HORTICULTURE IN NEW ZEALAND

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Grevillea mesnerii, a botanical firecracker from northern New Caledonia. Photo R. Lucas.

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Cordyline australis 'Karo Kiri' (Asteliaceae): a New Dwarf Cabbage Tree Cultivar from New Zealand

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Introduction

The New Zealand species of *Cordyline* have a long history of cultivation, and at least 38 cultivar names are recorded (Heenan, 1991a). The cultivars are mostly coloured foliage variants of *C. australis*, intraspecific hybrids between distinct *C. australis* cultivars, or interspecific hybrids between *C. australis* and other species. Apart from *C. australis* 'Karo Kiri', only one other cultivar, *C.* 'Ti Tawhiti', can possibly be regarded as being a mutant growth form (Harris and Heenan, 1991). Few of the *Cordyline* cultivars selected and introduced to horticulture have been formally named and described, and consequently there have been many problems with cultivar nomenclature and taxonomy (Heenan, 1991a, b).

C. australis 'Karo Kiri' is a valuable addition to the range of cultivars available as it provides a distinct and unique growth form that is not known in other *Cordyline* species, hybrids, or cultivars. This cultivar is regarded as originating from *C. australis*, and it indicates the type of variation that can occur through natural mutation.

Taxonomy

Cordyline australis (Forst.f.) Engl.
'Karo Kiri' cult. nov.

Description (Fig. 1, 2): Shrub with a single leafy trunk; up to 0.6 m tall after 1.5 years and 1.9 m after 9 years. Trunk diameter 18 mm at 1.5 years and 45 mm at 9 years; multiple trunks often result from pruning or stem damage. Bark thin and only slightly corky. Leaves densely placed, overlapping, stiff, patent, but drooping slightly with age, lanceolate and narrow-lanceolate to almost linear, striate, semi-glossy, green (137a*), 120–170 × 10–15 mm. Midrib indistinct on the adaxial surface; distinct and raised on the abaxial surface, narrowing to the leaf apex, 2.5–4 mm wide at the leaf base, 5–10 mm wide on the petiole, yellow-green (145a). Petiole appressed to the stem and becoming narrow near the lamina; 40–5 mm long, 24–28 mm wide at the proximal end, 6–8 mm wide at the distal end; adaxial surface white at the proximal end, green (137a) at the distal end; abaxial surface green (137a); margin membranous, white. Inflorescence not known.

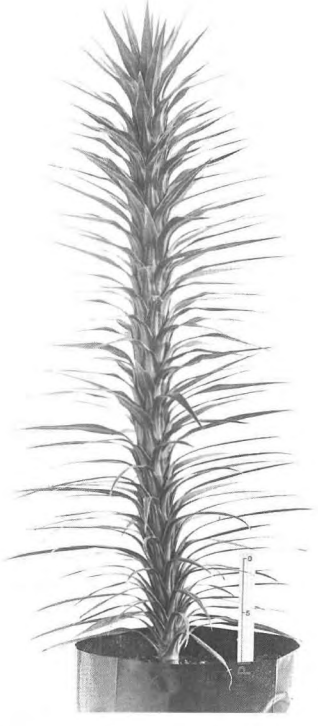

Fig. 1. A typical single-stemmed plant of *Cordyline australis* 'Karo Kiri'.

Fig. 2. Branched plant of *Cordyline australis* 'Karo Kiri', induced by cutting of the primary stem.

Chromosome number (Fig. 3): $2n = 38$ (M. I. Dawson, pers. comm., 1994), is in agreement with the chromosome numbers recorded for the New Zealand species of *Cordyline* (Hair and Beuzenberg, 1968). Voucher CHR 471152.

Origin and history: Raised from *C. australis* seed collected from an unrecorded locality in the North Island by Mr Trevor Bayliss in 1983. The seed was sown at Bayliss Nurseries, Christchurch, in 1983 and upon the growth of the seedlings it was observed that this plant differed from the others. On 27 December 1985 it was planted in a shrubbery at Bayliss Nurseries, and since 3 May 1991 plants have been evaluated by Landcare Research at Lincoln (accession 330/91).

Etymology: The cultivar epithet 'Karo' is an acronym of "known and recorded origin", and refers to plants of which Manaaki Whenua - Landcare Research has been involved in the breeding, trialling, and/or selection. This continues a procedure initiated by the Botany Institute, DSIR (Heenan, 1992). The epithet 'Kiri' is a Maori woman's name, and is also a Maori word for bark (Williams, 1957), which in this cultivar is thin and only slightly corky in comparison to *C. australis*.

Original standard specimen: Cultivated at the Landcare Research experimental nursery, Lincoln, New Zealand, *P. B. Heenan*, March 1994, CHR 471152.

Phenology: Not known to have flowered. Dwarf mutant forms often have an inability to initiate inflorescences (e.g., *Cordyline* 'Ti Tawhiti': Harris and Heenan, 1991).

Ornamental features: The aesthetic qualities of *C.* 'Karo Kiri' are its erect monopodial growth; the short, rigid, green, densely placed, and horizontally held leaves; the distinctive yellow green midrib

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* Royal Horticultural Society Colour Chart in association with the Flower Council of Holland. The Royal Horticultural Society, London. Flower Council of Holland, Leiden.

on the back of the leaf and petiole; the symmetrical head of foliage; and a tidy, groomed appearance. This cultivar is ideal for smaller suburban gardens where space is limited, or as an indoor or patio pot plant. It has been successfully grown in a glasshouse environment for three years, and it is particularly amenable to indoor pot culture. As a residential indoor plant it has been grown near a south-facing window of a hallway for over one year, retaining a healthy appearance and typical growth habit, and the leaves and trunk have not become excessively elongated.

The original plant, now nine years old, is still being successfully cultivated outdoors in Christchurch. It has been subjected to seasonal extremes of weather, including summer droughts, hot and dry northwesterly winds, winter frosts and snow, and cold southerly winds, without suffering any damage. Cabbage tree moth (*Epiphryne verriculata*) damage has been recorded from plants cultivated outdoors, but no other pests and diseases have been observed.

Fig. 3. *Cordyline australis* 'Karo Kiri' 2n = 38 (×3000). Photo M. I. Dawson.

Notes on recognition: The short, narrow, horizontal leaves immediately distinguish this cultivar from the other New Zealand *Cordyline* species, hybrids, and cultivars, which have much longer and strap-like leaves (for descriptions see Moore and Edgar, 1970 and Metcalf, 1987). *C.* 'Ti Tawhiti' is most similar to *C.* 'Karo Kiri' in that it usually maintains a dwarf growth habit, but this cultivar has leaves more typical of *C. australis* and it forms a bushy shrub because of a suckering habit (Harris and Heenan, 1991). Putative *C. pumilio* hybrids, also with long and strap-like leaves, have been described by Moore (1975).

Plant variety rights: Application for protection was made by Bayliss Nurseries Ltd on 11 January 1993 (Plant Variety Rights Journal 53: 3 [1993]), and protection was granted on 20 July 1993 (Plant Variety Rights Journal 55: 8 [1993]).

Acknowledgements

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The Ian Galloway Memorial Lecture (Wellington Branch,RNZIH) 1994: 'Trends in Urban Horticulture and the Role of New Zealand Native Plants'

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Irrespective of the field of horticulture in which we are involved, it is important to be aware of the trends and changes which are occurring. This includes fashion, which although transient has a major and increasing influence on what interests the gardening public.

More significant are changes in attitude to the ways in which we go about our business – which practices are acceptable and, which aren't. For example, some spraying practices acceptable twenty years ago are no longer so; products such as peat and plastic are being scrutinised; and the use of growth-regulating chemicals is under review in many countries, and banned in some others.

What's happening with plants is of particular interest to me, including how they are being produced and presented, the objectives of modern breeding programmes, and the nature of new releases.

The first part of this article will cover my perception of current trends in European horticulture. This is based on my observations and conversations when I visited Switzerland, Germany, Denmark, and Britain in 1993 (Northern Hemisphere summer). Clear distinctions could be drawn between the trends evident during this visit and those which were apparent to me when I visited in 1990. Undoubtedly there are connections between what happens overseas and what eventually happens in New Zealand.

Secondly, I will describe my impressions of current trends in urban horticulture in New Zealand, and what I think the future holds.

Finally, I will discuss the role New Zealand native plants are playing, and what their potential might be.

Plant Fashions in Europe

European horticulture is strongly influenced by fashions, which marketing takes great advantage of. The fashion scene there is very sophisticated, and what happens in horticulture is initially influenced by the clothing industry. Close and obvious links exist also between interior design and plant marketing.

Three separate trends were apparent to me when I visited Europe in July and August 1993.

Often, in larger garden centres, these three trends were clearly reflected by the layout of the stores. In one section everything was brightly coloured and 'up-market'. This fashion is described as 'kitsch', defined in the Oxford Dictionary as 'worthless, pretentious art', a definition which I endorse.

Nevertheless, it has a major influence on what the public is buying, and therefore on the range of plants being grown. Although a fairly small proportion of the public may be influenced by this trend, their average expenditure per person on plants and accessories appears to be relatively high.

Undoubtedly an increasing acceptance of brighter colours by the public is part of the reason that the new petunias have been so phenomenally successful. It is doubtful that such strong colours would have been as acceptable a few years ago.

Colours such as golds, yellows, reds, and violets are now more apparent in the marketplace, with different colours more popular at certain times of year.

It is very important for me as a plant breeder to be aware of the colours that sell at different times.

Bedding displays in public gardens are brighter now than I remember. I'm told by Japanese acquaintances that slightly brighter colours are gaining greater acceptance on their markets.

This fashion is apparent also in the design of dry goods, such as garden furniture, containers, and ornaments, which are typically distinctive and unusual in design.

This trend towards brighter colours is predicted by many of our nurserymen to reach here soon, after years of pastel shades being in vogue.

It is interesting to consider at this point our attitude to trends and fashions. Do we have a role in influencing fashion, or do we merely respond to it?

I'd like to think of New Zealanders as being relatively individualistic, but when I've just visited ten private gardens, which all looked much the same, I begin to wonder.

Equally apparent in Europe is a strong movement towards things, which are perceived to be natural. This trend may appear to be the antithesis of the kitsch-fashion, which is obsessed with things unnatural in appearance. However, plants aimed for the kitsch market are still often produced in a manner which also meets the current environmental requirements of the markets. These requirements appear to be largely market-driven, but in countries such as Germany they are controlled increasingly by legislation.

It is interesting that in Europe plastic pots are now widely regarded as unacceptable, requiring considerable energy to produce and posing disposal problems. Pots made from peat and paper are now widely used. Conversely, in New Zealand we are seeing a considerable increase in the use of hard plastic pots. This is largely viewed in the commercial sector as a step forward, in that it better meets their customers' requirements.

Attitudes to chemicals are changing, and in many countries their use is now restricted. In Germany chemical sprays are to be banned from home gardens and since 1987, their rose trials have not been sprayed. 'Pink Flower Carpet' won awards which it might not have achieved in trials subjected to regular spraying.

I think the response of the New Zealand public to the 'Flower Carpet' marketing campaign reflects a change of attitude. No longer are many gardeners prepared to spray regularly, if at all. There is an increasing demand for plants that do not require spraying or high maintenance. Being told that 'Flower Carpet' roses need only trimming with hedge shears once a year, and that spraying is seldom required, is exactly what the public wants to hear.

In future, I believe, much breeding work will focus on producing high-performance, low-maintenance plants which remain healthy without spraying. Restrictions on the use of growth regulators will see a vastly increased demand for plants that are genetically compact and dwarf. 'Dahlietta' is an example of a new range of genetically dwarf dahlia which are well received.

Osteospermum have become hugely popular pot plants, but require growth regulators to remain sufficiently compact. Plant breeders in Denmark are aiming to produce compact clones for pot plant production.

It is bedding plants which most rapidly reflect changes in breeding directions. The demand for improved performance in cultivation is clearly reflected by petunias. Until a few years ago, seed companies offered mainly large-flowered 'Grandiflora' types. These recover poorly from rain damage, and generally their performance in cultivation is inferior to that of the smaller-flowered 'Multiflora' strains.

The more resilient 'Multiflora' petunias now command a large share of the market, simply because gardeners want plants that perform. Most seed catalogues now list as many 'Multiflora' petunias as 'Grandiflora' types.

The new clonally propagated petunias such as 'Surfinia' ('Colourwave' in New Zealand) are a major development. Rain tolerance is improved, and the plants flower and remain attractive for longer. They are also much more expensive, but the public have shown their willingness to pay more for a better product.

'Surfinia' petunias demonstrate a renewed willingness by breeders to introduce new genetic material from the wild into their breeding programmes. Another example is a begonia species with golden flowers from South America, which is being used as a parent to produce golden- and yellow-flowered strains of fibrous begonia (*Begonia semperflorens-cultorum*).

Zinnia is amongst the many crops in which flower size has been sacrificed to attain improved garden performance. Again, this has been achieved using a species seldom previously seen in cultivation.

Genetic dwarfness is now exhibited by many seedlines, including sunflowers (*Helianthus annuus*).

The introduction of many new genera as seedlines has made the whole field of bedding plants more interesting than it once was.

Many vegetables have been developed as ornamentals, and are becoming very popular. Ornamental strawberries, tomatoes, sweet and chilli peppers, aubergines, and basil are among the many crops which now combine good looks with edible produce.

New techniques allow some crops to be produced satisfactorily without chemical treatment. Flowering of *Aster ericoides* cultivars is controlled by selecting cutting material at a suitable physiological stage. Infra-red light is used on cuttings to keep internodes short, resulting in compact plants. Day length is controlled according to the stage of the crop to regulate growth and flowering. Controlling plant habit and performance without chemicals must expand to meet increasing demand from the pot plant industry for plants which remain compact without the use of chemicals.

Evidently demand for species is growing at the expense of highly developed hybrids. Species are perceived as requiring less attention and spraying than hybrids, which is disputable.

People are wanting their gardens to resemble nature, and to attract insects and wildlife.

Whether this trend will become as popular here as in the overpopulated cities of Europe is doubtful, though certainly we have an ideal native flora for creating such gardens.

Many public gardens, including botanic gardens, are responding positively to change. Several people told me that they spray only when necessary, and as inconspicuously as possible. Every major botanic garden I visited was using some form of biological control.

In Europe, peat mining appeared to be less controversial than it is in Britain, where coconut husks (coir) are now widely used as a substitute for peat in potting mixes.

Fig. 1. *Dahlia dissecta*

Typically, botanic gardens are having to generate a higher portion of their running costs. This presents problems in some institutions, which very often don't like the public visiting anyhow.

The third major European trend, with close parallels in New Zealand, is termed 'Romantic'. The three trends are clearly catered for in major European garden centres, with 'Natural' products in one section, bright and unusual 'kitsch' products in another. A separate section aims for the romantically inclined, with packaging incorporating hearts, cupids, and suchlike, and plants decorated variously with butterflies and other trinkets.

Plants with a divaricating habit are regarded as particularly romantic. These are predominantly New Zealand natives, and to my great surprise the most popular of all at present is *Muehlenbeckia complexa*. Little known or cultivated here, it is selling by the millions in Europe. Usually it is trained up a support, and often decorated. It tolerates low light, combines with any decor, and is evidently a good conversation piece. It is marketed as 'dots in the air'.

Another popular New Zealand native is *Sophora prostrata*, and many others are being evaluated.

Trends in New Zealand

As in Europe, horticulture in New Zealand is becoming more sophisticated. Certainly gardening is extremely popular here, perhaps more so than anywhere else. Undoubtedly, fashion has a major influence on what is being grown.

Distinctions can be drawn between garden styles in different socio-economic groups. Those with relatively high disposable incomes tend to reflect current fashion more closely in the way they garden. They are sometimes called fashion leaders, but perhaps they are just the quickest followers.

I am told by management of Palmers Gardenworld that what sells well this year at their Remuera branch will be popular in other parts of Auckland in about two or three years time.

The major influences on garden styles in Auckland appear to be the media, and garden visits: private garden visits are now a significant industry.

Cottage gardening has been the most popular style, and continues to be so. Probably the single major influence is Sissinghurst, and few of our private gardens exhibit any typically regional or New Zealand flavour.

Private gardens in Auckland are a real mixture, and although many outstanding gardens exist I believe that their overall quality is poor. An average garden in a middle-class suburb contains a few trees and several low-maintenance shrubs, a surprisingly high proportion having golden foliage. A few roses are usually present, with occasional perennials and annuals scattered about. Obviously, colour has motivated most plant-buying decisions.

