PRACTICAL ROOT GRAFTING

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I propose to explain in detail one type of graft—root grafting—a very old method but from the point of "propagation", very much neglected. It is simple and works well with all apple, cherry, plum, peach, nectarine, and pear cultivars. Many ornamentals may also be propagated by this method—rhododendrons, camellias, wisterias, and some difficult conifers not easily produced by cuttings. Figure 1 illustrates the various type of root grafts that I will describe.

This type of graft can be made using a whole root or pieces of roots. For a whole root graft, it is advantageous that both scion and root be of the same size.

Usually the whip and tongue method is used but also the wedge or saddle graft can be used. The length of the root should be not less than half the length of the scion. If both are the same length, even better. This will depend a lot on the internode length of each cultivar or species, availability of material, and the depth to which the graft is to be planted.

If scion or root are not of the same size they will have to be matched on one side and possibly with the top bud of the scion in line with the matched side. Pencil-sized root and scion are ideal for this type of graft. Roots of larger diameter may be devoid of fibrous roots, depending on the species, and thus be more difficult to "take."

Due to the poor quality of the larger sized roots, most root grafts are done using piece roots, from 2 to 8 mm in diameter and 40 to 80 mm long. The diameter of the scion may vary from 3 to 20 mm with the same length as mentioned for the whole-root graft. I personally have grafted thousands of apple trees in the past using root pieces, with excellent results.

The scion is split at the bottom by starting through the bud (apple, cherry, etc.) or node, e.g. camellia, conifers This is very important: the scion is then divided into two halves of equal consistency (degree of density). If this operation is done properly, very often there is no need to bind the graft.

The best of one or two root pieces is wedge-shaped and slightly angled (8 to 15 mm long) and inserted into the split cutting on the bud side or node.

The second and smaller root on the opposite side is shaped in a similar fashion. For two root piece grafts a cutting needs to be at

least 6 mm or above in diameter. For smaller cuttings one root piece is more suitable.

Always remember to maintain the polarity of the roots in all the grafts. The best way to do it is to cut the top part of the root horizontally and the bottom on a slant. If this procedure is always adopted no mistakes will be made.

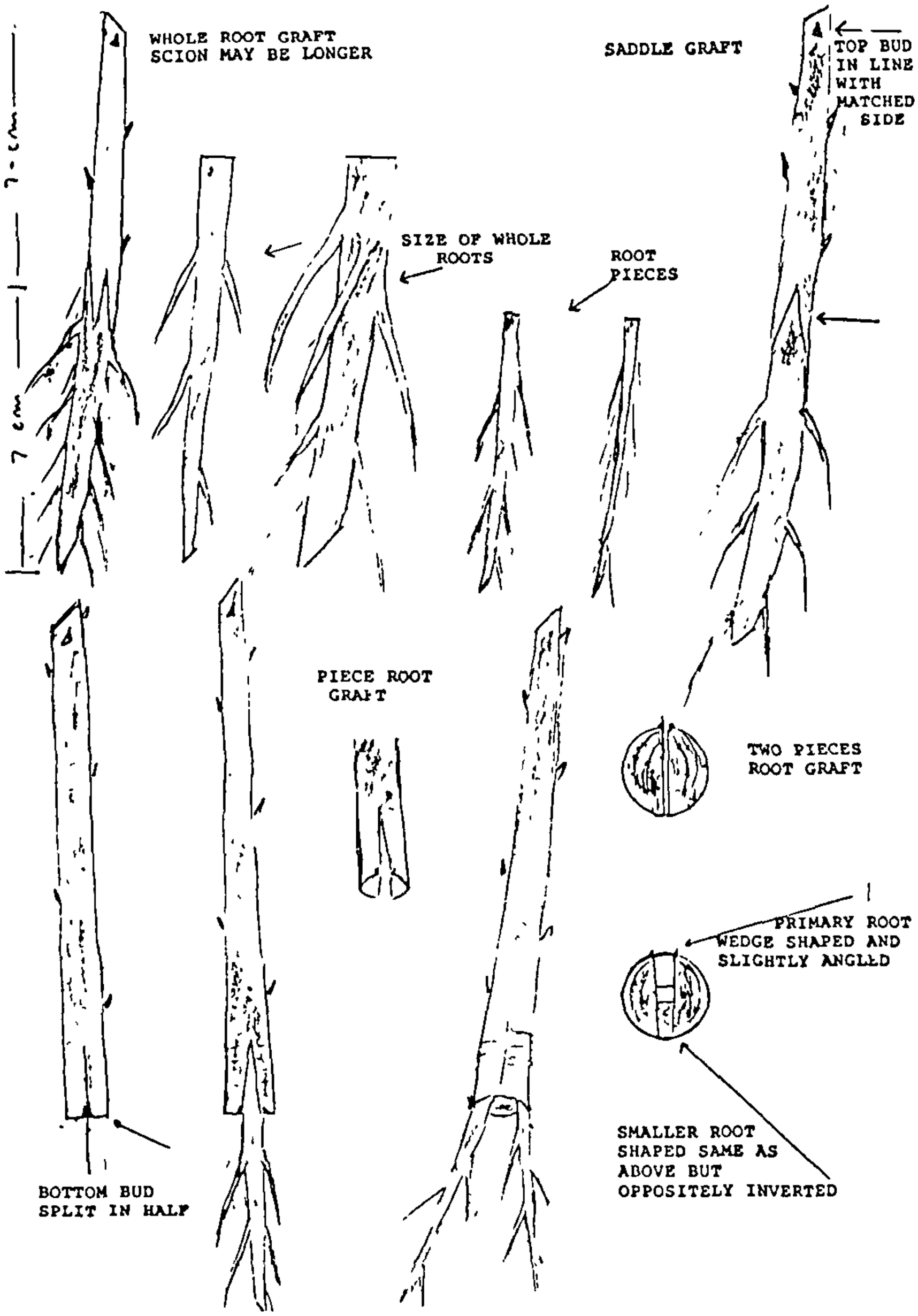

Figure 1. Several types of root grafts

For securing the graft, I have used, with good results, a 15 to 18 cm long piece of thread obtained from hessian, sugar bag, or burlap. This material will decompose very easily and will not constrict the graft. I do not recommend budding rubbers.

