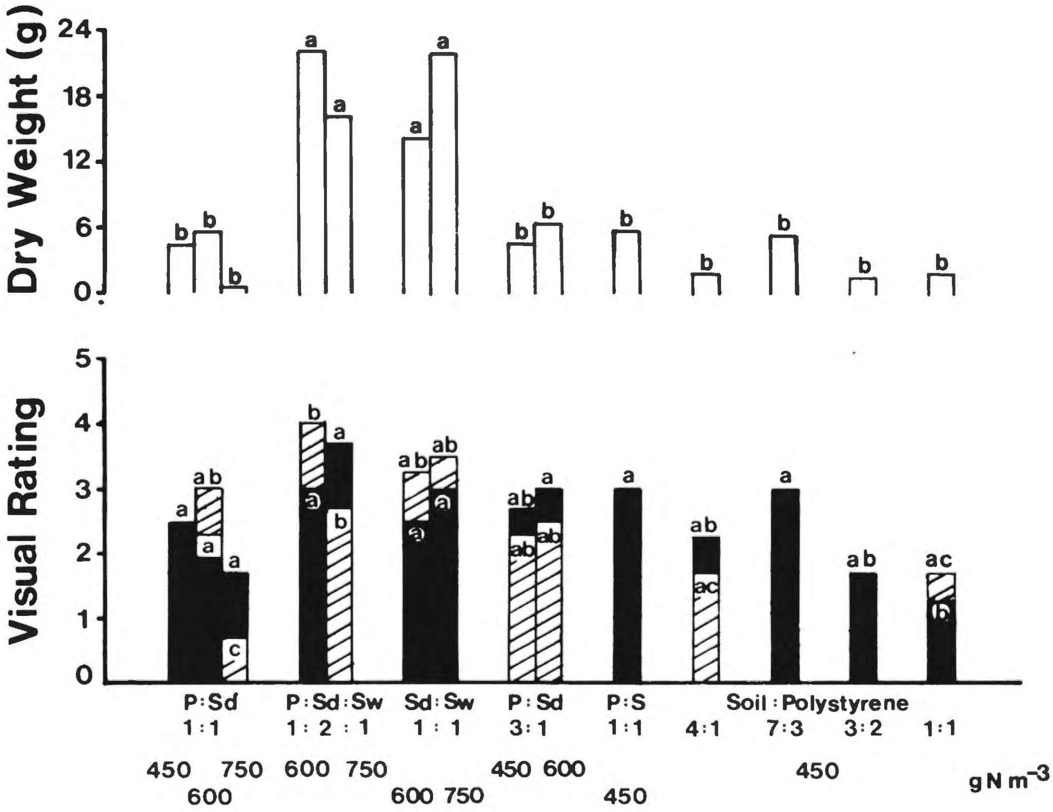

Fig. 4 The influence of media and N on dry weight and visual rating of *Fatsia japonica*. (P = peat; Sd = sand; Sw = sawdust; S = soil)

TABLE 1: The Influence of N-Source and Rate and Media on the pH, N-Concentration and Yield.

N-Source	N-rate (gNm^{-3})	Medium	pH	N Concentration (%)	N-Yield (g per plant)
Osmocote (26% N)	75	Peat:Sand(1:1)	6.5ef*	2.13bc	0.13ab
"	150	"	6.2c	2.26bcd	0.08ab
"	300	"	6.0bc	2.16bcd	0.13ab
"	450	"	5.8bc	2.30cd	0.09ab
"	600	"	5.8bc	1.99bc	0.11ab
# "	450	"	6.9fg	1.82b	0.03ab
# "	450	"	6.8fg	2.09bc	0.10ab
IBDU (31% N)	450	"	6.8fg	2.71d	0.03ab
Gold N (32% N)	450	"	6.7fg	2.31cd	0.04ab
Nitrolime (26% N)	450	"	7.4h	2.73d	0.01a
Osmocote (26% N)	0	"	7.6h	1.90bc	0.06ab
"	750	"	5.8bc	2.14bcd	0.03ab
"	600	Peat:Sand:Sawdust(1:2:1)	6.6ef	2.07bc	0.45b
"	750	"	6.4def	2.05bc	0.33ab
"	600	Sand:Sawdust(1:1)	7.0g	1.14a	0.18ab
"	750	"	7.0g	1.30a	0.29ab
"	450	Peat:Sand(3:1)	6.0bcd	2.13bc	0.10ab
"	600	"	5.3b	2.38cd	0.14ab
"	450	Peat:Soil(1:1)	6.2de	2.19bcd	0.12ab
Liquid NH_4NO_3 (ppm)	100	Peat:Sand(1:1)	6.5d	2.02bc	0.92cd
	400	"	4.3a	2.21bcd	1.08d
	700	"	4.3a	2.84d	0.81c
Osmocote + Liquid	75	"	6.2bcde	1.95bc	1.11d
NH_4NO_3 (100 ppm)	150	"	6.2bcde	2.3bcd	1.35d
	300	"	5.9bc	2.02bc	0.95d
	450	"	5.5b	2.02bc	0.98cd
Osmocote	450	Soil Polystyrene(4:1)	5.7bc	2.27bcd	0.04ab
"	450	" (7:3)	5.8bc	2.13bc	0.12ab
"	450	" (3:2)	5.7b	2.17bcd	0.04ab
"	450	" (1:1)	6.0bcd	2.21bcd	0.05ab
CV (%)			4.8	13.1	49.7

* means without a letter in common differ significantly at the 5% level (within each column).

\# these two treatments did not receive P or K fertilisers respectively.

growth was further enhanced (Figures 2 and 3). The optimum plant growth occurred at 150g N m^{-3} as a base-dressing plus liquid feeding of 250ml per bag per week of 100 ppm N, ammonium nitrate solution (Figure 3). In all cases the values for the second rating were lower than the first (Figure 3).

The different media did not appear to strongly influence the dry weight of fatsia while the ratings were even less affected (Figures 4 and 5). The best plants were produced in the peat:sand:sawdust (1:2:1) and the sand:sawdust (1:1) media with 600 and 700g N m^{-3} respectively. The soil:polystyrene mixes were shown to have little affect on fatsia growth although the heaviest plants with the highest ratings were grown in a medium of 70% soil and 30% polystyrene (Figure 4). Similarly, different ratios of peat and sand had no significant effect on plant growth except at high N rates while soil based media did not produce better or inferior plants than soilless media (Figure 4).

The addition of fertilisers to the media generally decreased the pH (Table 1). Increasing N levels depressed the pH while using IBDU, Gold N or Nitrolime to replace Osmocote had a lesser effect (Table 1). Using ammonium nitrate as a liquid fertiliser, the pH was very strongly depressed. However, pH was less strongly decreased when Osmocote and liquid N additions were combined (Table 1). Generally, the different media had similar influences on pH. As expected, the lowest pH was in the peat:sand (3:1; v.v.) mix, while the replacement of sand with sawdust, soil, or the addition of sawdust generally decreased the influence of peat (Table 1). It should be noted that the peat:soil (1:1) medium exhibited a lower pH than for the peat:sand (1:1) medium with nil N (Table 1). Increasing the level of polystyrene in the media did not significantly alter the pH while the sand: sawdust (1:1) medium exhibited a neutral pH regardless of N levels. PH values for various constitutents either singly or mixed as media have been shown previously to be strongly related to the origin and nature of each material and its proportional contribution in making up a medium (Goh and Haynes, 1977).

Analysis of tissue for N concentration and yield showed no differences when added N rates were varied apart from the maximum and minimum values (Table 1). The highest N concentration was at 450g N m^{-3} while the lowest was at the same rate but without added P to the medium (Table 1). The N source whether it be Osmocote, IBDU, Gold N, or Nitrolime exhibited a similar response although the highest N concentration occurred with IBDU or Nitrolime (Table 1).

Liquid fertiliser treatments almost linearly increased N concentration, but only foliar levels at low (100 ppm) and high (700 ppm) N rates were different giving values of 2.0 and 2.8% N respectively. However, when Osmocote and liquid fertilisation were combined there was no difference between these levels (Table 1). Nitrogen yields for liquid fertiliser treatments were higher than for N supplied as only Osmocote (Table 1). The maximum N yield for liquid feeding (1.35g N per plant) was at 100 ppm N plus 150g N m^{-3} from Osmocote and the lowest (0.8g N per plant) yield at 700 ppm N from ammonium nitrate. However, it was noticeable that N concentrations and yields were not significantly different when added N was supplied from Osmocote and ammonium nitrate solutions (Table 1).

Comparison of plants supplied with Osmocote (26% N) and grown in different media, indicated that those sand and sawdust had lower N concentrations than others within this group (Table 1). However, this was not apparent with the N yields per plant.

Plants grown in the soil media all exhibited high N concentrations while N yields per plant were generally low (Table 1). The highest levels were obtained from the peat:soil (1:1) mix, closely followed by the soil:polystyrene (70:30) medium (Table 1). While not significantly different, the N yields in peat media were decreased by added N except for the 3:1 peat:sand medium (Table 1).

DISCUSSION

It has been previously reported that *Fatsia japonica* is relatively tolerant of infertile conditions (Thomas 1981) and that related plants respond well to high fertiliser levels (Poole *et al.* 1968). This may be supported in the work reported here, where plant dry weight and visual appearance were depressed at 750g N m^{-3} and is probably due to N toxicity. However, N concentrations and yield in plant tissue did not show this, suggesting that the levels of added N may be important when plants were young. It was also noticeable that pH changes in the medium did not affect plant growth.

The application of N as Osmocote, IBDU, Gold N, or Nitrolime had no affect on plant growth, pH, or N yield and concentration. This was unexpected as the N release characteristics of the four additions showed that the added fertilisers released N over different periods of time (Goh 1979; Thomas 1980). However, the extended length of this experiment may have negated any effects of the different N fertilisers.

The influence of liquid fertilisation showed that fatsia may benefit from high levels of readily available N supplied over a long period, in comparison to using slow-release fertilisers. The depression of plant dry weight at greater than 400 ppm N (1.3kg N m^{-3}) was probably due to N toxicity. The heaviest plants were grown in media with Osmocote at 150g N m^{-3} plus weekly feeding with 100 ppm N. The superior results from both the liquid feeding and when combined with a base-dressing of Osmocote in comparison with only a base-dressing is probably due to liquid fertilisation supplying N as demanded by the plant or making up shortfalls in N supply particularly in the latter half of the experiment. The effects of liquid fertilisation and liquid plus Osmocote may be associated with pH where it was considerably lower at the higher N rates.

Generally, the different media failed to strongly influence fatsia growth, however both the peat:sand:sawdust (1:2:1; v.v.) and the sand:sawdust (1:1); v.v.) media produced heavier plants with higher N yields than other media, probably due to better aeration and drainage in these media (Goh and Haynes, 1977). The difference in growth between media did not appear to be associated with pH.

Generally, it would appear that *Fatsia japonica* are tolerant of a wide range of fertiliser and media conditions. Fatsias can be grown effectively in a peat:sand: sawdust (1:2:1; v.v.) or a sand:sawdust (1:1; v.v.) medium with a base-dressing of 150 and 300g N m^{-3} respectively plus weekly liquid feeding with 100 ppm N. The levels of P and K supplied to the media were adequate while liming at 6kg lime m^{-3} to give a pH of approximately 6 is recommended.

ACKNOWLEDGEMENTS

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Alpines in Containers

by

L.J. Metcalf

Alpines are traditionally grown outdoors in the rock garden, although in Great Britain, in particular, quite a number of people grow alpines in alpine houses, stone troughs and similar containers.

In New Zealand the alpine house is a rarity, but more people now appear to be growing alpines in pots and other containers. Possibly a considerable amount of this interest is due to the impetus given by the Canterbury Alpine Garden Society with its excellent exhibits at various shows.

This discussion will be mainly confined to growing plants in an alpine house. I first had experience with alpine houses in England when working at the nursery firm of W.E. Th. Ingwersen and Son at East Grinstead in Sussex. They had several houses in which alpines were grown in containers and they really demonstrated to me just how successful this form of cultivation could be. Of more recent years an alpine house was constructed in the Christchurch Botanic Gardens and there it was possible to indulge in the growing of native alpines in containers. In Queen's Park, Invercargill, there is also an alpine house and so it has been possible to carry on this interest.

Why grow hardy alpines in containers and under glass? Firstly, one has partial control of the growing conditions, namely watering, humidity and light. Then there is protection from unfavourable weather. Many of the plants that we like to grow in rock gardens flower during the winter or early spring when storms may damage their flowers. Under glass they are protected and flower to perfection. Also important is the fact that the plants are much easier to view. Most plants are quite small and when grown on a bench in an alpine house they are closer to eye-level and all are within easy viewing distance. It is not necessary to stoop nor scramble all over the rock garden to view them.

With many alpines and particularly some of the natives, which have been my main concern, it has been able to grow them ever so much better under glass than can be done outdoors. Specimen plants can also be grown to perfection, and especially with some of the *Celmisia* spp. and scree plants it has been possible to manage them very well in an alpine house, whereas outdoors they are often short-lived or very difficult to grow.

The partial control over climatic conditions is, to me, one of the most important factors. As is well known many alpines are covered by snow for 3-4 months every winter and there they are kept dry and at a fairly even, cool temperature. Some are quite adaptable and will grow very well under most garden conditions, but others do not like those winter conditions where rain and grey skies, alternate with frosts, or rather mild, sunny days. They either succumb to the wet conditions or, because their growing and resting periods are upset, they may not grow well and possibly not flower at all.

The importance of this was brought home to me several years ago with one of Christchurch's wet winters, which was very wet over its latter part. That winter, for the first time, I was able to have a Nova-roof cover placed over the holding frame for the alpine house, where many of the native plants are held for growing-on. For that wet part of the winter it was possible to keep certain plants, in particular, dry. Paradoxically, it was then necessary to make fairly frequent checks to ensure that none of the plants suffered from drought. The result, and I believe that it can be almost wholly attributed to the overhead cover, was that many plants were in much better condition at the end of the winter, and some which had not previously flowered, actually flowered that spring.

A surprising number of plants can be grown in quite a small house. It should be sited in an open situation with as much sun as possible and good air movement. The house should have maximum ventilation, preferrably with doors at both ends, good roof vents and side-wall vents. It may need some shading during the summer, but throughout the year attention must be paid to ventilation. During the summer, the house needs to be regularly damped-down in order to maintain the correct humidity and to replace the alpine dews and mists. One point to watch when growing plants under glass is that they are not made too soft and allowed to grow out of character.

In conjunction with the alpine house there should be alpine frames. Even without an alpine house and by just growing plants in frames it is amazing what can be done. In the Christchurch Botanic Gardens there are two types of frame, the conventional frame with glazed sashes which faces to the sun. The other is an open plunging frame on the south side of a wall so that it has maximum shade. This particular frame is covered during the winter with Nova-roof some 1.5-1.75m above the plants. It is quite airy and the roof is removed during early September. The sashes on the other frameare removed in late spring and replaced in late autumn. Both are very successful for growing a wide range of alpines.

Shade houses using laths or some form of shade cloth can be useful, but in my experience somewhat limited as only certain plants will tolerate the continual overhead shade and dampness, especially during winter. Woodland plants are more amenable to such conditions. I mainly use the shade house for the acclimatisation of plants after a collecting trip.

However, a very light and airy shade house, with minimum shading, could be quite useful for growing certain small shrubs and other plants. Some of the dwarf *Rhododendron* spp., dwarf conifers, primulas and so on would happily grow under such conditions.

For containers I still prefer clay pots, but as they are becoming more difficult to obtain plastic pots are being used more and more. The plastic can be perfectly satisfactory, but a well grown pan of *Saxifraga* spp., for example, looks much better in an earthenware container. When using plastic containers the mixture needs to be much freer draining.

Many alpines, and that includes bulbs, will grow perfectly well in a standard potting mix or one with some stone chips added to make it freer. For many of the native plants, in particular, I use a special mixture. I prefer it to be free-draining and yet nice and spongy so that it has good moisture retention.

The mixture I use is:-

Loam	4 parts by bulk
Peat	5 parts by bulk
Sand	2 parts by bulk
10mm Stone, Chips or Coke Breeze	- 4 parts by bulk
Shredded Sphaghum Moss	- 5 parts by bulk

Fertiliser in the form of Osmocote can be added and depending upon the plants to be grown, some lime.

I also used this mix for plants collected on field trips, except that no lime or fertiliser is added. Usually, such plants are fairly closely planted in ursery trays and then placed in the shade house until they become established. Only the larger ones or specials such as orchids are potted straight away. With such a mix they soon produce a good root system and they can then be potted individually or planted out.

Some scree plants are quite easy to grow, but others are more difficult and for them I use a special mixture. I have adopted what is known as a 3-stage potting technique. In the bottom of the pot is placed some of the potting mix described above, but with some extra sand added to make it nice and gritty. Into that the long, fibrous roots of the scree plants are placed. There are the roots which are normally found in the fine material in the bottom layers of the scree. Then build up the middle layer in the pot using the following mix:

Sand	1 part by bulk
10mm Stone Chips	1½ parts by bulk
Quarry Mix	1 part by bulk
Peat	1 part by bulk

Quarry mix is a mixture of crushed stones mainly ranging in sixe from 15-30mm.

The pot is then topped off with a 50/50 mixture of 10mm stone chips and quarry mix. With plants potted in this manner, summer watering has to be carefully watched so that the pots do not dry out and similarly in winter they have to be kept dry, but not too dry. With this method I have grown some scree plants most successfully.

Many plants grown in containers are improved with a bit of "window dressing". The usual method is to surface the pot with 10mm stone chips. Others such as *Saxifraga*, *Raoulia* and *Draba* spp. can be improved by placing one or two small rocks closely around the plant so that it grows onto them. The chips do have a mulching effect but they are not essential and of course if everything is surfaced with them the effect can be very monotonous.

Growing alpines in containers can be fun and very rewarding and in conclusion all that remains is for more people to try growing them in containers and to experience the pleasures of an alpine house.

The Propagation by Cuttings of Three Indigenous Montane Shrub Species

by

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ABSTRACT

Cuttings of *Olearia avicenniaefolia*, *Cassinia fulvida* and *Hebe odora* were collected in Spring, Summer, Autumn and Winter.

The effect of rooting hormone, wounding and bottom-heat on root growth of the cuttings was compared using a Rooting Index. Wounding combined with hormone treatment produced the highest Rooting Index. Wounding and hormone application individually produced significant increases in the Rooting Index for *O. avicenniaefolia*. For *C. fulvida* and *H. odora* wounding alone gave the greatest increase in the Rooting Index. These results were only significant for cuttings collected in winter and autumn.

Bottom-heat either had no effect or was deleterious.

INTRODUCTION

The vegetation of riparian zones is particularly important for stabilising channels conveying flood waters (O'Connor, 1979). Native species are used increasingly in revegetation work where long-term stability is important and/or in areas to which the public have access (Holgate, 1976).

Work at the Tussock Grasslands & Mountain Lands Institute (T.G.M.L.I.) has shown that native species will survive in moderately harsh environments but that suitable propagation techniques for seeds and cuttings need to be determined for each species. Although considerable research has been and is being done on propagation methods for natives in general (Anon, 1979; Badger, Cath & Ledgard, 1979; Cath, 1972; Dakin, 1974; Dakin & Mearns, 1975), there have been few attempts to test shrub species suitable for riparian revegetation.

This paper reports the results of trials which tested different methods of inducing roots to grow on cuttings of three native shrub species which had shown promise in experimental revegetation of riparian zones of the Kowai and Porter rivers. The species selected were *Olearia avicenniaefolia* (Raoul) Hook.f., *Cassinia fulvida* Hook.f., and *Hebe odora* (Hook.f.). Cuttings were collected at four different times of the year (Table 1).

MATERIALS AND METHODS

1. Collection of Cuttings

Cuttings were collected from mature plants at inland Canterbury locations where riparian revegetation experiments were taking place. *O. avicenniaefolia* cuttings were collected from the Porter river catchment, *H. odora* from the Kowai river catchment and *C. fulvida* from the Craigieburn stream catchment. For each species, cuttings were taken from 10-15 closely placed mature plants which could provide sufficient material for the trial without serious effects on their health and vigour. All cuttings for the season were collected on the same day (Table 1) and the same plants were used on each of the four collection dates. Most cuttings were tip cuttings, approximately 10-15cm long, at the semi-hardwood or hardwood stage.

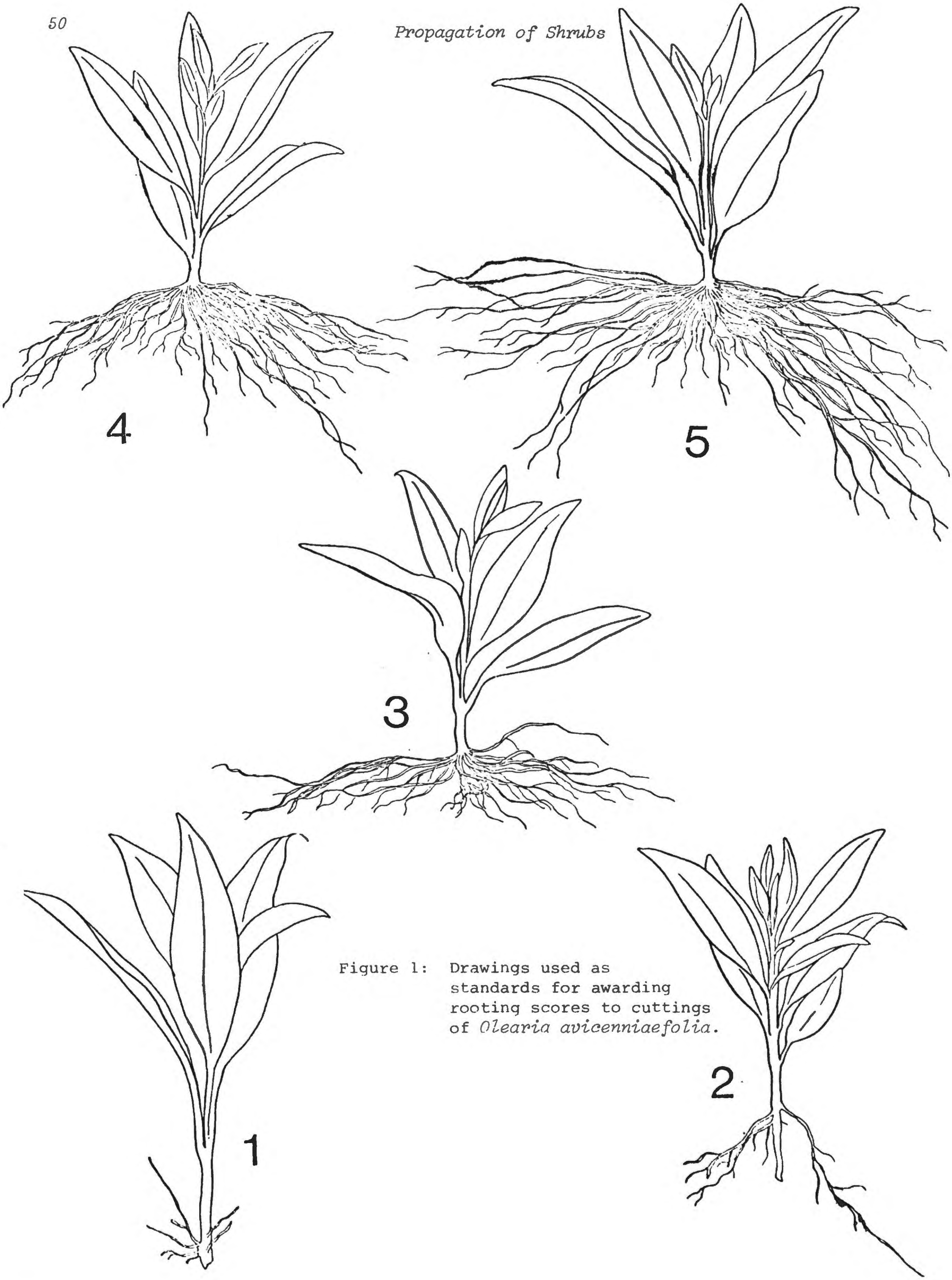

Figure 1: Drawings used as standards for awarding rooting scores to cuttings of *Olearia avicenniaefolia*.