Earlier this year I spent a day studying plantings in several recently developed middle-class subdivisions in suburban Auckland. I looked critically at plant selection and garden layout, and was generally unimpressed with the standard of both. My overall disappointment is epitomised by the use of trees, a high proportion of subjects being unsuitable for their location and in many instances for the region.

Collectively, the gardens seldom enhance the appearance of the street. This is despite the seemingly endless demand for information by the public. Television ratings for gardening programmes have been high, and the circulation of gardening magazines continues to increase. Public lectures are well attended. Last November we attracted 12,000 people in one day to the Auckland Regional Botanic Gardens rose festival.

Greatest interest is still being shown in flowering plants: 'If it's in flower, it sells.' The popularity of container gardening is increasing, partly because sections are now smaller. A much better range of containers and container-related products is now available.

While perennials are still the most popular plant group, we are seeing a greater demand for those which require minimal attention. Agapanthus were neglected until recently, but are now extremely popular. Recently I counted eleven different cultivars on offer at an Auckland garden centre; five years ago I doubt that I would have found more than one.

It is still colour which has the greatest effect on the people. Each summer we invite the public to select their favourite dahlia. The most popular recently has been 'Klara'. It has a poor growth habit, and its flower form and foliage are ordinary. But women in particular love its colour, and so it wins against others we may regard as better all-round plants.

We are also noticing an upsurge in the popularity of simple flowers, including many recently introduced species. Some genera, such as *Dahlia* and *Camellia,* had recently become unfashionable because of the large double flowers associated with them. With the recent introduction of small-flowered species and hybrids, they are regaining popularity. This year the most popular dahlia by public vote was a species.

Plant form is increasingly being considered by leading gardeners. In Auckland palms, cycads, aloes, and other plants of distinctive shape and foliage are in steady demand.

More topiary is evident in private gardens, and standards are now very popular.

Water features are being used increasingly in private gardens, and garden centres now offer small ponds suitable for decks or for digging into the lawn.

Many gardeners seem to have just rediscovered fragrant plants. Lavenders continue to be enormously popular, as do *Luculia*, *Daphne,* and fragrant roses.

There is great interest in climbers, although it seems that only climbing roses are being commercially exploited to any great degree. Conversely, we have noticed only a slight increase in the popularity of conifers.

Large garden centres are now stocking relatively few trees, with field-grown deciduous trees and fruit trees almost absent. Few new tree cultivars are being introduced to stimulate interest, though there are exceptions. Years ago we had only one form of *Michelia doltsopa*, now we grow five at the Auckland Regional Botanic Gardens, plus hybrids.

Fruit trees, apart from citrus, have lost popularity in home gardens. This may change with the introduction of new varieties such as 'Ballerina' apples, which require little space.

Surprisingly, considering the economic problems facing many families, Auckland garden centres reported a significant drop in sale of vegetable seedlings last spring.

Native Plants

The public are becoming more aware of some native plants, including those with distinctive foliage and form. *Meryta sinclarii* and *Griselinia lucida* are now widely used by landscapers. So is *Astelia chathamica*, which is more popular at present than *Phormium.*

Cordyline are being used as accent plants in containers; possibly this is influenced by their popularity in leading English gardens.

Phormium appears to be more popular in Europe than here. Partly this may be because most of those offered here are variegated cultivars, and variegated plants are not in fashion.

Until recently garden centres stocked mainly variegated coprosmas. These are less fashionable now, but the demand for other types is increasing.

Fig. 2. *Muehlenbeckia complexa*

Divaricating coprosmas are in demand, but seldom available. A recent photograph of *Coprosma virescens* in the *New Zealand Gardener* created huge interest at the time, and available stocks of this species sold out quickly.

This demonstrates a possible pitfall when trying to ascertain which plants are popular. The public can only respond to what they know about. I'm sure there are many natives which will become more popular as they become better promoted and more widely available.

In the past, most garden centres have positioned their native plants in an obscure corner. The plants have often been poorly produced, with no attempt to have them in flower at selling time. Would they sell exotics in this manner?

In spring 1993 some 40,000 well grown specimens of *Leptospermum* were sold by one grower. This level of sales was reached because the plants were in flower at point of sale, and because they were well marketed.

The presentation and labelling of natives was in the past basic, seldom promoting the image of the plants, and on this basis we were told that 'natives aren't popular'. It is pleasing that this has now changed, with well labelled native plants now offered in most large garden centres.

Public response to the introduction of *Clianthus puniceus* var. *maximus* demonstrates how commercially successful new native selections can be, if promoted well.

Owing largely to the improved marketing and presentation of many of our native plants, some are now being used in roles traditionally filled by exotics.

Some coprosmas are now being used in place of exotics for formal hedging.

Hebe and *Leptospermum* cultivars are being grown on standards.

Cordyline and *Astelia* are now often used as focal points in containers.

Plagianthus regius is now being used in Auckland as a substitute for silver birch (*Betula pendula*), which is prone to rust.

Considerable interest has been generated by the introduction of selected forms of *Metrosideros*, both species and hybrids. Increasingly these are being used in containers, especially where space is limited. At the Auckland Regional Botanic Gardens we have crossed *M. excelsa* with smaller species to try to produce small trees suitable for home gardens.

Another native which would benefit greatly from greater selection and breeding is kowhai (*Sophora microphylla* and *S. tetraptera*). Both exhibit considerable variation, and some individuals are quite outstanding.

Hebe is our best example of a native genus, the popularity of which overseas far exceeds what it enjoys here. In Europe, several million are sold each year.

New Zealand nurserymen often give quite reasonable explanations, such as disease problems, for not growing more natives. Most of the problems with *Hebe* can be overcome, as they are simply not suited to the production methods used for most other crops. Often a simple change, such as using different irrigation methods, is sufficient to produce a marketable crop easily.

Our breeding programme is endeavouring to produce hybrids free from disease problems.These new hybrids must also perform to a high standard in gardens. Equally important is their performance in containers under typical nursery conditions.

For *Hebe* to be further popularised here, we need to develop procedures to produce quality plants in flower at a time when the market is receptive to them. Such procedures have been devel-

oped in Europe, especially by Danish growers, some of whom are now finding it economic to produce plants by tissue culture. Plants produced in this way are commencing flowering as quickly as plants grown from cuttings. 'Wiri Prince', for example, produces its first flowers once the plants have developed ten nodes.

It should also be possible to develop hebes suitable for cut flower production. *Heliohebe hulkeana,* for example, provides long stems suitable for the cut flower market.

Cultivars of *Leptospermum scoparium* are now produced in large numbers in Europe. These are sold in small (10 cm) containers when in full bloom.

We are producing new hybrids for this market, as well as for our conditions. Some new cultivars flower continuously for up to six months in Auckland.

We have identified the ideal characteristics which new cultivars should exhibit. Flowering should be prolific right to the tips of the branches. This is important for both pot plant production and the cut flower market.

Cultivars which flower in autumn and winter, when little else is in bloom, have particular garden value. More dwarf cultivars which produce an abundance of high-quality flowers are required.

We aim eventually to offer a much wider range of flower colours and forms.

A key to our breeding objectives continues to be the introduction of genetic material from the wild.

The popularity of rengarenga (*Arthropodium cirratum*) has soared in recent years. Graeme Platt and I have accumulated a diverse genetic resource with which to work. Included are elite plants with broad, arching foliage and candelabra-like inflorescences smothered with flowers. We also have pink-flowered forms. Our objective is for rengarenga to eventually rival *Hosta* in the width and boldness of its foliage.

Chatham Island forget-me-not (*Myosotidum hortensis*) is another example of a native plant with bold foliage which is widely sought after now.

In the past, many gardeners have been wary of ferns. These have the reputation of being difficult, but in fact many of our native ferns are relatively easy to cultivate given suitable conditions. Thanks largely to the efforts of enthusiasts such as Sandra Van der Mast, the public are becoming more aware of this.

The major impediment to our native flora gaining wider acceptance by the gardening public remains one of attitude. Natives are often regarded as perhaps commonplace, whereas in fact many are distinctive to New Zealand and highly ornamental. Fortunately the character they contribute to our landscape and gardens is slowly but steadily becoming more widely recognised here.

Internationally much of our flora has great commercial potential, which could be exploited more fully for the benefit of our industry and our country.

Plant Raisers' Award, 1994

Riwaka Research Centre, HortResearch

Hops have been grown in the Nelson area for more than a century. Initially the cultivars grown came from Europe or the United States of America, but over the last 50 years the New Zealand industry has come to depend completely on cultivars bred at Riwaka Research Centre, once part of DSIR and now of HortResearch. These cultivars have been bred for New Zealand conditions and for New Zealand requirements – they produce high yields of hops of better quality for brewing, they are better suited to our climatic conditions, and they are resistant to diseases. Most of the crop produced in New Zealand is exported, and hops are therefore becoming a useful earner of overseas funds. The hop cultivars produced are enhancing New Zealand's competitive advantage in horticulture.

The hop breeding programme at Riwaka has focused on developing cultivars which are high in alpha acids, the precursors of the bitter taste in beer, and are seedless, a desirable attribute in brewing. Also, emphasis is now being placed on the development of good aromas, similar to those of European "Noble Aroma" cultivars. The programme for production of such cultivars involves a number of steps, as follows.

1. Acquisition of germplasm from overseas.
2. Evaluation of overseas cultivars under New Zealand conditions.
3. Production of triploid seedling populations by artificially doubling the chromosome number of selected female parents and crossing these to diploid male parents. The resulting triploid progeny do not produce seed.
4. Selection amongst these seedlings for promising commercial types.
5. Extensive evaluation in replicated trials for agronomic, chemical, and harvesting characteristics.
6. Detailed testing of the most promising selections with special emphasis on the suitability of the hops for brewing and with evaluation at both New Zealand and overseas breweries.

The release of a hop cultivar is thus the end result of many years of planning, research and evaluation. Five cultivars released from Riwaka are now the basis of the New Zealand industry:

- 'Super Alpha' ('Smoothcone' × OP), released 1976, seedless and high in alpha acids, occupies 35% of the planted area;
- 'Green Bullet' ('Smoothcone' × OP), released 1972, and 'Sticklebract' ('First Choice' × OP), released 1972, both seedless and high in alpha acids, make up 20% of plantings;
- 'Pacific Gem' ('Smoothcone' × 'Early Male'), released 1987, seedless and high in alpha acids, occupies 25% of commercial plantings;
- 'NZ Hallertauer' ('Hallertauer' × OP), released 1988, seedless and a dual-purpose selection with a medium content of alpha acids and high aroma type, now occupies 20% of commercial plantings.

'Smoothcone', the mother of many of these cultivars, was itself a Riwaka success, having been selected for its resistance to root rots.

The most recent cultivar, 'Southern Cross', which was released in February 1994, is notable for having a high content of alpha acids but a relatively low content of cohumulone, a desirable brewing attribute. An aroma selection as yet unnamed, which has an excellent essential oil profile, will be released in September 1994.

The Riwaka hop-breeding programme, initiated by R. H. J. Roborgh and A. A. Frost, and now under the direction of R. A. Beatson has been very successful in meeting the requirements of the New Zealand hop industry. The programme has resulted in the introduction of cultivars which are resistant to diseases, have high yields, are high in alpha acids, are high in aromas, and are ideally suited for the brewing industry. The programme has also gained international recognition for the quality of the cultivars produced.

Two cultivars are nominated for the Plant Raisers' Award as representative of the programme: *Humulus lupulus* ' Super Alpha' and *H. lupulus* 'NZ Hallertauer'.

The Potential of Three Montane *Hebe* Species for Breeding New Ornamental Cultivars

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Introduction

Hebe has given rise to a large number of interspecific hybrids, both in the wild and in cultivation. The first controlled cross was done in 1848 (Anon., 1851; D., 1887) by Isaac Anderson-Henry (1799-1884), when he crossed *H. stricta* var. *stricta* with *H. speciosa* to give *H.* ×*andersonii* (Anderson-Henry, 1868; Heenan, 1994). Other controlled crosses documented include those by John Luscombe (1806–1888) between 1850 and 1856 (Heenan, 1993) and by Robert Lindsay (1846–1913) in the 1890s (Lindsay, 1901; Anon., 1902).

Two of the earliest *Hebe* cultivars to be named were *H.* 'Coccinea' (Anon., 1850) and *H.* 'Rosea' (Anon., 1847). These are usually listed as selections of *H. speciosa*, but their rose flower colour indicates that they are probably spontaneous garden hybrids, with *H. speciosa* as the female parent. It was probably variation amongst the *Hebe* species that were cultivated in Britain and the hybridisation work of Anderson-Henry that led Hooker (1852) to observe that "the species hybridize with great facility."

The first suggestion of hybridisation in the wild was by Cheeseman (1906). Cockayne (1923) and Cockayne and Allan (1934) recognised numerous wild and artificial hybrids. Cooper (1954) studied variation in wild populations, including hybrids, from two localities near Auckland, and Frankel and Hair (1937) reported on the cytology and genetics of 37 artificial interspecific crosses.

The ease with which *Hebe* can spontaneously hybridise in cultivation, the abundant and viable seed set, the relative ease of germination (Simpson, 1976) and seedling growth, and the wide variation in growth form, flower colour, and phenology have limited the need for specialised breeding and selection programmes. Apart from the documented efforts of Anderson-Henry, Lindsay, and Luscombe, it seems that no other significant *Hebe* breeding programmes were undertaken until that of J. Hobbs, at the Auckland Regional Authority Botanical Garden in 1982. The objectives of Hobbs's breeding programme have been defined to include greater disease resistance, improved flower production and appearance, attractive foliage and growth habit, and reliable garden and nursery performance (Hobbs, 1991 and undated). In this programme 82 controlled crosses have been completed between 1982 and June 1993 (J. Hobbs, pers. comm., 1993), and 12 cultivars have been named and described. The *Hebe* species Hobbs identified as important parents include the northern and lowland *H. speciosa*, *H. diosmifolia*, *H. macrocarpa* var. *latisepala*, and *H. obtusata* (Hobbs, 1991).

It is generally accepted that many of the early *Hebe* cultivars have *H. elliptica*, *H. salicifolia*, *H. speciosa*, and *H. stricta* as parents (Lindsay, 1894; Okell, 1893). These species, in addition to several of the better known and more widely cultivated early cultivars, such as *H.* ×*andersonii* 'Andersonii', are probably the progenitors of a great number of the cultivars available today.

Horticultural use of montane and subalpine species of *Hebe* has not been properly explored or developed, perhaps because they have white flowers, short inflorescences, and are generally smaller in leaf size and growth habit. Selection of cultivars of montane species is restricted to variants which have different growth form or flower colour, for example *H. pimeleoides* 'McEwanii' and 'Glauco-caerulea', *H. buchananii* 'Sir George Fenwick', and the *H. pinguifolia* cultivars 'Pagei', 'Godefroyana', and 'Sutherlandii'. Lindsay appears to be one of the few breeders to have made controlled crosses involving montane species, having used *H. pimeleoides* as a parent of several hybrids (Lindsay, 1901; Anon., 1902). Hobbs has considered using montane *Hebe* species in his breeding programme. However, apart from two successful crosses involving *H. albicans* and *H. venustula*, this initiative has been thwarted by the inability of the montane species to flower in the warm climate of Auckland, where they are insufficiently chilled to initiate flowering (J. Hobbs, pers. comm., 1991).

This paper describes and evaluates seven crosses in *Hebe* made to explore the suitability of montane and subalpine species for the breeding and selection of cultivars.

Objectives

The objective was to investigate the potential of montane and subalpine *Hebe* species for breeding cultivars that would enhance the desirability of *Hebe* as a garden plant. This was done by making crosses between montane-subalpine and lowland species and their derived ornamental cultivars, to obtain new combinations of characters. Emphasis was given to a variety of specific characters, including prostrate and compact growth habit, grey and grey-green foliage, coloured flowers, flush flowering, longer flowering periods, and hardiness.

Parent plants

Two groups of plants were used as parents: *H. biggarii*, *H. decumbens*, and *H. pimeleoides* 'McEwanii' are hardy, prostrate or low-growing shrubs with small, grey or green leaves and white or pale-coloured flowers with a short flowering period; and *H. macrocarpa*, *H.* sp., *H. speciosa*, *H.* 'Wiri Charm', and *H.* 'Wiri Gem' have coloured flowers, are free-flowering, and have a long flowering period. A series of crosses were made between these two groups. A brief summary of the parent plants' origin and their main characters follows. More specific details of the leaf and inflorescence characters are provided in Tables 1 and 2. Detailed botanical descriptions are provided by Moore (in Allan, 1961) and Metcalf (1987).