Planting out for deciduous trees depends a lot on the climatic conditions. For subtropical Western Australia, grafts may be planted any time of year as soon as they are ready.

For colder areas, early winter grafts can be stored at 5 to 8 °C and planted out 4 to 10 weeks later. Store the grafts in a mixture of clean sand, perlite, and peat moss, which is reasonably moist. Plants susceptible to crown gall may be dipped in a solution of "No Gall." (fruit trees).

I prefer to see all these grafts planted deeply so that only two buds are exposed. Evergreen stock will have to be provided with a controlled environment to obtain a good "take."

With today's facilities—fog, mist, and temperature control—the success of this type of grafted cutting has improved greatly.

I have noted over the years, that cuttings of some plants, however reluctant to provide themselves with their own roots, will do so if a small root-piece is inserted at the bottom of the cutting. In this case, wounding and application of a rooting hormone will also help.

Other cuttings will produce roots better only on succulent successive young growth. Plant the graft at soil level and, as the young growth starts, cover it with more soil so that young roots can develop on the new growth. In this case the graft becomes a "nurse graft". Eventually the initial root from the graft may completely disappear. When you are sure that this will occur on a particular plant, then you can use a rubber tie; this will constrict the initial root and allow the young plants to develop their own roots.

As you can see, this system of grafting may be useful when conventional cuttings are not successful.

WEED CONTROL IN AUSTRALIAN NATIVE PLANTS AND SOUTH AFRICAN PROTEAS

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INTRODUCTION

The flora of Western Australia is diverse and unusual, ranging from the spectacular to the seemingly mundane. Sandplain and forest areas north and south of Perth, respectively, support over 8000 plant species, with perhaps another 1000 yet to be described.

Commercial plantings of Australian native plants in a row crop situation began in the early 1980's mainly in response to increasing export demand for species not widely distributed in the bush. In Western Australia, the area of native plants under cultivation has increased from 20 ha in 1980 to approximately 1080 ha in 1988 (9).

The area of South African proteas planted in Western Australia has also increased substantially, from virtually nil in 1983 to over 200 ha in 1988 (9).

Weed control in cultivated native plants and proteas is essential for optimum plant growth and flower yield. Weed control in native plants was not required when the flowers and foliage were being harvested from the bush. However, successful intensive cultivation on both virgin and established farm land is dependent on effective weed control.

WEED CONTROL METHODS

Weeds in native plants and proteas can be controlled using one or more of the following methods:

Soil fumigation. Soil fumigation can be used pre-planting to control early weed growth in perennial plants but the cost can exceed A$4000 ha^{-1} (6). Soil fumigation has not yet been used in Western Australia to provide weed control for field grown native plants or proteas.

Synthetic mulch. Synthetic mulch has been used on less than 10 ha in Western Australia to provide weed control in proteas Synthetic mulch has also been used on some large plantings of native plants and proteas in eastern Australia The cost of synthetic mulch ranges from A$1000 to A$12,000 ha^{-1}, depending upon mulch type and row width. Synthetic mulch cannot be used for *Anigozanthos* spp. where the tops are burnt each year to reduce the incidence of leaf diseases

Inter-row weed control. Inter-row weed control can be achieved either by mechanical means, or by using non-selective herbicides. Mechanical weed control can generally only be used on young plants before they grow into the row and make tractor movement difficult. A modified sod management system has been adopted by some growers where the inter-row weed strip is kept mown over winter and weeds along the row are controlled by careful application of a non-selective herbicide. Although the mown strip dies off in late spring, the weed residue helps hold the soil together and reduces plant damage caused by strong winds and sand blasting. On some native plants, like *Chamelaucium uncinatum* or *Banksia hookeriana*, where the lower growth is removed by pruning, non-selective herbicides like diquat and paraquat can be sprayed at low pressures right up to the base of mature plants without causing any damage.

Hand weeding. Hand weeding is very expensive, costing up to A$10,000 ha^{-1}, depending upon the severity of the weed infestation (6). Hand weeding is not really an option in most plantings except for large, easily-removed weeds.

Chemical weed control. Weed control using selective pre- and post-emergent herbicides presents an economic alternative to other forms of weed control. This will be examined in more detail below.

CHEMICAL WEED CONTROL

There is a lack of information on pre- and post-emergent herbicides used for weed control in Australian native plants and South African proteas grown for cut flower and foliage production. In Western Australia, the only selective herbicides registered for use in ornamental crops are chloroxuron, oxadiazon, fluazifop-butyl, and chlorthal dimethyl.

Although there is a paucity of information on herbicides registered for use in native plants and proteas, there is considerable information on herbicides tested on native plant species used for revegetation and timber production.

Pre-emergent herbicides successfully tested on various *Eucalyptus* spp. include oryzalin (3), oxadiazon (3, 5), terbuthylazine and terbumeton (11), simazine (1,4) and nitrofen (10).

Pre-emergent herbicides successfully tested on other native plant species like *Acacia saligna* and *Casuarina cunninghamiana* include oxadiazon and propyzamide (5).

Pre-emergent herbicides successfully tested on *Protea neriifolia*, *Leucadendron* 'Safari Sunset', *Leucospermum cordifolium* and *Banksia menziesii* include oxadiazon, oryzalin and oxyfluorfen (2).

Post-emergent herbicides successfully tested on various native plant species include fluazifop-butyl (5, 8), propazine (5), and sethoxydim (8).

Fluazifop-butyl has also been successfully tested against a range of *Banksia* spp., *Protea* spp. and *Leucospermum cordifolium* (2).

Table 1. Plant species tested by herbicide. Number is maximum [b] kg ha^{-1} a.i. applied with nil or very slight damage.