2. Cultivation

The cuttings were transported to Linoln on the day of collection, stored over-night in a cooler and set out in propagation trays in a greenhouse at T.G.M.L.I. the following day. The rooting medium was composed of 50% Southland peat and 50% manufactured coarse grade river sand. The peat was treated with methyl bromide whereas the sand was clean but unsterilized. The mix had a pH of 3.8 and a water holding capacity of 55.2% when fresh. The trays were watered by an automatic mist system operated by an electronic leaf. To guard against fungal attack the cuttings were sprayed every 10-14 days with Thiram fungicide.

3. Treatments

The following variables were tested:-

(i) Dates of collections. One collection was made in each of the four seasons, (Table 1).

TABLE 1: DATES OF PROCESSING CUTTINGS

Season	Date Collected	Date Set (1)
Winter 1979	28 July	30 July
Spring 1979	2 November	3 November
Summer 1979-80	14 January	15 January
Autumn 1980	23 March	24 March

Date Assessed (2)	No. of days from (1) - (2)
8 November	102
9 February	107
14 April	90
18 June	87

(ii) Cutting preparation

a) Wounding: Cuttings were wounded by removing a thin slice of bark for about 2.5 cm from the base with a scalpel. The wound exposed the cambium without cutting deeply into wood.

b) Hormone: The moistened end of the cutting was dipped into "Seradix" No. 2 root-forming hormone powder (0.3% beta indolebutyric acid active ingredient). Excess powder was shaken off.

c) Wounding & Hormone: Where cuttings receive both treatments, they were wounded first as this is reported to result in a maximum response in other species (Hartmann and Kester, 1975).

(iii) Bottom-Heat

Bottom-heat was applied by a heating cable looped through the growing medium. Temperature was regulated by a control unit coupled to a capillary thermostat to give a mean bottom-heat, bed-temperature of approximately 23°C. Bed-temperatures with and without bottom-heat were monitored continuously with a three-pen thermograph.

4. Trail Layout

Cuttings from each collection date were laid out into two blocks, each composed of two main plot treatments (bottom-heat and no bottom-heat). Within each main plot treatment were two sub-plots each containing 12 treatments of 3 species x 2 hormone treatments x 2 wounding treatments. The trial for each cutting collection date contained 10 cuttings/treatment/replication/species (320 cuttings/species/collection).

5. Lifting and Grading Cuttings

After about three months (Table 1), which earlier work at T.G.M.L.I. had shown to be sufficient for the development of adequate root systems on these species, the cuttings were carefully lifted with a spatula and examined. Root length, the length of the stem over which roots were sprouting, and the distribution of roots around the stem were measured. We also recorded the general health and vigour of the shoots, root dieback and rot, and the presence of disease organisms and flowering stems.

A general score was then assigned to each cutting on a scale from 0-5 summarising the growth, vigour and general health of the root system. The scoring technique was designed to cover the range of rooting potentials of the species and was standardized by a set of line drawings (Fig. 1) and photographs.

The scoring system was as follows for each species (Fig. 1 shows that for *Olearia*).

0 - No roots initiated.
1 - Poor - few small roots, unevenly distributed.
2 - Below average - moderate number of

small roots or smaller number of longer roots. More evenly distributed.

3 - Average - moderate number of roots of average length. Fairly even distribution of roots around stem.

4 - Above average - plentiful number of roots of good length with an even distribution around the stem.

5 - Excellent - abundant long roots. Excellent root distribution around stem.

The effects of the treatments were compared by combining the mean rooting score with the number of cuttings rooted and expressing it as a "Rooting Index".

$$\text{Rooting Index} = \frac{\text{Number of cuttings rooted}}{\text{Total number of cuttings}} \times \text{rooting scores.}$$

These Rooting Indices were subjected to analysis of variance using the programme Crypto Teddybear. (J.B. Wilson, Version 79.)

RESULTS AND DISCUSSION

1. Use of bottom-heat

Bottom-heat did not improve the Rooting Index in any trial and significantly reduced it in the winter trial with *H. odora* (Table 2).

TABLE 2: Mean Rooting Index for cuttings with and without bottom-heat.

	Bottom-heat	No bottom-heat	S.E. of difference
		Olearia avicenniaefolia	
Winter	10.83	12.63	3.306
Spring	3.93	4.59	2.598
Summer	0.86	0.51	0.323
Autumn	1.03	2.54	0.690
		Cassinia fulvida	
Winter	5.23	7.16	1.347
Spring	0.55	0.03	0.222
Summer	0.09	0.00	0.048
Autumn	0.60	1.10	0.449
		Hebe odora	
Winter	2.92	7.01	1.290*
Spring	0.00	0.00	-
Summer	0.02	0.03	0.021
Autumn	0.00	0.00	-

N.B. * indicates significant differences at 5% level.

In addition, all three species cuttings from the winter collection showed an increase in the incidence of root rot and root die-back in the bottom-heat treatment (Table 3).

TABLE 3: Number of cuttings from the winter collection with rot or die back.

	Total No. of cuttings rooted	Percentage with root rot
O. avicenniaefolia		
No bottom-heat	93	9.7
Bottom-heat	87	70.1
C. fulvida		
No bottom-heat	68	16.2
Bottom-heat	54	57.4
H. odora		
No bottom-heat	59	11.9
Bottom-heat	39	79.5

The effect of bottom-heat on root formation in cuttings is very variable. Some workers have demonstrated a positive effect (Wells, 1958; Henrard, 1962). Others report that bottom-heat is generally unnecessary (Vekhov & Iljin, 1934). Nelson (1966) tested plants from 88 taxa and found that bottom-heat was beneficial in 64 and deleterious in 14.

Out results show that there is no benefit from bottom-heat for the species which we used.

2. Collection dates and rooting success

For all three species, the number of cuttings that rooted was greatest in the winter collection. Only a small number of cuttings of *O. avicenniaefolia* and *C. fulvida* collected in spring and autumn and even fewer from the summer collection, rooted successfully. None of the *H. odora* cuttings collected in spring and autumn rooted and only four rooted from the summer collection (Table 4).

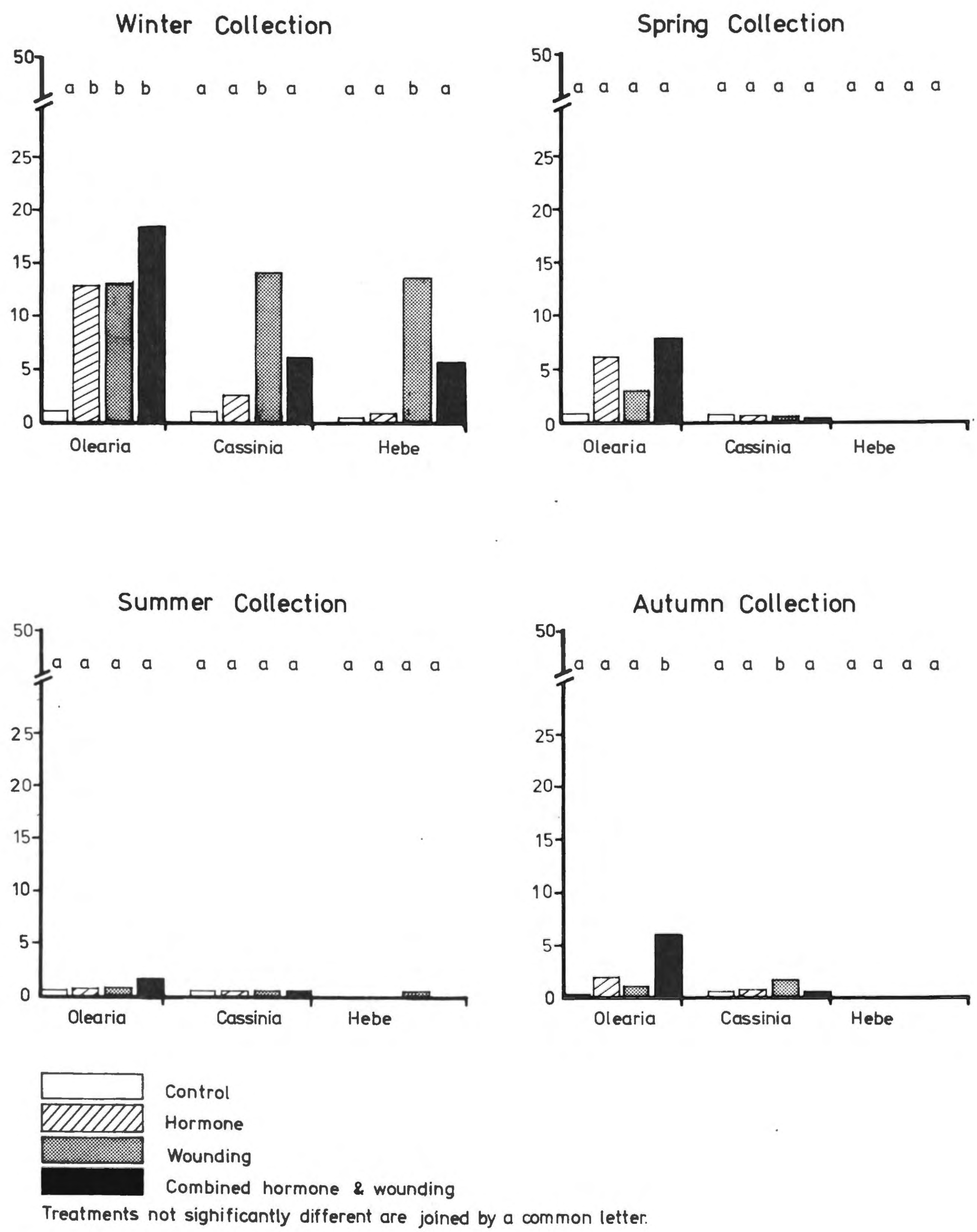

Figure 2: Rooting indices for treatments at each collection date.

TABLE 4: Total number of cuttings that rooted at each collection date.

	Olearia	Cassinia	Hebe
Winter	180 (56%)	122 (38%)	98 (31%)
Spring	75 (23%)	13 (4%)	0
Summer	35 (11%)	4 (1%)	4 (1%)
Autumn	74 (23%)	41 (13%)	0

Other workers have found that the optimum date for collecting cuttings varies with the species. Hulme (1979) suggested that cuttings of alpine species taken during April and May (October and November in the Southern Hemisphere) gave the best results. Dakin & Mearns (1975) found that rimu cuttings collected in September and March rooted most successfully, Cath (1972) found that mountain beech cuttings collected in October rooted better than those collected in September and November, and Miller (1976), in his work on conifers, found July to be a better month than June or August. Bodger et al. (1979) recommended March for the collection of *Hebe* spp. and for *Cassinia vauvilliersii*. Cuttings collected between late January through to early May gave an average strike of around 80%.

All three of the species we tested showed that collection at the end of July, the winter period of growth dormancy, was the most successful. Collection at other dates gave very poor results. Even the winter success rates were not high and a number of factors may have contributed to this.

a) Age of stock plants

Cuttings from younger stock plants or those containing some juvenile tissue generally root more readily than those from older plants (Rumbal, 1974). But the most suitable stock plants in the revegetation areas were large mature shrubs. The mature nature of the wood may have contributed to the success of the wounding treatment.

b) Fungal infection

For the autumn collection there were indications of fungal attack. *Fusarium* spp. were recorded from all three species and *Rhizoctonia solani* from *H. odora*. As the collection date (Table 1) for one period overlapped the assessment date of the preceeding period, the glasshouse could not be sterilized between collections. This may have led to a build-up of disease organisms in the permanent structures of the glasshouse during the study period.

c) Nutrition

Platt (1979) has suggested that a major problem with collecting cuttings from the wild is that plants which appear healthy can be suffering from chronic mineral deficiency. Cuttings removed from such plants show poor rooting ability. He suggests that if stock plants are established at a nursery site with adequate nutrition then rooting success can be much improved.

3. Hormone and Wounding treatments

In our experiments, the response of *O. avicenniaefolia* to the treatments was different from that of the other two species.

a) *O. avicenniaefolia*

For cuttings collected in winter in the Rooting Index for the hormone, wounding and combined treatment was in each case significantly better than the control ($p = 0.05$) (Fig. 2). For the autumn collection, the Rooting Index for the combined treatment was significantly better ($p = 0.01$) than the wounding, hormone or control treatments. For cuttings collected in spring and summer no treatments differed from the control.

In winter cuttings, woundings and hormone independently promoted rooting.

The Rooting Index for the combined treatment is higher than for the wounding or hormone treatments for all collection dates and significantly so in autumn ($p = 0.05$).

b) *C. fulvida* and *H. odora*

Wounding was significantly better than the control for both species, but hormone and combined treatments showed no improvement over control. For *C. fulvida* the result was significant in the autumn ($p = 0.01$) and winter ($p = 0.05$)

collections, while for *H. odora* it was significant only in the winter collection (p = 0.05) (Fig. 2).

Wounding of species is generally considered to improve rooting (Wells, 1952; Howard, 1973; Edwards, 1978). At the optimum date for collection, all three of our species showed significantly improved rooting after wounding. For *C. fulvida* and *H. odora* wounding treatment gave the only significant result. As previously suggested, the mature age of the stock plants may have contributed to this.

It is now generally accepted and experimentally confirmed that hormones of the auxin type, such as indole acetic acid (I.A.A.) and indole butyric acid (I.B.A.) are necessary for the initiation of adventitious roots on stems (Gautheret, 1969). This has resulted in the wide application of synthetic auxin hormones, "rooting hormones", in modern horticulture for stimulating cuttings to root (Howard, 1974).

But rooting hormones do not always improve rooting. Wells (1955) and Witcomb (1978) both recommend dipping cuttings in a talc preparation of rooting hormone. Prockter (1976) does not advocate this as a general practice although he concedes that rooting hormones are of value for cuttings which otherwise will root only with difficulty.

For New Zealand native species, Dakin (1974) and Dakin & Mearns (1975) found that the application of I.B.A. to cuttings of rimu (*Dacrydium cupressinum*) improved both the root spread and the number of roots formed. Cath (1972) also found that I.B.A. in talc gave better results for cuttings of mountain beech (*Nothofagus solandri* var. *cliffortioides*).

In our experiments, only one species, *O. avicenniaefolia* showed a significant response to hormone alone and this was only in the winter collection.

This species also showed a significant response to the combined wounding and hormone treatment in the winter and autumn collections. For the autumn collection, the combined treatment gave the only significant response. A possible explanation for this is that wounding facilitates the uptake of the hormone. Edwards (1978), Miller (1976), Nahlawi (1970) and Wells (1962), have all found that wounded cuttings have a greater capacity for the uptake of applied hormones.

ACKNOWLEDGEMENTS

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Upland Vegetation in Bhutan—Extracts from a Field Diary

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INTRODUCTION

The Kingdom of Bhutan situated between India and Tibet in the eastern Himalayan region, is only about one third of the size of the South Island of New Zealand, but in this small area there is great diversity of vegetation formation, and a very large number of plant species, possibly in excess of 4,000. Although the country lies approximately between 26° and 28° north latitude, which is equivalent to the Brisbane area in the southern hemisphere, the altitudinal variation from about 250 metres above sea level in southern Bhutan to 7500 metres in the north, means that the vegetation changes from sub-tropical through to alpine herbfield.

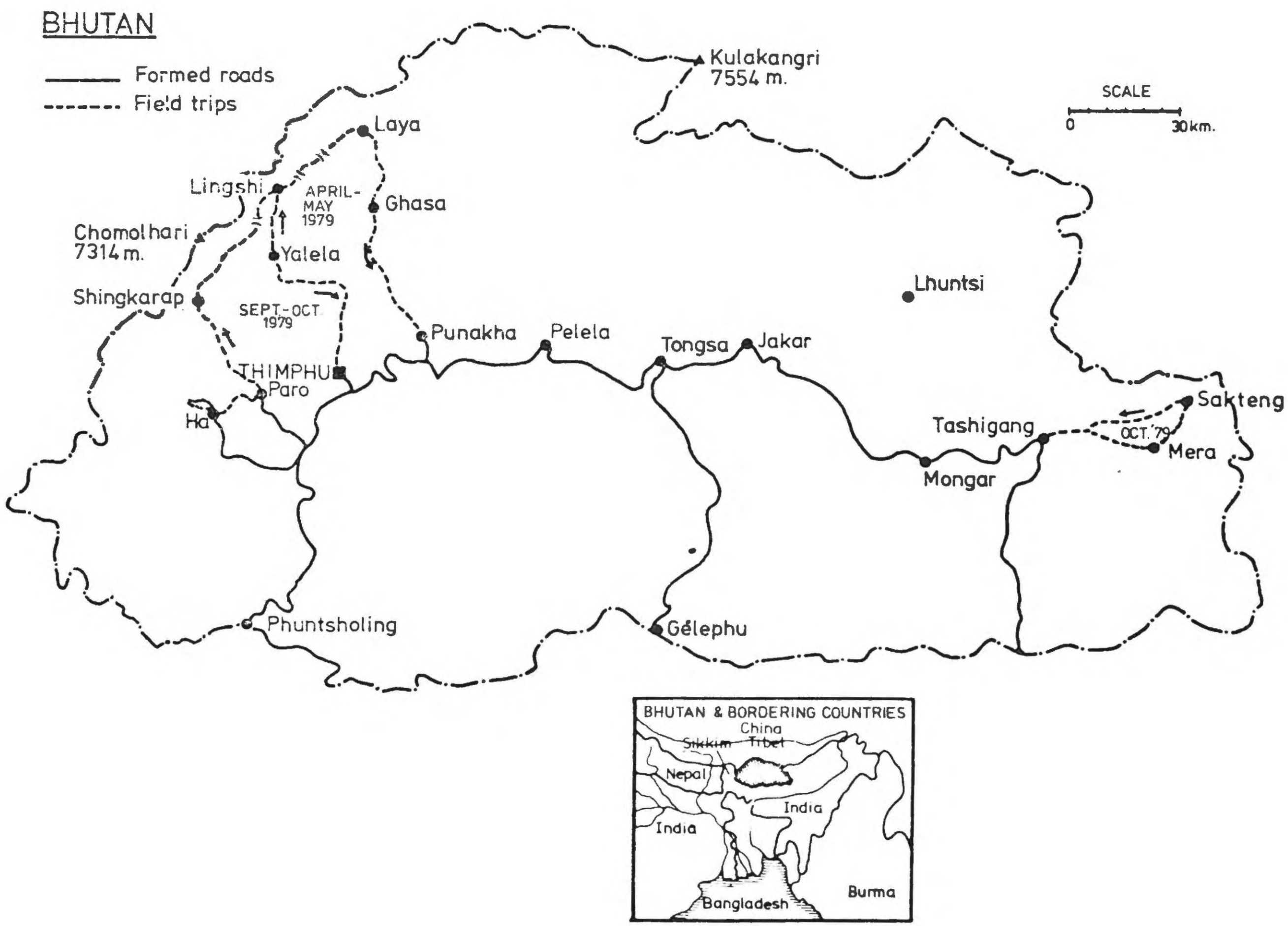
Many people travel to Nepal and Sikkim to trek and to admire the vegetation, particularly in the rhododendron season. By comparison few tourists enter Bhutan, for a variety of reasons but principally perhaps because the Government had the good sense to realise the harm that could come from a too rapid and inadequately planned development of the tourist industry. Nor has it been easy for individuals to obtain permission to enter for scientific study and exploration of the vegetation, although of course names like William Griffith (1838), R.E. Cooper (1914 and 1915) and Ludlow and Sheriff (several expeditions from 1933-49) stand out in connection with notable plant explorations of Bhutan.

Because of this situation it is understandable that I did feel especially privileged when in the spring and autumn of 1979 I was able to visit some of the more remote alpine areas of Bhutan in the course of a consultancy with the Food and Agriculture Organisation. My terms of reference, and for that matter my special interests, were pasture and pasture development related, and I feel sure that much was missed in the botanical and horticultural field. For example, absence during most of the monsoon seasons meant that many species were not seen in flower, nor were they collected.

In late May and early June the countryside was extremely dry and the people were being exhorted by the monks to take part in special prayers and processions which would induce the onset of the monsoon rains. Alpine pastures were close grazed, brown and lifeless and it seemed doubtful if they would recover sufficiently to carry the yaks through the summer, quite apart from the remainder of the year.

In September the contrast was extreme. In the terraced valleys below about 2400 metres altitude, white rice and red rice nearing harvest made patchwork quilt patterns in the fields, and red chillies adorned the wood-shingled roofs of the houses. In the alpine pastures growth and colour abounded, and plants had appeared that had given no hint of existence four months before.