Hebe biggarii

Origin Eyre Creek, Eyre Mountains, Southland, G17577[1]; prostrate and decumbent growth habit; small, grey, broad elliptic to ovate leaves; inflorescence short, flowers white; flowering August to October.

Hebe decumbens

Origin Little Mount Peel, Canterbury, G17116; prostrate selection; small, dark green, oval, elliptic to broad elliptic leaves with reddish margin; inflorescence short, flowers white; flowering November to December.

Hebe macrocarpa

Origin Great Barrier Island, G19587 (selected by G. Platt – J. Hobbs, pers. comm., 1993); upright and shrubby growth habit; large, green, elliptic-oblong leaves; inflorescence long, flowers

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[1] Landcare Research experimental gardens accession number

pink; flowering May to December (Allan, 1961; Metcalf, 1987).

***Hebe* sp.**

Origin Ahipara, Northland, G18416; compact and rounded shrub; green, elliptic-oblong leaves; inflorescence long, flower lavender in bud, later fading to white; flowering during autumn and winter in Christchurch. This species has been referred to as *H.* sp. (X) (Eagle, 1982) and *H.* 'Bartlett' (Druce, 1992).

Hebe speciosa

Origin unknown, G18939; upright and shrubby growth; large, dark green, broad elliptic, obovate, and oval leaves; inflorescence long, flowers magenta; flowering January to October (Allan, 1961; Metcalf, 1987).

***Hebe pimeleoides* 'McEwanii'**

Origin unknown, G17102; compact and spreading shrub; small, grey, elliptic leaves; inflorescence branched, flowers pale lavender; flowering in December.

***Hebe* 'Wiri Charm'**

Origin garden hybrid, *H.* 'Wiri Jewel' × *H. diosmifolia* 'pink', G19599; compact and spreading shrub; green, elliptic-oblong, oblong leaves; inflorescence branched, flowers deep rose purple; flowering April to December (Hobbs, 1991).

***Hebe* 'Wiri Gem'**

Origin garden hybrid, *H.* 'Wiri Jewel' × *H. diosmifolia* 'pink', G19600; compact and upright shrub; green, elliptic-oblong to oblong leaves; inflorescence branched, flowers rose; flowering April to December (Hobbs, 1991).

Methods

All crosses were made in a glasshouse. Flowers were emasculated, and a thick smear of pollen was placed on the receptive stigma. The flowers were not bagged, but the large amount of pollen placed on the stigma would limit contamination by foreign pollen. Seed capsules were collected when they turned brown, and seed was either removed manually or the capsules were allowed to dehisce in a paper bag. Seed was germinated at 12°C and 15°C, pricked out into a 50 mm tube, and then planted in the Landcare Research experimental gardens at Lincoln. Plants from each cross were grown in the same row. Appendix 2 provides details of pollination, seed collection, sowing and germination dates, and numbers planted out.

Observations were made during October 1993 on plant height and breadth, leaf dimensions, inflorescence length, number of flowers per inflorescence, and flower colour. Flowering observations were made on the 15th of each month from January 1992 to December 1993; records for *H. pimeleoides* 'McEwanii' × *H. speciosa* began in December 1991 and ended in January 1994 to include their main flowering period. A plant was recorded as being in flower if it had even one flower open.

Measurements of the leaf and inflorescence characteristics of the parents were made on the actual plants used for the crosses, except for *H. biggarii* which died during 1992. Data for this species was obtained from three other plants of *H. biggarii*, all wild transplants from the Eyre Mountains. Parent plants were not included in the experimental garden planting. Information on shrub breadth and height for these has been supplemented from plants grown in other plots at Lincoln of a similar age to the hybrids (Appendix 1).

Results

Several of the crosses had a large number of progeny, so five individuals from each cross were selected to represent the range of variation present. Their specific leaf, growth habit, and inflorescence characters are presented in Tables 1 and 2. Data for all plants have been plotted in Fig. 1–12. The number of plants available for examination in all but one hybrid group was significantly less than the number originally planted out (Appendix 2), as a severe frost in early October 1991 resulted in numerous deaths.

Hebe biggarii* × *H. speciosa

Leaves (Fig. 1, 13; Table 1): The parents and their progeny have a similar elliptic-oblong, broad elliptic, and obovate shape and width-to-length ratio, but the progeny have leaf sizes closer to the small-leaved *H. biggarii*. One plant has small leaves within the range for *H. biggarii*. Leaf length among the hybrids varies between 12 mm and 36 mm. The leaf colour of all the hybrids is grey-green, which is intermediate between the green and grey of the two parents.

Growth habit (Fig. 4; Table 1): Growth habit of the progeny is represented by two distinct morphs. Thirteen plants are broad, compact, and have a densely branched habit similar to *H. biggarii*; this may be in response to frost and snow damage during the 1992 and 1993 winters. The remaining five plants (3/6, 3/10, 3/12, 3/14, and 3/16) are broader and more robust, have prostrate primary branches, and prostrate, spreading, and occasionally erect secondary branches and branchlets, and did not suffer from frost and snow damage during the 1992 and 1993 winters.

Phenology (Fig. 7, 13, 14; Table 1): The five plants that did not suffer frost and snow damage flowered for 10-11 months. They were in full flower during September to November, and had only scattered inflorescences during the late summer, autumn, and winter. Individual branchlets produced a long succession of pairs of inflorescences. Peak flowering coincided with that of *H. biggarii*, and the sparse flowering period coincided with that of *H. speciosa*. The thirteen plants that suffered cold damage have probably not flowered in a regular pattern, having only sparse flowers during March to May. During spring and early to mid summer they made only vegetative growth to replace that damaged the previous winter.

Flowers of all hybrids are red-purple. The inflorescence length and number of flowers per inflorescence are intermediate between the parents, as is the inflorescence length to leaf length ratio, but this is slightly closer to *H. biggarii*. January is the only month in which flowers have not been recorded on any plant.

Horticultural potential: There are currently few good cultivars available with a prostrate and decumbent habit of growth that are hardy, have coloured flowers, and are free-flowering during September-November. Plants 3/6, 3/12, and 3/16 have been selected for further trialling in containers in a nursery situation.

***Hebe biggarii* × *H.* 'Wiri Charm'**

Leaves (Fig. 1; Table 1): These hybrids have an elliptic-oblong and broad elliptic shape and a width-to-length ratio more similar to *H. biggarii* than to the larger, narrower leaves of *H.* 'Wiri Charm'. Their size is closer to the small-leaved *H. biggarii*, but leaf length does vary between 11 mm and 29 mm. Leaf colour of the hybrids is grey-green, intermediate between the green and grey of the two parents.

Growth habit (Fig. 4; Table 1): Four of the plants have a similar compact, spreading, and rounded habit of growth which is approximately twice as broad as high. One plant is prostrate, sparsely branched, and has less height than *H. biggarii*; it also has small leaves within the range of *H. biggarii*. All plants flowered so profusely that they had difficulty in putting on new growth after flowering was completed. The plants have not suffered damage due to frost or snow.

Phenology (Fig. 8, 14; Table 1): The hybrids had a flowering period of 9–10 months; full flowering occurred between August and November, coinciding with *H. biggarii*. Three of the hybrids flowered continually from autumn through to early summer, producing a long succession of pairs of inflorescences. The only months in which flowers were not recorded in a given season are December-March. Flowers of all hybrids are red-purple. The number of flowers per inflorescence is intermediate between the parents, but the inflorescence length to leaf length ratio is very high for four of

Table 1. Comparison of shrub habit and leaf and inflorescence characteristics of *Hebe biggarii, H. speciosa, H.* 'Wiri Charm', *H.* 'Wiri Gem', and the putative hybrids *H. biggarii* × *H. speciosa, H. biggarii* × *H.* 'Wiri Charm', and *H. biggarii* × *H.* 'Wiri Gem'.

Parents and hybrid progeny	CHR number	Shrub habit (breadth/ height, mm)	Leaf width (mm) n=5	Leaf length, LL (mm) n=5	Inflorescence length, IL (mm) n=5	Flowers per inflorescence n=5	IL : LL ratio	Flower colour RHS*
biggarii 18709	471179	430/230	4.9±0.18	10.9±0.8	19.2±1.93	16.2±1.15	1.76	White 155
biggarii 18709B	471178	340/130	5.0±0.0	12.0±0.4	29.0±1.87	18.2±1.39	2.41	White 155
biggarii 18709C	471177	300/170	5.8±0.25	13.2±0.7	37.4±0.87	32.8±2.22	2.83	White 155
speciosa	471180	1320/710	38.8±1.3	83.8±3.8	89.4±6.59	109.8±11.81	1.06	Red-Purple 70A
'Wiri Charm'	471181	700/460	11.8±0.5	45.0±1.3	81.0±3.66	51.4±3.93	1.8	Cyclamen Purple°
'Wiri Gem'	471160	750/520	8.8±0.12	40.4±1.6	67.0±7.23	49.75±11.95	1.65	Cyclamen Purple°
biggarii × *speciosa* 3/6	471161	950/150	12.6±0.4	27.6±0.1	61.6±2.48	50.6±4.42	2.23	Red-Purple 74A
biggarii × *speciosa* 3/10	471175	980/240	12.4±0.4	27.0±1.4	63.8±4.29	48.0±3.96	2.36	Red-Purple 74A
biggarii × *speciosa* 3/12	471169	1100/230	14.6±0.4	32.2±1.8	66±2.38	47.6±2.8	2.04	Red-Purple 74A
biggarii × *speciosa* 3/14	471170	1080/270	13.8±0.1	32.0±0.3	63.8±1.85	50.8±2.08	1.99	Red-Purple 74A
biggarii × *speciosa* 3/16	471167	720/230	13.0±0.1	31.8±1.3	58.0±3.3	51.6±5.62	1.82	Red-Purple 72B
biggarii × *'Wiri Charm'* 6/1	471168	610/280	9.4±0.48	25.0±1.4	57.2±1.59	53.4±6.44	2.28	Purple 78B
biggarii × 'Wiri Charm' 6/2	471174	670/250	6.6±0.24	19.6±0.3	50.6±3.28	54.2±15.55	2.58	Purple 78B
biggarii × 'Wiri Charm' 6/3	471176	710/350	5.9±0.25	15.9±0.1	48.6±1.43	64.0±4.24	3.05	Red-Purple 72B
biggarii × 'Wiri Charm' 6/4	471172	690/370	8.4±0.4	18.6±0.7	51.0±2.48	45.0±10.27	2.74	Red-Purple 72B
biggarii × 'Wiri Charm' 6/5	471173	370/100	6.0±0.27	11.8±0.6	21.4±0.92	36.2±4.14	1.81	Red-Purple 74C
biggarii × 'Wiri Gem' 22/1	471166	920/280	9.6±0.25	23.8±0.8	57.8±5.17	84.4±34.33	2.42	Red-Purple 72B
biggarii × 'Wiri Gem' 22/2	471162	810/205	9.4±0.25	22.6±0.4	60.4±3.93	44.0±3.78	2.67	Red-Purple 62C
biggarii × 'Wiri Gem' 22/3	471164	500/230	4.8±.2	16.2±2	35.6±0.93	23.4±1.86	2.19	Red-Purple 62B
biggarii × 'Wiri Gem' 22/4	471171	530/130	7.6±0.25	19.8±0.8	57.4±2.31	134.2±23.6	2.89	Purple 78A
biggarii × 'Wiri Gem' 22/5	471163	390/200	7.0±0.31	19.4±1.9	39.6±2.04	34.2±3.86	2.04	Red-Purple 71B
biggarii × 'Wiri Gem' 22/6	471165	170/140	6.2±0.37	16.2±0.1	25.0±0.89	19.0±1.14	1.54	Purple 75B

* Royal Horticultural Society (London) Colour Chart in association with the Flower Council of Holland (Leiden).

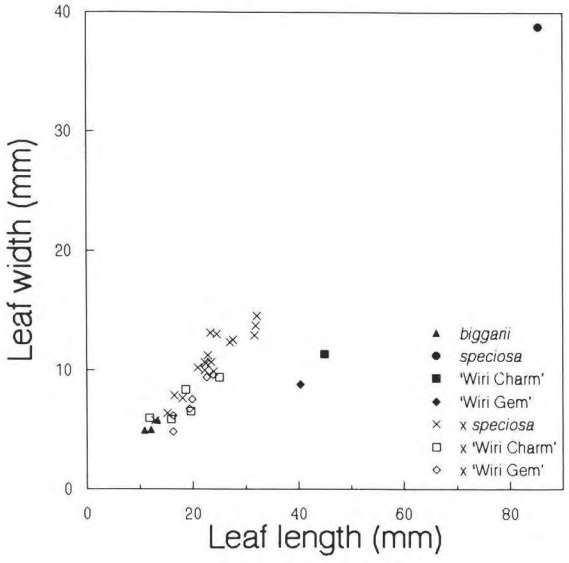
° Hobbs (undated) described the flower colour of *H.* 'Wiri Charm' and *H.* 'Wiri Gem' as "cyclamen-purple (74A RHS)"

Opposite page

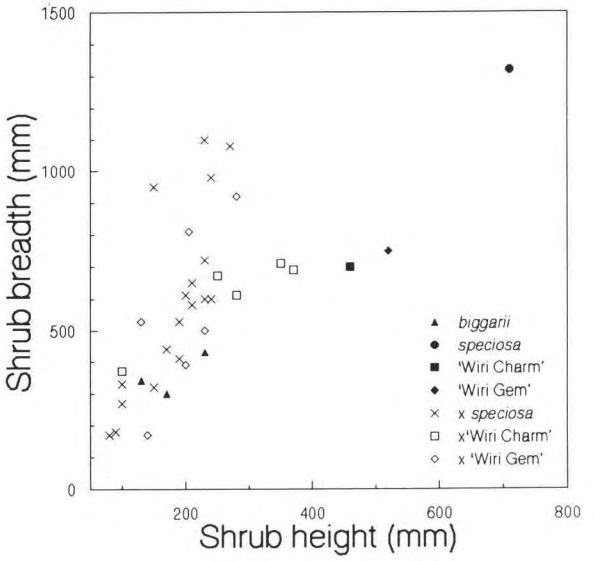
Fig. 1–3. Leaf characters of *Hebe* hybrids: 1. *H. biggarii* hybrids; 2. *H. decumbens* hybrids; 3. *H. pimeleoides* 'McEwanii' × *H. speciosa.*

Fig. 4–6. Shrub habits of *Hebe* hybrids: 4. *H. biggarii* hybrids; 5. *H. decumbens* hybrids; 6. *H. pimeleoides* 'McEwanii' × *H. speciosa.*