Species or Cultivars[a]	bromoxynil	chloroxuron	chlorthal dimethyl	diflufenican	linuron	methabenzthiazuron	metribuzin	nitrobenzoic acid	oryzalin	oxadiazon	oxyfluorfen	phenmedipham	prometryn	sethoxydim	simazine
Anigozanthos manglesii cv. FMB	0.2	-	-	S	1.1	-	VS	0.22 +	4.5	-	S +	-	0.55	-	1 +
A. pulcherrimus	0.4	S	13	S	0.55	1.4	VS	0.22 +	4.5	8	S	0.8	0.55 +	0.36	S +
A. rufus	-	VS	13	-	0.55 +	1.4	VS	-	4.5	8	-	1.6	-	0.36	1 +
Boronia heterophylla	0.2	-	-	0.1 +	1.1	-	S	0.22	4.5	-	S	-	1.1	-	2
Chamelaucium axillare	-	-	-	-	-	-	0.7	-	4.5	8	-	-	-	0.36	-
c. uncinatum cv. Alba	0.4	-	-	0.1	1.1	-	0.7	0.44	4.5	8	0.24	-	1.1	0.36	1 +
C. uncinatum cv. Mullering Brook	0.4	-	-	0.1	1.1	-	0.7	0.44	4.5	8	0.24	-	1.1	-	1 +
C. uncinatum cv. Purple Pride	0.2	-	-	0.05	1.1	-	0.7	0.44	4.5	8	0.12	-	1.1	0.36	1 +
Helichrysum cordatum	VS	-	-	0.1	0.55	-	VS	0.44	4.5	-	0.24	-	1.1	-	VS
Hypocalymma angustifolium	VS	-	-	0.1	1.1	-	S	0.44	4.5	-	0.12	-	1.1	-	VS
H. xanthopetalum	-	-	-	-	-	-	S	-	4.5	8	-	-	-	0.36	1 +
Lxodia achilleoides	0.2	-	-	0.1	0.55	-	VS	0.44	4.5	8	0.24	-	1.1	0.36	1 +
Macropidia fuliginosa	-	2.25	13	-	1.1	1.4	-	-	-	-	-	1.6	-	-	-
Scholtzia oligandra	-	-	-	-	-	-	0.24	-	4.5	8	-	-	-	0.36	1 +
Thryptomene denticulata	0.4	-	-	0.1	1.1	-	0.7	0.44	4.5	8	0.24	-	1.1	0.36	1
Verticordia monadelpha	-	-	-	-	-	-	0.48	-	4.5	8	-	-	-	0.36	2 +
V. plumosa	0.2	-	-	S +	1.1	-	-	0.22	4.5	-	012 +	-	1.1	-	1
V. sp. cv. Coolamia	0.4	-	-	0.1	1.1	-	0.35	0.44	4.5	-	S +	-	1.1	-	1
Leucadendron sp. cv. Silvan Red	0.4	-	-	0.1	1.1	-	S	0.44	4.5	-	0.24	-	1.1	-	2
Protea cynaroides	0.4	-	-	0.05	0.55	-	S	0.44	4.5	-	0.24	-	1.1	-	1
Protea neriifolia	0.4	-	-	0.1	1.1	-	0.35	0.22	4.5	-	0.24	-	1.1	-	2 +

Note: [a] Plants established as rooted cuttings in 140 mm pots with 1:1 coarse sand and composted pine bark mix.
[b] Maximum of rates tested.
S Sensitive
VS Very Sensitive.
+ Variable results obtained. Test rates indicated with caution.
- Not tested.

HERBICIDE EXPERIMENTS IN WESTERN AUSTRALIA

Three pot experiments were conducted in Western Australia from 1988 to 1990 to examine the effects of 21 pre- and post-emergent herbicides on a range of Australian native plant species and three protea species. A summary of the maximum herbicide rate tolerated by a range of plant species is provided in Table 1.

Field research on Australian native plants is being conducted in 1990 to further examine promising herbicides identified in the initial pot experiments.

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ROOT FORMATION IN *MALUS PUMILA* 'NORTHERN SPY' CUTTINGS USING ETIOLATION

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There has been a renewed interest in the use of etiolation as a technique for aiding propagation of difficult to root plants. Etiolation occurs when plants or shoots are grown in the absence of light and was reported in the 19th century to be of assistance in propagation (9). Reid (8) studied etiolation in relation to propagation of camphor cuttings and an anatomical study suggested, among other things, that etiolated shoots were less lignified and had decreased cell wall thickness. Many people over the years have investigated etiolation (1, 5) but the mechanism whereby etiolation promotes rooting is still poorly understood. Delargy and Wright (1) have shown the benefit of etiolation on the apples, 'Bramley's Seedling' and 'Malling Merton III'.

Severe pruning and proximity to roots are known to influence the rooting potential of shoots (5) and stool beds have been used to provide a source of apple shoots that result from both very severe pruning and a close proximity to roots (7).

The experiments reported here investigated the effects of etiolation and auxins on the rooting of stool bed cuttings of the apple, 'Northern Spy', which is widely used as a clonal rootstock in the Australian apple industry.

MATERIALS AND METHODS

Pre and post harvest treatments were applied to cuttings produced on a 9-year-old Northern Spy stool bed. The main treatments for etiolation and IBA are shown in Table 1. The combinations of treatment factors are shown in Table 2. These treatments were applied in spring, 1987, and repeated in spring, 1988.

Etiolation was achieved by covering the stool-bed with a tunnel 750 mm high and covered with a sheet of 0.152 mm black polythene plus an outer hessian cover. The bed was sprayed with Benlate prior to placing the cover in situ when shoots were 7 to 10 mm high. Daytime temperatures under the cover were on average 9 °C above ambient. However, to prevent possible heat damage, an additional white plastic cover was added on days when ambient temperature reached 23 ° C. This limited the temperature in the tunnel to a

maximum of 29 ° C. After 4 weeks, when shoots had grown 120 to 150 mm, etiolation was halted by removing the light-proof covers and replacing them with 50% black shade cloth to prevent damage caused by rapid exposure of etiolated shoots to full sunlight. This shading remained in place until cuttings were harvested (10 to 15 days).

Table 1. Main effects of etiolation and IBA treatment on root parameters

Treatment		Rooting percentage	Root number	Root length (mm)
Etiolation	-	26 2	2 0	24 5
	+	64 1	8 4	51.1
LSD 5%		17 7	3 4	20 6
IBA	-	34 2	3 1	43 6
	+	68 8	9 5	40 9
LSD 5%		16 7	3 2	NS

On the day etiolation was halted, approximately one-third of the shoots were banded to maintain a localized area of etiolation. Banding was achieved by covering the stem in the region 20 to 70 mm above soil level with black Velcro strips as described by Maynard *et al.* (6).