During visits to the field areas, travel was by mule or pony, and it was not often practicable to stop and dismount to take notes and collect botanical specimens. Specimens were mainly collected near campsites or during short walks downhill from the passes. Tape recorded commentaries made while still on horseback seemed to be the most practical way of noting species and other vegetation detail, en route. Taped records were then transcribed into note books at the first opportunity, usually in camp the same night. Extracts from such a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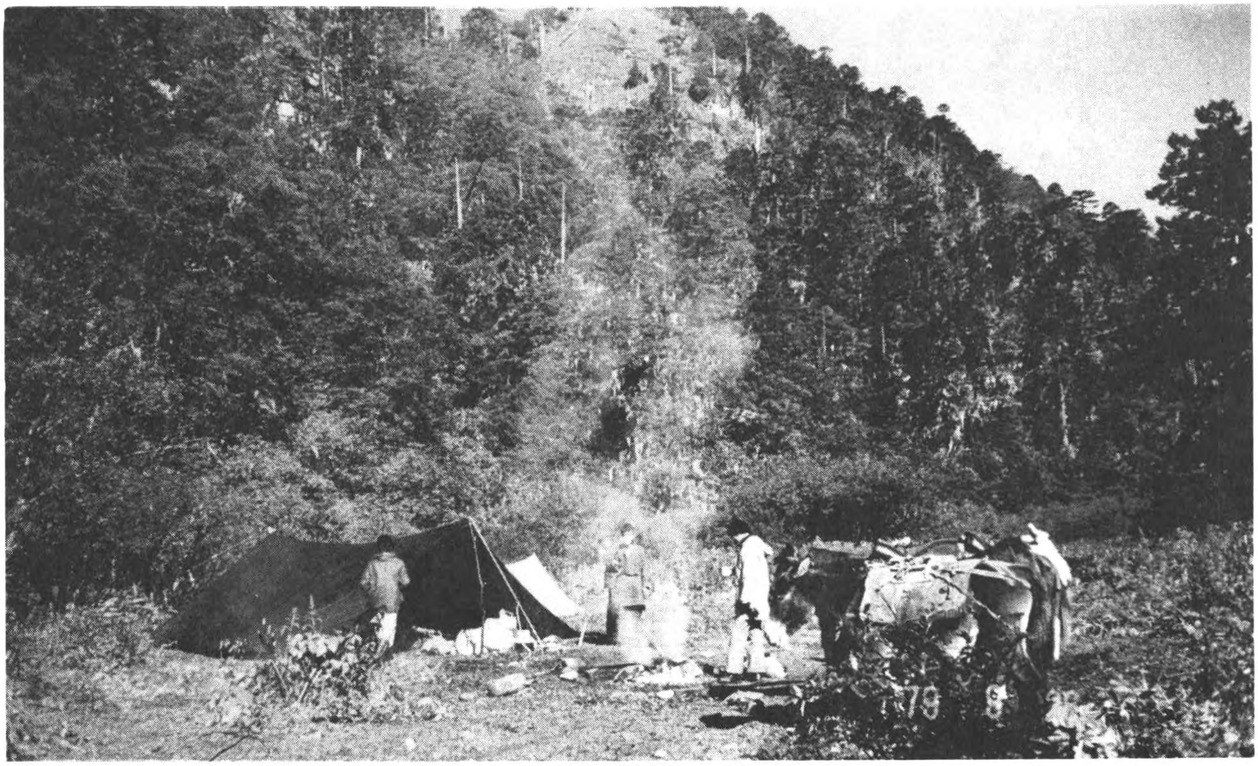

Figure 1: Campsite at 3570 metres altitude in a clearing in Juniper forest. Wild parsnips and tall *Sanguisorba* form the dominant cover in the clearing.

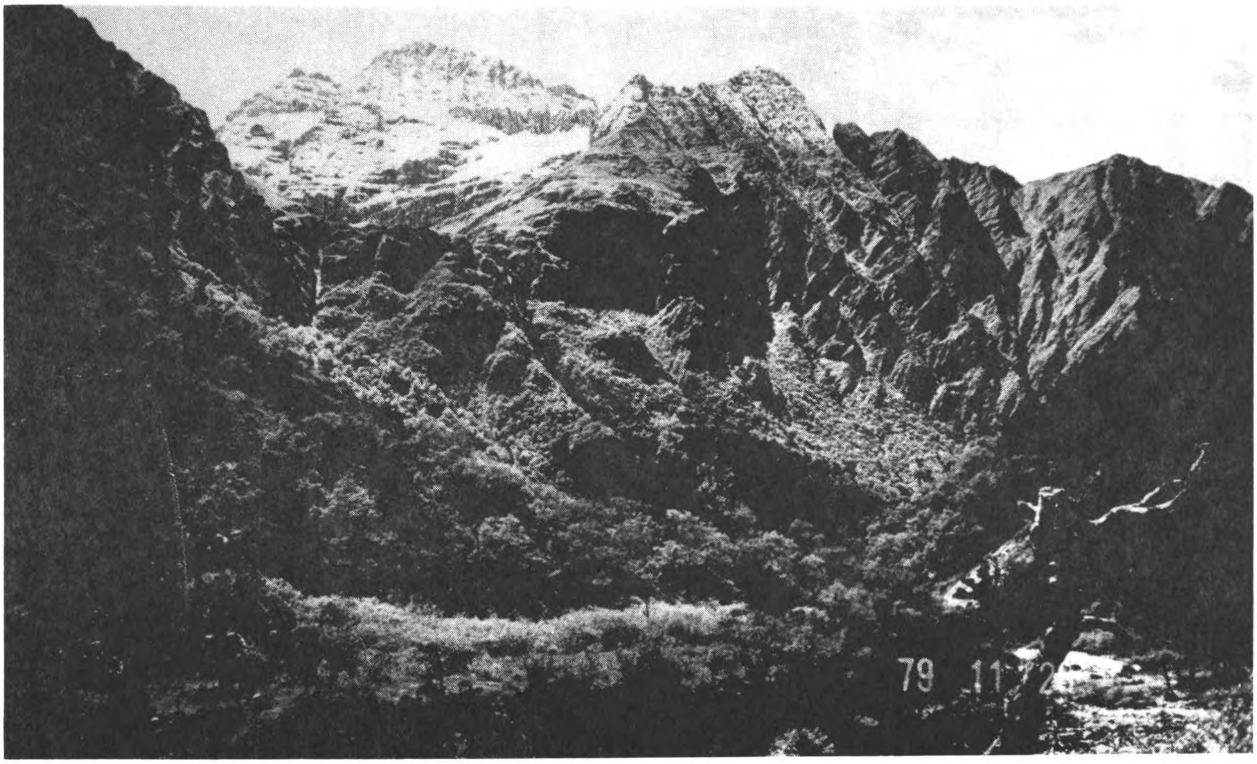

Figure 2: Steep, north-east facing mountain slopes in the 3700-5200 metre range, with birch forest on lower slopes running out to alpine grass/shrubland.

taped record covering in diary form a few days journey from Paro to Lingshi in north west Bhutan are presented here, in essence much as they were recorded. They give an impression of the variation in vegetation with changes in altitude, and the contrasts between spring and autumn in this part of the Himalayas.

FIELD DIARY RECORD

"Thursday, 27 September 1979

We started from the overnight camp at about 2680 m (8800 feet) at 7.30 a.m. There are now five people, with seven "horses", three for riding and four pack. At first we travel through forest with a fairly thick undergrowth of ferns, and a wide variety of shrubs. Light overnight rain has now stopped but there is fresh snow on the tops at about 4300 metres, and mist is hanging about the hills. In small stone-edged fields along the valley at 2700 m, there are crops which appear to be field peas with a mixture of blue and white flowers. Common along the wayside are daisy type flowers, an Aster of some kind rather like the Michaelmas daisy, a ragwort-like *Senecio*, and many columbines and yellow flowered *Potentillas*. At 2900 metres there is the first *Piptanthus nepalensis*, and the track side is well lined with *Pieris*. *Piptanthus*, a tall bushy legume has a place somewhat like broom in New Zealand. Its yellow flowers were prominent in April and early May at altitudes of up to 3600 metres or more. It is reputed to be unpalatable, and is possible poisonous to livestock, and consequently is a useful pioneer on some slipped areas in the forest. At these middle altitudes it can also be an invader of open native pastures. *Pieris* and *Daphne* species cover much the same altitude range as the *Piptanthus*, and the *Daphne* flower in particular was widespread through the forest in the spring. Traditionally the *Daphne* bark was used for paper making - perhaps some species more than others. The poplars along the river bank look like *P. yunnanensis*. At 3050 metres (10,000 feet) in a clearing by stone hut we stop for lunch at a place called Shingkarap. The vegetation has been eaten out by passing horses like ours; docks and elderberries abound. Heading on, we see red currants with fruit at 3300 metres; on open south west facing slopes above this, silver birch is predominant. On the open spaces of the valley floor, close to the stream, tall *Calamagrostis* grass clumps predominate along with a rhubarb type plant, but I understand that the latter is not eaten by locals. Most of the way up the valley there has been small type of daisy, probably an Aster, standing 15-20 cm tall. There is good colour in the forest from maples or sycamores, yellow today but sunshine would give a golden hue. Camp for the night is made in a clearing 3570 metres altitude where most of the cover seems to be the tall Parsnip, *Heracleum*. There is much of the "burnett", *Sanguisorba diandra* here too.

Friday, 28 September

There was heavy overnight rain, then frost and we had to wait until the sun came down to the campsite at 8.15 before the ice thawed on the tents, and we could pack them away. It is a beautiful, clear, sunny day with a lovely view of the sacred mountain Chomolhari (7314 metres) in the distance. We are in a clearing, with a mixture of Juniper and silver birch the main species about us. The main reddish colour in the hillsides appears to be from a *Sorbus* of some kind.
As we go along the valley this morning the forest margin grasses are *Trisetum*, *Agrostis*, fine fescues and a few drooping headed *Agropyrons*. At 3700 metres, we are almost out of the thick birch. Along the lower edge of the forest on the south east facing there is much willow. There is still some *Piptanthus* and much of the wild parsnip which gives the country most of the colour - the yellow anyway. There are hosts of wild flowers - so many that it is difficult for me to describe. There are large yellow *Senecios*, and some small ones. The anemones seem to be over, but there are some blue, trumpet like flowers, Gentians I think. There are quite thick beds of Aster mixed with brome grass and *Agropyron*. This must have been saved for winter pasture, and growth is vigorous at present. We have passed through some fir, but the dominant tree now is Juniper. There is still abundant *Sanguisorba* along the edges of the trail, and I saw a small species of *Impatiens*. We call them "Triffids" in our garden at home. I introduced some of the locals with us to

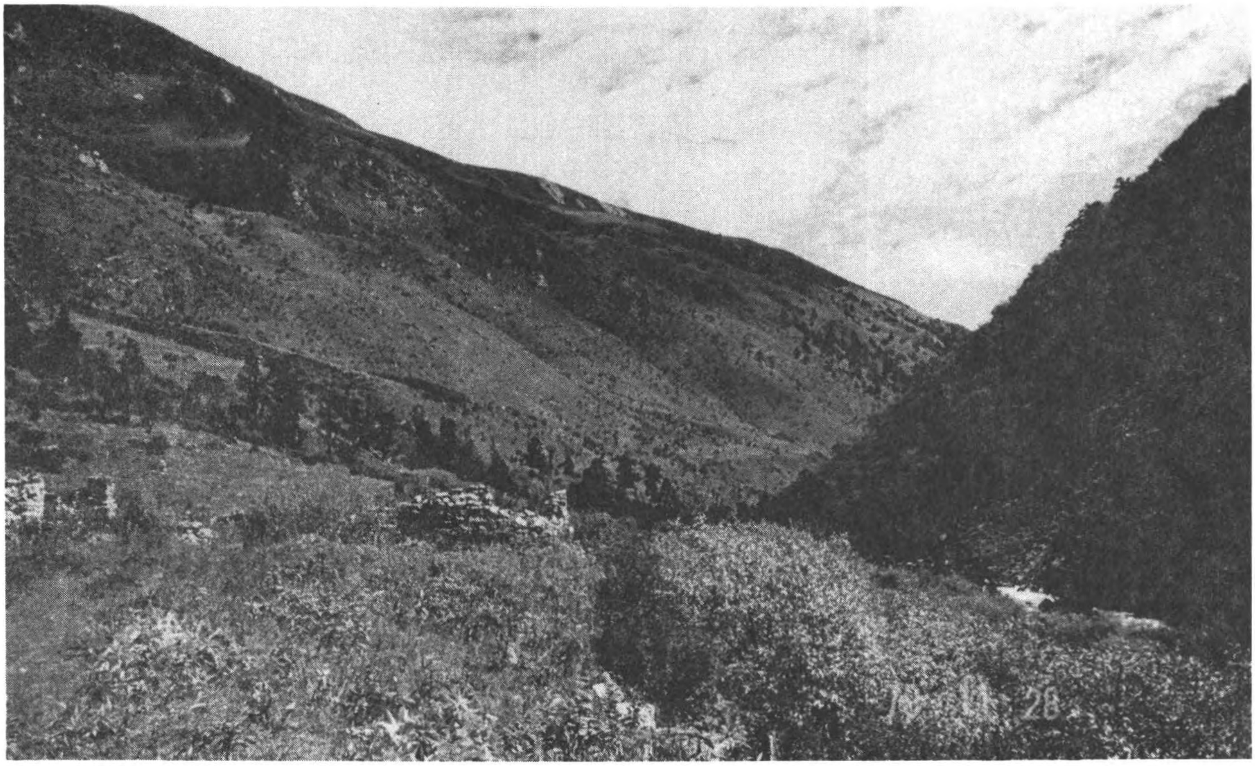

Figure 3: Warmer, westerly facing pastures in the Juniper zone at 4000-4300 metres, with birch forests dominant on the colder east facing.

Figure 4: Cold summer grazing land at 4500-5000 metres altitude. Marmots graze the rolling country in the middle distance.

the uncanny feeling of the seed capsule exploding in one's hand. At 3750 metres, larch on the valley floor is beginning to colour. Some of the brightest ground colour is coming from the brilliant red *Euphorbia*.

At 3860 metres, along the stream bank there are willows still - mainly a black willow type, with some tall, rather dock-like plants with light green leaves. There is a good mixture of grasses and other herbs, dominantly *Agrostis*, but with a high proportion of a white flowered *Anisotome*-like plant. Another little herb has a primula type leaf, light green and glabrous, and the flower head has small decumbent bells. Other grasses are *Agropyron*, some smaller fescue and *Helictotrichon*. The *Sanguisorba* the locals call 'jadum' is common, and there is still enough of the parsnip to give a good colour to the landscape. On the south facing and above the river there are scattered Junipters with the willow distribution mainly riparian. The cold north facing slopes have silver birch running high, mixed with some redder colour from *Sorbus*. These north facing slopes are very stable, well covered between the birch clumps which seem mainly to colonise the gravelly soils below cliff faces.

At 11.30 a.m. we are slightly below 4000 metres. About 200 metres above us now there are some yaks grazing on the sunny south-east facing. We can see the pass for tomorrow and also a very sharp, snow covered peak, due north, which appears to be Tsheringme Gang or Kungphu, (about 6800 metres). There are two or three stone houses here and the Juniper appears to diminish rapidly in quantity, possibly just through proximity to the houses. Amongst the wild shrubs near the houses there are tall straggly forget-me-nots, with very clinging seeds.

It is now 12.15 p.m. We have stopped for camp, at 4070 metres (13,350 feet), at a place called Jangothang, with just one house nearby. This is my highest altitude camp so far. The grasslands around here are in very good heart with growth on the hillsides about 20-25 cm tall. The predominant grass is the drooping headed *Bromus himalaicus* but there is a good variety, with several species of *Poa* and *Festuca* and at least one species each of *Agrostis*, *Trisetum*, *Helictotrichon*, *Agropyron* and *Deschampsia*. Herbs other than grasses probably provide more than 50% of cover, and there is good variety also here. Apart from most of those mentioned along the way, species include two *Cyananthus*, a variety of *Potentilla* species, *Lactuca cooperi*, several *Primulas*, *Pedicularis*, the small dock *Polygonum, viviparum* and the eidelweiss-like *Lentopodon*. The locals have an interesting name for most species of the wooly-grey, *Anaphalis* genus. They call them 'apaigutu'. I understand it means something like 'wooly headed old man'! *Anaphilis xylorhiza* is common here. The yaks are grazing down towards this area. The woman from the house says that she and her family are here for about six months of the year, but the men are at present cutting grass at higher altitude, to bring in for winter feed. She has been prevailed upon to let us have firewood for the night.

Saturday, 29 September

8.00 a.m. We leave Jangothang to go north east towards Lingshi Dzong and the Veterinary dispensary at Jambethang. We climb almost immediately. On a traverse of a due south facing slope, there is the unpalatable *Ephedra* (rather like a leafless broom) and the closely grazed *Cotoneaster* combined to give a good protective ground cover mixed with Iris, some shrub *Potentilla* and occasional dwarf rhododendron. The grasses seem to be the same as those seen yesterday except for *Stipa* which is just about to flower. (There is also some *Deyeuxia* but this appears to favour the colder north facings.) The country looks green, but there is only 5 cm of growth at most, and there will not be much here for the yaks coming down from summer grazing. Small blue and white flowering *Anemones* are quite common.

At about 4300 metres, the valley opens out to quite an extensive area with an easy rolling land form, but stony and unproductive. There is short vegetation, much as before, but more of the 'eidelweiss' plant, also the small dandelion, a high proportion of primulas (one still in flower) and a large number of a gentian species with its blue trumpet shaped flower, about 3 cm in length. Of interest here is the population of marmots - a bit like large American ground hogs. They are grey brown in colour, look to be about 70-100 cm long, inclusive of tail,

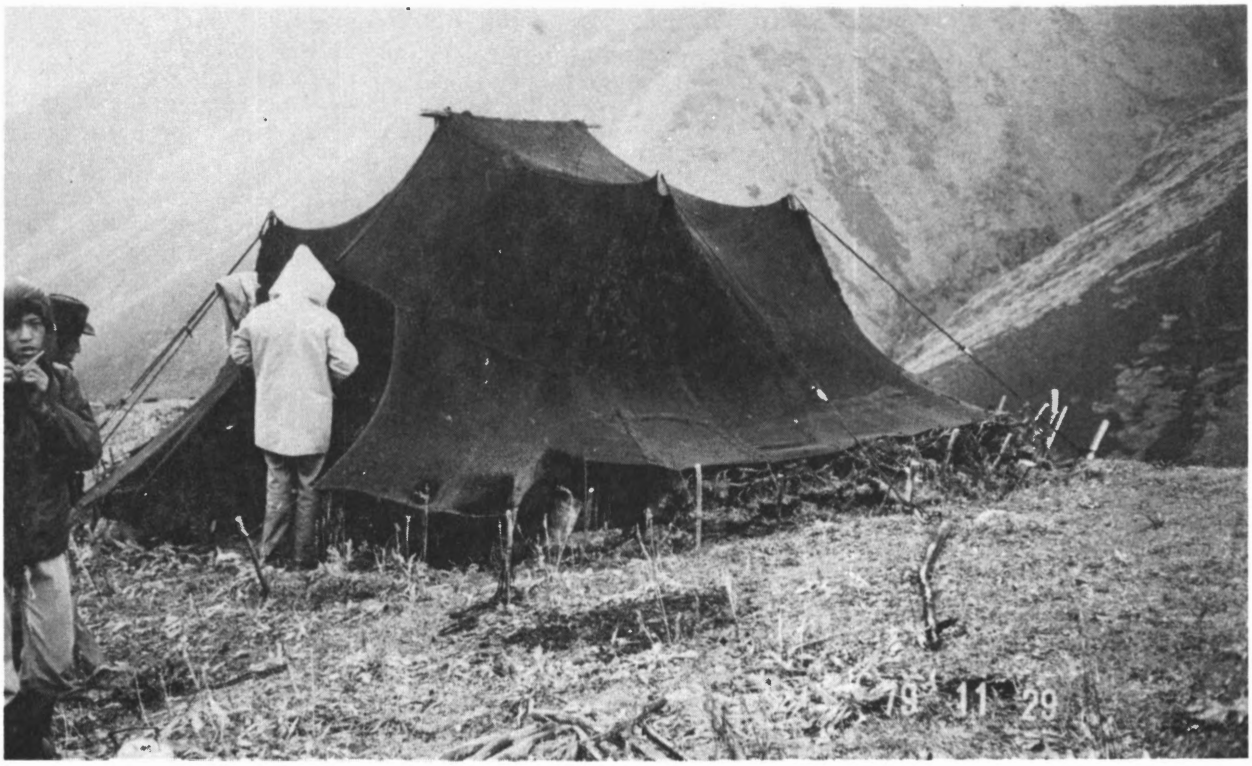

Figure 5: A Tibetan style tent of woven yak hair is used by members of the herding family as it moves with the yaks on summer grazing in north west Bhutan.

and maybe weigh about 10-12 kg. As we approach they take off with a kind of lolloping run, and disappear into their burrows.
At 9.45 a.m. we are now approaching the saddle of Ngile La. The scree is almost bare of vegetation, but there is a small *Potentilla* and some *Poa* and *Festuca* species. On the pass, at 4670 metres (15,320 feet) by my altimeter, the men are allowed a small bar of chocolate - nothing for the ponies unfortunately, but now the going is downhill and all the men walk. This gives me more chance to collect plant specimens. (From the summit of the pass down for 300 m altitude, I collected a variety of grasses and other herbs, few of which I knew at the time, but which were later identified as specimens of *Poa*, *Deyeuxia*, *Deschampsia*, *Festuca*, *Agrostis* and *Arenaria*, *Gentiana*, *Soroseris*, *Anaphalis*, *Picrorhiza*, *Eriophyton*, *Potentilla*, *Sibbaldia*, *Morina*, *Cremanthodium* and the blackberry-like plant *Rubus irritans*.)

I got left behind while collecting specimens but about halfway between the summit and Lingshi Dzong, I come down to a yak herder's tent. Our horsemen are inside, sheltering from the light rain and bargaining for some yak cheese. The tent of woven yak hair is made to a Tibetan pattern and looks a little draughty but certainly keeps the rain out. The whole family is up here with the herd, from grandmother to the babe-in-arms. As we leave the tent the barefoot young lady of the house returns with a heavy load of Juniper branches for the smokey fire. She is coy about having her photo taken.

We arrive at the Veterinary Dispensary at Jambethang at 1.00 p.m., to be greeted enthusiastically by the veterinary assistant Tsherwang Rinzen, last seen in May. The altimeter shows 3990 metres (about 13,090 feet), which gives good agreement with the last visit. Looking at the vegetation now here, I am pleased to see the tremendous contrast from the Spring. Then the ground was almost bare, and uniformly light brown. Now after the monsoon there is a wide range of species and autumn gives a tremendous amount of colour to the landscape. Tomorrow is Sunday, appropriate for a rest day, and it looks as if it will rain anyway.

Sunday, 30 September

We stay at the dispensary all day. Steady rain, falling for most of the day, but the dispensary has a small iron, drum-like stove called a 'bhukharee', mostly fed on dried yak dung. I pressed all the plant specimens collected so far, and discussed names of local native plants with Tsherwang. Apart from the *Sanguisorba* known as 'jadum', there is the grey, furry-leaved herbaceous legume known as 'losem meto', now with seed pods, but I am told that it has blue flowers. It is a *Thermopsis* species. It does not look very palatable but is apparently grazed by the yaks in winter. There were no sign of these plants in the spring but the seed was widely scattered on the almost bare ground that existed at the time.