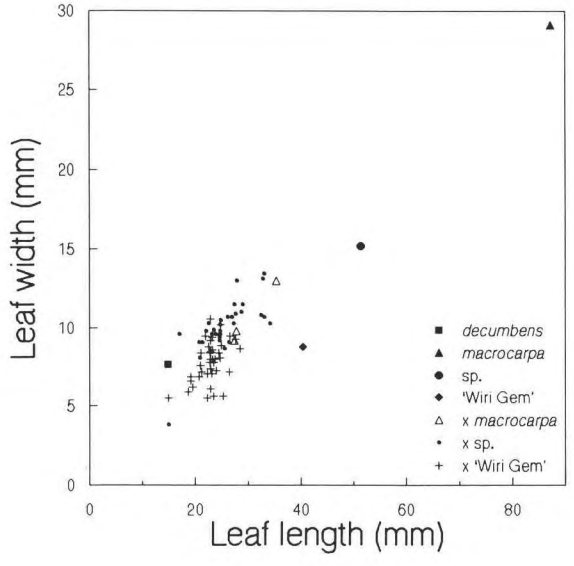
1. *Hebe biggarii* hybrids



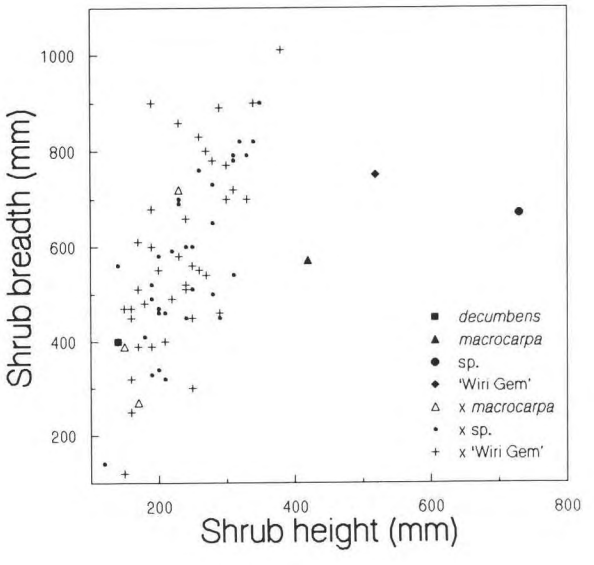
4. *Hebe biggarii* hybrids



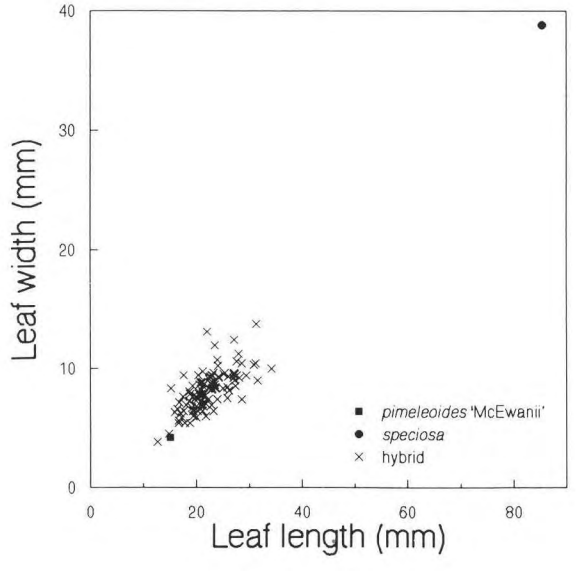
2. *Hebe decumbens* hybrids



5. *Hebe decumbens* hybrids



3. *Hebe* 'McEwanii' x *H. speciosa*



6. *Hebe* 'McEwanii' x *H. speciosa*

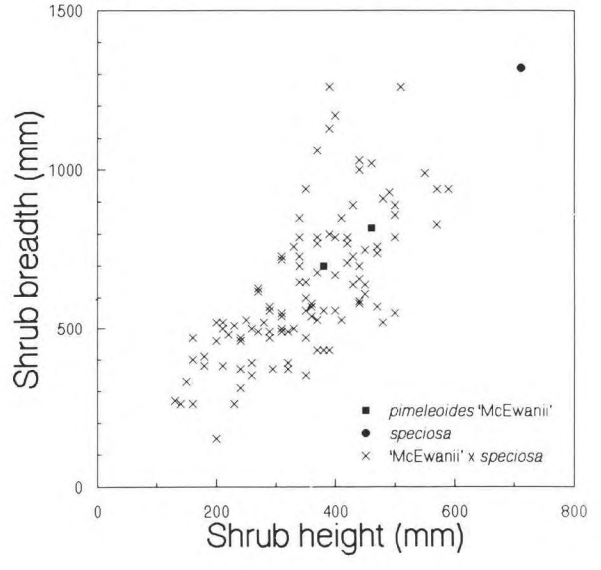


Table 2. Comparison of shrub habit and leaf and inflorescence characteristics of *Hebe decumbens*, *H.* sp., *H. macrocarpa*, *H.* 'Wiri Gem', and the putative hybrids *H. decumbens* × *H.* sp., *H. decumbens* × *H. macrocarpa*, and *H. decumbens* × *H.* 'Wiri Gem'.

Parents and hybrid progeny	CHR number	Shrub habit (breadth/ height, mm)	Leaf width (mm) n=5	Leaf length LL (mm) n=5	Inflorescence length, IL (mm) n=5	Flowers per inflorescence n=5	IL:LL ratio	Flower colour RHS*
decumbens	471182	400/140	7.7±0.37	18.0±0.2	17.2±0.86	15.2±0.73	1.16	white 155
sp.	471183	670/730	15.2±0.7	51.3±1.7	58.8±8.29	44.2±3.21	1.14	white 155
macrocarpa	471184	570/420	29.1±1.7	87.2±2.5	112.6±2.5	83.0±8.0	1.29	red-purple 63B
'Wiri Gem'	471160	750/520	8.8±0.12	40.4±1.6	67.0±7.23	49.75±11.95	1.65	Cyclamen purple°
decumbens × sp. 38/2	471185	580/200	13.1±0.6	32.8±1.9	43.4±2.54	35.4±4.51	1.32	white 155
decumbens × sp. 38/6	471186	460/210	9.6±0.65	16.9±3.7	54.6±2.06	46.0±2.4	3.23	white 155
decumbens × sp. 38/17	471187	760/260	10.7±0.7	26.9±0.9	50.0±3.78	46.2±2.05	1.85	white 155
decumbens × sp. 38/19	471188	820/320	11.5±0.7	27.4±0.3	37.0±2.28	35.4±1.07	1.35	white 155
decumbens × sp. 38/31	471189	470/200	10.5±0.5	24.8±1.5	36.2±2.2	31.6±1.16	1.45	white 155
decumbens × *macrocarpa* 39/1	471190	720/230	13.0±0.4	35.4±2.3	56.4±3.66	38.2±4.44	1.59	white 155
decumbens × *macrocarpa* 39/2	471191	270/170	9.8±0.2	27.8±0.7	— — —	— — —	— — —	— — —
decumbens × *macrocarpa* 39/3	471192	390/150	9.2±0.2	27.4±0.7	— — —	— — —	— — —	— — —
decumbens × 'Wiri Gem' 36/6	471193	610/170	7.1±0.29	22.2±1.4	26.4±1.02	24.0±1.92	1.18	— — —#
decumbens × 'Wiri Gem' 36/15	471194	390/170	6.2±0.25	19.5±0.4	20.0±1.26	16.2±1.46	1.02	— — —#
decumbens × 'Wiri Gem' 36/17	471195	520/240	8.9±0.1	24.9±0.6	29.2±1.68	27.8±0.96	1.17	— — —#
decumbens × 'Wiri Gem' 36/21	471196	450/250	6.9±0.24	20.7±0.8	29.6±0.92	31.0±2.16	1.42	— — —#
decumbens × 'Wiri Gem' 36/34	471197	1010/380	10.2±0.8	24.8±0.8	56.4±2.52	40.4±2.97	2.27	— — —#

* Royal Horticultural Society (London) Colour Chart in association with the Flower Council of Holland (Leiden).

° Hobbs (undated) described the flower colour of *H.* 'Wiri Gem' as "cyclamen-purple (74A RHS)"

Flower colour not seen

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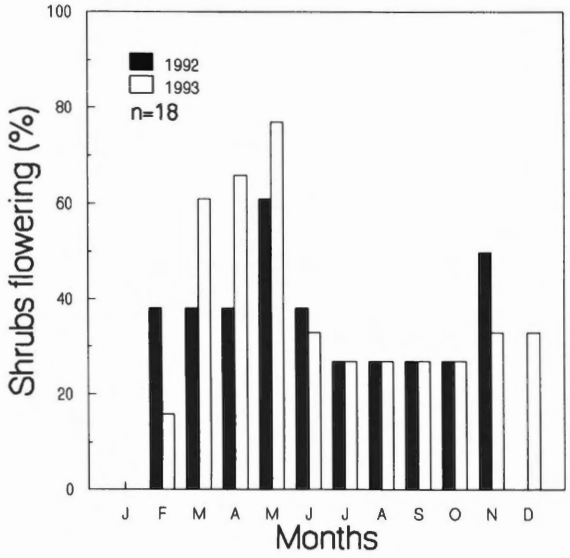
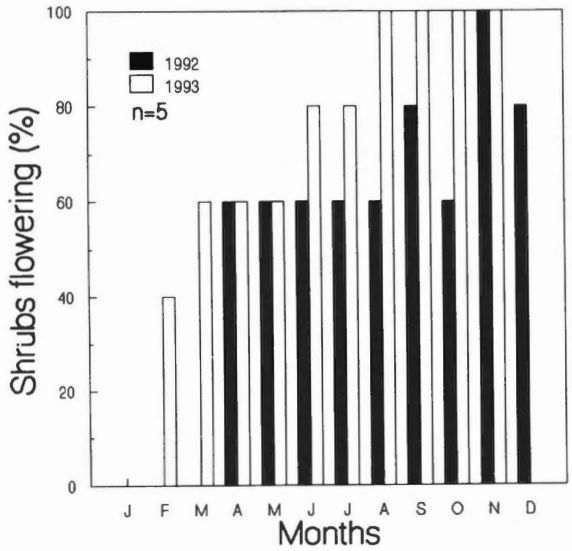
Fig. 7–9. *Hebe biggarii* hybrid flowering times and percentages: 7. *H. biggarii* × *H. speciosa*; 8. *H. biggarii* × *H.* 'Wiri Charm'; 9. *H. biggarii* × *H.* 'Wiri Gem'. Fig. 10–12. *Hebe decumbens* and *H. pimeleoides* 'McEwanii' × *H. speciosa* hybrid flowering times and percentages: 10. *H. decumbens* × *H.* sp.; 11. *H. decumbens* × *H.* 'Wiri Gem'; 12. *H. pimeleoides* 'McEwanii' × *H. speciosa*.

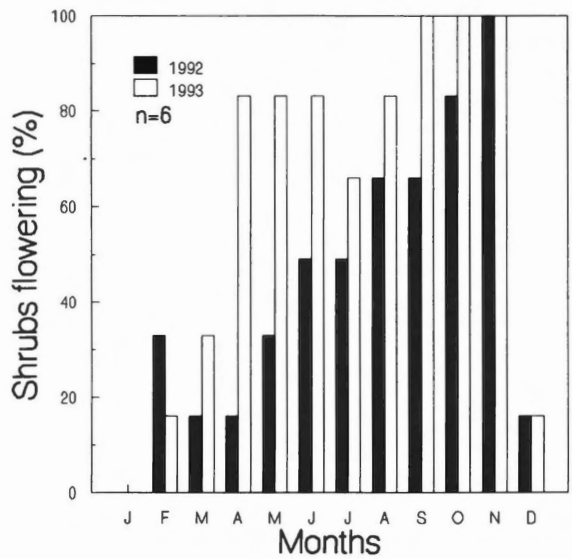
7. *Hebe biggarii* x *H. speciosa*



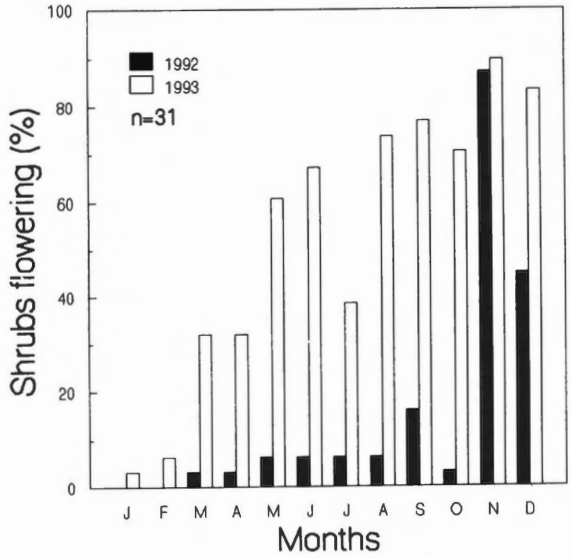
8. *Hebe biggarii* x *H.* 'Wiri Charm'



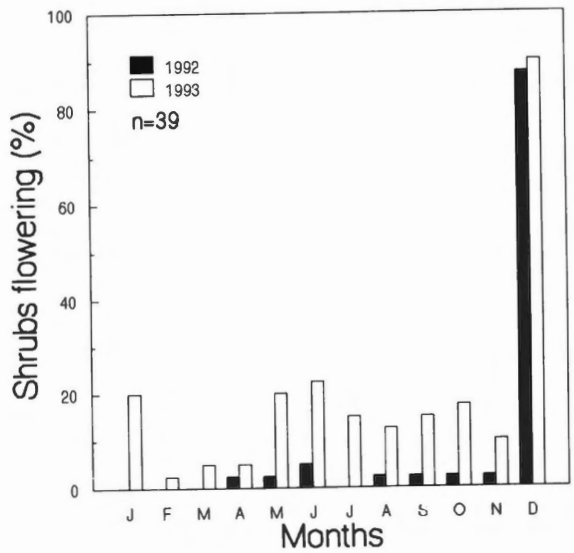
9. *Hebe biggarii* x *H.* 'Wiri Gem'



10. *Hebe decumbens* x *H.* sp.



11. *Hebe decumbens* x *H.* 'Wiri Gem'



12. *Hebe* 'McEwanii' x *H. speciosa*

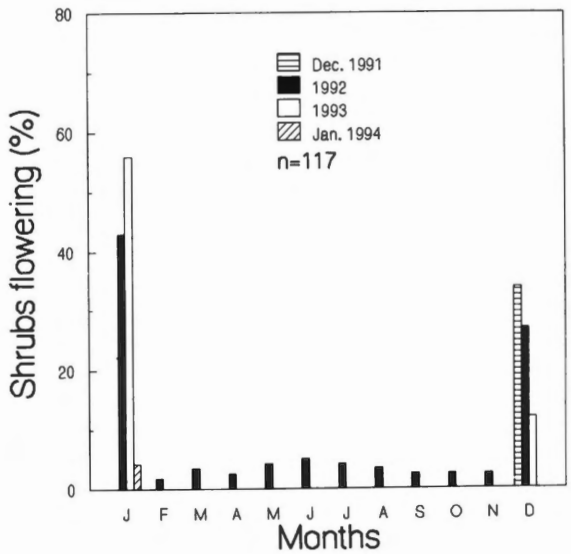


Fig. 13. *Hebe biggarii* (left), *H. speciosa* (right), and *H. biggarii* × *H. speciosa* (centre) leaf and inflorescence characters

the hybrids. This means that flowers are raised well beyond the leaves.

Horticultural potential: Hybrids 6/1 and 6/3 have been selected as having a high horticultural potential, and are being trialled to assess their suitability for containerised production. They are early, free, and long flowering, hardy, and have a compact growth habit. Their prolific flowering during September-November and restricted new growth later in the season make it essential to remove old inflorescences after peak flowering. However, these very features could make them ideal as pot plants, particularly in Europe, where this use of *Hebe* is well established.

***Hebe biggarii* × *H.* 'Wiri Gem'**

Leaves (Fig. 1; Table 1): These hybrids have an elliptic, broad elliptic, and elliptic-oblong shape and a width-to-length ratio more similar to *H. biggarii* than to the larger, longer, and narrower leaves of *H.* 'Wiri Gem'. Leaf size is closer to *H. biggarii*. It is surprising that leaf size in some of the hybrids is not greater and more variable, given that *H.* 'Wiri Gem' has leaves which are more than four times longer than their width, and the large-leaved *H. speciosa* is one of its parents. Leaf colour for five hybrids is grey-green, and for one (22/2) it is light grey, all intermediate between the green and grey of the two parents.

Growth habit (Fig. 4; Table 1): Five of the plants are spreading shrubs two and four times broader than high; the sixth is much smaller, with breadth and height similar. Plants 22/1 and 22/2 are more robust and vigorously growing than the others. Hybrid 22/4 flowers so profusely that it has difficulty putting on new growth after flowering is completed. The plants have not suffered damage from frost and snow.

Phenology (Fig. 9, 15; Table 1): The hybrids had a flowering period that peaked during September-November, coinciding with the flowering of *H. biggarii*. During 1992 there was a gradual increase in flowering from March to November, and in 1993 the plants began to flower much earlier. This difference could be due to the youth of the plants in 1992, their first flowering year. During April-August 1993 five plants flowered, coinciding with *H.* 'Wiri Gem' and its parents *H. speciosa* and *H. diosmifolia* (Metcalf 1987). No plants flowered during January, and only one or two in December, February, and March. Flowers are purple or red-purple, fading to white before they fall. Inflorescence length and the ratio of inflorescence length to leaf length vary amongst the hybrids. Of particular interest is variation in the number of flowers per inflorescence. In hybrids 22/1 and 22/4 the number is very high owing to their having mostly compound inflorescences; the other hybrids have mostly simple racemes and fewer flowers per inflorescence.