Semi-hardwood cuttings (six weeks old) 100 to 120 mm with soft tips removed, taken from the stool beds, and with proximal ends cut to a node, were propagated in tubes (25 mm × 75 mm), and irrigated by intermittent mist in a glasshouse. Banded cuttings were trimmed to a node within the continuously etiolated area. Propagation medium consisted of equal parts by volume peat, perlite, and coarse granite sand (particle size 2-6 mm). The rooting medium was heated to ensure a minimum temperature of 21 ° C, and 50% black shade cloth was placed 500 mm over the cuttings. The maximum and minimum air temperatures in the glasshouse during the rooting period were 28 ° C and 18 ° C, respectively. When auxins were used, idolebutryic acid (IBA) 2500 mg/l (50% aqueous acetone) was applied to the basal 8 mm via the concentrated quick-dip method as described by Howard *et al.* (5).

After 4 to 6 weeks in the propagation bed cuttings were examined to determine the number of rooted cuttings per treatment. Root number and root length were also recorded.

With the exception of two treatments (see Table 2) the number of cuttings per treatment was 20 Results were analyzed by analysis of variance using years as blocks. The statistical package used for analysis was Genstat 5.

RESULTS

The main treatment effects for etiolation and IBA are given in Table 1 and show that etiolation significantly increased percent rooting, root number, and root length, whereas IBA increased percent rooting and root number but did not significantly alter root length.

Individual treatment effects are shown in Table 2. IBA increased rooting but the effect was greatest when cuttings had not received any prior etiolation. When cuttings had been etiolated and banded, the increase caused by IBA failed to reach statistical significance. The percentage of rooted cuttings was higher on banded cuttings but in neither case did the difference between banded and equivalent non-banded treatment reach significance.

Either IBA or etiolation appeared to stimulate root number but data clearly shows that the largest and only statistically significant effect results from the combination of etiolation, banding, and IBA treatment. Differences among treatments with respect to root length were not statistically significant.

Table 2. Individual treatment effects on root parameters[x]

Treatment			Rooting Percentage	Root number	Root length (mm)
Etiolation	Banding	IBA			
-	-	-	5 0	0 5	10 2
-	-	+	47 5	3 5	38 7
+	-	-	37 5	3 7	57 1
+	-	+	75 0	5 4	47 5
+	+	-	60.0[1]	5 0	63 5
+	+	+	84.0[2]	19 7	36 5
LSD 5%			29 0	5 5	NS

[x] The number of cuttings per treatment was 20 except these indicated 1=15 cuttings in 1988, 2=17 cuttings in 1988

DISCUSSION

IBA or etiolation increased rooting but the increase was greater where cuttings received both treatments and the maximum response was obtained if localized etiolation was maintained until cuttings were harvested. These results are in close agreement with those reported (2) for 'M-9' cuttings produced on hedge rows. However, the relative increase caused by IBA alone was greater for 'Northern Spy' than for 'M-9'.

Maintenance of localized etiolation by banding did increase the number of rooted cuttings but the effect was not statistically significant. This is in contrast to the results of Delargy and Wright (1) who showed that continued local etiolation was critical for rooting.

However, they harvested cuttings almost twelve months after initial etiolation and presumably any root promoting effect due to only a short-term initial etiolation had been lost by extended exposure to light.

The strong effect of continued etiolation plus IBA on root numbers has not previously been reported for apples. Delargy and Wright (1) also obtained maximum root numbers with the same treatment combination but the relative increase over treatments receiving either continued etiolation or IBA was not as great.

These results show that 'Northern Spy' can be propagated from semi-hardwood cuttings produced on stool beds. In the short-term, beds could produce both summer cuttings and a winter harvest of rooted shoots but it is not known whether a bed could sustain dual production over a number of years.

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PROPAGATION OF WESTERN AUSTRALIAN TERRESTRIAL ORCHIDS

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INTRODUCTION

Western Australia has over 350 species of native orchids (1) and all are terrestrial with the exception of two epiphytic species, found only in the Kimberly area. The majority of these 350 species are found in the southwest corner of the state. The flowers of terrestrial orchids are usually smaller and more delicate than those of the more commonly cultivated exotic epiphytes, but have a wide variety of form and colour. Many, such as the *Thelymitra, Diuris* and *Caladenia*, would make attractive horticultural subjects. Unlike the epiphytic orchids, which are an important part of the floriculture industry, terrestrial orchids have not been commercially exploited to any significant degree. Potential growers have probably been discouraged by both the lack of efficient propagation methods and the long dormancy period.

In order to survive hot, dry summers terrestrial orchids have evolved a deciduous growth cycles (Figure 1) and spend 4 to 6 months of the driest part of the year as a dormant subterranean tuber. The single exception is *Cryptostylus ovata*, the only orchid of the southwest to retain its leaves all year round. Following the first consistent autumn rains (usually in March) the terrestrial orchid begins to grow and develop shoots and roots. As the plant develops it forms a symbiotic association with a specific mycorrhizal fungus found in the surrounding soil. This fungus breaks down complex carbohydrates from organic material in the soil to simple sugars that can be readily utilised by the orchid (2), and is also thought to protect the orchid from infection by pathogenic fungi. Once the shoot has extended and become green the plant becomes photosynthetic and the orchid begins to put down a new replacement tuber for the next season. The orchid may then, if conditions are suitable, flower and produce seed. The vegetative parts of the plant then senesce and the process is repeated the following year.

The presence of a species specific mycorrhizal fungus is thought to be necessary to initiate seed germination (3). In the wild, seed germination occurs during the cool, damp conditions of autumn and correlates with a peak of mycorrhizal fungus growth. Those seedlings which survive the winter put down tubers in the spring as days become warmer and drier. The first flowering of these