The word 'Meto' means flower. Rhododendron generally is 'eto meto', but at the altitude here, the dwarf rhododendron which must flower very rarely is called 'mam'. 'Chungli meto' is the name for the low growing *Cyananthus* with its blue trumpet flower. They tell me it is very highly regarded, as being very good for the yaks for milk production. The small pink-flowered *Pedicularis* called 'luru' is used as a medicine.
Grasses generally, are called 'tsa'. The *Stipa* species is "gema" here, but names for the same plants may vary considerably from district to district. The large number of *Umbelliferae* all appear to be 'tonkey', and the small *Polygonum* is 'panja meto'.

Monday, 1 October

Today, according to Sangey, Bhutan goes onto "Bhutan time"; this means a half-hour advance on Indian time which will give slightly longer evenings. We visit the villages of Goin and Chebisa, have 'Soocha' (butter tea) several times, also 'bang cha' (barley brew) and a yak meat, potato and rice meal at the headman's house. Along the way the occurrence of grasses is patchy - occasionally grass is very good, but mostly it is rare. Some of the strongest grasses are the *Poas*, but I think the broad leaved *Helictotrichon* looks more promising for development. A tussocky type *Danthonia* species persists in some of the rocky situations. The wild parsnip seems to have been harvested by the people of Goin for winter feed, as it is hanging in the trees to dry. The locals call it 'Dhum-kap'.

Figure 6: A young woman from a yak herder's family returns with a heavy load of Juniper branches for the tent fireplace. The major broadleaf plant seen is *Crementhodium oblongatum* a yellow flowered composite.

Figure 7: A small herd of yaks in overnight encampment in a clearing in *Abies/Rhododendron* forest at 3,350 metres altitude.

At Jambethang, we look again at the site on the hill which had been examined in some detail in the spring. In May the estimate on the transect line was for 36% plant cover (inclusive of 10% grass), 18% moss and litter, and 44% bare. Now that the rains have come the total plant cover has increased to about 95%, but the amount of grass cover is virtually unchanged. Sedges have increased but most of the summer growth comes from *Thermopsis*, *Cyananthus*, *Anaphalis* and various *Umbelliferae*. There are about three herbaceous species and one shrubby species of *Potentilla*, and abundant *Cotoneaster*. The colours are attractive to look at. The plants may not be so attractive to the yaks, but by spring almost everything will have been eaten.

Tomorrow we need to mark out a possible trial area of five acres, and will also talk to most of the locals about their problems in the region. On Wednesday we leave on the downhill run as it were, back to Thimphu, although the first stage involves a traverse of Yale La (4750 metres). I saw it under snow and in different company in April-May, but expect that it will be less intimidating this time. We anticipate taking four days to reach Thimphu, making eleven days for the round trip."

CONCLUSION

The journey back to Thimphu, main town and administrative centre of Bhutan was, in fact, accomplished in three days. On the second day of the homeward journey, one pony showed symptoms of poisoning and became unfit, and unsafe to ride on the narrow mountain track, so we pushed two stages into one in order to reach veterinary help a day earlier. By that time the pony had recovered anyway. Later in October, in company with another New Zealander a visit was made to alpine pastures in Eastern Bhutan where both sheep and yak were grazed. Here there was contrast again, the people were very different from those in the west, the pastures and the livestock were different, so altogether that must become a different story.

ACKNOWLEDGEMENTS

To Andrew Grierson and David Long, Herbarium, Royal Botanic Gardens, Edinburgh, and Dr Thomas Cope, Herbarium, Royal Botanic Gardens, Kew, for the identification of many plant specimens.

Castle Hill Reserve for the Preservation of Flora and Fauna — *Ranunculus paucifolius*

by

L.W. McCaskill

8a Kauri Street, Riccarton, Christchurch.

This plant reported by J.D. Enys in 1879 is confined to an area of six hectares of limestone debris in a gently-sloping basin surrounded by limestone cliffs and tors west of the homestead of Castle Hill Station at an altitude of 760m. Until 1948 it was confined to an area of 1.4 hectares and because of trampling by livestock and defoliation by sheep and hares was in danger of extinction, the number of plants being 32, (possibly a few more). There were 75 in 1940.

The plant, rarely more than ten centimetres tall, has a stout, sometimes branched rhizomatous rootstock which normally grows down slopes. From the roostock, fleshy roots up to 30 centimetres long descend vertically. Plants seem to thrive best when the tops of the rootstock are three to five centimetres below the surface. The deciduous leaves are radical, on stiff petioles, three to seven centimetres long and up to six centimetres in diameter, three-lobed with the lobes overlapping and the margins finely toothed or crenate. They are greyish-green to ashen-purple in colour, somewhat fleshy, and with some brown epidermal pits. Seedlings have tuber-like rootlets.

Flowers are produced from early October to early December. The five sepals are pale yellow and five millimetres or more long. The flower is 2.5 to five centimetres in diameter with five to eight (sometimes more) round-tipped golden petals and has a dense cluster of yellow stamens. The fruiting heads are small, globose, with few achens, the style subulate and curved. A feature (an adaption to the preferred habitat of fine debris) is a reflexing of the pedicels of the ripening fruits downwards between the leaf basin. The attached fruits are pulled or pushed into the loose, usually moist debris beneath the leaves.

In 1940, the average number of leaves of the 75 known plants was 3.5 (greatest number, seven); yet a plant in the homestead garden, at least 20 years old, had 200 leaves and another had 60. Plants with three and four leaves were fenced from hares and stock; six years later they had 20 and 23 leaves respectively. Animals obviously were the cause of this reduction in the numbers of leaves.

RESERVE

In 1948 the owners gave 5.5 hectares of freehold on the east side and surrendered 0.9 hectares from the leasehold on the west. The total of 6.4 hectares was fenced by Lincoln College students in March 1948 and declared a Reserve for the Preservation of Flora and Fauna in July 1954. (Protection was effective from the time the fence was erected.) Seeds were sown and seedlings and divisions of plants were planted on new sites thought to be suitable until by 1972 there were approximately 300 plants. These were pegged by "clumps" in October-November 1973 and the numbered pegs accurately surveyed. At present there are 175 clumps mapped. Existing policy is to sow seed in proximity to existing plants, especially those in "new" sites. It is thought that all favourable sites within the fence are now inhabited by approximately 400 plants. Seed production is small in relation to the number of flowers and germination under natural conditions is slow and low (up to ten percent after four years). Morality of seedlings is high due to surface drought and movement of debris by wind and water. At one stage it was hoped to raise plants horticulturally and transplant from pots into suitable areas in the reserve. Germination failed completely. But this year Botany Division DSIR have shown (Margaret Simpson, pers comm) that seeds germinate freely at 5^{o}-25^{o} -5^{o}. All available seed in future will be treated in this way. Hopefully there will be plenty of plants for establishing the *Ranunculus* in the hoped-for extension of the reserve on the saddle to the east.

With the exclusion of stock and hares, both native and exotic plants, especially *Poa acicularifolia*, *Hieracium pilosella*, *H. prealtum*, *H. lachenalii* and *Chrysanthemum leucanthemum*, progressively stabilised part of the loose debris and completed with the *Ranunculus*, reducing flowering and seeding and even causing complete suppression. Since about 1962 all plants have been kept free of all competing growth.

In addition to the *Ranunculus*, the following plants found in the reserve, while not confined to it, are not found outside the Castle Hill basin: *Carex opinata*, *Wahlenbergia brockiei*, *Myosotis colensoi*, *M. traversii* var.*cinarescens*.

The only detailed explanation of the probably history of *Ranunculus paucifolius* was put forward by Arnold Wall who studied the whole area over many years and the reserve area closely in 1917-18. He wrote (1920): "It is the product of drought or steppe climate which directly caused the development of its xerophytic characters... It is adapted only for life under very special and peculiar conditions, e.g. its confinement to gentle gradients and a limestone soil which conditions have been provided and preserved for it by a series of fortunate chances, in one small locality only...

Its life history may be summed up conjecturally. Originating in the very remote past during a period of drought (which was probably very long) somewhere within or not far from an extensive area of Tertiary limestone, this plant acquired marked xerophytic characters and flourished, maintaining itself with ease; and as the area on which it grew was slowly and gradually eroded (or in parts more rapidly by glaciation) it was restricted to areas continually diminishing in size and farther and farther separated from one another until it remained in only one very limited area peculiarly situated and adapted to its needs.

Here, as in its original state, it had little or no severe competition to meet and overcome, and for countless ages it has continued to exist there, surviving at least one great period of glaciation, which its habitat escaped; at least one pluvial epoch, which could not be favourable to it; and finally the various dangers resultant upon human occupation - depredations of stock and of hares and rabbits, pest and blights, and agricultural necessities and accidents, such as the plough and wax match. Thus within its own narrow nook, secure from the competition of rivals, this strange plant, relic of an earlier day and clime, is passing slowly, and it may be premitted to fancy, unreluctantly away before oure eyes in an age-long euthanasia".

Since 1940 it has been my aim to learn more about this delightful plant, to work for the deferment of its euthanasia, and to use it to assist the public, particularly young people, in finding out what conservation really means.

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Some New Cultivars of N.Z. Plants

by

L.J. Metcalf

Invercargill.

Nothofagus

Although several species are widely grown as garden plants there has been little sign of any distinct variation which would allow the selection of any cultivars. *Nothofagus fusca*, the red beech, is the most commonly grown species and it is this one which has given rise to one cultivar which is already in cultivation with the possibility of a second yet to be introduced from the wild.

Nothofagus fusca 'Bert Newman'

This is a dwarf form of *N. fusca* which was discovered by Mr A.W. Newman, a nurseryman of Gore, Southland. Mr Newman states that it was a chance discovery, and it was not until he had it in cultivation that its distinct character became apparent.

Some twelve to fifteen years ago he gathered it, along with some other wild seedlings, from the roadside in the Eglinton Valley, Fiordland. Sooner, or later these seedlings would have almost certainly been destroyed by the road grader had they not been collected by Mr Newman. Where the seedlings were gathered was in the midst of a pure stand of *N. fusca* so that this cultivar is unquestionably, of that species.

In cultivation one particular seedling failed to develop a leading growth and it was eventually realised that this particular plant was a dwarf. In time Mr Newman took some 40-50 cuttings, a reasonable percentage of which rooted, and not long afterwards the parent plant died. It is difficult to propagate from cuttings, although, no doubt, as it becomes more widespread in cultivation, propagation may become easier.

Nothofagus fusca 'Bert Newman' is a very slow growing plant and after ten years may be no more than 15cm tall by 20cm across. It has not been possible to study it in cultivation for very long, but the average annual increment would appear to be from 1 to 1.5cm.

Nothofagus fusca (Hook. f.) Oerst. cultivar 'Bert Newman' *cultivar nova*.

The foliage is typically that of juvenile *N. fusca* with the leaf blade measuring 7-13 x 6-13mm. Petioles up to 5mm long. The leaves are generally coloured red with the colour being most intense duirng the colder months of the year. In cultivation it forms a densely compacted, bun-shaped shrub. The given name is in honour of its discoverer.

Astelia

Over recent years several species of the genus *Astelia* have become popular in cultivation. They can be used for many of the purposes for which *Phormium* is used, and also for a number of purposes for which *Phormium* is not so suitable. The principal species in cultivation are *A. fragrans*, *A. nervosa* and *A. chathamica*. Other species are also in cultivation, but they tend to be localised and not yet widely grown throughout the country.

Astelia is a plant of great promise, and with some of the species showing a reasonable amount of diversity there is scope for the selection of cultivars from plants in the wild. Work has already commenced upon the production of garden-bred cultivars and it is only a matter of time before the first ones make their appearance. Meanwhile the first wild selected plants are described here for

Nothofagus fusca 'Bert Newman'
This garden-grown specimen is approximately 10 years old.

Astelia nervosa 'Alpine Ruby'

naming.

Astelia nervosa 'Alpine Ruby'

This is a most distinct form of *Astelia nervosa* and it was brought into cultivation by a Mr J.C. Gdanitz, father of Mr Kevin Gdanitz, proprietor of the Camside Nursery, Woodend, Canterbury. This *Astelia* was first discovered in the Catlins area (South East Southland), by an old bushman, sometime between 1910 and 1914. The discoverer told Mr Gdanitz, who was engaged in cutting bush at that time, of its existence on one of the higher, rocky parts of the area, and gave directions telling how to find it. Mr Gdanitz followed the directions, given to him, and found the plant just as described. He grew it in his own garden, near Kaiapoi, until about 1966 when the property was sold. His son then took the plant to his nursery and commenced propagating it. As yet Mr Gdanitz does not have a stock sufficiently large to permit its sale.

Astelia nervosa 'Apline Ruby' is, in size, shape and general characters, similar to most common forms of the species. It forms robust clumps up to 80cm tall. Leaves up to 115cm long by 3.5cm wide, stiffly arching. Upper surface of the leaf a rich claret colour with the pellicle giving a lustrous, silvery sheen. Under surface silvery-white.

Astelia nervosa Hook. f. cultivar 'Alpine Ruby' cultivar nova.

This is a magnificent plant and one which is destined to make quite an impact once it comes onto the market. On the upper surface of the leaves the brightly-coloured nerves break through the silvery-pellicle to give the leaf its intensity of colour. The silvery-white undersurface is also enlivened by the thin lines of the nerves showing through. *Astelia nervosa* 'Alpine Ruby' is a female plant and as such will have great value as a parent for hybridisation. In fact, the first batch of F_1 seedlings has already been raised from this plant. Their growth over the next few years will be eagerly watched, particularly with a view to making further crosses. To this end, other variants of *Astelia nervosa* are being collected and grown, as are one or two promising species.

The cultivar name was chosen by Mr Kevin Gdanitz.

Astelia nivicola 'Red Gem'

Astelia nivicola is found throughout the wetter mountain districts of the South Island where it grows in snow hollows, alpine meadows and amongst snow tussocks. There is a certain amount of variation with the form of the plant, but it is with the colour of the foliage that the greatest amount of variation occurs. Each district appears to have its own variations. *Astelia nivicola* 'Red Gem' was discovered by Mrs Pat Stuart, of Waipahi, on the Kaihiku Range just south of Clinton in South Otago. It was found near the summit and Mrs Stuart said that it stood out from amongst the other plants because of its colour. *Astelia nivicola* 'Red Gem' - this is a selection of the type form of the species (*A. nivicola* var. *nivicola*). It forms low, clumps from 15-18cm tall, with leaves measuring 10-20 x 1-2.5cm. The leaves as is typical with many forms of the species tend to arch rather suddenly near the base, with the terminal portion of the leaf being somewhat horizontally inclined. Particularly during the colder months of the year the upper surface of the leaf turns a distinct reddish colour which is overlaid by the silvery pellicle. The under surface is quite a strong silvery-white.

A. nivicola Ckn. ex Cheesem. cultivar 'Red Gem' cultivar nova.

This is a most attractive plant which will not only be a very fine plant for the rock garden, but grown in quantity it will make a unusual ground cover plant. It would also be useful for growing in the front of a border where it can be used to contrast with, or compliment the surrounding vegetation. The cultivar name was chosen by Mrs Stuart. This *Astelia* has been offered for sale for the first time this year, although it is not yet widely available.

The Chinese Brassicas

by

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The Chinese brassicas consist of: the Chinese cabbage complex (*Brassica campestris*, n = 10), Chinese kale (*B. oleracea*, n = 9), and Chinese mustard (*B. juncea*, an amphidiploid n = 18). Strickly speaking this species should be called brown mustard, not being of Chinese origin.

Specific names used in this paper are the ones suggested by Smith and Welch (1964), and now generally recognised. Chinese names are those used by Herklots (1972), who gives the equivalent Chinese characters which may be referred to. There may be different names, and the same character may be pronounced differently in the various Chinese languages and dialects. Common English names sometimes used for Chinese brassicas have been avoided as much as possible. Names such as celery cabbage and celery mustard have been used for different species by different authors, and only serve to increase the confusion.

The three cultivated diploid brassica species and the three amphidiploids derived from them by hybridisation are shown in the table below:

TABLE (derived from Nieuhof 1969)

European turnip and rape, and Chinese cabbage and complex:
B. campestris (n = 10)

European swedes: *B. napus* (n = 19)	Brown mustard: *B. juncea* (n = 18)
European cole crops: and Chinese kale: *B. oleracea* (n = 9)	Black mustard *B. nigra* (n = 8)

Ethiopian kales:
B. carinata (n = 17)

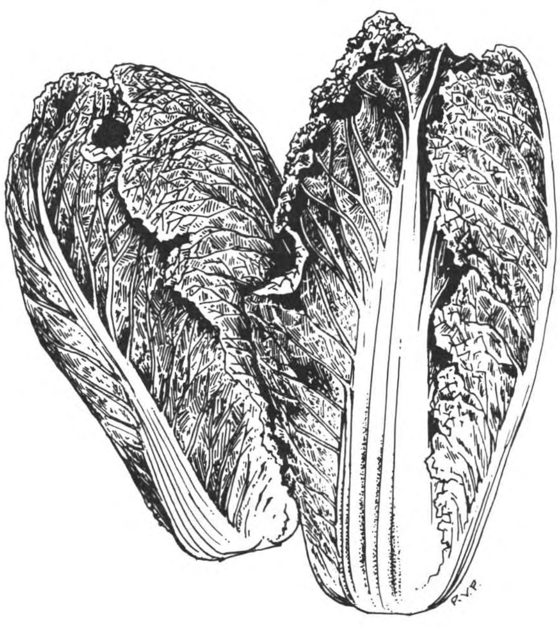
Two parallel processes of evolution of cultivars have occurred, in the East with *Brassica campestris*, and in the West with *B. oleracea*, though possibly the time scale in the East is shorter. Hui-lin Li (1969), commenting on the Ch'i-min-yao-shu (essential arts of the people), which was written by Chia Ssu-hsieh in the late 5th or early 6th centuries, notes that the principle green vegetable then cultivated in what is today Northern China was the mallow, *Malva verticillata*. He suggests that this esculent fell from favour once a method of extracting oil from seed had been evolved, and the mucilagenous texture of mallow was no longer so desirable. However, it is equally valid to speculate that Chinese cabbages grown as annuals, were much simpler to manage and higher yielding than a perennial mallow. For whatever reason, the change is now complete. *Malva verticillata* has reverted to weed status in China and is only occasionally found as a cultivated plant, in the foothills of the Indian Himalayas.

Little attempt has been made in Europe (and countries with populations largely of European descent) to cultivate Chinese cabbage. There would appear to be no reason to replace western cultivars of *B. oleracea* with eastern cultivars of *B. campestris* in temperate climatic zones, especially if the crop is destined to be served boiled in the European manner. Under tropical conditions, however, the heat tolerance of Chinese cabbage is a distinct advantage.

Smith and Welch (1964) have placed Chinese cabbage into two groups.

The Pekinensis group of *B. campestris* (syn. *Brassica pekinensis*) is the large, cylindrical, heading, light-green-leafed

Brassica campestris
var. *chinensis*



Brassica campestris
var. *pekinensis*

cabbage of Northern China, the Shantung Pe-tsai of Herklots (1972). The Chinensis group (syn. *B. chinensis*) is more generally grown in the south of China and throughout tropical South East Asia. Herklots refers to it as Chinese white cabbage or paak ts'oi. This is usually a smaller, more open plant than pe-tsai; the leaf is often dark green and has prominent white midribs.

Professor Chia Wen Li of Shandong Agricultural College has suggested that the Pekinensis group could have arisen from a backcross of a plant of the Chinensis type with the turnip, *B. campestris* ssp. *rapifera*, (vide Talekar, 1980).

Chinese kale, *B. oleracea* v. *albiflora O. kunze* (syn. *B. alboglabra* Bailey), called Kaai laan by Herklots, is a quick growing annual plant which is harvested when the white flowers are just opening. It is probably the variety of *B. oleracea* best adapted to the tropics. It is quite unlike any other 'kale'.

The brown mustards, cultivars of *B. juncea* called Kaai t'oi by Herklots, have been cultivated in China and India since the earliest times. *B. juncea* is a variable species, and some cultivars are not easily distinguished in the field from other Chinese brassicas. Usually the central stem is quite prominent and leaf bases quite widely spread. A simple taste test is the best means of identification when plants are not in flower.

In India one brown mustard cultivar is grown as a vegetable in the lower Himalayas, but the species is mainly grown as an oilseed crop (Prakash, 1980). Even here there is a problem of identification. The common oil-seed crops of India are the yellow and brown sarsons (*B. campestris* var.*oleifera*), and these are currently being crossed with Chinese cabbage cultivars to produce a leaf vegetable more suited to the Indian palate (Verma *et al.* 1979).

B. juncea cultivars generally have a low tolerance of cold. They are stimulated to flower by long days, and not by periods of low temperature (Tsunoda *et al.* 1980).

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The Role of the Royal N.Z. Institute of Horticulture in Horticultural Education and Examination

by

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Historical Development

An understanding in a concise manner of the origins and purpose of the Royal New Zealand Institute of Horticulture is important in reviewing the Institute's role in horticultural education.

As early as the turn of the century the Department of Agriculture was training four young orchard instructors at the State Horticultural Station, Waerenga (now Te Kauwhata). Because this station began supplying fruit trees, trees, shrubs, and hedge plants to growers, the nurserymen of the time banded together to protest this movement by the State. The outcome was the formation in 1904 of the New Zealand Nurserymen's and Seedsmen's Association.

It was at the conference of the Nurserymen's Association in Wellington in 1916 that Mr A.H. Shrubshall gave a paper on the subject of "Education in Horticulture". From this beginning the idea of horticultural training began and the need evolved for an organisation to put the idea into action.

Between 1916 and 1922 further forays into horticultural education were made by such organisations as "The N.Z. Fruitgrower" (1919), "The N.Z. Association of Nurserymen" (1920) and the short-lived "New Zealand Bud Selection Committee" (1922). It was at the first annual conference of the New Zealand Bud Selection Committee that the proposed rules of a yet to be formed New Zealand Pomological Board were read. The objectives were bold and idealistic. However, at this meeting, instead of the Pomological Board being established, the words "New Zealand Institute of Horticulture" were inserted and the Institute was born.

An objective which has become a primary activity of the Institute since its inception has been "to promote and assist horticultural education".

The first recorded reference to any sort of formal training on a New Zealand wide basis was in 1922 when at the N.Z. Nurserymen's Conference in Taranaki a remit was discussed to set up a "Dominion School of Horticulture". The mover of the remit was a Scotsman, Mr Bobby Nairn but it was the Englishman, Mr A.H. Shrubshall who had really blazed the trail in the intervening years. At subsequent conferences horticultural education and the need for a qualification in horticulture were discussed but not until 1927 was an official diploma gazetted through Parliament.

A scheme of examination had been designed stating that "the Diploma should be a guarantee of proven ability". The first examinations leading to the National Diploma in Horticulture (N.Z.) were held in 1929.