Horticultural potential: Hybrids 22/2 and 22/4 have been identified as having horticultural potential, and are being trialled for containerised production in a nursery. They have a long flowering season, peak flowering during September-November, good flower colour, and a low, compact growth habit. They flower so heavily during September-November that they have difficulty in producing vegetative growth after flowering, and could be ideal as pot plants.

Hebe decumbens* × *H. macrocarpa

Leaves (Fig. 2; Table 2): These hybrids have an elliptic and broad elliptic shape and a width-to-length ratio similar to *H. macrocarpa,* but the size is closer to *H. decumbens*. Leaf length varies between 21 mm and 40 mm, and the length is close to three times the width. The green leaf colour lacks a dark red margin characteristic of *H. decumbens*.

Growth habit (Fig. 5; Table 2): Two of the plants have a breadth greater than twice their height, and the other is only slightly broader than its height.

Phenology (Table 2): Only one plant has flowered, for a short period during December and January. The flowers were white.

Horticultural potential: None apparent.

***Hebe decumbens* × *H.* sp.**

Leaves (Fig. 2; Table 2): The hybrids have an elliptic, elliptic-oblong, and broad elliptic shape and a width-to-length ratio more similar to *H. decumbens* than to *H.* sp.; one plant has leaves almost identical to *H. decumbens*. Leaf length for *H. decumbens* and hybrids is about $2^{1}/_{3}$ times the width, but for *H.* sp. is almost $3^{1}/_{2}$ times the width. In 12 of the 31 hybrids the green leaves have reddish margins, a characteristic of *H. decumbens*.

Fig. 14. Continuous flowering of *Hebe biggarii* × *H. speciosa* hybrid 3/14 (left) and *H. biggarii* x *H.* 'Wiri Charm' hybrid 6/1 (right).

Growth habit (Fig. 5; Table 2): The low, spreading habit, with plants about twice as broad as tall, is characteristic of *H. decumbens* rather than *H.* sp., which is erect.

Phenology (Fig. 10; Table 2): The plants began flowering in March 1992, and a few have produced a small number of inflorescences during the autumn and winter months. In 1993 flowering began in January, and except in July the number of plants flowering gradually increased throughout the year. Flush flowering is restricted to November and December, coinciding with *H. decumbens*. During autumn and winter only a few inflorescences were produced, coinciding with *H.* sp.

Most of the hybrid flowers are pale lavender in bud, opening white. Five plants selected as representing the hybrid group have an inflorescence length and number of flowers per inflorescence more similar to *H.* sp. than to *H. decumbens*.

Horticultural potential: These hybrids have limited horticultural potential because the November-December flush of flowers is neither prolific nor spectacular. The inflorescences are not densely placed, and only 2 or 3 pairs are produced. Hybrid 38/6 has been selected for further trials as it has a compact growth habit, small leaves, and exceptionally long densely placed inflorescences.

***Hebe decumbens* ×*H.* 'Wiri Gem'**

Leaves (Fig. 2; Table 2): These hybrids have an elliptic, elliptic-oblong, and broad elliptic shape, and a width-to-length ratio and size closer to *H. decumbens*. Leaf length varies between 13.5 mm and 34 mm, and 26 of the 39 plants have the red margin characteristic of *H. decumbens*.

Growth habit (Fig. 5; Table 2): The hybrids display a wide range of variation in breadth, which is between two and four times their height. The growth habit is very similar to that of *H. decumbens*.

Phenology (Fig. 11; Table 2): Peak flowering was in December, coinciding with *H. decumbens*. Only 2 or 3 pairs of very short inflorescences are produced, although scattered inflorescences were evident during the rest of the year on many plants. Flower colour is generally red-purple, quickly fading to white.

Horticultural potential: Limited by the short peak flowering period and the few, short inflorescences.

Hebe pimeleoides* 'McEwanii' × *H. speciosa

Leaves (Fig. 3): These hybrids have an array of elliptic, ovate, and obovate shapes similar to and intermediate between the parents. Size is closer to the small *H. pimeleoides* 'McEwanii' than the large *H. speciosa*. The colour is various shades of green; no plants have the grey leaves characteristic of *H. pimeleoides* 'McEwanii'.

Growth habit (Fig. 6): The shrub habit is very variable, and a significant number of the plants are smaller in both breadth and height than *H. pimeleoides* 'McEwanii'. Ten of the smaller plants have closely placed and congested branchlets and a very short leaf internode. No plants approach *H. speciosa* in breadth or height.

Phenology (Fig. 12): The main flowering period, December-January, coincided with *H. pimeleoides* 'McEwanii'. The few inflorescences produced were usually between 20 mm and 40 mm long. Flower colour is generally red-purple and quickly fades to white. Thirty-three of the hybrids have not flowered.

Horticultural potential: Limited by poor flowering performance.

Discussion

Hebe biggarii is an excellent female parent for breeding new garden hybrids. It provides dwarf, prostrate, and compact growth, grey-green foliage, flush flowering during September, October, and November, and cold hardiness. In the crosses reported here it has not inhibited the useful characters derived from the male, including inflorescence length, number of flowers per inflorescence, flower colour, and the long flowering season.

In contrast, *H. decumbens* has performed indifferently as a female parent. The growth habit and leaf characters of the hybrids provide a range of variation from which it would be possible to select some excellent horticultural forms, but in contrast the flower and inflorescence characters are poorly developed. The flush of flowers produced during spring and early summer are not outstanding, and inflorescences are only infrequently produced throughout the remainder of the year. There was significant interhybrid variation in the vegetative and floral characters. *H. decumbens* ×*H.* sp. hybrids produced reasonably long inflorescences with a good number of flowers, and the leaf shape, colour, and texture and the overall growth habit were similar, even though the measurements differed between individual plants. In contrast, *H. decumbens* × *H.* 'Wiri Gem' produced short inflorescences with few flowers, and there was a range of variation in leaf shape, colour, and texture, and in growth habit. None of the *H.*

Fig. 15. Heavy-flowering simple and compound inflorescences of *Hebe biggarii* × *H.* 'Wiri Gem' (hybrid 22/4).

decumbens hybrids produced a long succession of flowers on a single branchlet.

Hebe pimeleoides 'McEwanii' also showed limited potential when crossed with *H. speciosa*. The hybrid plants displayed an array of variation in both growth form and leaf characters which could allow selection of specific garden-worthy individuals. However, the potential of new cultivars is restricted by inferior floral characters, including short inflorescences with few flowers, sparsely produced and placed inflorescences, no succession of inflorescences, and a feeble period of flush flowering.

A poor horticultural assessment has also been recorded for other hybrids not described in detail here. For example, four plants that are hybrids between the free and abundantly flowering *H.* 'Lavender Lace' and the winter-flowering *H.* sp. (crossed here with *H. decumbens*) have not produced any flowers after three years of field trials at Lincoln.

To understand the specific characters that a particular species, hybrid, or cultivar offers the breeder, it is essential that more controlled crosses are formally trialled and described. Too many new cultivars are selections from open-pollinated seed or are spontaneous seedlings that differ only slightly in growth habit, leaf characters, inflorescence type, and flower colour from other species and cultivars available. Controlled hybridisation offers the opportunity for designer crosses and the breeding and selection of plants that have specific characters.

Another suggestion for future workers is that crosses be done between a species or species cultivar and known hybrids, as this allows for some control over the progeny. For example, interspecific F_1 hybrids are usually uniform in vegetative and floral characters. Inter-hybrid crosses are generally highly variable, as there is a significant amount of genetic variation in what are effectively F_2 hybrids. Species or species cultivar crosses with a hybrid give less variation, as the species provides only a limited amount of genetic variation and hence some stability in the cross. The levels of variation do depend on the homogeneity or heterogeneity of the parents.

The potential of controlled hybridisation and the selection of new cultivars in *Hebe* has not been properly explored, and as the hybrids described here and by Hobbs (1991) illustrate, plants with outstanding horticultural merit can be raised.

Acknowledgements

I thank Warwick Harris, Bill Lee, and Bryony Macmillan for their constructive criticism of the draft manuscript; Stuart Oliver and David Purcell for assistance in the recording of plant flowering and measurements; and Karryn Muschamp for photographing Fig. 13, 14, and 15. Funds for this research were provided by the Foundation for Research, Science and Technology under Contract C09310.

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Appendix 1. Approximate age of plants when data gathered (11–15 Oct. 1993).

Species	Age (months)
biggarii (18709, b, c)	47*
decumbens	39*
macrocarpa	41*
pimeleoides 'McEwanii' (19779)	39*
pimeleoides 'McEwanii' (17102)	48*
speciosa	48*
sp.	48*
'Wiri Charm'	36*
'Wiri Gem'	36*
pimeleoides 'McEwanii' × *speciosa*	39#
biggarii × *speciosa*	34#
biggarii × 'Wiri Charm'	32#
biggarii × 'Wiri Gem'	32#
decumbens × *macrocarpa*	29#
decumbens × sp.	29#
decumbens × 'Wiri Gem'	29#

* Age of plant when rooted as a cutting or transplanted from the wild as a seedling.

\# Age from germination of seed.

Appendix 2. Date of pollination, seed collection, seed sowing and germination, number and date planted, and survival of *Hebe* crosses.

Hybrid group	Pollination	Seed collected	Seed sown	Germination	Planting date (and number)	Survival at 20 Oct. 1993
pimeleoides 'McEwanii' × *speciosa*	22 Dec. 1989	— — —	10 Jul. 1990	28 Jul. 1990	27 Nov. 1990 (222)	117
biggarii × *speciosa*	16 Aug. 1990	5 Nov. 1990	20 Nov. 1990	16 Dec. 1990	24 Sep. 1991 (18)	18
biggarii × 'Wiri Charm'	25 Aug. 1990	6 Dec. 1990	10 Jan. 1991	20 Feb. 1991	24 Sep. 1991 (14)	5
biggarii × 'Wiri Gem'	17 Oct. 1990	17 Dec. 1990	10 Jan. 1991	3 Feb. 1991	24 Sep. 1991 (12)	6
decumbens × 'Wiri Gem'	8 Nov. 1990	3 Feb. 1991	25 Apr. 1991	4 May 1991	24 Sep. 1991 (53)	39
decumbens × sp.	11 Nov. 1990	3 Feb. 1991	25 Apr. 1991	7 May 1991	24 Sep. 1991 (65)	31
decumbens × *macrocarpa*	26 Nov. 1990	3 Feb. 1991	25 Apr. 1991	4 May 1991	24 Sep. 1991 (72)	3

Royal New Zealand Institute of Horticulture Citations for the Award of Associate of Honour AHRIH (N.Z.) 1994

SAMUEL DARRAGH McGREDY CBE, JP

Samuel Darragh McGredy is known to rose lovers around the world simply as Sam McGredy - one of the most distinguished modern rose breeders in the world, whose plants are valued wherever roses are grown. His own breeding is impeccable, as he is the fourth in a line of Sam McGredys – all rose breeders – dating back to the 1880s in Ireland. His father died when Sam IV was only two, leaving the nursery and breeding establishment in trust for him.

Sam was sent off to boarding school in Enniskillen and then spent a very happy year at Mercersburg Academy, Pennsylvania, U.S.A. He returned to Northern Ireland in 1949 and studied at Greenmount Agricultural College, where he gained a Diploma of Horticulture, and at Reading University. It was at Reading that he really developed his love of rugby.

After working at Woking for a year he returned to Portadown to take over the family business. He had little to help him in his rose breeding – all his father's records in the period between the two world wars had been pulped as a contribution to the war effort. McGredy started with all the best modern roses from America and Europe, and started pollinating to see what would happen. And what notable results he soon started achieving, with now famous plants such as 'City of Leeds', 'Mischief', and 'Molly McGredy'. His first real recognition came with the Gold Medal awarded to 'Orangeade' in 1959.

Mr McGredy had already proved himself as a most successful rose breeder when he emigrated to New Zealand in 1972. In his book *Look to the Rose* he confided "I've had a love affair with New Zealand ever since I came here on a visit in 1961." There were a number of reasons for leaving Ireland. Running a mail-order business was not easy during the Troubles, when any parcel was viewed with suspicion. There was his love of rugby (he was a senior rugby referee); and there was his belief that New Zealand was a good place for his family. The shift was most successful, and Mr McGredy is now a New Zealand citizen. As he admitted in a recent article (*Metro*, October 1988), "Now I'm the most one-eyed New Zealander you'll ever meet. My heart is here, this is home."

Many of Mr McGredy's earlier releases originated from work he did in Ireland, before he came to New Zealand. He is now releasing wonderful roses bred, born, and selected in New Zealand. He has recently announced his retirement from active breeding, even though he has thousands of seedlings, the assessment of which will keep him busy until the beginning of the next century. Only one in possibly every ten to twenty thousand seedlings meets the criteria of a top rose. That Mr McGredy has raised so many notable plants indicates the scale of his work, with millions of seedlings raised and, more important, his eye for what makes a good rose and his sense of what the public wants. Certainly his remarkable list of awards for his roses indicates that much, much more than simply luck is involved. The more notable include:

- 7 All-American Awards
- 15 Gold Medals of The Royal National Rose Society (U.K.), and numerous awards of The President's International Trophy for the Best New Rose. Winners include 'Mischief', 'Elizabeth of Glamis', 'City of Belfast', 'Molly McGredy', 'Matangi', 'Priscilla Burton', and 'Solitaire'. The President's International Trophy is the highest award given to a rose by The Royal National Rose Society. It must have won a gold medal in the year the award is given, and it must have an outstanding quality.
- 4 Golden Rose of The Hague Awards. The Hague Rose Trial is probably the most respected of all rose trial garden competitions. The premier award, The Golden Rose, is considered to be the most prestigious of all rose awards, and Mr McGredy is the only person to have won it four times. He has also received a special award from The Hague Rose Trials for his achievements in rose breeding.
- Queen Mary Commemorative Medal, awarded to successful British rose hybridists, 1957 and 1973
- 10 Gold Stars of the South Pacific
- numerous Gold Awards of the Belfast Rose Trials
- the British Association of Rose Breeders (BARB) Award
- the James Mason Memorial Gold Medal (for a modern rose which has given particular pleasure to rose lovers), 'Trumpeter', 1991
- the Clay Cup for rose fragrance
- the Dean Hole Medal, Royal National Rose Society, 1988
- a Gold Medal of the Royal Irish Horticultural Society
- the New Zealand Rose Award of the National Rose Society of New Zealand, 1986
- the Australian Rose Award of the Australian Rose Society, 1988.

Mr McGredy's plants are continuing to win awards. In 1993 alone he took the All-American Award ('Spek's Centennial'), a Golden Rose of the Hague ('Rock 'n' Roll'), the Rose Introducers of New Zealand Award ('Susan Devoy'), and Auckland Rose of the Year ('Dublin Bay').

Mr McGredy's international standing is probably best exemplified by citing two outstanding achievements.

In 1977, the Year of the Rose, the British Post Office released a commemorative issue of four rose stamps which included 'Elizabeth of Glamis', one of Mr McGredy's best roses. That year he was also one of the breeders asked to speak at the symposium on breeding of the Centenary International Rose Conference.

In 1988 Mr McGredy was awarded the Dean Hole Medal for his major contributions to the rose and to the development of modern roses in both Northern Ireland and New Zealand. This medal commemorates Reynolds Hole, Dean of Rochester and founder of the Royal National Rose Society, and is the highest award bestowed by the Society. In 1990 he was awarded the local equivalent, the New Zealand Rose Award.

For a plant breeder the most satisfying measure of success is not the recognition by peers or awards or medals (no matter how numerous these may be), but the numbers of plants which have been sold and grown. By this measure Mr McGredy has been most successful; and again we quote only a few examples. In 1970 one of his roses ('Mullard Jubilee') fetched a record fee of $24,000 for naming rights – enough in those days to buy a reasonable house. ('Mullard Jubilee' subsequently gained a Gold Medal from the Royal National Rose Society and the All-American Award.) In 1978 an article in *The Rose Annual* reported how a panel of expert rosarians had voted on the twelve best floribunda roses introduced in the previous ten years. Six of those twelve roses were raised by Mr McGredy. His success continues today – 'Sexy Rexy' has probably been more widely planted in New Zealand than any other rose.