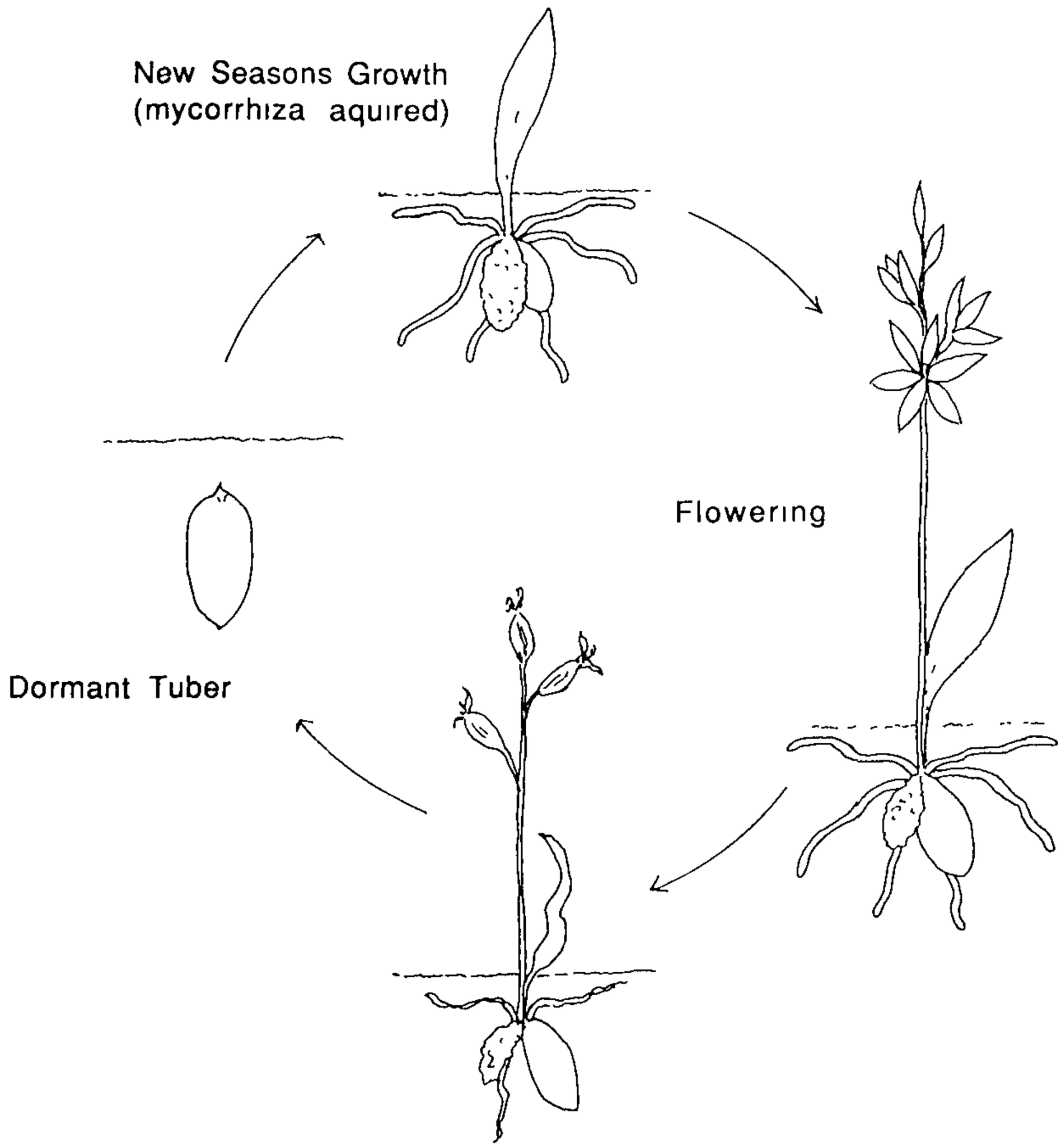

Figure 1. Growth cycle of a Western Australian terrestrial orchid.

new orchids does not normally occur for at least 2 to 3 flowering seasons.

METHODS OF PROPAGATION

At present terrestrial orchids are propagated by orchid growers primarily by vegetative means and through seed germination. The first of these methods relies on the natural propensity of certain species to produce more than one replacement tuber each year. By carefully removing the new tuber from the plant after it has formed, the orchid can be induced to produce another new tuber. This can be repeated so as to produce several new tubers in one growing season (4).

Germination of orchid seed under natural circumstances requires the presence of a species specific mycorrhizal fungus; this presence may be assured by sprinkling orchid seed around the base of the parent plant in autumn. A few of these many thousands of seeds will germinate and produce seedlings, some of which will survive to produce adult plants. Greater efficiency in seed germination and production of seedlings can be achieved through the use of *in vitro* techniques.

In vitro propagation of terrestrial orchids has been achieved through the following techniques:

i) symbiotic germination—co-cultivation of seed with a species of specific mycorrhizal fungus,

ii) asymbiotic germination—germination under sterile conditions, and

iii)tissue culture—micropropagation from the vegetative parts of the orchid.

SYMBIOTIC SEED GERMINATION

The first step in propagating from seed is the isolation of the specific mycorrhizal fungus from each orchid species to be propagated (Figure 2). The infected parts of the orchid, usually the roots, leaf collar or the underground stem, are collected from the wild during the full flush of vegetative growth (5). The plant tissue is surface sterilized, the intracellular fungal coils or pelotons removed with a very find glass needle and placed on fungal isolation medium (6). Alternatively the infected section of tissue can be cut into small cubes and placed on a fungal isolation medium; the fungus will then grow out of the plant tissue into the surrounding medium. The fungus is then subcultured to obtain a pure culture and tested for mycorrhizal efficacy through its ability to stimulate germination and growth of orchid seed. Mycorrhizal agents for each orchid species are then maintained in cold storage for future use.

Once an effective mycorrhizal fungus has been isolated it is used to germinate seed. Surface sterilized orchid seed is spread thinly over a sterile filter paper on low nutrient medium (0.25% oatmeal agar). Several small cubes of mycorrhizal fungus on potato dextrose agar (PDA) are then placed on the edge of the filter paper, the plate sealed and incubated at RT in the dark. The seed will usually germinate within 4 to 6 weeks at 20° C.

ASYMBIOTIC SEED GERMINATION

If a suitable mycorrhizal fungi is unavailable, as is the case for many *Thelymitra* species, orchid seed can be germinated asymbiotically on a complete nutrient media. Various complex media including Knudson C, Vacin and Went, Fast, and modified Burgeff's Pa5, (7, 8) have been used. The orchid seed is surface sterilized, spread thinly over the nutrient agar then the plate sealed and stored in the dark at 20° C until germination occurs. This process is considerably slower than symbiotic germination, commonly taking 2 to 4 months, with some species taking 8 months or more.