As early as 1928 moves were under way to establish formal lectures at Technical Schools (as they were then known) provided sufficient numbers of horticultural students could be registered, to justify the payment of lecturers. It is interesting to note that because the number of registered students in horticulture was less than 60 in 1931, no correspondence lessons could be arranged from the Correspondence School in Wellington. The Education Department reply stated that the Government was too busy dealing with the economic depression.

In 1932 the Examining Board of the Institute decided to ask the Education Department to provide for the teaching of Botany and General Science in all post primary schools. Not until 1946 was this to be introduced by Government.

At an Executive meeting in 1936 the Institute decided to approach the University of New Zealand asking for the establishment of a horticultural course at Massey College. But it wasn't until 1943 that the Principal of Massey advised the Institute that it would be offering instruction in horticulture for the Institute's examinations. Lincoln College proposed setting up a course of instruction in horticulture for returned servicemen.

By 1946 Lincoln College had established its own courses leading to degrees and diplomas in horticulture. Massey University began its diploma and degree courses two years later. The Chairs in Horticulture were set up at Massey in 1963 and Lincoln in 1965.

Of much significance to the Institute in 1943 was the introduction of correspondence lessons in horticultural subjects by the Department of Education through the Technical Correspondence School. (Now the Technical Correspondence Institute.)

The apprenticeship system of training in horticulture began in 1938 and a large number of apprentices continue on after gaining their Trade Certificate to pursue the N.D.H.

The partnership between the T.C.I. and the Institute's examination system has evolved into a most successful dichotomy. The T.C.I. retains two positions on the Institute's Examining Board and very close and harmonious contact is maintained between the two organisations. It is vital that this remains so for the benefit of students and for the employing industries concerned.

These brief notes indicate the historical role that the Institute has played in pioneering horticultural training, education and examination since its inception in 1922.

Sound Policies

Some basic principles and policies which have evolved and been adhered to right up to the present time are worth discussing.

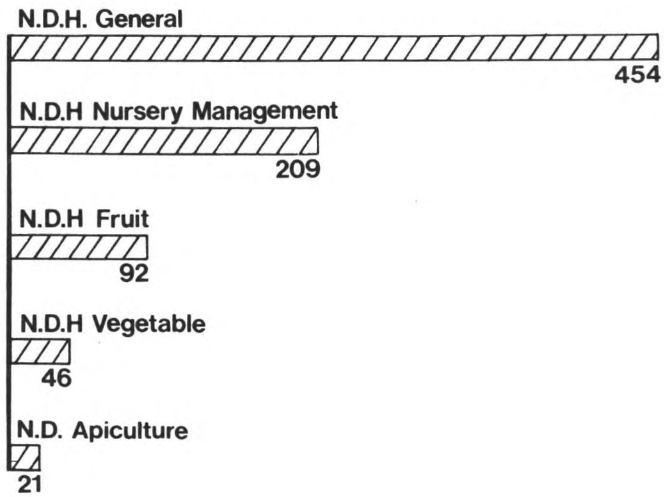
Firstly, the examination of the Institute's students, who are taking the various certificates and diplomas, has become a major responsibility. Over the years there has been continual review and revision to meet changing needs. It must be noted that the Institute provides a system of examinations which lead to recognised qualifications. It does not train or educate in a formal sense. Its primary role is to guide students, to monitor their progress, to assist them in their special subject areas and to help them through the study and presentation of their theses.

Secondly, the Institute has at all times upheld the standard of its examinations. Occasionally pressure has been brought to bear to allow more passes but at no time has the Examining Board faltered in its belief that the qualifications should be "a guarantee of proven ability". This policy has been supported over the years, not only by those who have been successful in the examinations, but also by those who began the long road of study.

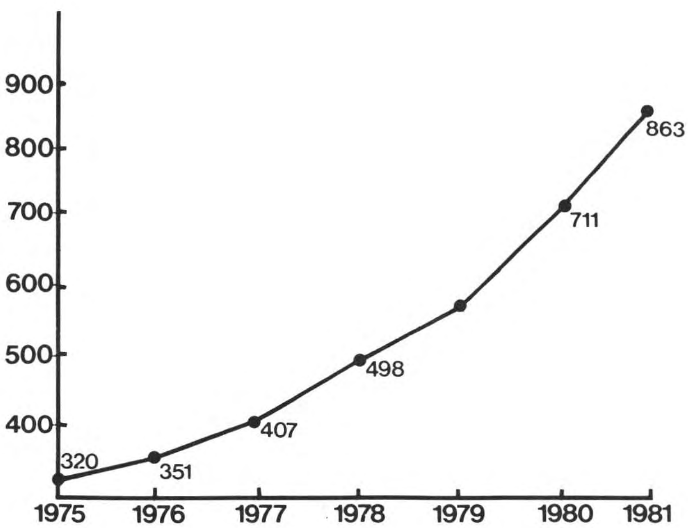
Thirdly, the great strength of the National Diploma in Horticulture has been in its continued emphasis on the practical side of horticulture. Because the profession and industry of horticulture is very much a "doing" activity the need for excellence in horticultural operations, fortunately, has never been lost sight of. Perhaps the recognition of this aspect of horticulture has been one of the reasons why enrolments to take the certificates and diplomas has continued to increase almost at an alarming rate.

Fourthly, the system of approved practical placement of students and the requirement of full time horticultural work while studying has ensured that a full understanding of theory and practice is gained. This combination has produced a dedicated horticultural craftsman enabling the holder of an N.D.H. to command respect and recognition in any field of either commercial or amenity horticulture.

Fifthly, it has been the policy of the Institute to maintain links as closely as possible with the horticultural producer groups who employ their students. Up until 1971 there was one basic Diploma in Horticulture with specialisations in certain disciplines. However, after prolonged negotiations with the major producers, namely, the fruit industry, the vegetable and produce growers industry and the nursery industry, separate National Diplomas were introduced. The fourth and general diploma was maintained particularly to serve the



R.N.Z.I.H. DIPLOMA & NATIONAL CERTIFICATE REGISTRATIONS
1981



R.N.Z.I.H. STUDENT REGISTRATIONS
(Hort. Cadets not included)

amenity horticulture area. This general diploma today draws the greatest number of students but the N.D.H. (Nursery) has a significant following.

Horticultural Cadet Training

In 1976 there began in the Waikato - Bay of Plenty area a horticulutral cadet training scheme to serve the rapidly expanding sub-tropical fruit industry. Notably the Kiwi-fruit industry was spear-heading this development. The cadets are part of the Agricultural Training Council farm cadet scheme but in 1979 they became horticultural cadets in their own right.

Cadet-ship is over a period of three years with block-courses, day release tuition and T.C.I. correspondence being given. Already cadet training committees have been set up in other centres, namely Auckland, Hawkes Bay, Gisborne, Nelson and Otago. Further committees are programmed for Northland, Taranaki, Southland and Canterbury.

The Institute of Horticulture is the Examining Authority for the cadet scheme's Certificate in Horticultural Practice with oral and practical examinations now being held in Tauranga, Hawkes Bay, Nelson and Otago. Enrolled cadets in 1980 totalled 209, 1981, 329 and in 1982 the estimated figure is 450.

The Institute's role in the cadet training scheme is to oversee the examination requirements and provide the moderation required to ensure that a uniform qualification is achieved throughout New Zealand.

The Present Situation

While a claim can be made for the success of the N.D.H. system of training and examination it must be recognised that over the past five or six years there has been a rapid acceleration in horticultural interest on a nation wide scale.

Students registered with the Institute total more than both Lincoln College and Massey University horticultural students combined.

The breakdown in registrations over the Institute's Diplomas for 1981 is as follows:

N.D.H. General	454
N.D.H. Fruit	92
N.D.H. Vegetable	46
N.D.H. Nursery Management	209
N.D. Apriculture	21
Hort Sales Certificate	41
Certificate - Hort Practise	49
	912

The Examining Board of the Institute is currently revising the Examinations Approval Notice with the intention of having the updated syllabi gazetted in 1982.

Indications are that there will be a slight reduction in emphasis from botanical subjects to an increase in emphasis in horticultural management subjects.

The Thesis which continues to bother and elude many senior students will be retained. The difficulty in reading and researching to present an acceptable thesis cannot be denied and every effort is being made to offer appropriate assistance to students who do not have ready access to a University for guidance.

The Future

It is obvious that the interest in horticulture will continue for a long time into the foreseeable future. Proof that people have accepted house plants as a permanent feature inside the home can be seen by the buoyant pot plant industry.

Proof that people are staying in their own home sections more than before can be seen by the vitality of the seed and garden centre businesses.

And proof that New Zealand can produce first quality fruit, vegetables, trees, shrubs, cut flowers, mushrooms and other crops yet to come can be seen by the ever increasing volume of horticultural exports.

The Government now is lending its support in the way of export incentives, rural bank loans, training incentives plus other incentives to encourage horticultural production. Transport and marketing will be the major problems of the future but provided quality of the product is beyond question, then the world tomorrow will seek more of our horticultural production.

The Institute of Horticulture will continue to be vigilant in meeting the training needs of the practical horticulturist for it is this person who will be called upon to "produce the goods".

Loder Cup Award, 1980
Mr R.H. Mole

The Wellington District Council of the Royal New Zealand Institute of Horticulture nominates Raymond Harold Mole of 160 Wilton Road, Wilton, Wellington, for the Loder Cup Award for 1981, for encouraging the use and cultivation of the native flora throughout New Zealand, and particularly in Wellington.

In 1962, the Mole family came to New Zealand from Southern Rhodesia and Ray joined the staff of the Wellington City Parks Department as the Curator of the Otari Open Air Native Plant Museum. Ever since 1962 Ray has turned his interest in New Zealand's native flora into his life's interest and love. While he is in that happy position of working and being associated with native plants, their protection and propagation, he also puts many countless hours into the love and protection of our flora and in doing so has spread his enthusiasm to many other people. It is for these additional hours, the additional enthusiasm, that we commend him to you as a worthy recipient of the Loder Cup.

Ray Mole has given many public lectures, written articles and demonstrated the value and versatility of native plants. The inspired enthusiasm which he has imparted to the ever increasing parties of school children who visit Otari, is of particular note. By opening students minds to the beauty and possibilities of New Zealand's vegetation he has greatly increased the future likelihood of conservation and use of our native flora. Ray Mole has also convinced a wide variety of departments, local body administrators and suburban gardeners of the value of changing planting policies in Wellington, and elsewhere, to favour our native plants.

Since 1962, with the stimulation of the native plants at Otari, Ray Mole has been involved in a wide range of horticultural activities, mainly involving the use, propagation and protection of native plants. His horticultural interests have extended to include lecturing, escorting field trips for W.E.A., the Royal Forest & Bird Society and assisting botanical societies with field trips, plant care information and identification of plants. In addition he has marked Trade Certificate examination papers for the Department of Education for six years and has taken care with the training of horticulture apprentices. In an average year he is involved with 30 school parties visiting Otari.

In the winter planting season Ray's weekends are generally taken up with supervising volunteer groups assisting in the beautification of Wellington's coastal areas, parks and road verges. Of course, the majority of such planting features native shrubs.

Ray Mole's knowledge of New Zealand's native plants is known world wide. His articles have appeared in many publications including the N.Z. Gardener, the Royal Forest & Bird Protection Society's Journal and the Royal N.Z. Institute of Horticulture's Journal. In 1976 Ray Mole was awarded the Associate of Honour of the Royal Horticultural Society, London, England, in recognition of his work at Otari. While this award is conferred for distinguished service to horticulture in the course of employment and is limited at any one time to 100 recipients, it does signify Ray Mole's recognition in the field of New Zealand's native plants.

Ray's evenings are often given over to progressive associations and local groups in delivering lectures and giving advice and encouragment in the use of native plants.

Ray has given impetus to the development of walking track systems and assisted in the formation and development of Wellington's new Outer Town Belt. Tracking work and his advice has also extended to other parks beyond Wellington City, including large native bush areas at Silverstream and Eastbourne.

While Ray Mole has given scientists and students valuable assistance in the identification and cultivation of native plants and has widened his knowledge in botany, his distinguished contribution has been in the horticulture and aesthetic fields - placing the appropriate plants into Wellington's landscape.

More recently Ray Mole has assisted the Wellington District Council as Tree Registration Officer, work which generally involves the assessment of native flora in the Wellington region. He has also acted as a catalyst in the planned construction of an interpretive centre for Otari, which will be an additional educational amenity.

Ray's academic training started at the Oaklands Horticultural College, St. Albans, England, and continued at the Royal Horticultural Society Gardens, at Wisley, where he obtained the Wisley Diploma and the National Diploma in Horticulture (Inter.).

Through the R.N.Z.I.H.* he also obtained the N.Z.N.D.H.** in 1971.

In 1955 he moved from England to Southern Rhodesia where he developed a 400 acre estated into a Botanic Garden. In 1962 Ray moved to New Zealand.

To Ray the epitome of beauty is New Zealand's humble cabbage tree. Over the years he has opened so many eyes to this and the general splendour of our bush that this District Council truly believes Ray Mole should be awarded the Loder Cup in recognition of his achievement.

* = Royal New Zealand Institute of Horticulture Inc.

** = National Diploma in Horticulture (N.Z.) issued by the Royal New Zealand Institute of Horticulture by examination.

Citation for the Award of Association of Honour A.H.R.I.H. (N.Z.) 1981

Mrs M.J. Amos

Mrs Joy Amos as we all know her, arrived in New Zealand in September, 1958 from Britain; she has a Bachelor of Horticultural Science (London) and an English N.D.H. She commenced her duties with the Department of Agriculture in Auckland in October, 1958 as an instructor in horticulture; her duties were defined as horticulture advisory work specialising in ornamental horticulture but over the years at times her official duties have covered every aspect of horticulture. Her personal interest has always been in floriculture and ornamental horticulture. In her early years with the department when the New Zealand Journal of Agriculture was an official publication, Joy wrote the monthly notes on the flower garden; she is the author of many articles and departmental information leaflets. She retires from the department at the end of February, 1981.

In 1972, Joy was given the added responsibility in the department of the development of ornamental horticulture throughout the North Island. This included organising seminars and field days for nurserymen and flower growers. In these recent years she has made an especially important contribution to the growing marketing and packaging of cut flowers both for the local and the overseas markets. She has keenly pursued her overseas contacts and has patiently gleaned from the knowledge of local specialists the necessary techniques to meet the demands of our climate; she has also helped in selecting cultivars suitable for the different markets. She has organised seminars, carefully chosen her speakers to stimulate discussions to increase the growers skills and enthusiasm in growing the different flower crops.

She has for many years been an active member of the Institute in Auckland and was elected a fellow in 1979; she has assisted in the show judging classes conducted by the Auckland District Council. She was an examiner in the Auckland venue of the oral and practical exams. She is an excellent plantswoman and served on the Award of Garden Excellence Committee; similarly her wide experience with plants is proving invaluable in her services with the Technical Advisory Committee for the A.R.A. Botanic Garden at Manurewa.

In Auckland Joy has been most generous with her services to both amateur and professional societies of horticulture; no matter what the demands she has always willingly met them; her contribution to horticulture in the Auckland area has been far greater than that demanded by any department. We feel sure that Joy will continue to contribute to horticulture even in her retirement. It is with great pleasure that the Auckland District Council would like to nominate Mrs Amos for the Award of Associate of Honour.

Mr G.B. Malcolm

George Brington Malcolm was born of farming parents at Richmond, Nelson, in 1917 and was educated at Richmond Primary School and Nelson College. After a wide range of farming and orcharding experience in Nelson, Blenheim and Hawkes Bay, he commenced his horticultural studies at Wilson's Nurseries, Hastings, where he was engaged in most aspects of nursery production, including propagation of ornamental trees and shrubs, fruit trees, roses and asparagus growing.

To facilitate his studies for N.D.H., he accepted a position in 1941 at the Christchurch Botanic Gardens, Domains Board, as a fifth year trainee under the direction of the late Mr J.A. McPherson and gained experience in most sections of the gardens, including propagation, and lectures from eminent people.

He was subsequently employed by the Christchurch City Council under the direction of the late Mr M.J. Barnett, gaining experience in all facets of Parks and Reserves work, including specialist training in tree surgery and for several years was foreman of the municipal nurseries. It was during this period he completed his N.D.H.

In 1948 he accepted a position with the Housing Division, Ministry of Works, Christchurch, and was responsible for the horticultural and landscape work throughout the Canterbury district and at that time established a departmental nursery at Christchurch. Several years later he was appointed to the position of landscape officer for the South Island engaged on national works projects and during this period he provided periodic services to head office, Wellington.

In 1962, he was appointed to the position of senior landscape officer, Ministry of Works (based in Christchurch) in charge of the landscape section for New Zealand, and during this period a substantial landscape section was established, including new nurseries, and landscape architecture began to be recognised as an integral part of national works.

In 1974, with the amalgamation of the landscape architecture section with the environmental design section, town and country planning, George Malcolm was appointed to the position of Inspecting Landscape Architect (based in Christchurch), but with national responsibilities connected with environmental planning and design, technical responsibilities for all nurseries and holding grounds throughout New Zealand as well as heading the Christchurch environmental design team which operates on a regional basis covering national projects in the South Island. He also has responsibility for the Christchurch nursery which produces 100,000 trees and shrubs annually for national works and other projects throughout the South Island.

George Malcolm for many years (largely singlehanded) pioneered landscape arhcitecture within the Ministry of Works and Development.

He has been involved in a wide range of environmental projects calling for experience in horticulture, landscape planning, assessments, and design and operational activities connected with the following divisions of the Ministry of Works and Development:

Town and Country Planning
Landscape Planning and assessments
Power
Roading

Civil Engineering
Architectural
Water and Soil
Hydro projects
Motorways, roading deviations
Airports and other works
Universities, high schools, national buildings
Irrigation schemes, river studies

as well as other agencies and Government departments, including the N.Z. Forest Service and Housing Corporation of N.Z.

Some of the projects he has been involved in include the following:

Landscape development of Benmore hydro project mid-Waitaki, where nearly 500,000 trees were planted.
The Taupo-Wairakei road deviation, S.H. 1.

Both of the above projects received the N.Z. Institution of Civil Engineers' environmental award in 1973.

Several other projects are:
Manapouri-Te Anau hydro project
University of Canterbury
Upper Buller Gorge revegetation, and many others.

In 1972, he was awarded an Honorary Associate of the Institute of Landscape Architects (United Kingdom), Hon. A.I.L.A., in recognition of his pioneer work in landscape architecture in this country and is the only New Zealander to be the recipient of this high honour.

George Malcolm has been a member of the Royal N.Z. Institute of Horticulture over many years and in 1971 was elected a fellow, F.R.I.H. On occasions in earlier years he has acted as examiner and supervisor of N.D.H. theses and for a period was on the Christchurch district executive.

He is a foundation member and associate of the N.Z. Institute of Landscape Architects and served on the executive for a period of four years until 1976 and is currently an examiner for the Institute's temporary examination system. He was elected a fellow F.N.Z.I.L.A. in 1976, being one of the first two fellows elected by the Institute.

In 1975, he was elected a fellow of the N.Z. Institute of Parks and Recreation Administration Inc., F.I.P.R.A.

In 1972, he was granted the first N.Z. Government lanscape architecture study tour and visited U.S.A., Canada (I.U.C.N. Conference), United Kingdom and Europe.

In 1978, he was appointed to the Hanmer State Forest Advisory Committee.

He has lectured to many organisations at dominion conferences and at local level, including the following:

Royal N.Z. Institute of Horticulture
N.Z. Parks and Recreation Administration Inc.
N.Z. Institute of Surveyors
N.Z. Ecological Society
Garden Clubs
Tree Planting Associations
County Councils
Catchment Board
Men of the Trees
Waitaki Lakes Committee
Dunedin Amenity Society
Young Farmers' Clubs
Beautifying Societies
The Forest and Bird Society
Schools
Departmental Training Courses

He is also a member of N.Z. Ecological Society, Forest and Bird Society, N.Z. Tree Crop Association, Canterbury Fruitgrowers' Association and takes an active interest in commerical horticulture.

George Malcolm, during his long service to the N.Z. Government, has done a great deal to improve the N.Z. environment and promote the profession of horticulture in this country. He has been responsible for planting many millions of trees, both native and exotic.

Also, the Christchurch nursery over many years has provided training for Lincoln College pre-entry students and N.D.H. students.

The Nutrient Budget as an Aid to Assessing Orchard Soil Fertility

by

R.J. Haynes

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INTRODUCTION

Increasing concern for the conservation of the environment has led to the widespread realisation that the excessive use of fertilisers is undesirable. Fertilisers, particularly those containing nitrogen, require much fossil fuel as energy in their manufacture and this is an increaingly expensive and moreover a diminishing resource. The raw materials used in the manufacture of phosphorus and potassium fertilisers are mined and the reserves of economically workable concentrations do not have an infinite life. Excessive use of fertilisers can also lead to the pollution of groundwater, streams and lakes.

Apart from such considerations, the cost of fertiliers is an important factor in the economic production of crops. Furthermore, the use of too much fertiliser can not only be wasteful but can actually be harmful to the crop, often by adversely affecting crop quality. This is particularly true where excessive fertiliser additions lead to a nutrient imbalance within the plant.

An understanding of the movement of nutrients in the soil-plant system is a necessary prerequisite for assessing what rates of fertiliser addition are desirable. For example, different quantities of nutrients are removed from the soil reserves in the harvested yield of different crop plants. The leaching loss of nutrients below the crop rooting zone also varies greatly among soils depending primarily upon rainfall. Thus, fertiliser inputs to maintain the fertility of a soil will depend upon, among other things, the extent of leaching losses and the particular crop being grown. Thus, quantification of the movement of nutrients into, within and out of agricultural ecosystems (agro-ecosystems) is important from both the environmental and agronomic standpoints. Such transfers of nutrients within agro-ecosystems may be described in terms of nutrient budgets which can supplement the results of field experiments and provide useful general indications of the fertiliser requirements of crops (Cooke, 1975).

Very little attempt has been made to construct nutrient budgets for orchards. For example, nutrient budgets from 65 agro-ecosystems from around the world have recently been described in detail (Frissel, 1978) but of these, only one related directly to the general orchard situation. Greenham (1976, 1980) has compiled estimates of nutrient uptake by fruit trees from early American work and from more recent research at East Malling Research Station (U.K.) while Haynes and Goh (1980a) recently presented data on the distribution and budget of nutrients in a commerical apple orchard in Canterbury, New Zealand.

This article does not attempt to extensively review existing data on nutrient budgets in orchards; it merely serves to illustrate the value of such data as a tool in estimating the fertiliser requirements of orchards.

NUTRIENT BUDGET

Construction of a nutrient budget involves the measurement of inputs (e.g. fertilisers) and losses (e.g. removed in the harvested crop) of nutrients from the crop-soil system. For example, the amounts

TABLE 1

Distribution of dry matter and nutrient content in the components of the total vegetation of a 14-year-old Golden Delicious apple orchard in winter (kg/ha). Data from Haynes and Goh (1980a).