It can take ten years to breed a new rose and bring it to market. A rose breeder must therefore be a businessman, he

must be able to predict what will be successful. The aim is to produce a rose that is different, one that is novel, one that is really distinct and that stands out. Much of Mr McGredy's early work was directed towards using floribundas to upgrade hybrid tea roses. One of his most important aims was to develop plants that were healthy and vigorous. Mr McGredy's efforts have not, however, been limited to floribundas. He has produced many outstanding climbers, large-flowered and remontant, giving many flowers in the autumn. Probably the best is 'Handel', very free flowering and vigorous, the blooms a most attractive creamy white with a distinctive carmine edging. This rose was awarded a remarkable 8.6 out of 10 by the American Rose Society. His 'Picasso' led to a succession of the novel 'hand-painted' roses, of which perhaps the best known is 'Matangi'. He was one of the first to produce ground cover roses, starting with 'Snow Carpet', and he has also produced miniatures.

Mr McGredy is a successful businessman and entrepreneur. He travels widely and regularly, and is known to all important rose breeders throughout the world. He is one of the most successful of professional horticulturists in this country. He has, moreover, contributed significantly to the welfare of the industry and to people's enjoyment of roses. He has served for many years on the committees of horticultural organisations:

President, International Rose Plant Breeders Association (CIOPORA);
Secretary, Confrerie of International Rose Breeders, 1969– ;
Member, Northern Ireland Agricultural Trust, 1970–1972;
Secretary, Rose Introducers of New Zealand, 1988– ;
Member for 20 years, Council, Royal National Rose Society (U.K.);
Member for 3 years, Council, National Rose Society of New Zealand;
Patron: Auckland Horticultural Council; North Harbour Rose Society; Taupo Rose Society.

He has been particularly active in promoting the development of the Rose Introducers of New Zealand International Trial at the Auckland Regional Botanic Gardens, Manurewa, Auckland. This trial allows the commercial potential of roses to be assessed, with roses judged under Auckland conditions and allowing promotion of new roses to the public. The winning rose is named Auckland Rose of the Year, and the success of the trial – the enjoyment of the actual judging – is in large part due to the flair and imagination of Mr McGredy. Inevitably, in 1990, the first year of judging, he won every single prize available.

New Zealand is indeed fortunate that Mr McGredy considers this country his home, for we have benefited greatly from having live with us one of the most famous of all modern rose breeders. He has also been most generous in helping the development and advancement of horticulture in this country. There is no doubt that he has made a major contribution to horticulture both in New Zealand and throughout the world. In 1994 this was recognised by his being appointed CBE in the Queen's Birthday Honours. The Auckland Branch, in conjunction with the National Rose Society of New Zealand, now has great pleasure in nominating Mr Sam McGredy for election as Associate of Honour of the Royal New Zealand Institute of Horticulture.

KENNETH STUART MILNE
BAgrSc, PhD

Ken Milne was born on 13 February 1941. He has long been associated with and committed to horticulture, and in particular the plant sciences. He attended Feilding Agricultural High School before moving to Massey University, where he graduated BAgrSc in 1963. He continued at Massey to complete a Masterate in Agricultural Science, where his thesis topic was concerned with fungal diseases in lupin, indicating an early interest in plant health. This interest was continued in his PhD studies, undertaken from 1965 to 1968 at the University of California, Davis. The title of his dissertation was 'Identification of cucurbit viruses in California'.

Im 1969 Ken embarked on his career at Massey University with his appointment as a Lecturer in the Department of Microbiology and Genetics, where he progressed to Senior Lecturer in 1970 and Reader in 1976. In 1977, following a reorganisation of departments, he was appointed Head of Department of Horticulture and Plant Health, receiving a Personal Chair in 1979.

Ken was responsible for development and expansion of the University's Plant Growth and Fruit Crops units as well as holding positions on the Academic Committee and Research Policy Advisory Committee. Further rationalisation of plant science resources in the Faculty of Agricultural and Horticultural Science resulted in the formation of the Department of Plant Science in 1992. This large department, with Ken Milne as its head, includes groups with expertise in agronomy, horticultural science, plant science, plant health, postharvest horticulture, landscape management, and seed technology. The Department currently has close to 100 postgraduate students from New Zealand and overseas engaged in plant science research. Since 1988 Ken has been elected representative on the Massey University Council, at a time when universities are going through a period of great change.

During his time at Massey Ken has been the major supervisor for a number of postgraduate students who became involved in his virology research programme. His students have identified a number of debilitating viruses present in ornamental plants such as daphne, carnations, flowering cherries, nerines, and zantedeschia. Ken has had a concomitant interest in ensuring that appropriate methods were applied to free the plants from known viruses. He has advocated the production of high-health plants for commercial propagation, so as to improve the quality of plants for both the nursery industry and the consumer.

Ken has always had a major interest in ornamental horticulture, and much of his research has been with ornamental plants. He was also actively involved in the establishment of the New Zealand Nursery Research Centre in 1975, and acted as Chairman of the Centre's Advisory Committee. He has always encouraged a close relationship between the New Zealand Nurserymen's Association and Massey University, particularly in research and extension. He is Chairman of the Management Committee of the Manawatu Tree Trust, has recently been appointed as the New Zealand Vice-Chancellor's Committee representative on the Loder Cup Selection Committee, and is a trustee of the New Zealand Agrichemical Education Trust.

In the late 1970s Ken, along with several other horticultural scientists, recognised the need for this discipline to have its own identity in New Zealand. He became Chairman of the Steering Committee set up in August 1980 to examine the feasibility of establishing a Society of Horticultural Science in New Zealand. In 1981, at the Inaugural Annual General Meeting at Massey University, he was elected unopposed as the first President of the Society – a position which he held until 1984. He remained on the Council as Immediate Past President until 1986, and was appointed a Fellow of the Society in 1987.

Professor Ken Milne has made a major contribution to horticulture in New Zealand as a researcher, as an educator, and as a senior administrator at Massey University, and is a most worthy nominee for the award of Associate of Honour, RNZIH.

KEITH RICHARD WILLIAM HAMMETT
BSc (Hons), PhD, FRIH (NZ)

Dr Keith Hammett is one of New Zealand's most distinguished horticulturists, and has a well earned reputation for his achievements in ornamental plant breeding. He is still a comparatively young man, but his career is outstanding for the progress he has made with such a wide range of plant material.

Dr Hammett was born in the United Kingdom, and there can be little doubt that he was both born and bred a gardener. Both his grandfathers were professional gardeners, and his father was a keen amateur gardener. As a schoolboy Keith was infected by the gardening bug and took control of the family garden. His family lived just south of London, and although only a small amount of land was available he managed to pack a great deal into that garden. He also achieved notable success: he started growing border carnations, and was given encouragement by experienced carnation exhibitors. He participated in both local and national shows, and while still at school won the Thain Cup, a prize for carnations. This enthusiasm for carnations has continued until today.

Keith then completed a BSc (Hons) in botany and a PhD in plant pathology at the University of Southampton. Studying at university limited his ability to exhibit in shows, but perhaps that strong competitive urge was expressed instead in rowing, as a member of the Southampton University 1st Rowing Eight. Keith did not, however, completely forget horticulture, and during his time at university he grew sweet peas to finance his studies, and served on the committee of the National Sweet Pea Society. He is now a Life Member of the National Sweet Pea Society (U.K.).

In 1967 he emigrated to New Zealand with his wife and family, and he is a now a New Zealand citizen. He joined the staff of Plant Diseases Division, DSIR, at Mt Albert, Auckland, and there his work was involved mainly with aerobiology, general plant pathology, fungal taxonomy (especially of the powdery mildews), and therapeutants. In 1980, when Plant Diseases Division was split into two separate research divisions, Dr Hammett decided to acknowledge that his research interests were moving more and more into general horticulture and pomology. He therefore transferred to the Division of Horticulture and Processing, and remained with that division and successor organisations for the next twelve years. During that time he worked on a number of 'minor' crops such as melons and chestnuts, was responsible for divisional activities with plant patents and plant varieties, and played an important part in the development of the pepino (*Solanum muricatum*) as a fruit crop. In more recent years he has been involved in cytogenetic and taxonomic studies into various genera, including *Lathyrus*, the sweet pea, with a particular interest in yellow pigmentation and heat tolerance. Dr Hammett's work as a scientist is summarised in many reports and 31 scientific papers. He left HortResearch in September 1993, and is now a plant breeder in the private sector, although he has retained a connection with HortResearch by being appointed an Honorary Fellow of that institute.

As soon as Dr Hammett first arrived in New Zealand he entered the local horticultural scene, becoming involved in the organisation of the 'Garden Weeks' in 1967 and 1968. He also soon started his first New Zealand garden, at Mt Roskill, where the family initially lived in a state house. He later shifted to a four-hectare block at Massey, which gave him real scope for planting and allowed the development of a series of plant breeding programmes.

Dr Hammett's success in plant breeding is undoubtedly due in part to his skill and to his hard work. More important, perhaps, has been his insistence that the goals of his programmes be properly established. He has a very keen critical eye and a fine sense of flower aesthetics. He believes that the breeder must supply an array of options in order to produce cultivars for international release, depending on opportunities and the right timing. The breeder must consider the growth form, the vigour of the plant, and its flowering season, as well as the blooms. The plant must be both disease-resistant and garden-worthy. Scent is likewise important. A new cultivar must also be novel, and must stand out from the competitors. And, of course, since plant breeding and production are now big business, a new plant must be easily propagated. Dr Hammett has summarised his approach thus: "It needs only vision and ability to define goals and to move step-wise towards them."

Not many people, however, have that clear vision or sense of direction that has allowed Dr Hammett to make significant progress with such a remarkably wide range of plants. He has produced more than 110 fully commercial cultivars, many of which have been exhibited and marketed throughout the world.

Carnations and other *Dianthus*

Dr Hammett has extended his early interest in carnations by developing an exciting range of compact, sweetly scented, repeat-flowering dianthus, and he has also developed high-quality border carnations. These have been marketed in New Zealand through garden centres and by mail order, and have also been exported overseas. Early successes were 'C. W. Hammett', 'Buttercup' (syn. 'Topline Supreme'), 'Herald', the 'Kiwi Pink' series, and 'Far Cry'. Now one of his aims is to produce a really good yellow dianthus.

Chrysanthemums

Dr Hammett has developed two strains of chrysanthemum (*Dendranthema*), including the novel 'Magic Carpet' dwarf chrysanthemums. These too have been marketed in New Zealand and throughout the world.

Dahlias

Dr Hammett is perhaps best known for his dahlias. He has developed clonal exhibition cultivars of dahlia which have earned him both national and international recognition, as they have won top trial-ground and showbench awards around the world.This has led to the formation of a New Zealand tuber-producing industry based on the 'Hammett' dahlias. He has also produced a dark-leaved dahlia strain, and his cultivar 'Quantum Leap' recently won recognition at the Bredene Dahlia Trial in Belgium. Another notable achievement is his miniature decorative seed strains of dahlia, the 'Showpiece' series. These took the dahlia world by storm, as the plants produced were the equivalent in quality to many named cultivars. The Thompson and Morgan Catalogue of 1989 quoted a letter from one very satisfied customer: "I have been growing dahlias for 45 years including seedlings and I said to my wife 'no way can you get quality and mini decorative form from seed like the illustration,' so she said the only way to find out is grow some! Well I can say right now that the illustration doesn't flatter them one iota ..."

Dr Hammett's successes with dahlias have won him many awards both in New Zealand and overseas, including the Silver Medal of the National Dahlia Society of New Zealand (1992), the American Dahlia Society Gold Medal (1988), and the National Dahlia Society (U.K.) Overseas Raiser Award (1990). The Institute's own Plant Raisers' Award to Dr Hammett in 1988 recognised his achievements with dahlias, specifically his seed strains: 'Elizabeth Hammett', a plant of outstanding merit with its beautiful mauve flowers, and winner of top awards in New Zealand, the United Kingdom, and the United States; and 'Pineholt Princess', a splendid canary-yellow decorative dahlia with particularly finely divided foliage, which won the Champion of Champions Award at the 1987 National Dahlia Show in Napier.

Sweet peas

Dr Hammett has developed three distinct strains of sweet pea, two of them novel bicoloured strains. The most spectacular was perhaps 'North Shore', with its navy blue standards and pale violet wings and its rich scent. It won a well deserved Award of Merit from the Royal Horticultural Society. Local production of seed of these strains has permitted exports to many parts of the world. Another of his sweet pea cultivars recently won a First Class Certificate at the 1992 Scottish Sweet Pea Trials.

Dr Hammett has had many achievements with other plant groups – for example, he has worked on polyanthus, on petunias, and now on clivias. A particular interest has been the recreation of some of the now lost strains of florists' flowers such as polyanthus and carnation. His achievements have earned him international recognition, and in recent years he has travelled widely overseas, and is in much demand as a guest speaker. His work has also had important commercial implications: his plants have been grown commercially in New Zealand, thereby creating employment; they have often largely replaced imported material, saving the country overseas funds; and they have been extensively exported, securing this country overseas earnings. The success of his plants has added to New Zealand's reputation as a centre of horticultural excellence and innovation, and as a supplier of some of the best plants available.

His success in plant breeding has been due largely to his clarity of thought. He also has the ability to write clearly, and his books *'Plant Propagation'*, *'Plant Training, Pruning and Tree Surgery'*, *'Soil Care'*, *'The World of Dahlias'*, and *'Dahlias in New Zealand, 1990'* have brought his knowledge and experience to a wide audience. He is well known for his popular articles and, more recently, for his appearance on TV gardening programmes. He is among the most scholarly in this country working on aspects of garden and flower history.

Dr Hammett has also done much voluntary work for horticultural organisations. For example, he has shown a continued interest in the development of the Auckland Regional Botanic Gardens, especially the well known breeding programmes established there. He is Honorary Curator of dahlias at the Botanic Gardens. He has contributed to the administration of the National Dahlia Society of New Zealand, and he is an Associate Editor and Contributing Editor for the American Dahlia Society. He has also devoted much time to the collection and collating of information for the New Zealand Plant Collections Scheme. This will be of tremendous importance to plant breeders and nurserymen, as well as to plantsmen. It will provide the basis for the protection of our germplasm resources of ornamental plants.

Dr Keith Richard William Hammett has rendered distinguished service to horticulture in this country, and has contributed significantly to the standing of New Zealand horticulture throughout the world. Miss Joan Dingley, Associate of Honour, and the Auckland Branch have much pleasure in nominating Dr Hammett as an Associate of Honour of the Royal New Zealand Institute of Horticulture.

RONALD FLOOK AWARD 1994

This new Arboricultural Association award recognises contributions to the advancement of arboriculture in New Zealand in its many phases. The recipient must demonstrate a deep empathy with trees whether from functional or aethetic aspects.

The recipient of the 1994 and first award is Murray King, JP, Masterton.

Whether you drive through the Wairarapa or view it from the air, you do not look far without seeing trees with which Murray King will have had an association. As Chief Soil Conservator to the Wairarapa Catchment Board and later as its General Manager, Murray King had a profound influence on changing the Wairarapa from what was a bare often eroding, and somewhat hostile district, to today's more settled, mature and planted landscape.

Important aspects of Murray King's work include:

- The Whareama Catchment Scheme – the first of its kind in New Zealand that addressed hill country erosion and flooding as related problems that need equal treatment.
- Establishment of poplar and willow nurseries to provide the plant material needed for soil erosion control.
- Establishment of two Soil Conservation Reserves against the Haurangi range, and successful control of massive erosion through tree planting.
- Implementation of the Wairarapa Wind Erosion Control Scheme and the subsequent ongoing promotion of well planned and managed shelterbelts on the Wairarapa plains.
- Identification of potential eucalypts and acacia species used for shelter and erosion control in Australia, and their subsequent testing under Wairarapa conditions, and the publication of a reference textbook *Eucalypts in the Wairarapa* which incorporated the identification and recording of most species growing in the district.
- As a member of the National Shelter Working Party, Murray King helped to establish and review the need for shelter in New Zealand's rural environment and the need for associated research requirements.
- Promotion of trees on farms through Soil Conservation Farm Plans and Catchment Schemes, and also for production of timber, shelter, shade, amenity value, and beauty. Protection of remnant areas of native bush on farms throughout the district. An active and ongoing involvement in the Wairarapa Farm Forestry Association, both as Office bearer and as an individual member.
- Planning and execution of the extensive tree planting programme at Henley Lake.

Murray King has made a most significant contribution not only in his professional capacity but also as a volunteer working for the community, and it is this latter contribution which the Ronald Flook Award rewards especially.