In both procedures, once seeds have germinated and protocorms formed they are subcultured onto the appropriate medium and placed under lights at 20° C. When symbiotically germinated seedlings have grown to about 10mm and begun to form droppers they are deflasked into pasteurised perlite: sheoak (*Allocasuarina fraseriana)* mulch, under fog and in 70% shade.

Asymbiotically germinated seedlings are not deflasked until droppers are well formed and tubers have begun to develop. After 4 to 6 weeks under fog the seedlings are transferred to mist and 70% shade where they remain for several months. Dormancy is induced at the beginning of summer by gradually drying out the trays of seedlings. The tubers that form are then collected and repotted in a well draining potting mix with 2 to 3 cm of sheoak mulch on the surface.

TISSUE CULTURE

The micropropagation of epiphytic orchids has been achieved from most vegetative parts of the plant: shoot and protocorm apices, flower stalk nodes, root and leaf tips (9). Terrestrial orchid species however produce very little vegetative growth on each plant that is suitable for explants. The underground parts, the primary shoot (produced underground), the underground stem, and the roots are heavily infected with symbiotic bacteria and fungi, making sterilization of this tissue extremely difficult. Leaf material is also often heavily contaminated as terrestrial orchids are affected

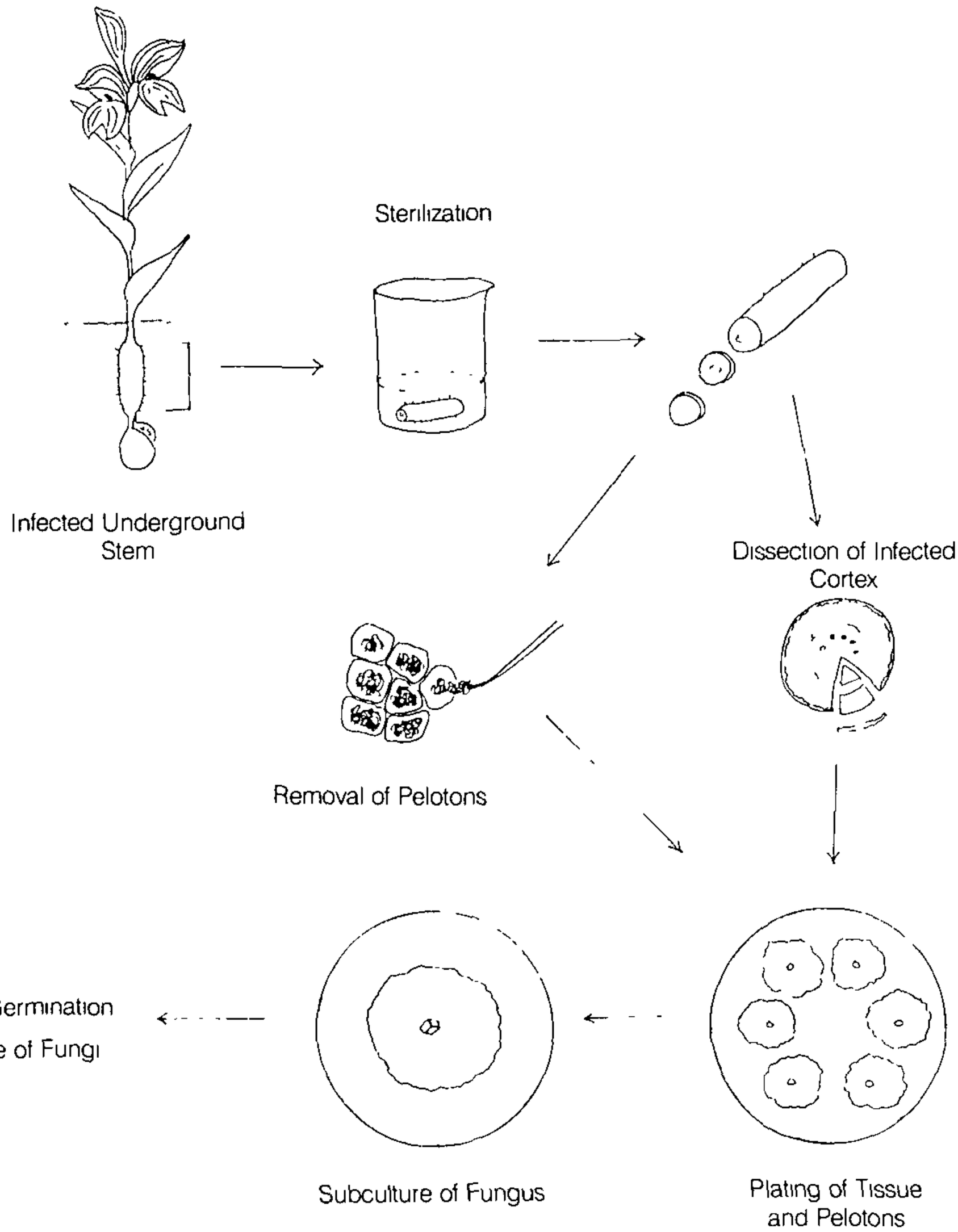

Figure 2. Isolation of mycorrhizal fungus

by rusts and prone to insect damage. As a result very little work has been done in this area and only two Western Australian terrestrial species, *Diuris longifolia* and *Thelymitra crinita* have been successfully tissue-cultured (8).

Protocorm apices from asymbiotically germinated seed and flower spikes of *Thelymitra crinita*, and flower spikes of *Diuris longifolia* were used as explants. The slices of tissue were placed on modified asymbiotic germination medium (Burgeff Pa5) containing added vitamins and the cytokinin, benzyladenine. The formation of protocorm-like bodies (plb's) and multiple shoots occurred within 50 days from protocorm apices. Flower stalks proved to be less productive, as neither stem nodes nor stem slices formed callus or multiple shoot cultures. A few nodes cut from the base of very immature flower buds have however produced plb's for both *T. crinita* and *D. longifolia*. Larger shoots and plb's have been subcultured onto Burgeff's Pa5 to induce root production. No *T. crinita* and only a few *D. longifolia* have produced roots in vitro, but no plants have been deflasked.

CONCLUSIONS

Although there have been significant developments in techniques for propagation of terrestrial orchids, at present these procedures are still slow and inefficient at producing large numbers of viable adult plants. Although efficient seed germination has been achieved with a number of species, the mycorrhizal fungi have not been isolated from many other species and some of these will not germinate asymbiotically. As a result some of the most horticulturally desirable plants are unavailable by any means.