	Dry Matter	N	P	K	Ca	Mg
Apple Trees	20302	67.3	11.6	50.7	104.4	11.5
Grass Sward	5648	171.9	9.7	149.8	51.8	12.7
Total Vegetation	25950	239.2	21.3	200.5	156.2	24.2

TABLE 2

Annual nutrient losses and returns for a mature Golden Delicious apple orchard (mean values for 2 years' data). Data from Haynes and Goh (1980a).

	Amount ha/yr	kg/ha/yr N	P	K	Ca	Mg
LOSSES						
Removed in fruit	5950 kg	21.3	4.0	120.0	4.4	3.7
Removed in prunings	507 kg	3.9	0.5	2.3	5.6	0.6
TOTAL REMOVED		25.2	4.5	22.3	10.0	4.3
Leaching Loss	381 mm	33.1	0.1	1.7	44.7	35.3
TOTAL LOSS		58.3	4.6	124.0	54.7	39.6
RETURNS						
Leaf-fall	2211 kg	32.6	3.9	25.7	53.5	6.7
Petal fall plus fruitlet drop	227 kg	3.2	0.3	4.3	1.5	0.4
Foliar leaching	133 mm	1.9	0.4	3.1	1.1	0.7
TOTAL RETURN		37.7	4.6	33.1	56.1	7.8
Grass Mowings	10873 kg	507.7	28.4	108.5	90.7	21.0

TABLE 3

Annual nutrient inputs and budget for a mature Golden Delicious apple orchard (mean values for two years' data). Data from Haynes and Goh (1980a).

	Amount ha/yr	kg/ha/yr				
		N	P	K	Ca	Mg
Rain	792 mm	-	-	5.0	4.2	2.9
Irrigation water	191 mm	9.6	-	1.9	17.1	1.3
Fertiliser		71.6	20.4	57.2	14.0	5.6
TOTAL INPUTS		81.2	20.4	64.1	35.3	9.8
Inputs minus losses		+22.9	+15.8	-59.9	-19.4	-29.8

of nutrients removed in a crop can easily be calculated if the elemental nutrient content and yield of the crop is measured. The transfers of nutrients from one component to another can also be quantified in a budget (e.g. return of crop residues to the soil).

The grassed-down deciduous orchard receives nutrient inputs in the forms of fertilisers, irrigation water, rain, orchard sprays and dust. The cyclic return of nutrients occurs in throughfall, leaf-fall in autumn and by return of grass clippings following mowing. Nutrient losses occur through the removal of fruit crop and pruning wood from the orchard as well as leaching and gaseous losses.

1. Nutrient distruction within vegetation

Before discussing gains, losses and returns of nutrients within the orchard, it is interesting to look at the amounts of nutrients within the trees (tops plus roots) and orchard sward (tops plus roots). The results for a 14-year-old Golden Delicious orchard in Canterbury, New Zealand (trees spaced 4m within rows 5m apart) are shown in Table 1.

Demand for nutrients by the sward followed the pattern N > K > Ca > Mg > P, while that for the trees followed the trend Ca > N > K > P = Mg. Over two thirds of the N and K in the total vegetation occurred in the sward component. For P and Mg, the nutrient reserves were equally distributed among the sward and trees, but two-thirds of the Ca reserves occurred in the tree wood.

2. Nutrient losses

The quantity of nutrient elements removed from orchards in the harvested crop is of course very dependent on both the variety of tree and the cropping season. Results presented in Table 2 indicate that considerable amounts of K and to a lesser extent N, are removed in the fruit crop. British data (Greenham, 1976) have confirmed this assertion. In fact, K is the most abundant nutrient in the apple fruit and a very high proportion of net annual uptake of this element is taken from the orchard each year in the crop. The data of Haynes and Goh (1980a) for example, showed that during winter the amount of K in the total tree biomass was 50.7 kg K/ha (Table 1); (33.9 kg K/ha in trunk and branches and 16.8 kg K/ha in roots). This is about half that which was taken from the orchard each year (120 kg K/ha) in the harvested crop.

Quantities of nutrients removed in the pruning wood do not seem to be large (Table 2), but they are significant particularly in the case of Ca. The large amount of Ca removed in the pruning wood in comparison with that lost in the crop illustrates the immobility of this element within trees. In fact, although only a small amount of Ca was lost annually in the crop (4.4 kg Ca/ha), the amount of Ca in the total tree biomass in winter was large (104.4 kg Ca/ha).

Nutrients can also be lost from the orchard by being leached down the soil profile below the tree rooting zone. Such losses obviously differ tremendously between orchards due to differences in rainfall, irrigation, fertiliser rates and levels of available nutrients present in the soil initially. Leaching losses of all the major nutrient elements, except the immobile phosphate can be reasonably large. In the study of Haynes and Goh (1980a), leaching losses of K were small (Table 2), but this is not typical of most situations. The small leaching losses of K from the orchard studied were probably due to the large amounts of K being taken up by the trees and removed annually in the fruit crop. Annual removals in this way amounted to twice the annual fertiliser inputs of K (Tables 2 and 3).

Gaseous losses of N through denitrification (the gaseous loss of nitrogen, N_2, and nitrous oxide, N_2O) have not been measured in the orchard. Such losses are sometimes estimated as about 10 per cent of the fertiliser N applied, although losses are highly dependent on environmental factors such as moisture content, aeration, temperature and pH.

3. Nutrient returns

The major returns of nutrients taken up by trees occur as leaf-fall (Table 2), but also include shed blossoms and fruitlets and nutrients washed or leached from trees leaves and bark (foliar leaching) during periods of heavy rainfall.

Nutrient returns to the orchard floor by the cut grass sward are very large in magnitude in comparison with leaf-fall from the trees. The quantities of nutrients returned in clippings on the orchard studied were in the same order as those found in many temperate pastures (Wilkinson and Lowrey, 1973). In all probability, the sward takes up most of the nutrients released by its mowings, thus rendering them unavailable to the trees.

However, the cycling effect of the mown sward can apparently maintain nutrients such as P and K in plant-available forms and thus increase uptake of these elements by the trees (Stott, 1976; Haynes, 1980). The growth of the grass may also reduce leaching losses of nitrate-N and thus reduce concomitant losses of nutrient cations such as Ca and Mg (Haynes and Goh, 1980b). The elimination of the grassy vegetation from the orchard floor often leads to a gradual loss of basic cations (e.g. Ca and Mg) from the surface soil and a consequent decrease in soil pH (Haynes and Goh, 1980c).

It should also be noted that the large amount of N used by the grass sward during its growth (Table 1 and 2) can have extremely detrimental effects on the growth of young trees (Goode and Hyrycx, 1976). This is because young apple trees do not possess a large extensive root system so that the tree roots compete directly with the roots of grasses for available soil N and also water. Thus, clean cultivation, to eliminate such competition, is often practised in the first 5 years or so of an orchard's life.

4. Nutrient additions

Nutrient additions may occur, to a small extent, in rainfall, irrigation water and dust. By far the greatest inputs are added as fertiliser applications (Table 3).

The quantities of fertiliser added to an orchard depend upon recommendations made to the grower and his own judgement. In the particular orchard used by Haynes and Goh (1980a), Nitrophoska blue was applied in September and November of each year, each at a rate of 200 kg/ha. In the first year, an additional dressing of 100 kg/ha of urea was applied in February.

Additions of N to the orchard may also occur through symbiotic N_2 fixation if clover species are present in the swards. In comparison with all grass swards, the beneficial effect of a white clover sward on N uptake and growth of trees has been demonstrated in young apple orchards (Bould and Jarrett, 1962). However, in a mature apple orchard, shading of the ground near the base of the trees during summer plus the fact that orchard swards are often allowed to grow reasonably high before mowing means that the clover component of the sward is often out-competed by the faster, taller growing, less light-demanding grasses (Haynes and Goh, 1980d). Thus, input of N to orchards in this way is difficult to assess and probably differs greatly among orchards.

5. Inputs minus losses

The budget of nutrients (inputs minus losses) for the orchard site studied by Haynes and Goh (1980a) is shown in Table 3. The values shown are only applicable to the particular site studied and the results cannot be applied directly to different orchard sites.

It is evident that losses of nutrient cations (K, Ca and Mg) exceeded inputs so that a net loss occurred. The total annual input of K during the two years was approximately half the amount taken from the orchard at fruit harvest. However, the reasonably high reserves of plant-available K in the soil, plus the possibility of the release of clay-fixed K, resulted in the trees showing no signs of K-deficiency. Although total losses of Ca and Mg substantially exceeded total inputs, fertiliser inputs were similar in magnitude to losses in fruit crop plus pruning wood. Hence the negative budget values for Ca and Mg do not indicate that higher fertiliser applications are required, rather they probably reflect large leaching losses due to more-than-adequate fertiliser inputs in previous years.

The positive nutrient budget for N and P, plus the fact that fertiliser inputs greatly exceeded amounts taken from the orchard in fruit plus pruning wood, indicated that the rates of fertiliser N and P applied were higher than required.

GENERAL DISCUSSION

Potassium is the most abundant nutrient in the apple fruit, hence the level of cropping will greatly influence the demand for K and therefore the requirement for potash fertilisers. In direct contrast, the Ca content of fruits represents only a tiny proportion of the total uptake of the element by the tree. The fact that Ca deficiency is a common nutritional disorder of apple fruits (Sharples, 1980; Vang-Peterson, 1980) emphasizes the fact that such a disorder is usually a problem of distribution within the tree which is caused by the characteristic immobility of Ca within plant tissues (Vang-Peterson, 1980). A deficiency of Ca, and sometimes Mg, can be induced by an imbalance of cations within the tree, particularly if excess K applications have been applied (Greenham, 1980; Shear, 1980).

The contents of Mg and P in apple fruits are small and of the same order as are their contents within the trees themselves. Generally, the small quantities of these elements utilised by trees means that repsonse to P and Mg fertilisers are not common except on very deficient soils.

Although the N content of the fruit is moderately high, as is its content in the tree framework, a deficiency of N is not common except on young orchards with grass competition. In fact, historically fruit growers have had more problems in trying to restrict N supply than in trying to increase it. A high supply of N during late summer characteristically results in a depression in fruit redness and in keeping quality of the fruit. The use of grass in orchards was at one time seen as a means of limiting the availability of soil N during summer to improve fruit colour. Growers then found it necessary to apply fertiliser nitrogen probably, at least in part, to maintain the grass. Now that the herbicide strip is used down tree rows, competition between the tree and grass roots is substantially reduced (Atkinson, 1977; Atkinson and White, 1980). In Europe and the U.K., where the herbicide strips are wide (one-third herbicide strip and two-thirds grass are sometimes used) there is again a problem of how to restrict the availability of N. Several workers have suggested that applications of N to mature orchards growing in the herbicide strips are not necessary (Bramlage *et al.*, 1980; Greenham, 1980).

CONCLUSIONS

Robinson (1980) recently concluded that researchers have made little progress in the last ten years towards establishing reliable techniques for predicting quantitatively the nutrient applications required for deciduous tree fruit crops. This is largely because although the nutrient status of some soils (as determined by soil tests) is found to be correlated with leaf nutrient content of fruit crops growing on them, in other cases no such relationship is found. In fact, the large reserves of nutrients within the framework and roots of mature fruit trees means that the nutrient content of the leaves and fruits may not be related to that in the soil. Further, fertiliser applications to a mature orchard may not affect the growth and leaf and fruit nutrient status of the trees for some years after their application.

Soil tests can give indications of potential deficiencies, oversupplies or imbalances of nutrients within the soil while leaf analysis can confirm or diagnose nutrient deficiencies, toxicities or imbalances within the tree. Estimates of nutrient removals in fruit crop plus pruning wood, when used in conjunction with soil and leaf analysis, are liekly to give useful guides to the fertiliser requirements of orchards. Nevertheless, nutrient budgets constructed throughout the life of orchards under different management systems are still required in order to accurately predict the fertiliser needs of orchards at different stages of development.

In general, nutrient budget studies have concluded that many commercial orchards receive too much fertiliser, particularly N and P (Greenham, 1980; Haynes and Goh, 1980).

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Wilt Diseases in *Calceolaria multiflora* and *Senecio cruentus* cultivars

by

R. Lucas

Extracts from a thesis for the National Diploma of Horticulture (N.Z.), submitted by R. Lucas in 1977.

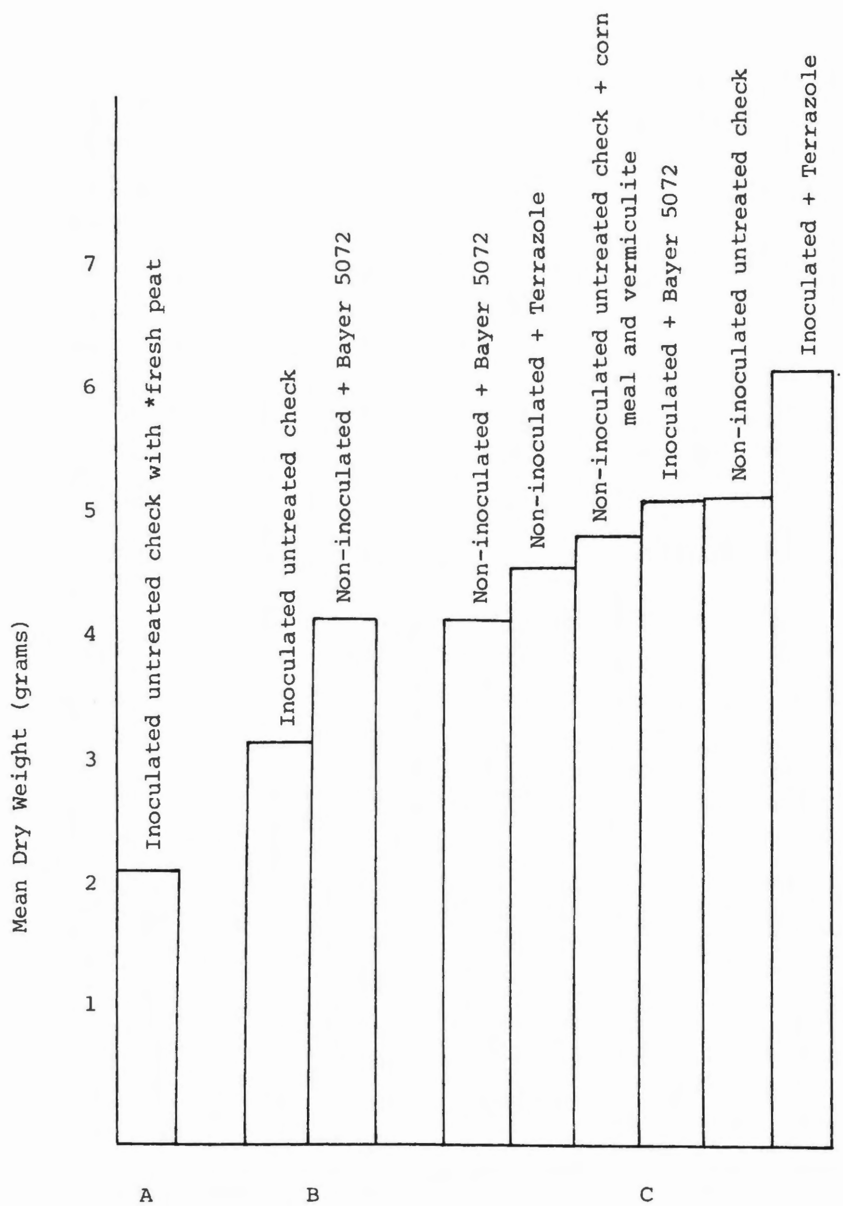
This work has shown that the losses in calceolarias and cinerarias due to wilt and unthrift that have regularly occurred for many years at the Berhampore nursery (Wellington) have been due to root and crown infection by *Pythium* or *Phytophthora.* These genera of fungi are known collectively in horticulture as the 'water-moulds', a term reserved by mycologists for members of the *Saprolegniales*, a related group generally of little direct horticultural importance. In some instances *Pythium* and *Phytophthora* occurred together, forming a disease complex. Both parasites are soil-borne and may exist therein as facultative saprophytes. Both were satisfactorily controlled by the incorporation of either Bayer 5072 (Dexon-fenaminosulf) or Terrazole (etridiazole) fungicides into potting media prior to use, although the Terrazole wettable powder formulation was found to be less soluble than Bayer 5072 and consequently was not always immediately effective when applied to inoculated media.

Infection by *Pythium debaryanum* caused damping-off in young calceolaria seedlings and a chronic wilt or unthrift condition in older plants (Fig. 1). The 40% loss in mean dry weight recorded for nine-week old calceolarias grown on in a *Pythium* infected medium (see Fig. 2), serves to demonstrate the degree of loss that commonly occurs. *Pythium* was isolated from a glass-house water-trough, a hose-end and from a bin of prepared-peat at the Botany Department glasshouses (Victoria University, Wellington), thus demonstrating the apparent ubiquity of this pathogen under glasshouse conditions. It would appear that the facultative, saprophytic growth phase of this pathogen is an extremely important factor in spreading contamination and that the prior disinfection of potting mixes does not in itself provide future protection for susceptible plants.

Phytophthora erythroseptica was isolated from acutely wilted calceolarias and cinerarias. The sporangium and spores of this fungus are illustrated in Figs 3 and 4. Pathogenicity tests have shown this fungus to be a virulent pathogen in both hosts, although cinerarias (Fig. 5) appeared to be more prone to infection than calceolarias. *P. erythroseptica* was isolated from mature plants only, whereas susceptibility to *Pythium* infection appeared to decrease as plants became older. *Pythium* was isolated from infected plants more often than *Phytophthora* and it is considered that *Pythium*, although not as virulent is probably responsible for greater overall plant losses. Both pathogens are favoured by a high soil moisture content.

Results have shown that under the same environmental conditions, the soil-based Berhampore mix manifested a higher incidence of diseased plants than occurred in the peat-perlite mix. It is considered that the colloidal system in the soil fraction of the Berhampore mix constitutes an extremely favourable environment for the development of the water-moulds, due to the static nature of the colloid-bound soil water and the intimate association of organic matter with this water. Personal observations have also suggested that *Pythium* infection is more troublesome in nurseries during the winter months. The movement of water through a potting mix is undoubtably further impeded by a combination of colder temperatures and a shorter photo-period, which would result in reduced

Fig. 2. Mean dry weights recorded for calceolarias grown under various fungicide treatments. Groups A, B and C are significantly different at the 0.05 level.



* Peat prepared from a previously unopened bale.

evaporation and transpiration respectively. Both environmental factors are operational during the period in which cinerarias and calceolarias are usually grown, and may promote further plant losses, especially in glasshouses with inefficient heating systems. Robertson (1973), found that *Pythium* populations in a topsoil were highest during the period July-September inclusive and that high populations were favoured by high soil moisture levels. It is therefore obvious that an initial requirement for the successful control of the water-moulds is a critical appraisal of the potting medium in respect to its water retention and drainage properties. Other factors of general importance are i) the efficiency of the soil disinfection method and ii) an awareness of the ways in which recontamination commonly occurs in nurseries.

Nursery potting mixes in New Zealand are commonly disinfected by either steam or methyl bromide. The water-moulds (*Pythium* and *Phytophthora)* are readily controlled by steam, being susceptible to temperatures 50°C (Baker & Roistacher 1957). Excellent control is therefore the rule when steam is competently applied, Methyl bromide, however, is not a particularly good fungicide and if applied at rates lower than 2 lb (2 cannisters) per 1.5m^3 of potting mix, may not successfully control some fungi (Munnecke, 1957). Thus it is conceivable that under certain conditions some fungi (and perhaps some water-moulds), may survive the disinfection process and become sources of contamination.

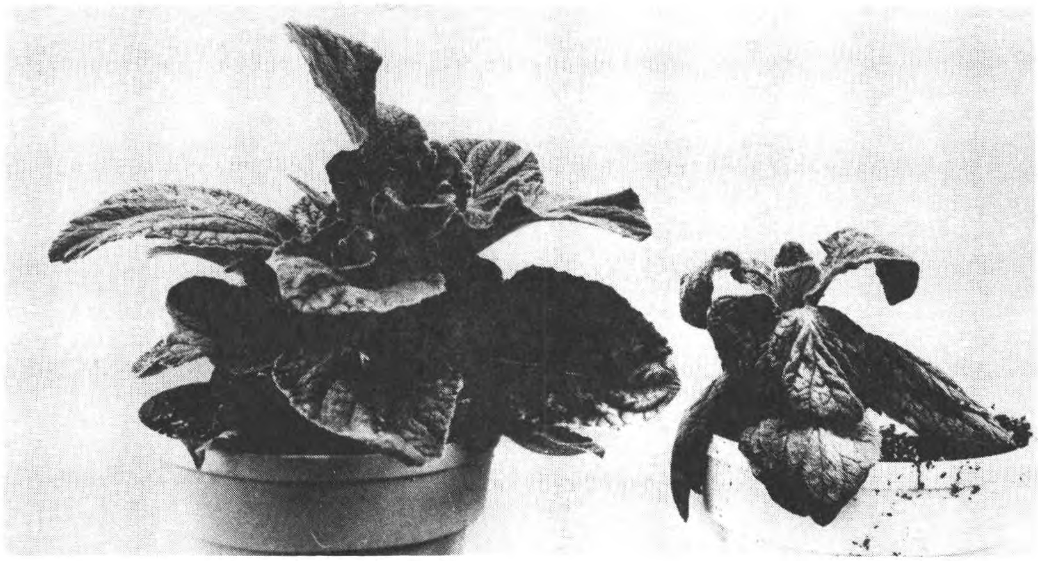
Cultural methods have been employed for many years in an attempt to reduce recontamination in trays and pots.
These include:

i) The use of clean pots, trays and equipment.
ii) The prevention when watering, of water splash between pots or from adjacent bench surfaces into pots.
iii) The placement of pots on 'clean' benches, only, and not on floors of glasshouses, or some outside areas that may be contaminated.

There can be little doubt that much recontamination occurs from unwashed or ineffectually washed pots in those nurseries where pots are continuously recycled. The effective control of water-mould fungi in pot residues, however, is not considered feasible except where seed trays are disinfected with the potting mix. In this case the untreated mix is disinfected in the trays which are staggered in stacks under polythene sheeting and treated with methyl bromide. There does not appear to be an easy method for similarly treating potting mix residues in recycled pots, however. Washing pots under nursery conditions can, at best, merely reduce potential inoculum density, due to the tedium of the chore.

Similarly, the control of water-splash when watering and the selective placement of pots and trays are not considered to be effective feasible control measures. In the course of this work it was shown that seedlings grown in a sterile perlite-only medium became infected with *Pythium* when grown under glasshouse conditions. Financial considerations together with continual civic demands for ornamental plants ensures that glasshouse space is used to the full and inevitably, certain trays and pots are placed on floors, under benches, or are located on contaminated benches. As a result it is considered that, in general, these control measures are neither particularly helpful, nor effective.