Essential Oils in New Zealand

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Introduction

Many plants, both cultivated and growing in the wild, have strong odours, particularly when crushed to release aromatic chemicals. These chemicals can be extracted to produce essential oils and oleoresins, which are used commercially as ingredients in fragrances and food flavours. In this article we describe some of the native and introduced plants that have (or could) become commercial essential oil crops in New Zealand.

Several of our native plants, including ferns, mosses, and liverworts, were used by Maori as perfumes. One of these was mairehau, *Phebalium nudum*. Since this shrub is a member of the citrus family, Rutaceae, it is not surprising that its leaves contain a citrus-scented essential oil (Cooper & Cambie, 1991).

Many of the traditional European essential oil plants such as thyme, wormwood, rose, coriander, mint, fennel, celery, and oregano have been introduced into New Zealand and grow exceptionally well here. Several are now commonly found in our adventive flora.

In recent years a feature of agronomic science in New Zealand has been investigation of potential new commercial crops. Crop & Food Research Institute programmes encompass long-term, market-oriented research on essential oils, medicinal plants, culinary herbs, new vegetables, plant extracts, and edible fungi, with the aim of developing crops for New Zealand's economic benefit.

Considerable research has been undertaken in the past, but production of essential oils on a commercial scale in New Zealand has been tentative. At present only boronia, manuka, and pink pine are extracted to supply commercial quantities of essential oils or oleoresins. Although there is an adequate technological base for growers to produce a wide range of crops, ultimately their adoption is based on commercial decisions and market conditions.

Background

Volatile oils are commonly called essential oils because they represent the 'essence' or odour constituents of the plant. Essential oils are complex mixtures of volatile aromatic components found in plants, while oleoresins are mixtures of non-volatile compounds (resins) and essential oil compounds. An estimated 2000 to 3000 aromatic compounds are used in flavours and fragrances, and approximately one-fifth of these are of natural origin. Of these, about 300 essential oils and oleoresins are in common use. The industry is continuously looking for new ingredients.

Depending on the plant group, oils are made through direct synthesis by the cell, by decomposing resin layers in the cell wall, or by breakdown of other chemicals. Oils are located in specialised glands or ducts in a variety of tissues, such as petals (rose), other floral parts (lavender, clary sage), leaves (thyme, sage, mint, manuka), roots (angelica, valerian), fruits (coriander, dill, citrus), or wood (pink pine). Within each tissue, the cellular location of the oils is characteristic of the plant family (Craker, 1990).

Several methods can be used to extract oils; the main ones involve distillation using steam or boiling water, or extraction with a volatile solvent. The former process yields a product commonly known as essential oil, while the latter yields a product known as a concrete or oleoresin, which can be further purified to produce an absolute. Solvent extraction is often used for products with very low yield from steam distillation, such as rose or boronia. Solvent extraction of rose is used to retain 2-phenyl ethanol, which is largely lost during steam distillation.

A modern method of recovering essential oils employs liquid carbon dioxide. The plant material is enclosed in a sealed pressure chamber and liquid carbon dioxide (formed by holding the gas under high pressure) is used to dissolve the volatile oil. Upon release of the pressure, the carbon dioxide evaporates, leaving the pure oil. Highly specialised equipment is needed for this process, the main advantage of which is the ability to extract oils at relatively low temperatures (compared to steam distillation), thereby reducing the possibility of chemical changes in the product. This technology is very expensive, and is used only for high-value extracts.

Essential oils and oleoresins are purchased on their chemical, physical, and olfactory qualities. These qualities depend on the species and on environment, climate, soil conditions, agronomic factors such as harvest time, post-harvest handling, and distillation method. The essential oil content of plants can be highly variable in yield and/or chemical composition. Further, there may be chemotypes within a species, and these can be selected for particular oil qualities or for increased yields. It is therefore important to work with industry to obtain an accurate definition of the market requirements for each oil or oleoresin, which will also guide future research and development.

Research Strategy

The Crop & Food Research essential oils programme has two important structural levels – primary and secondary testing. Plant material is obtained from all over the world, grown, and distilled to allow a primary quality test. If these samples meet market standards secondary testing begins, involving an interactive study of agronomy, extraction, and chemical parameters to define the best methods to produce oils of high yield and optimum quality. The secondary testing programme compares initial quality tests with further accessions for improved yields and composition and to allow elite lines to be identified and selected in different environments.

Distillation methods have to be developed, since existing procedures are frequently kept confidential in the industry. For each crop it is necessary to define the distillation requirements such as crop preparation, still packing, stillpot, condenser and separator temperatures, distillation time, and separator efficiency (Denny, 1987).

Chemical content of the distillate is critical to attaining the standard of quality required commercially. Oil samples are sent overseas to specialists for evaluation and feedback, and approval by industry of the oil quality is fundamental to the success and direction of the programme.

Introduced Plants

Peppermint, dill, fennel and parsley herb and seed oils of internationally acceptable quality were produced in the 1970s and 80s on a small commercial scale in New Zealand. They did not become established permanently, mainly because of problems associated with marketing arrangements, disease control, and management difficulties (Perry et al., 1993).

Currently, the only introduced species producing small commercial quantities of product is boronia. However, there is interest amongst growers and investors in establishing clary sage, coriander seed, dill and tarragon oils for export markets. Many other oil-bearing species have been tested in the wide range of soil and climate types available throughout New Zealand. For example, some common weeds have potential. Briar rose (*Rosa rubiginosa*), an endemic weed of Central Otago and Marlborough, has sweet-smelling leaves that are being tested as a resource for essential oil production. The oil has a green-apple odour, and could have potential as a perfumery ingredient.

Many *Eucalyptus* species, which thrive in New Zealand, are used to produce essential oils. The genus has a wide range of oil composition and biological activity. *Eucalyptus* seed lines from Australia have been established to assess the potential for producing specific target components. Production and distillation studies are proceeding.

Specific issues involved in developing an essential oil industry may best be illustrated by way of a few examples.

Coriander (*Coriandrum sativum*)

In commerce, coriander is broadly divided into two types according to the size of the fruit, which is an indication of volatile oil content. The large fruit types (3–5 mm diameter), grown in tropical and subtropical countries, have a low volatile oil content (0.1–0.4%) and are used in the spice trade. Smaller fruit types (1.5–3 mm), produced in temperate regions, contain 0.4–.8% oil, and are highly valued as a raw material for essential oil. The main area of production is Eastern Europe, and the oil is used predominantly as a flavouring agent. In addition to the traditional essential oil, there is also a specialist oil extracted from coriander herbage. Although coriander crops have been successfully grown in Canterbury, and essential oil from the fruit or herb has been extracted, there is a high risk of disease and crop failure.

Crop & Food Research trials have shown that accession, environment, crushing intensity, and distillation time have a critical influence on yield and composition of coriander fruit oil. Post-harvest treatment can have dramatic effects on yield and composition of coriander herb oil. The major component of the oil from freshly harvested coriander herb was *E*-2-decenal, and chopping the herb before distillation increased oil yield. However, storage of chopped plant for 2-6 hours before distillation produced oils with different aromas that had *E*-2-decen-1-ol as the major component (Smallfield et al., 1994). Distillation practice can profoundly alter the chemical balance in an essential oil. However, disease is the major factor limiting further development of coriander, and we have identified *Pseudomonas* (flower blight) as a particular problem. The primary source of infection is thought to be from seed, but we have not yet been able to identify an effective chemical control strategy for infected crops. Until this breakthrough is made, it is unlikely that coriander will become an extensive essential oil crop in New Zealand.

Thyme (*Thymus vulgaris*)

The essential oil is distilled from the leaves of thyme, and yields can range from 0.1% to 1.0%. Thyme has naturalised well, and now covers extensive areas of dry, sunny country in Central Otago. Thyme is native to the Mediterranean region, and scientific investigations of the populations there show that seven distinct chemical types, or 'chemotypes', are known, each with a distinct composition (Stahl-Biskup, 1991). The characteristic aroma and flavour of thyme are attributed to the level of phenols in the oil, thymol being the preferred phenolic component. Two phenolic chemotypes are present in Central Otago crops, one containing thymol and the other containing carvacrol as the most important component of the oil (Morgan, 1989). The thymol chemotype is the most widespread, and the carvacrol chemotype is most commonly found near Ophir, although individual plants of the carvacrol chemotype can be found scattered through populations of the thymol chemotype (Morgan, 1989). Expression of the chemotype is genetically controlled, so plants derived from these populations and grown under standard conditions maintain their chemical differences.

Within a chemotype, seasonal factors play an important role in determining the yield and composition of thyme oil. A recent study (McGimpsey et al., 1994) on a thymol-dominant population in Central Otago showed that highest yields of high-quality (phenol-rich) oil were obtained after flowering had ceased in December. In winter, oil yields were approximately 25% of the peak summer yield, and the major component of the oil was found to be *p*-cymene, a precursor of the phenolic compounds thymol and carvacrol. An early olfactory evaluation considered that the Central Otago thyme was "too different" from the main world crop in Spain. For this reason, 23 species and accessions of thyme are being tested for oil quality, and further wild-collected material is being assessed.

Rosa damascena 'Trigintipetala'

The essence of the rose flower, captured by extraction, is one of the most valuable flavour and fragrance products used. The main production areas are Turkey, Morocco, Bulgaria and France. Roses grow well with irrigation in the semi-arid climate of Central Otago. An experimental plot of *Rosa damascena* 'Trigintipetala' has been harvested for the last three years. The 600 plants, producing over a 6-week period in their third flowering year, yielded 3.4 tonnes of flowers. Oils, concretes, and absolutes have been produced and analysed. At Redbank an oil yield of 0.01–0.02% has been achieved from steam distillation, while solvent extraction yields are about 10 times that amount. Flower yields on our production area peaked at 9 t/ha, which is more than double the reported Turkish production. We have identified hand-harvesting of the flowers as the major impediment to crop adoption, as even the best pickers have not exceeded a picking rate of 6 kg/hour. It takes 5 tonnes of flowers to produce one litre of rose oil by steam distillation. Although the oil has met market quality and flower production is high, the production of rose oil in New Zealand appears uneconomic because of the high costs associated with harvesting the flowers by hand. To complete our research on rose production, we will field-test vacuum collection to establish the feasibility of mechanically assisted rose flower harvesting.

Lavender (*Lavandula angustifolia*) and lavandin (*L. ×intermedia*)

Oils from cultivars of lavender and lavandin are used in many fragrance applications, and yields are typically 0.3–0.7% for lavender and up to 2.0% for lavandin. Most essential oil is now produced from high-yielding lavandin cultivars, but oil from the lower-yielding *L. angustifolia* commands higher prices in the marketplace owing to its lower camphor content. The potential for lavender oil production in New Zealand has been under investigation for several years. 'Grosso', a lavandin cultivar imported from France, has performed consistently well over a number of seasons at several sites in the drier areas of the country, achieving acceptable market quality. However, the international market for lavandin oil is very competitive, and price margins may be too low for viable export production in New Zealand at present. So far, none of the lavender cultivars trialled has produced oil that consistently meets international quality requirements, although there

may be opportunities to supply the less demanding tourist, craft, and aromatherapy markets.

Boronia (*Boronia megastigma*)

Boronia, a native of Western Australia, is now grown commercially in the Nelson region, and in 1993 1500 kg of flowers produced 7 kg of concrete. Hexane extraction of the freshly harvested flowers yields concretes rich in ß-ionone, a component used in the perfume and food flavour industries. Interest in boronia growing was stimulated by Alan Scott in 1984, and the subsequent research into plant selection, agronomic needs, and distillation practices has achieved commercial viability. The performance of boronia plants grown from seed is very uneven. To assist selection, an index of the performance of individual plants is being developed using criteria such as plant vigour and habit, flower production, time and ease of harvesting, and concrete yield and composition. Elite plant lines can then be clonally propagated. Pests and root diseases are a major problem. A leaf-hopping psyllid that eats developing flower buds can reduce harvestable flower yields to uneconomic levels. Root diseases can cause widespread death, and a specific research programme is identifying pathogens and determining control strategies.

Native Plants

Although New Zealand natives have been relatively little explored, production of manoöl from pink pine for the fragrance industry has developed into a small but successful industry. More recently, the identification of biologically active compounds in a manuka ecotype has led to its commercial development. Other aromatic plants and resins were used by Maori for perfume (Cooper & Cambie, 1991). Assessment of these substances and a search for new compounds are under way.

Manuka (*Leptospermum scoparium*) and kanuka (*Kunzea ericoides*)

One of the first Europeans to reach New Zealand, Captain James Cook, recommended an aromatic tea made from manuka. This shrub, from the oil-rich family Myrtaceae, grows throughout New Zealand. Steam distillation of its foliage yields a pleasant essential oil containing mono- and sesquiterpenes plus the unusual ketone leptospermone. Oil yield varies between populations: yields between 0.01% and 0.7% have been recorded. Kanuka, a related species with a similar geographical distribution, also produces a fragrant oil, with similar or slightly higher yields than manuka. Four compounds with antiviral activity have recently been discovered in the leaves of kanuka. Both manuka and kanuka oils are of interest as fragrances in toiletry formulations for the domestic market. After positive biological activity testing manuka oil from a selected line of *L. scoparium* has been developed for local and export markets under the trademark Manex.®

Despite all this interest there have been no detailed studies of the factors affecting yield and quality of manuka and kanuka oils. Such studies are vital to support the production of oils of defined qualities, much as for Australian tea tree oil (extracted from a related species, *Melaleuca alternifolia*).

Manuka is well known for its polymorphy (Yin et al., 1984). Although plants within a population are generally more similar to each other than plants from different populations, there is still considerable within-population variability (Warwick Harris, Landcare Research, Lincoln, pers. comm.). Preliminary results show that there are major differences in chemical composition and biological activity of oils from different manuka populations. Further work is planned to define the extent of variation within populations, and to identify elite types. If manuka oil is to be used for its biological activity – for example, in skincare products – it is important for potential producers to realise that there is natural variation in New Zealand populations.

Horopito (*Pseudowintera colorata*)

Research in our Bioactive Natural Products programme has demonstrated insecticidal activity for extracts of horopito, a member of the Winteraceae family. The active compounds were two sesquiterpene dialdehydes. Horopito samples from different areas of New Zealand contain different proportions of these. One of the compounds, polygodial, is a well known insect antifeedant and active antifungal agent. The antifungal effect of polygodial is enhanced by the common essential oil component anethole. A polygodial-rich extract from horopito could be developed either as a natural antifungal agent or as a natural insect deterrent.

Conifer oils

Good yields of essential oils can be obtained from the foliage of New Zealand's 20 native conifer species. Oils from foliage represent a renewable resource, as opposed to compounds extracted from heartwood, such as manoöl. These foliage oils have been studied at the universities of Auckland and Otago, but generally before modern separation and structural identification techniques were available. The conifer oils contain mono- and sesquiterpenes, as expected, but also remarkably high levels of diterpenes, which are relatively rare in essential oils. Several diterpenes were first isolated from (and named after) New Zealand trees; for example, phyllocladene from *Phyllocladus* species and rimuene from rimu, *Dacrydium cupressinum*.

Recently, Perry and others at the University of Otago (Perry et al., 1993) have shown that there can be much variation in oil composition within a single species, and that new compounds can be found. In particular, New Zealand conifer oils may contain new sesquiterpenes, which are of potential interest to the perfumery industry. *Podocarpus nivalis*, the snow totara, has given an oil yield of 0.3%. Preliminary results from the University of Otago have shown that some plants contain high levels of the aromatic sesquiterpene spathulenol. Samples of oils with distinct compositions will be submitted to perfumery companies for assessment.

The heartwoods of other New Zealand conifers are rich in oxygenated diterpenes, such as podocarpic acid and manoöl. Manoöl is of interest to perfumiers because it can easily be converted into acetals with powerful ambergris-type odours. The wood of pink pine, *Halocarpus biformis*, is the best natural source of manool, yielding up to 6–8% by dry weight. Westchem Industries Ltd have been producing manoöl for seven years by extracting it from dead pink pine logs recovered from areas replanted in *Pinus radiata* (B. H. Robinson, pers. comm.).

Extracts of other native plants are being investigated for biological activities with commercial potential beyond the perfume and flavour industries. Insecticidal activities of ferns and conifers have been reported, and a range of these plants have been surveyed for antibiotic substances. So far, we have discovered a wide range of potentially useful biological activities, including antifungal compounds from two liverwort species.