Additionally, there have proved to be considerable problems with deflasking. Most terrestrial species suffer large losses on deflasking; for instance, with the genus *Thelymitra*, roughly 75% of seedlings fail to produce tubers, while for the *Caladenia* this is closer to 95%. Also those plants which do survive their first year often do not survive the following year. Losses over the second season have proven to be equally large (approximately 75%). As a result there is a need for a considerable amount of research into optimising media and techniques before an efficient propagation procedure has been developed.

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PHOSPHORUS AND IRON EFFECTS ON THE EARLY GROWTH OF SOME AUSTRALIAN NATIVE PLANTS

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Abstract. Seeds of 61 native Australian species of the genera *Acacia, Banksia, Grevillea,* and *Hakea* were germinated and grown-on in a pine bark based medium which had been amended with two levels of Fe, added as ferrous sulfate, and five levels of P, added as single superphosphate The species were ranked in groups according to the severity of foliar symptoms

In a second experiment, *Banksia ericifolia* seedlings were grown in a pine bark/peat mix amended with seven levels of Fe, added as ferrous sulfate, and seven levels of P, added as single superphosphate Shoots at 12 weeks ranged in colour from dark green at the highest levels of Fe combined with the lowest levels of P, to yellow and/or dead at the lowest levels of Fe combined with the highest levels of P

Guidelines for interpretation of analytical data for potting media to be used for growing "P-sensitive" plants are given

INTRODUCTION

A number of plants native to Australia and Southern Africa, particularly in Proteaceae and Mimosaceae, have been reported to show foliar symptoms ranging from necrosis and premature senescence of old leaves and chlorosis of whole shoots to general unthriftiness when supplied with even quite modest levels of soluble phosphorus (P). This phenomenon has been observed in the field on sandy soils amended with superphosphate (5), in solution culture (6) and in soilless potting media (2, 4). The observed symptoms have been attributed to uptake by the plants of P in excess of the amounts commonly available to them in natural ecosystems.

The experiments reported here were designed to widen the range of species tested and to investigate the role of iron (Fe) in the response to P in soilless potting media.

MATERIAL AND METHODS

Experiment 1. Seeds of 61 species (Table 1), were germinated in undrained pots of a soilless potting medium comprised of ground *Pinus radiata* bark, German peat (Eurotorf), and siliceous sand (6:3:1). All nutrients except P and Fe had been added in adequate amounts. Half of the medium was amended with sufficient $FeSO_4 \cdot 7H_20$ to give about 19 mg/L Fe (actual 18.6 to 21.2) in a 1:1.5 2 mM DTPA extract (1). Sufficient was added to the other half to give about 34 mg/L Fe (actual 31.8 to 37.8). These concentrations have been found to be insufficient and sufficient, respectively, for

a wide range of plants (1). Single superphosphate was added to five subsamples of each of these media to give 3 to 27 mg/L P in 2 mM DTPA extracts. The pH throughout was about 5.5 (water). Foliar symptoms were assessed at appropriate times (6-18 weeks) after sowing.

Table 1. Maximum concentrations of P tolerated by a range of species growing in a soilless potting medium at two levels of extractable Fe

P tolerated in extract at Fe (mg/L)		Species
34	19	
3	<3	*Acacia merrallii, Grevillea leucopteris, Hakea bucculenta, H francisiana, H. petiolaris*
5	<3	*A imbricata, Banksia benthamiana, B brownii, B lemanniana, B leptophylla, B sphaerocarpa, G banksii, H salicifolia*
5	3	*A baileyana, A decurrens, A. spectabilis, H sericea*
8	7	*A dealbata, A glaucoptera, A ligulata, A lineata, A montana, A myrtifolia, A. retinodes, H laurina*
11	3	*B tricuspis, H rostrata*
11	10	*A argyrophylla, A baileyana* 'Purpurea,' *A burkittii, A calamifolia, A. floribunda, A iteaphylla, A. menzelii, A microcarpa, A. papyrocarpa, A paradoxa, A. rigens, A rivalis, A rotundifolia, A sclerophylla, B aculeata, B laricina, B speciosa, G intricata, G robusta, H suberea*
>20	14	*A cyclops, A fimbriata, A hakeoides, A melanoxylon, A nyssophylla, A pendula, A ramulosa, A sophorae, H. muelleriana*
>20	>25	*A longifolia, A saligna, A truncata, A victoriae, H leucoptera*

Experiment 2. *Banksia ericifolia* seedlings were grown in a soilless potting medium comprised of *Pinus radiata* bark and peat (7:3) contained in undrained pots each holding 260 mL medium. The medium had been amended with the following, in mg/L: $CuSO_4.5H_2O$ (20); $MnSO_4.H_2O$ (20); $ZnSO_4.7H_2O$ (15); $B(OH)_3$ (3.4); K_2SO_4 (200) Subsamples were amended with $FeSO_4.7H_2O$ at eight rates up to 3 g/L and single superphosphate at eight rates up to 444 mg/L (40 mg/L P), in all combinations. All subsamples were adjusted to about pH 5.6. There were 10 replicates of each treatment. Shoot quality was assessed 13 weeks after sowing with pregerminated seeds

RESULTS AND DISCUSSION

Experiment 1. In *Acacia,* symptoms typical of those associated with P toxicity—chlorosis, necrosis, and premature shedding of oldest pinnate leaves—were observed mainly in plants in media having the highest levels of P and lower Fe content. The symptoms in *Banksia, Grevillea,* and *Hakea* were always chlorosis of youngest leaves and were consistent with Fe deficiency. The symptoms tended to be most severe at the lower Fe level and the highest P levels. The range of response is summarised in Table 1.

Experiment 2. The first signs of foliar symptoms—chlorosis of youngest leaves—began to appear about 5 weeks after sowing seeds. Chlorosis appeared first and was most severe in media with no added Fe. Amendment with increasing levels of Fe delayed or totally eliminated tip chlorosis but, at every level of added Fe, increasing P gave increasing severity of chlorosis. Severe chlorosis was followed by necrosis of leaf tips and sometimes death of shoot tips.