Furthermore, the use of hygiene control measures is based on the often erroneous assumption that the potting mix is uncontaminated with a water-mould flora at the stage when seed trays or pots are processed and lined-out in the glasshouse. This work has demonstrated the presence of *Pythium* in prepared-peat prior to its incorporation in a potting mix and it would therefore seem that many mixes are contaminated before they arrive at the potting bench. The practice of only disinfecting certain constituents of potting mixes can also result in a contaminated medium. Robertson (1973), collected samples of soils, sands and pumices used in potting mixes throughout New Zealand. He isolated sixteen distinct species of *Pythium* from these samples. Pathogenic species were found in large numbers in many of the soils and were also isolated in lesser numbers from the sands and pumices. The major source of New Zealand peat, at Waitakaruru, near Thames, was also sampled by Robertson. Results for *Pythium* from the peat-fields were negative. This result agrees with the negative result obtained in this work when peat from a previously unopened bale was sampled for *Pythium*. The ease with which peat can become



Chronic wilt in calceolaria caused by *Pythium debaryanum*.

Incipient wilt stage of *Phytophthora erythroseptica* in cineraria.
(Healthy plant on right).

contaminated with *Pythium* has nevertheless been demonstrated herein by the isolation of *Pythium* from prepared peat. It follows that the likelihood of regularly producing an uncontaminated potting mix is therefore remote. Furthermore, the isolation of *Pythium* from a glasshouse water-trough and from a hose-end at the Botany Department glasshouses, shows that sources of inoculum are constantly nearby under glasshouse conditions and that some recontamination of disinfected mixes is inevitable. The obvious solution to this problem is the incorporation of an efficient fungicidal agent into the mix before use.

On the basis of the work carried out herein on calceolaria and cineraria, both Bayer 5072 and Terrazole can be recommended for this purpose. These results are in accord with those of Robertson (1971) who found these fungicides to give good control of *Phytophthora* spp. in tomato, apple seedlings and *Pinus radiata* seedlings and in *Pythium ultimum* damping-off of *Alyssum* seedlings.

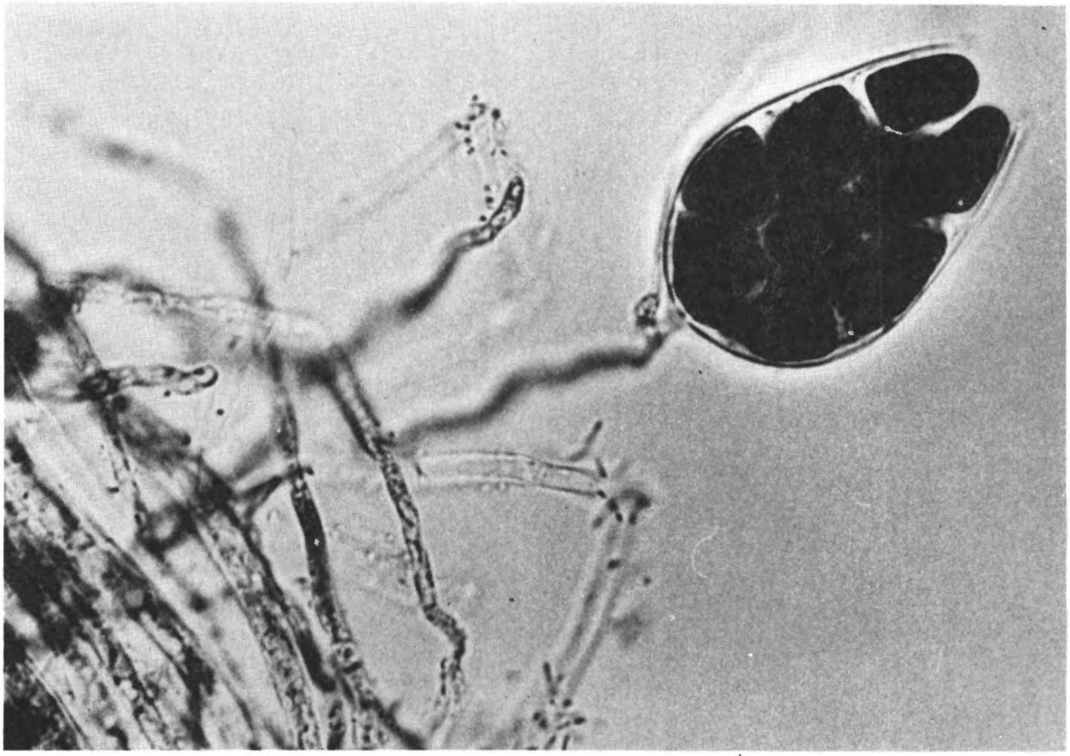
In this work, Bayer 5072 gave better control in cinerarias, whereas Terrazole gave the better control in calceolarias. Bayer 5072 has a very bright yellow colouration and even when diluted to working strength in the soil can be seen on lighter coloured fractions. This characteristic is very useful for determining the extent of dispersal of the fungicide through the potting medium. Unfortunately, this material needs to be used with caution, because it is extremely toxic. Bayer 5072 has an acute oral L.D. 50 of 60 ppm, is classified as a SIII pt. 2 poison and is consequently a highly hazardous material. Nursery staff if exposed to this chemical during potting up, pricking out or seed sowing work would need to be issued with protective aprons or overalls, and rubber gloves. Staff would also need to be familiarised with the degree of hazard associated with this chemical. A further alleged disadvantage of Bayer 5072 is that this material is subject to photo-chemical degradation when solutions of the formulation are exposed to light. This effect is reputed to impair its efficacy and reduce the period for which control is effective. Tests have shown (Hills and Leach, 1962) that the fungicidal effect of this material in solution is lost after twenty four hours exposure to day light. No loss of efficacy was noted under the trial conditions operative for this work, however, the control with Bayer 5072 was maintained over a five week period. Thus photo-decomposition does not appear to be a critical factor when the material is incorporated into a potting medium and subsequently situated under subdued light conditions, as occurs in glasshouses during winter, or when heavily shaded in summer.

Terrazole in this work, did not give as good overall control of *Pythium* and *Phytophthora* as Bayer 5072 but can nevertheless be highly recommended for the purpose. It has an acute oral L.D. 50 of 1,000 ppm and therefore has the advantage of being a relatively safe material which could easily be introduced into nursery mixes without the necessity of involving stringent safety meaures to ensure staff safety. It does have a rather pungent, although not disagreeable odour, that is apparent at working concentrations.

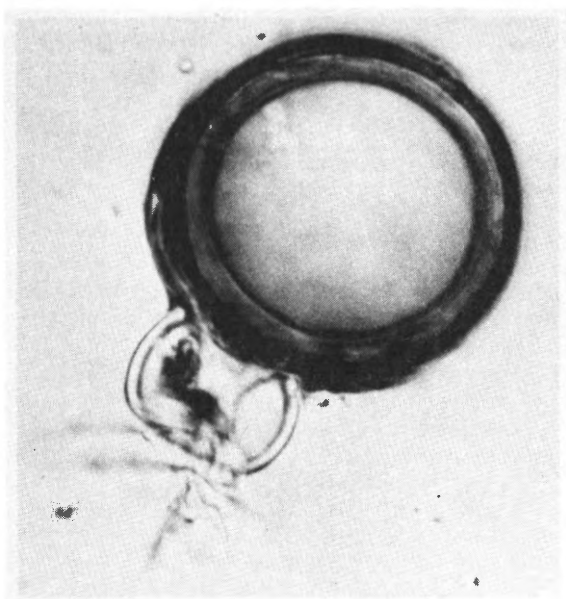
The respective manufacturers claim these materials to remain effective for four to five weeks, and suggest soil drenches as a continuing means of applying the materials. Robertson (1971) showed that this method of application generally gave less satisfactory results than soil incorporation, probably as the latter method distributes the material more efficiently. Both cineraria and calceolaria are pricked out and potted several times during production; drenching should therefore be unnecessary provided they are changed to a fresh mix every six weeks or thereabouts.

The effect of water-mould fungi on seedling bedding plants and on ornamentals generally has not been well documented in New Zealand, although losses appear to be common and frequent. Upon the writer's recommendation Bayer 5072 has been incorporated into seed sowing mixes at the Berhampore nursery during the past eighteen months and has resulted in greatly reduced seedling losses caused by damping-off. Observation suggests that the protection achieved in slow growing subjects, viz. polyanthus and *Begonia* is extremely good, with germination and seedling numbers being greatly improved also in *Nemesia*, *Lobelia* and pansies.

It is also very likely that significant



Phytophthora erythroseptica: Sporangium immediately prior to release of zoospores.



Phytophthora erythroseptica: Oospore and amphigynous antheridium.

losses occur in many other herbaceous ornamentals as a result of water-mould infection. Here too, the regular incorporation of a suitable fungicide in conjunction with the judicious manipulation of the potting mix constituent ratios, could significantly increase the number of healthy plants obtained.

The over-increasing growth of our larger cities is reflected by a concomitant pressure on their Parks Department for greater and more efficient plant production. Emphasis on bedding plant and potted plant production is still high, in spite of spiralling costs and the labour intensive nature of the operation. There is no doubt, however, that flowering plant displays, whether situated outside in beds, or arranged in conservatories under glass are a constant source of public interest and also function as an effective tourist attraction. Their continued value, therefore, is manifest. The demands for greater production together with the inter-related factors of higher wages, costlier overheads and reduced working hours, necessitate the need for efficient and effective production techniques. If these present trends continue, efficiency may demand that nurseries specialise in producing larger numbers of a restricted range of plants. High cost, labour intensive horticultural operations must become more efficient. The incorporation of effective fungicides into potting mixes will ensure that regular overproduction is not required in order to compensate for expected plant losses. This factor alone must promote production by releasing labour for further production duties. The regular use of fungicides in potting mixes must in future become an integral part of successful nursery production processes, whenever wilt susceptible subjects are grown.

(Ridomil and Previcur fungicides have recently been released onto the N.Z. market and are suitable alternative materials to use against the water mould fungi discussed in this paper. Ed.)

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Cordyline australis 'Alberti'

by

B.A. Jury

Pukeawa Nurseries and Gardens, Mahoetahi Road, R.D. 42, Waitara.

In 1900 a Belgium gentleman, (name unknown) grew a mass of cordylines from seed. He discovered among the thousands of ordinary looking seedlings one variegated one which he pricked out and took great care of. He was so pleased with the specimen that he named it *Cordyline australis* 'Alberti' after the king of that time.

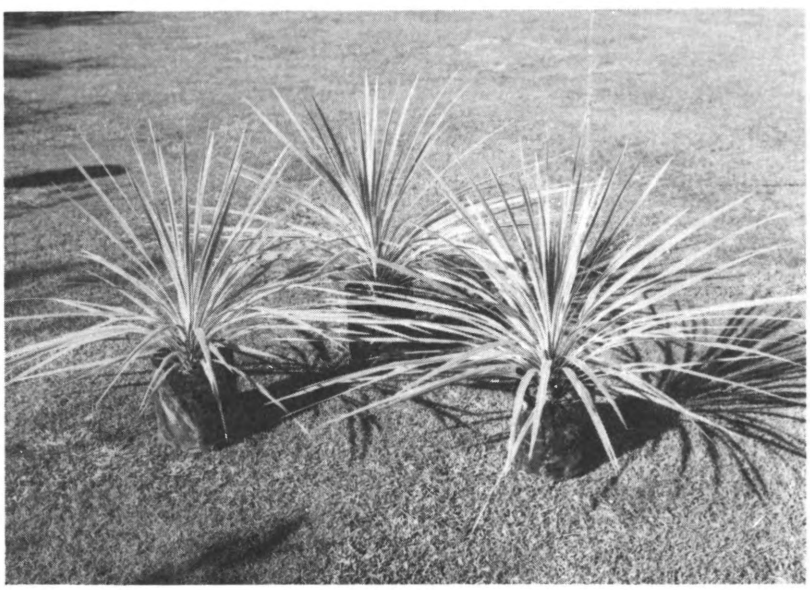
Hilliers Nursery in England, a nursery very well known for having a comprehensive list of the rare and unusual, obtained a few plants from the Belgium gentleman through cuttings. Occasionally the cabbage tree would produce an off-shoot on the side of the trunk and with almost constant care occasionally one was able to obtain a new plant in this way by surrounding the base of the shoot with spagnum moss and soil, covering the whole thing with plastic, thus keeping the moisture content. If one was fortunate enough, the shoot would send out side roots into the soil and thus could be separated from the parent tree. Very tedious and very slow.

About 1918 Mr Cook from Gisborne, New Zealand, spotted some plants in Hilliers and purchased two which he brought back to New Zealand. About 1930 Mr Cook gave a plant to Mr V.C. Davies of Duncan & Davies, New Plymouth. Mr Davies worked on his tree and managed to produce a handful of cuttings after many years. About 1960 Mr Davies gave Mr F.M. Jury of Tikorangi a plant and Mr Jury managed to raise a handful of plants over the next fifteen years. Propagation was almost an impossibility, or so we thought, until the Japanese came to New Zealand in the early 1970's and showed Duncan & Davies and Mr Jury how to propagate cordylines from root divisions.

Mr Jury's son and daughter-in-law set up a nursery in 1976 and having access to Mr Jury's stock plants worked on propagating through root divisions over the next five years and in 1979 released a few plants to customers and by 1981 have just built up enough to sell a few wholesale to Garden Centres throughout New Zealand. It has been a long, slow process of trial and error and the success rate is by no means 100% yet. The plant is now non-existent in England.

It is unfortunate that *Cordyline australis* 'Alberti' does not flower to produce seed but it does provide us with the challenge and for Mr B. Jury it has been an enjoyable and rewarding one to master.

Mature specimen of
Cordyline australis 'Alberti'



Young plants of *C. australis* 'Alberti'. Leaves are green in the centre with a dominant yellow edge which is tinged with blush pink. Growth rates are slower than for the bronze and green cultivars which lack variegation.

The Effects of Thinning 'Gala' Apples

by

J.M. Hawkes

Extracts from a thesis for the National Diploma of Horticulture (Fruit) (N.Z), submitted by J.M. Hawkes in 1978.

INTRODUCTION

Under conditions where a heavy fruit set takes place on apple trees some degree of thinning is normally required to produce fruit of marketable size. Thinning avoids a tendency toward biennal bearing and also helps increase fruit colour and quality (Batjer 1965).

The amount of thinning normally required varies from one variety to another. Some require little or no thinning at all to produce crops of good size whereas other varieties must be heavily thinned to bring fruit up to a size suitable for marketing. Some varieties have an in-built ability to self-thin, whereas others require a considerable amount of fruit to develop to a desirable size.

In the past the practice of thinning by hand was the only method of thinning. In more recent times the use of chemicals (in the blossom-early fruit set period) has gained a great deal of favour. Chemical thinning has the advantage of removing fruit from the tree at a much earlier stage than hand thinning, enabling the remaining fruit a greater period to increase size and also promote flower initiation for the following season.

It is a general practice in orchards today to chemically thin the crop early, and then follow up by hand thinning to reduce the crop to the required level at a later stage. In this case chemical thinning reduces the amount of hand thinning required, promotes more regular bearing by removing the bulk of the excess crop prior to flower initiation.

Little is known about the effects of different chemicals or the rates required to thin the apple variety 'Gala' in Hawkes Bay. This is also true of the degree of thinning required for this variety either by hand or chemicals or a combination of both to reduce the fruit set to such a level as to produce fruit of a desirable marketable size.

It is the purpose of this thesis to determine the degree of thinning required to bring the fruit up to an acceptable size to meet market requirements.

EXPERIMENTAL WORK

Two separate trials were set out in two orchards in Hawkes Bay. Orchard 'A' on the southern side of Hastings City. Orchard 'B' on the northern side of Hastings City.

Part One - Chemical Thinning

In this section of experimental work two chemicals ANA & Carbaryl were compared against unsprayed trees. ANA was used in two different treatments and carbaryl as follows:

ANA x 2

The first chemical treatment applied to the trees was the first application of ANA in the double application treatment.

The first treatment applied on 17/10/77 was timed to be applied at full bloom. In this treatment 25ml of 'Planofix ANA' (which contains 4.5% ANA) was added to 227 litres of water this gave a rate of 5 parts per million of ANA plus 570ml of glycerine. The use of glycerine with ANA reduces the quantity required by assisting its uptake.

By reducing the quantity of ANA a reduction in leaf damage is achieved. This treatment was applied to the trees in the late afternoon.

Weather conditions at the time were fine and mild with a light northerly breeze.

The second application of ANA was applied to the area on 26/10/77 nine days after full bloom. The same rates of ANA and Glycerine were used as in the first application. This application was applied mid-morning. Weather conditions at the time were fine and mild following a 2.8°C frost.

ANA x 1

The one application of ANA x 1 treatment was applied on 20/10/77 three days after full bloom. Approximately 50% of the petals had fallen. This application was at the same rates of ANA and Glycerine as applied in the first application on the ANA x 2 trial.

This application was applied to the trial in the late afternoon. Weather conditions at this time were fine and warm with a light northerly breeze.

Carbaryl

The carbaryl treatment was applied on 3/11/77. This was about 2 days after complete petal fall. The rate used was 225g of 'Septan 80W' in 225 litres of water.

Weather conditions at the time of application were overcast and calm following a cool night. The spray was applied mid-morning but was followed an hour later by heavy continuous rain, 19.9 mm falling in the following 24 hours.

Because of the rainfall following the initial application a second application of carbaryl was applied on 8/11/77 using the same rates as in the original application. Weather conditions were fine and warm with a light northerly breeze.

Application of Chemicals

The thinning chemicals were applied to treatments by the use of a motorised pump and four hundred and fifty litre tank mounted on a trailer unit. Spray was delivered to a hand-gun by rubber hose, the pressure at the pump was between 2000 kPa and 2700 kPa.

When spray was being applied to the trees it was directed on to the upper areas of the trees. Davidson (1966) states because of the tendency for thinning sprays to overthin the lower parts of the tree these parts should be sprayed very lightly or avoided altogether.

Approximately 9 litres of spray was applied to each tree in the treatment. Trees were sprayed to the point of run-off.

Part Two - Hand Thinning

In this section three rates of hand thinning were compared against a control block.

Hand Thinning Trials

Hand thinning trials were undertaken to find the effects on fruit size at harvest of three treatments of hand thinning.

The three treatments planned were:

a. Treatment One

This was designed to produce fruit in the A size group or larger (A group contains counts 100 and 113). To achieve this it was planned to reduce the crop on each tree down to 6 fruits per cm^2 of butt area. This would in effect give a heavy thinning rate.

b. Treatment Two

Was designed to produce fruit in the B size group (B group contains counts 125 and 138). To achieve this size it was planned to reduce the crop to 9 fruit per cm^2 of butt area. This would give the effect of an average thinning.

c. Treatment Three

Was designed to produce fruit in the C size group (C group contains counts 138 and 150). To achieve this it was planned to reduce the crop to 12 fruit per cm^2 of butt area. This would give the effect of a light thinning.

d. Control

A fourth area was used as a control treatment. This was the control block from the chemical thinning trials. No fruits were removed from this treatment.

To achieve a maximum benefit from any advantages gained from the chemical thinning trial the same trees were used as in the previous trial.

This gave a situation that is practised in commercial orchards where chemicals are used to reduce the number of fruits early and then is adjusted by hand thinning to the required level at a later date.

Treatment One - Heavy Thinning

To achieve the maximum advantage from the chemical thinning and also to maximise the results of this trial, the trees that had been chemically thinned by the two applications of ANA were used as the heavy hand thinning trial. This because the ANA x 2 application had reduced the fruit load by the greatest amount of the three treatments and had reduced the fruit load to heavy thinning in comparison with the other two treatments.

Treatment Two - Average Thinning

The trees that had one application of ANA were used in treatment two. This was because in comparison with the other two treatments the ANA x 1 treatment had reduced the crop load by an average amount.

Treatment Three - Light Thinning

The third treatment was selected to be applied to the trial originally having the applications of carbaryl. This was because carbaryl had reduced the crop by the least amount of the three treatments and therefore could be considered the light treatment.

SUMMARY AND CONCLUSIONS ON EXPERIMENTAL WORK

It was found in the trials undertaken in this project that only a small amount of thinning needs to be undertaken to produce the best monetry return on Gala in Hawkes Bay. The results of trials A & B showed that only a few fruits were removed by the three different applications of chemicals. When these results were being assessed the author felt that at the time the results from the two applications of ANA gave the only worthwhile result. Now with the results of the hand thinning available, it appears that the lesser rate of thinning, as achieved by the one application of ANA or Carbaryl, may now give a worthwhile result. However, as none of the chemically thinned trees were left unthinned through to harvest the value of thinning as obtained by the chemical cannot be gauged accurately.

From observations made throughout the trials the rates of thinning obtained from the two applications of ANA could have been too high and the single applications may in fact bring the best returns, where chemicals are used as the only method of thinning.

Where hand thinning is practised as the sole method of thinning, the removal of small under coloured fruits from the insides of the tree and from under fruiting arms plus small amounts of diseased fruits is probably sufficient thinning to bring a good return.

Also it must be pointed out that no costs were calculated for the time involved in hand thinning operations in these treatments. This was not attempted, as it was considered that as the hand thinning operations carried out on these trials involved using a hand operated counter, therefore only one hand could be used while thinning. This plus to obtain an accurate thinning the trees were gone over several times, each time more fruits were removed until the required level was achieved. Because of this, the time involved to thin the treatments was much greater than would normally be expected and if recorded would not have presented a true picture of the true cost of the thinning of the three treatments undertaken.

With the results obtained, any hand thinning costs involved would have only improved the return on the lightly thinned treatments, as these would have required less hand thinning time, therefore the monetry return would have been even greater than those obtained. The only exception would have been some improvement in the value of the control treatments but this would probably not have greatly altered the final results.

Where both hand and chemical thinning is planned if a reasonable result is achieved by the use of chemicals, little or no hand thinning should be required, to bring the best returns.

As the final results have shown if the Gala trees obtain good size and colour early in the season and the bulk of the fruit can be harvested in two or three picks good results can be obtained. Even when several more picks are required as was demonstrated in trial D with only three picks being taken during the export period good returns are still achieved from the lightly thinned treatments. When the remainder of the crop is taken into account as local fancy and standard grades this improved the position of the control treatment and made this appear the best return. However, not thinning at all lengthens the harvest period for this variety and this can complicate management problems. This must be considered when calculating the value of this treatment.

Even when the value of both trials C and D are added together (see figure 9) the lightly thinned treatments still show the best value.

Although some improvement in colour was obtained through the heavier thinning treatments the difference between treatments would not have warranted heavy thinning just as a means of obtaining better colour. Any improvement in colour would have been off-set by the loss in the quantity of fruit harvested.