Conclusion

New Zealand offers excellent growing environments, and has the technological base for growers to produce a wide range of essential oil crops, but ultimately adoption is based on commercial decisions and market conditions. Close co-operation between research personnel, growers, marketers and end-users will be vital for the orderly and progressive development of the industry. The Crop & Food Research Institute has research information, and can provide technical assistance to help growers make decisions about essential oil production. Our programmes seek to find new products and technology, leading to confidence in the industry and ultimately to investment. In the year to December 1992, New Zealand imported approximately 100 tonnes of essential oils worth

more than $2.8 million. There is potential for some import substitution on the domestic market, but most new production of essential oils should be aimed at specific export markets. The world trade in flavour and fragrance is estimated to be $15 billion and growing 5% per annum. Together with the trade in other plant-derived products and extracts, it is an industry that provides interesting possibilities for producers in this country.

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Book Review

Bulbs for New Zealand Gardeners and Collectors by Jack Hobbs and Terry Hatch. Godwit Press, Auckland, N.Z., 1994. ISBN 0-908877-37-4. $59.95.

In recent years there has been an unprecedented upsurge in the publication of horticultural and gardening books by New Zealand authors for New Zealand conditions. Trees and shrubs, particularly New Zealand natives, roses, rhododendrons, camellias, etc., have all been generously dealt with.

Until 1991, with the publication of the Hugh Redgrove-edited book on bulbs and perennials, this subject had been largely ignored, apart from garden magazine articles.

Bulbs for New Zealand Gardeners and Collectors is published on quality paper and is a delight to follow, particularly in the largest section of the book devoted to the description of 120 genera and 800 species of bulbs.

The genera are listed in alphabetical order in upper-case letters highlighted in blue and clearly separated from the last-described species of the previous genus.

There are chapters on bulbs in their native habitats and in cultivation in both garden and containers, on propagation, on pests and diseases, and – for the non-botanically knowledgeable – on what constitutes a bulb.

The authors have trodden with great skill through the minefield of nomenclature using, where possible, current names from the most up-to-date authorities. They admit that many of these changes are not yet universally accepted, and that it is undoubtedly disconcerting to find an old friend pictured with an unfamiliar name printed beneath. With some exceptions, the authors have provided the best known synonym with the name change, to minimise confusion. There is the odd spelling mistake, more likely a printer's error than the authors'; and how refreshing to see the generic name *Chlidanthus* correctly spelt and not, as it is so often written, *Childanthus*.

In most cases the photography is excellent, making the species easily recognisable. I wonder, will the manufacturers of colour film ever be able to provide a product capable of accurately capturing the glorious blue of *Chionodoxa forbesii* or *C. sardensis*?

Rarely is a book published that completely satisfies or is without error, and this book is no exception. Illustrations are most frequently pointed out to the reader as "opposite above" and "opposite below"; and then there is the odd transposition. Perhaps fewer pages could have been devoted to dahlias and begonias – there are innumerable books written on these. Far better to have given these pages to genera omitted altogether, i.e., *Merendera, Bellevalia, Eremurus*, or to have expanded the number of *Colchicum* species described to include some of the more dainty members, e.g., *C. cupanii, kesselringii, triphyllum*, etc.

There is the publisher's nightmare come true on page 153, where after a description of *Rannunculus cortusifolius* the reader is directed to an illustration of a *Rhodopohalia,* the *R. cortusifolius* illustration having been omitted. And is that really an illustration of *Arisamea triphyllum* on page 52?

The presence of scent, pleasant or otherwise, is mentioned for a number of genera and species, but what of *Tigridia vanhouttei*? A good description is given, but there is no mention of the foul smell the flower emits on a warm day.

Some guidance is given as to the ease or invasiveness of some of the species, notably in the genera *Allium* and *Oxalis*. It should be noted, however, that seven of the *Allium* and nine of the *Oxalis* species described are listed by MAF as prohibited imports into New Zealand in the latest proposed import regulations.

The publishers consider "that this book brings the subject to the attention of gardeners and collectors". Dedicated collectors, I am sure, will have already graduated to monographs of their favourite genera. For the keen gardener, whose knowledge of bulbs extends only to those available at the local garden centre, this book (despite the drawbacks outlined) should prove an invaluable introduction to the beauty and diversity of the world's bulb flora.

The book is rounded off with an excellent up-to-date bibliography, an index, and a useful list of New Zealand and overseas suppliers of bulbs and seeds. At $59.95 it is good value.

Des Riach

Nelumbo nucifera 'Alba Grandiflora' — The Sacred Lotus

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The Victoria lily (*Victoria amazonica* and *V. cruentus*) is widely grown in public gardens worldwide, and has gained a reputation as something special because of its large size and the myths associated with its floating leaves and their ability to support children. However, the sacred lotus (*Nelumbo nucifera* Gaertn.), an aquatic plant less widely known, has upstaged the Victoria lily since it flowered in the lily pond of the Wellington Botanic Garden's begonia house.

Nelumbo nucifera is a member of the family Nelumbonaceae, and is found in Asia from Iran to Japan and south to Australia. There is one other species in the family, *Nelumbo lutea* (Willd.), the American lotus or water chinquapin, found in eastern North America.

The sacred lotus is a perennial, aquatic herb with a spongy rhizome that spreads readily. Large, bluish-green, orbicular leaves are borne horizontally on long petioles, and can rise almost 2 metres above the water. The leaves have a unique waxy water-repellent covering causing water to form droplets on striking the leaf. The solitary bisexual flowers are beautifully fragrant and can reach up to 30 cm across. The fruit of separate hard-walled nuts is almost as attractive as the flower. The seed is famous for its longevity, with some found in peat deposits still viable after 1000 years.

There are several cultivars listed, with flower colour varying from white through pink to red. Double forms are available.

Cultivation in the Wellington Botanic Garden

Plants of the cultivar 'Alba Grandiflora' were obtained from Wai Mara Horticulture, Warkworth, through David Fenton in Lower Hutt. Propagation was by division. Our first three planting attempts were unsuccessful, probably because we planted at the wrong time, when daylight hours were too short. In 1993 we planted successfully in October. Care is needed to prevent damage to the rhizome, as even a slight nick can induce rotting. We planted the rhizome in a large container, but a milk crate lined with shade cloth would do. The container was piled with loam, and the rhizome was planted just below the surface. A thin layer of coarse sand was added to prevent the loam from escaping as the container was lowered into the pond. The surface of the container was placed about 30 cm below the water level. The pond temperature fluctuated between 26 and 28°C, and maximum light was ensured.

The first two or three leaves were small and lay flat on the water. Later leaves grew up to 40 cm across and were up to 90 cm above the water surface. The leaves were tightly rolled when emerging from the water, and easily pierced adjacent lily pads, including those of the Victoria lily, creating an unusual sight.

The plant flowered in March, and had three flowers in all, the first two about 19 days apart, and the third about a month later. The flower stems stood well out of the water and opened during the night, closing by early afternoon of the first day. On the second day the flower remained open longer, and on the third the petals began to fall. The flowers were about 25 cm in diameter and pure white with yellow stamens. After flowering the first seed head developed, turning brown in about 6 weeks. On cutting it open the seed was found to be infertile, although subsequent seed heads contained some viable seeds.

Once the plant was established it was fed weekly with two tablespoons of the fertiliser mixture

- sulphate of ammonia (6 parts)
- superphosphate (4 parts)
- potash (1 part)

This was reduced to fortnightly feeding during mid April. At this time the plant was 4–5 metres across and growing rapidly before its expected dormancy over the winter months.

The only pests encountered were red spider mite, but these were kept under control by the introduction of the predator 'Mite-E.'

[See illustrations on back cover.]

Sir Victor Davies Award 1994

The 1994 Sir Victor Davies Award to a younger horticulturist has been made to Marian Jones, Manurewa, Auckland.

After leaving school Marian joined the staff at the Auckland Regional Botanic Gardens, completed a Trade Certificate in Horticulture in 1985, and continued study towards a National Certificate in Horticulture. Experience at the Botanic Gardens led to a particular interest in herbs and the building-up of a salvia collection of over 100 species and cultivars which became a National Reference Collection and a special feature of the Gardens. A keen and active member of the New Zealand Herb Federation Marian was a founding member of the Plant Conservation Committee of the Federation and has represented the Federation in the development of a National Plant Collection Group.

Marian has contributed articles on herbs to various publications and gives many talks on this popular topic.

The University of Auckland Botanic Garden?

A.D. Palmer and J.P. Adam

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From the earliest days of their development it was intended that the grounds of Auckland University become a Botanic Garden. This is clearly indicated by the following quote from a letter written in 1925 by the Architect Roy Lippincott to the then President of Auckland University College, Geo. Fowlds.

"With regard to the layout of the grounds about the new buildings ... We have conferred with Professor Johnson, and he agrees with us that in the plantings we must arrange them not only to obtain the best landscape effect, but also so that they will have a value to the University as a small botanical gardens ..."[1] Incidentally the same letter proposes a trained horticulturist to undertake the planting, and suggests a wage for him of £6 per week.

Newspapers of the time refer in an article on the new Arts building in Princes Street to the "Grounds as an Arboretum", and talk about "... a fine plan for beautifying and using the rest of the grounds has been carried out already in part ... under the supervision of Dr T.L. Lancaster of the biological department in collaboration with the architect Mr R.A. Lippincott. The method of planting may best be seen on the northern part of the Princes Street frontage. The flowering plants have been distributed according to the colour of their blossoms. Mauve veronicas, yellow kowhai and red manuka are examples. Trees have been planted only in spots suitable for trees and shrubs where shrubs alone are needed."[2]

The same article, subheaded "Native Botanical Garden," says: "In time the college will have a native botanical garden unequalled in Auckland, perhaps even in the North Island. Auckland City has no adequate collection of native plants. The Domain and the city parks have been laid out chiefly in exotics, and there is nothing that can compare, for instance, with the New Zealand section of the botanical garden in Christchurch. This is regrettable, because in the climate of Auckland every New Zealand plant can be grown except hardy alpine species from the South Island. If all goes well Auckland University College will fill the deficiency before long. All the plants will be properly labelled, and the garden is certain to be of great value to biology students."

The University has increased in size considerably since the articles were written, but the planting philosophy has not changed markedly. The grounds now cover some 117 hectares, ranging from sports fields at University Park to botanical reserves in the Waitakere Ranges. They include, in the grounds of Old Government House, one of the most historically important gardens in New Zealand. The planting around the Arts building – with many later additions by Professor Laurie Millener and Professor Jack Rattenbury – has matured into a collection of native trees and shrubs second to none in Auckland. Recent additions include collections of northern *Hebe* species, to replace some trees and shrubs damaged by the refurbishment of the building. A herb garden at the School of Medicine contains plants of medicinal value, and the new Marae grounds have plants chosen for their cultural and medicinal importance, including an important collection of flax with outstanding properties for weaving.

Old Government House Grounds and Associations with the Auckland Domain Botanical Garden

A Government House was built during 1840/41 on the block of land today bounded by Princes Street, Waterloo Quandrant, Symonds Street, and plane tree lined Alfred Street. The original prefabricated house, it is believed, stood on the present site of old Government House, constructed in 1855/56 after the first house burned down in 1848.

The earliest written record of gardening on the site of old Government House is the *'Cultivations of Potatoes'* grown by the local Maori that a Mr Williams was commissioned to purchase by Lieutenant Governor Hobson in 1840.[3] Oaks sent as acorns from Sydney were planted about 1845,[4] and vine cuttings and shrubs were sent in 1841 from the Sydney Botanic Garden.[5] The gardens remained enclosed after the 1848 house fire, secure from wandering stock.[6]

During 1853 writer J. Askew described that there was a *"neat lodge and large white gate at the entrance"* to the Government House site, and that in the garden *"specimens of all the New Zealand flora and many rare plants from different parts of the world are to be found ..."* [7] One could speculate that some of these plants were cultivated by the Colonial Secretary, Dr Andrew Sinclair, a keen botanist and friend of Joseph and William Hooker of Kew Gardens.

With the construction of the present house in 1855/56 it seems that the architect, William Mason, was to take an interest in the layout of the grounds followed by (Sir) Edward Stafford the Premier.[8]

Although the then Government House and grounds developed in this way in Waterloo Crescent, it was not always intended to be so. In fact it was the intention of Governor Hobson and some subsequent Governors to build a permanent house in the Auckland Domain or Government Domain / Auckland Park, as the colonists knew this large public

Fig.1. Aerial view of the main campus with old Government House in the foreground.

park.[9] It is a 10-minute walk from old Government House and was the venue of the 1990 Kiri Te Kanawa homecoming concert.

Intensively cultivated gardens, including a botanical garden, were established in the centre of the Auckland Domain and became known as the Government Gardens. Here many economic and ornamental plants were grown for the Governor's own use and for the colonists in a 'squared'-style garden.[10] A Government Gazette notice in 1851 announced that the Government Gardens would be open to the public on Wednesdays and Sundays, from noon till sunset, for "accommodation and recreation ..."[11]

Published references to a botanical garden being developed in the Government Domain first appear in the New Zealand Parliamentary debates of 1870, when during a discussion on funding for the Wellington Botanical Gardens Mr Hugh Carlton, member of the General Assembly for the Bay of Islands, said "*In 1856 a sum (£300) was granted by the General Assembly for the establishment of a Botanic Garden in Auckland, and having voted for that should be ashamed not to vote for this ...*"[12]

Current Planting Plans

Our University Landscaping Standard states, with regard to planting:

"Planting plans will be prepared by University Grounds Staff within constraints laid down by the Site Development Committee after consultation with the Site Development Consultant, the building designer and the user departments.

"An overall theme will be decided on early in the building programme to allow as much time as possible for collecting together specific plants to fit the theme.

"As well as meeting the general site development objectives, planting development will aim to provide a botanically interesting and attractive collection which includes teaching material for departments such as Botany and through adequate labelling of plants in appropriate areas, provide information for staff, students and the public."[13]

Planting plans are once again developed in-house, as they were in the early days. One reason for this is that Landscape Architects employed for this purpose for a while in the seventies were unwilling to adhere to the required philosophy, and produced at times some quite impractical and grotesque plans.

Recent plantings around some of the newer buildings developed in the eighties have geographical themes, with collections from China and Japan, North and South America, Australia, and the

Fig. 2. *Pennantia baylisiana*, one of the rare species on campus. Photo J.E. Braggins.

Mediterranean. We also have a formal German garden and a Swedish garden. New Zealand theme gardens feature plants from the Chatham Islands and a northern offshore islands collection. A large collection of cycads feature in an area currently being developed.

The University can boast an extremely comprehensive plant collection. We consider that a vital aspect of maintaining the collection is clear, accurate, and botanically correct labelling. As a result of our own research, both here and overseas, into the various types of labels available we decided on a photo-engraved anodised aluminium label. This is seen as a long-lasting, cost-effective type of label. Apart from the inevitable losses from vandalism, the labels we first put up some ten years ago are as good as new today. We do our own typesetting on computer, and the negatives produced and used in the process by Metal Image Ltd[14] are held by them and are available for others to use, thereby considerably reducing the cost of second and subsequent copies of each label.

Another aspect of collection maintenance that we focus on is the accurate recording of all plantings. To this end we have purchased an Amiga 2500 computer, and we are currently developing a graphical database on it. The program we are using is called 'Superbase', which allows the storage of pictures as well as text. We intend to use a colour video camera to take still pictures of important plants and also general shots of the grounds. These will then be digitised by the computer and stored in the database. With program development we hope to be able, for example, to screen a picture showing a section of the grounds, with 'buttons' on the trees and shrubs which can be clicked on with the mouse to show relevant information from the database.

The core of each database record will be as laid down in the International Transfer Format for Botanic Garden Plant Records, so that we have the capability to readily exchange information with other botanic gardens (our Amiga is IBM-compatible as well). However, we will not limit ourselves to the data fields specified in the Transfer Format, as our own information needs will sometimes be at variance with theirs.

Well, are we a botanic garden? We certainly have an extremely valuable plant collection. We have our own botanists and taxonomists. Our collection is being progressively labelled and recorded. We are involved in the propagation and distribution of rare and endangered plant species: the first plants of *Hebe breviracemosa* were raised by us, and specimens of *Metrosideros bartlettii* were first planted on campus in 1987. We were also the first to establish a plant of *Myrsine oliveri* in cultivation. Unlike most other gardens we can also boast a guaranteed 20,000–25,000 visitors a day. We'll let you decide!

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