The results obtained from these two trials have been calculated out using 1978 prices for fruit and the picking cost deducted where approximate wages as paid this season also.

The grades used in grading the fruit were also grades that applied in this season.

Any changes in the future to these costs, payments or grades could alter the value of each treatment and would need to be revalued applying any new criteria.

RELATED ASPECTS

This subject was undertaken for study because little was known of the effects of thinning on Gala apples.

While involved in this study several other avenues of investigations have emerged.

Further work could be undertaken on the effects of pruning on final fruit size, quantity and colour. This would demonstrate what was observed while carrying out the thinning trials on the two separate properties used in this subject, in that the lower vigour trees carrying only an average fruit load on open trees produced better colour and size earlier than did the heavier cropping more vigorous trees on the second orchard.

Another avenue of research would be in using other chemicals as well as those used in these chemical thinning trials in combination, alone, at varying rates and at different stages of blossom and fruit development.

An interesting result may be achieved if trials were to be carried out using a combination of pruning and thinning techniques, although through the use of the correct pruning techniques no thinning may be necessary at all.

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Book Review

MISS WILLMOTT OF WARLEY PLACE

by

Audrey le Lievre

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Riches and power are not normally an attribute of the horticulturist. But the subject of this biography, Ellen Willmott, (1858-1934) successfully linked this unusual triumvirate together. Born into a well-to-do upper-middle-class family - her father was a solicitor who was also a very sound financer, making very profitable investments in the world-wide railway boom - Ellen Willmott eventually inherited both the family finances and the family house, at Warley Place in Essex and she then devoted the rest of her life to spending that fortune on horticultural pursuits. This biography is the fascinating story of that progression - although one may justifiably equally say it was a down-hill path, to a lonely and financially-difficult end.

Miss Willmott was obviously a complex person, and Audrey le Lievre traces her story well. Miss Willmott inherited a sense of her own importance and she moved easily into the upper eschelons of society, becoming friend and confidant of Edward VII and Queen Alexandra, and George V and Queen Mary. She used these social contacts for the benefits of her horticultural interests. Cajoling, bullying manipulating - she made her determined way forward in collecting, publicising, and distributing the varied range of plant material she grew at Warley Place. Even today, almost 50 years after her death, there are few knowledgeable gardeners unaware of the range of "Willmottiae, Willmottianum", or "Warley, Warleyensis, Warley Rose" species or cultivars which commemmorate the family name or that of the family estate. Ceratostigma willmottianum, Corylopsis willmottiae, Cistus "Warley Rose", Lilium davidii "Willmottiae", Aethionema "Warley Rose", Epimedium warleyense, Paeonia obovata var. willmottiae, Scabiosa caucasica "Miss Willmott", and Rosa willmottiae are some of the shrubs, bulbs, perennials and alpines one still finds, even in New Zealand horticultural references; Mrs le Lievre lists eight pages of plants which once bore these appendages.

To collect, grow and select these manifold forms and varieties required tremendous endeavour, and this is where the family fortune was used to the full. She bought prodigously, to supply not only Warley Place, but also her European gardens at Tresserve at Aix-Le-Bains, France, and at Boccanegra, close to Sir Frederick Hanbury's famous garden 'La Mortola', Italy; and their culture was on an equally prodigous scale too.

The garden staff at Warley Place alone totalled 104 in its heyday - all equipped with their uniforms of green and natural straw boaters, green silk ties and navy-blue aprons. Little wonder that even the Willmott family fortunes - with railway stock in New York, the Argentine, London and Liverpool, and of such a character that Ellen Willmott's annual birthday present from an aunt was 1,000 - began to bend under the strain. It was a slow but inexorable change. When Miss Willmott died she was living in just three rooms of the enormous three-story Warley Place.

But the decay took more than thirty years to reach its climax. In the interim the social manipulation of the garden and its plants continued, and the seed lists were sent out world wide. Even the last seed list, in 1932, contained over 600 names - and the buying went on by the thousand. Not satisfied with an interest in plants themselves Miss Willmott entered the publishing field, too.

"The Genus Rosa" was published for her between 1910 and 1914, in twenty five parts. The price of a guinea per part did not recoup the costs, and since Miss Willmott was totally unsatisfied with anything except the best of paper, printing and of colour reproduction for the 131 beautiful watercolour plates by Alfred Parsons, the costs still mounted. Eventually parts languished unsold on the shelves; today, parodoxically, it is worth between $1,400-1,600. Another of her publishing ventures - "Warley Gardens in Spring and Summer" - a fine collection of collotype plates of her famous garden - made a total of 7.1.8 for its author!

But these ventures made her name and her reputation. Her contacts with the Royal Horticultural Society, the prime arbiter of taste and fashion in horticulture, were considerable. Not only was she one of the initial recipients of the Victoria Medal of Honour, its prime honour, but she belonged to several of its committees over long periods - the Lily, Narcissus, and Floral B. More significantly, she played a major part in obtaining Wisley, the present-day Royal Horticultural Society gardens, for the Society; she was largely instrumental in persuading her later neighbour at Boccanegra, Sir Thomas Hanbury, to buy Wisley's 60 acres and present it to the Society. Undoubtedly, a woman of ability, drive and charm - and accustomed to getting her own way.

Yet Miss Willmott had her bitter side. One gains the impression from Mrs le Lievre's biography, that to Ellen Willmott people were to be used because they were useful, or ignored and even denigrated if they were not. Her relationships with her wide-ranging nursery contacts were singularly unhappy, for she queried her accounts, delayed payment, and expected stock to be kept for her over long periods without charge. The delivery of copy for "The Genus Rosa" drove the publisher, Messrs John Murray, almost to distraction; and her garden staff at Warley Place regarded her warily. Whilst generally fair she is known to have deducted the equal of a newly-acquired 5/- per week old-age pension from the wages of an employee, when he elected to carry on working. With treatment meted out in this manner even her circle of intimates contracted. There is no doubt but that towards the end of her life she enjoyed the fight as much as she enjoyed winning.

It is from human foible like this that our world is made. Without her tenacity and drive the horticultural field would be the poorer. We are indebted to Mrs le Lievre's efforts for this pioneer study of a complex and interesting person. The definative study still has to be written, but in the interim this account can provide an excellent service by whetting our appetites about an era and style we shall never see again.

S. Challenger

International Code of Nomenclature for Cultivated Plants 1980

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From the Preface of the 1980 Cultivated Code:

The last edition of the International Code for the Nomenclature of Cultivated Plants (abbreviated in common usage to Cultivated Code) was published in 1969 (Regnum Vegetabile Vol. 64, pp. 32).

The last ten years have seen the question of cultivar nomenclature rising steadily in importance, largely because of the various international and national measures in operation to protect buyers of plant material and to provide for plant breeders' rights. The International Commission for the Nomenclature of Cultivated Plants, whose various editions of the Cultivated Code have provided the main scientific background now embodied in cultivar-name legislation, is glad to note how closely the Cultivated Code and corresponding legislation are in accord and is glad also that the hope expressed in the preface of the 1969 Cultivated Code, that the edition then produced would be adequate for the following decade, has been fulfilled. The articles in the 1969 Code were re-arranged and renumbered to improve their logical sequence and ease of consultation, but the hope was recorded that the new arrangement might prove adequate even through subsequent amendment. The Commission have found that this is indeed so, and the arrangement and numbering of the articles conform exactly with those of the previous edition.

Though a great many detailed changes have been made in the text of the present edition, largely to clarify meaning or add examples, the overall text is very similar to that of the 1969 edition. The principal changes are as follows:

1. A clearer distinction is drawn between cultivar names and trade-marks applied to cultivars, and between cultivar registration and registration of trade-marks which may be applied to cultivars (Arts. 3,4,53,56).
2. It is explicitly stated that a cultivar may, on occasion, be co-extensive with the botanical category under which it is classified (Art. 10).
3. A forestry provenance, when sufficiently distinctive, may be treated as a cultivar (Art. 10).
4. Particular growth-habit forms which are retained by appropriate methods of propagation are treated as cultivars (Art. 11).

5. Segregates of interspecific or intergeneric crosses resembling one parent in nearly all its characters are classified under this parent, not under the hybrid combination (Art. 13).
6. The formula designating somatic hybrids is expressed using the multiplication sign with parenthesis (round brackets) (Art. 14).
7. Latin cultivar names derived from botanical epithets published before 1st January 1959 are regarded as validly published as long as they are in conformity with the present Code (Art. 27).
8. The different significance of a botanical varietal epithet in italics and the same epithet in Roman type used for a cultivar and typographically distinguished is spelled out and exemplified (Art. 27).
9. The various approved ways of printing cultivar names are set out in greater detail (Art. 29).
10. It is strongly recommended that cultivar names should not incorporate the common name of the plant (Art. 31A).
11. Chinese, Japanese and Korean books are considered validly published when reproduced from a hand-written original, irrespective of date (Art. 37).
12. Conditions for re-use of cultivar names are made more stringent (Art. 48). Appendix II of the 1969 Code has been omitted since there has been no re-numbering of articles and recommendations in the current revision.

(* Available from July 1981.)

The Development of the Process Tomato

by

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INTRODUCTION

The cultivated tomato (*Lycopersicon esculentum* Miller) is a widely grown, warm season, annual vegetable. When first introduced from the New World to Europe early in the 16th century, the tomato was regarded as an exotic botanical curiosity. The belief that tomatoes were inedible and poisonous, largely because of their relationship to the nightshades, persisted for several centuries. Although cultivated and consumed in Italy and Spain during this period, it was not until 1840 that the tomato gained any acceptance in the U.S.A. In England, the myth that tomatoes were vile and inedible continued virtually until the 20th century. Tell (1977) suggests that the warm sunny climates of Italy and Spain helped ripen the fruit more successfully than the cooler climates of Great Britain and Northern Europe, thus leading to its earlier acceptance in those Mediterranean countries.

Since 1900, the tomato has increased in popularity not only as a food in its own right, but also as an important ingredient in many processed foods. The most extensive production occurs in the U.S.A. In 1980, nearly 7,000,000 tonnes worth US $1,000 million were produced of which 80% was processed. Nearly 90% of the processed tonnage was produced in California. Per capita consumption in the U.S.A. was 25kg. In New Zealand, consumption is approximately 20kg per head.

This article outlines some of the developments that have occurred in the breeding of the process tomato since it was introduced and domesticated.

ORIGIN AND DOMESTICATION

The centre of origin of the tomato is a narrow strip of land between the Andes and the Pacific Ocean, extending from Northern Chile to Ecuador (Jenkins, 1948). It was once thought that the centre of domestication was Peru, largely from use of the name *mala peruviana*, which was applied to the tomato after its introduction into Italy. Most authorities now agree that the tomato was domesticated in Mexico and that the introductions to Europe were from this country rather than from areas further south (Jenkins, 1949; Rick, 1976, 1980). The word tomato, in fact comes from the Aztec word *tomati*. Again there is general agreement that the most likely ancestor is the wild cherry tomato (*L. esculentum* var. *cerasiforme*), a weedy agressive species found in Mexico and Central and South America.

The cultivated tomato is one of nine species placed in the genus *Lycopersicon*, which is divided into two subgenera; *Eulycopersicon*, the red-fruited species and *Eriopersicon*, the green-fruited species. The species of these two subgenera are shown in Table 1.

Table 1. The species of the genus *Lycopersicon*.

Eulycopersicon (red-fruited)	*Eriopersicon* (green-fruited)
L. esculentum	*L. cheesemanii*
L. pimpinellifolium	*L. chilense*
	L. chmielewskii
	L. glandulosum
	L. hirsutum
	L. parviflorum
	L. peruvianum

EARLY BREEDING

No large fruited tomatoes have ever been found growing in a wild state indicating that the American Indian did an outstanding job of improving the tomato by selecting for large fruit size (Crill *et al.* 1977). These large fruited types were introduced into the Old World from Mexico and later were reintroduced to the North American continent. The five basic types reintroduced into the U.S.A. were the Cherry, Plum, Pear, Old Round and Large Red.

Prior to 1920, tomato improvement was based on selection of chance variants that originated as a result of mutation, spontaneous outcrossing or recombination of preexisting variation (Rick, 1976). Such selection succeeded in developing cultivars adapted to widely differing environments. Since then, more rapid progress has been made in developing new cultivars through the use of modern plant breeding methods and techniques. However, the success of any plant breeding programme is dependent on the genetic variation available. Rick (1980) points out that a great wealth of tomato germplasm is available consisting of modern and old cultivars, primitive cultivars, breeding lines wild forms of *L. esculentum* and the exclusively wild species.

As labour became a scarce and expensive resource in California, attention was directed towards developing a tomato that could be mechanically harvested. This work was pioneered by G.C. Hanna of the University of California, at Davis, who succeeded in breeding into a single cultivar, smallness and compactness of plant, concentrated ripening and fruits of size and shape able to withstand machine harvesting, while incorporating the necessary characteristics of disease resistance, yield and quality (Rick, 1980). This cultivar was known as VF 145.

Since this development, much effort has been devoted to breeding tomatoes suitable for mechanical harvesting and processing. The development of the process tomato is really the development of the 'once-over mechanically harvested' tomato for processing. For once-over harvesting, plant growth habit, concentrated flowering and fruit setting ability, concentrated maturity and vine storage determine the efficiency of machine harvest. Quality factors determine the processing ability of tomatoes.

PLANT HABIT

Prior to 1914, all tomatoes were indeterminate in growth habit. The *sp* (self-pruning) gene appeared as a spontaneous mutation in a Florida field in 1914 and has been extensively used in many breeding programmes since then. The *sp* gene gives a plant, in which the branches terminate their growth at approximately the same distance from the centre of the plant. In addition, the plant flowers more abundantly than the normal indeterminate plant. These criteria have enabled breeders to produce tomato plants with small determinate vines and concentrated fruit setting and ripening facilitating once-over mechanical harvesting.

George and Berry (1974), state that for efficient mechanical harvesting, vine size is important in its effect on the machine as to ease of vine pick-up and effectiveness of fruit removal. During pick-up, fruit should separate with ease and without the pedicel and calyx. The *j-2* (jointless pedicel) gene is being widely used to overcome this problem. At least two jointless pedicel genes are known. The first of these proved to have undesirable side effects. Flower clusters did not terminate but produced further growth, leafy calyces and inflorescences. The *j-2* gene does not produce these side effects, although fruit of early cultivars possessing this gene had a tendency to shatter at the core when separating from the stem. Recent cultivars are free of this defect.

EARLINESS

Earliness is an important characteristic in some breeding programmes particularly where tomatoes must be grown during a short season. An early maturing tomato advances and extends the harvesting season and thus is of great significance in machine harvesting (George and Berry, 1974). In contrast to multiple handpick harvesting, mechanical harvesting involves a once-over destructive harvest. Harvesting is delayed until the crop has fully matured whereas with the old handpick system, harvesting began earlier, as fruit was picked as soon as ripe.

Workers studying earliness have divided the growth of the tomato into several stages. These include:

1) seeding to germination
2) germination to first true leaf
3) first true leaf to first flowering
4) first flowering to fruit setting
5) fruit set first ripe
6) first ripe to peak fruit.

These components of earliness are under complex genetic control and are considerably affected by environmental factors such as weather and cultural practices. For breeding purposes it is possible to condense these stages to two, viz.

1) seeding to flowering
2) flowering to first ripe fruit.

Butler (1976) states that it is in this second stage where most selection pressure has been applied and where genes for earliness are most easily selected.

Several workers have attempted to find tomatoes which are cold tolerant and/or able to germinate at low temperatures (10°C). Lines able to germinate at low temperature have been identified (Smith and Millett, 1964), but this character has not been bred into any process tomatoes as yet. Nevertheless, some early maturing cultivars are available. The cultivar Castlong has been successfully used in New Zealand as an early maturing process tomato.

FRUIT SET

A feature of tomato breeding has been the improvement in fruit set through changes in floral structure. Latin American cultivars and wild species have a well exerted stigma facilitating cross pollination. When these cultivars were introduced to Europe, the lack of suitable pollinating insects meant that fruit setting was diminished. Rick (1976) postulates that selection would have been made for better setting lines with less exposed stigmas. In glasshouse culture, the selection pressure would have been even stronger because wind-induced vibrations that aid pollination, as well as insects would have been excluded. As a result, the stigma of most cultivars became fixed at the mouth of the anther tube. In the past decade, the stigma position was shifted again to a position well within the anther tube. This change which further improves self pollination and thus fruit set has virtually eliminated cross pollination and is a feature of all modern California tomato cultivars.

High temperatures reduce tomato yields. Many cultivars suffer severe blossom drop when exposed to day/night temperatures of 26/20°C and temperatures of 30/20°C prevent fruit set (Stevens and Rudich, 1978). In temperature sensitive cultivars, fruit set is reduced at high temperatures because of a reduction in the production of viable pollen and pollen transfer to the stigma. Cultivars with high temperature setting ability, e.g. cv Saladette have been bred.

TOMATO COMPOSITION

The composition of tomatoes is shown in Table 2.

Table 2. Composition of tomato fruit.

Constituent	%
Total solids	7.0-8.5
Insoluble solids	1.0
Soluble solids	4.0-6.0
Sugar	2.0-3.0
Acid	0.3-0.5
Soluble protein, amino acids	0.8-1.2
Mineral constituents	0.3-0.6
Salt	0.05-0.1

Tomatoes usually contain from 7-8.5% total solids, of which about 1% is skin and seeds. Glucose and fructose comprise 50-60% of tomato solids with the total sugar content varying from 2.2-3.5%. The polysaccharides in tomatoes constitute about 0.7% of tomato juice, of which 50% are pectins, 25% are cellulose and 25% are xylans. The acid in tomato is almost entirely citric.

Fresh tomatoes, tomato juice and other processed tomato products contain significant amounts of several nutrients necessary for human nutrition. Vitamin C activity in tomatoes is present as reduced ascorbic acid, at 25mg per 100g. One medium tomato will supply about 40% of the U.S. Recommended Daily Allowance (R.D.A.) of 60mg for adults and about two-thirds of the R.D.A. of 40mg for children. Thus it is possible to meet all vitamin C requirements from tomatoes. Tomatoes are also a good source of vitamin A which is present as carotene. Fresh ripe tomatoes and tomato juice contain 1000 International Units (I.U.) of vitamin A per 100g. Thus a medium tomato should supply 20% of the adult R.D.A. of 5000 I.U. In addition, tomatoes contain small amounts of the B complex vitamins: thiamin, niacine and riboflavin. Of the minerals present, tomatoes contain significant amounts of iron.

George and Berry (1974) consider that much tomato breeding has been oriented towards the production problems of growers and that improvement of yield and disease resistance has taken precedence over quality. Nevertheless, over the last decade, considerable attention has been given to the evaluation and improvement of total and soluble solids, colour, acidity and flavour.

TOMATO SOLIDS

Both soluble solids and insoluble solids are important components of process tomatoes. Soluble solids are important in product recovery, while insoluble solids are important in fruit firmness, viscosity and vine storage. A strong positive relation exists between fruit firmness and viscosity or consistency (Stevens, 1976). This occurs because thick walls result in increased firmness and normally also increase alcohol insoluble solids. The viscosity potential of tomatoes is determined mainly by the content of alcohol insoluble solids which include the pectins and cellulose. Thus thick walled, firm fruit tend to have higher viscosities than thin walled juicy tomatoes. This high viscosity is very important to processors that sell products which have consistency as an important quality characteristic, such as sauce.

Although most machine harvested cultivars are bred to have a concentrated fruit set and ripening, inevitably all of the fruit does not set or ripen simultaneously. Environmental factors greatly influence the setting and ripening of the fruit. New cultivars, particularly the 'square-round' types possess the characteristic known as 'vine storage'. This means that early maturing fruits remain in good condition while later maturing fruits ripen. It also means that where harvesting is delayed because of the weather or factory problems, fruit remains sound till it can be harvested. The reasons why some cultivars break down less quickly than others are not fully known, but are probably due to several factors. Some cultivars have lower levels and/or lower activity of the enzymes that break down the fruit such as the enzyme pectolase. Firm thick walled fruit have higher levels of pectins and cellulose. If there are more of these components present and break down occurs at a normal rate, then fruits remain firmer for longer. Thus the development of cultivars with more pectins and cellulose has been a major breakthrough in process tomato breeding in that not only yield but also quality of the tomato has been markedly improved. Cultivars such as UC 134 have nearly twice the content of alcohol insoluble solids of the earlier VF 145 types.

It has been more difficult to improve the soluble content of tomatoes. The concentration of soluble solids can be increased but generally at the expense of yield. Hanna (1971) states that there is a leaf:fruit ratio which is difficult to overcome. In breeding for machine harvest, breeders have been reducing vine size and consequently leaf area while increasing fruit load at the same time. Stevens (1978) points out that there is a strong inverse relationship between yield and total soluble solids. Judicious use of irrigation in California can result in substantial increases in solids usually with a decrease in yield. It appears that this problem may be solved by using the wild species *L. chmielewskii*. Rick (1974) has transferred the nigh solids (10%) of *L. chmielewskii* into breeding lines similar to VF 145. Stevens (1978) states that crosses with these high sugar breeding lines has resulted in new strains which have high yield, high total solids and a greatly increased dry matter yield relative to VF 145 -B7879.

COLOUR

Fruit colour is an important quality criterion of both fresh and processed tomatoes. The colour quality of tomatoes depends on the total amount of carotenoid pigments and the ratio of lycopene:B-carotene. The 'high crimson' lines developed from a Philippine have an intense red colour controlled by the crimson gene og^c. This gene is being extensively used in the breeding of high colour cultivars in Canada (Mohr, 1976). High colour is due to an increase of lycene and a reduction in *B*-carotene. This means that the nutritional value of the tomato is reduced. The actual reduction depends on the parental background and differs for different cultivars. Lee and Robinson (1980) report that in the isogenic line Crimson New Yorker, vitamin A is reduced by 60%. The use of this gene will be limited where tomatoes are important in providing vitamin A in the diet.

FLAVOUR

Stevens (1973) considers that flavour in modern process cultivars is poor, because of the relationship between yield and solids. These cultivars, with their high fruit:leaf ratio and heavy concentrated fruit set have less photosynthate than hand picked cultivars with low fruit:leaf ratio and scattered fruit set. This means that less sugars are available for storage in the fruit. In addition, thick walled lines have less locular area where acids are normally stored. Acid concentration and pH are also important in tomato flavour and processability. The pH for processing tomatoes should be less than 4.4. Some cultivars because of their tendency to have lower sugars do not have a sugar:acid ratio of 8.5 which imparts good flavour. Other cultivars may have this ratio but still have poor flavour because of low solids, low acidity and high pH.

CONCLUSION

It has been possible to breed highly suitable once over machine harvest process tomatoes. Very firm, high yielding tomatoes have been released although this has sometimes been at the expense of quality. Breeding is now being directed towards improving quality particularly by improving photosynthetic efficiency.

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