Quality score data at harvest recorded in Table 2 clearly show the effects of Fe and P and the extent of interaction between them. The data indicate desirable levels of extractable Fe and P for optimum visual quality of this species.

Table 2. Quality score of *Banksia ericifolia* seedlings growing in a soilless potting medium amended with Fe and P The scale is from dead plants = 0 to the greenest = 11 Plants with a score of 8 were *just* of acceptable commercial quality, but lower-scoring plants were too chlorotic

Fe in 2μM DTPA ext	P in 2 μM DTPA extract mg/L							
mg/L	0 4	1 0	2.6	3 6	6 7	8	8 5	11 1
7 7	4.2	1 8	1 9	2 2	1 7	2 0	1 2	2 7
13	6 6	4 2	2 3	3 1	2.3	2 6	2 2	1 8
20	7 2	6.5	6 6	5 4	4 3	4 3	4 5	3 6
25	8 1	8.1	6.6	6.6	4 3	5 2	4 7	4 2
43	9 1	8 9	8 2	8 0	7 0	6.3	6 2	5.4
45	10 1	10 2	9 9	9 4	8 4	8 2	7 6	6.8
49	10 0	10 5	10 0	9 6	8 6	9 3	8 8	7 2
70	10 6	10 4	10 2	10.6	9 7	9 9	9 9	8 9

It is clear that in this species the observed foliar symptoms were those of Fe deficiency. At low levels of added P this deficiency was due to an absolute shortage of Fe in the medium, but at higher Fe even modest levels of extractable P interfered with the use of Fe by the plant.

IMPLICATIONS FOR PLANT PROPAGATORS

Potting media for plants known to be sensitive to even modest levels of P should be very well endowed with Fe. When ferrous sulfate is the source of Fe it is desirable to add enough to give at least 40 mg/L Fe in a 1:1.5 volume 2 mM DTPA extract. This is provided by about 1 to 1.3 g/L $FeSO_4 \cdot 7H_2O$ if the medium is mainly pine bark and its pH about 5.5. At pH 5, sufficient Fe may be provided by 0.7 g/L $FeSO_4.7H_2O$.

Including FeEDDHA in the mix may be necessary if some species are to be free from Fe deficiency symptoms.

It is also essential for very sensitive species to keep the P content of the propagation medium to a low level. A 1:1.5 volume 2 μM DTPA extract of the medium should contain no more than about 2 mg/L P at potting. The concentration might be extended to about 7 or 8 mg/L if the Fe concentration in the extract is over about 65 mg/L, but management is easiest if the P concentration is kept below 2 to 3 mg/L. As little as 0.1 g/L single superphosphate provides this. The only safe way to be sure is to have the medium analysed.

Most of the Nutricote range of controlled release fertilizers are safe to use, as are low-P Osmocotes (8 to 9 month, 1.6% P or less). There is anecdotal evidence that Osmocote Plus formulations containing up to 3.5% P, used at up to about 3 g/L, should be safe to use (3).

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BIOLOGY AND PROPAGATION OF AUSTRALIAN RUSHES AND SEDGES

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INTRODUCTION

Australian Cyperaceae (sedges) and Restionaceae (rushes) are important components of the Western Australian cutflower industry. They are used fresh, dry, and dyed as greens or as fillers in dry floral arrangements. One species, *Ecdeiocolea monostachya* (Ecdeiocoleaceae) is also being examined for fibre extraction. Most plant product is collected from the wild or from semi-managed wild stands usually on private land. The total Western Australian production of these plants for local consumption and export is 3 to 4 million stems annually and is set to increase.

Twenty species (representing 2% of the 391 species of rushes and sedges native to Western Australia) have been utilised with 12 species used intensively. The main eastern Australian species used are: *Caustis blakeii* and *Restio tetraphyllus*, and important Western Australian taxa are *Caustis dioica* (and morphs), *Leptocarpus scariosus*, *Evandra* spp., *Mesomelaena* spp. and *Restio ustulatus*. A number of other taxa show equal promise as horticultural subjects but are rare, of restricted distribution, or grow in inaccessible locations, e.g. *Reedia* sp., and *Restio* spp. and are thus not commercially viable at present.

The development of commercial horticulture of reeds and rushes depends on the availability of mass propagated greenstock. Except for *Cyathochaeta*, most rush and sedge species of commercial value are difficult to propagate by seed or vegetative division. This paper will outline recent developments for propagation of Australian rush and sedge species which have potential for commercial row cropping of some species.

DISTRIBUTION AND GROWTH FORMS

Rushes and sedges are widespread and common in all vegetation types in Western Australia. Commercially significant species occur in the Mediterranean-type climatic zone in the southwest of the state with picking concentrating on the south coast region from Esperance to Augusta. Most rush and sedge species grow in dryland sites favouring free-draining nutrient deficient soils Some of the significant commercial species grow in seasonally inundated swamps and wetlands.

All species possess a subsurface rhizome which serves as a repository for dormant buds and/or nutrient storage. The rhizome extends on a seasonal cycle of activity often in concert with production of new photosynthetic parts. Roots produced on the rhizome may be fibrous or thick and fleshy. In some species terminal fleshy swellings on some roots act as nutrient/moisture reserves.

The vegetative spread of a clone is via the rhizome. Species are tuft forming (< 10mm long internodes along rhizome) or possess creeping clones (with 1 to 40cm long internodes). Some tuft-forming species (e.g. *Tetraria capillaris* and *Lepidosperma tenue*) produce daughter plants at the end of 10 to 20 cm long rhizomes.

Above ground shoots or culms are more or less leafless in the Restionaceae while the Cyperaceae produce annually a basal tuft of ephemeral leaves. In both families new culms are produced annually, old culms senescing after 2 to 3 years. New shoots and rhizome segments are produced from late March until early September (autumn to early spring). New roots are produced concomitant with shoot production, and flowering occurs in autumn or spring following culm maturation. Some Restionaceae produce attractive culm branchlets that are very fine and hair-like as in the eastern koala fern (*Restio tetraphyllus*) and some western Restio species.

Restionaceae are mostly dioecious while Cyperaceae are monoecious. The flowers of all rushes and sedges are generally insignificant and in most species are produced in aerial spikelets or clusters. Scarious bracts which subtend the flowers in many species are often attractive, coloured brown or deep maroon and are persistent (e.g. *Leptocarpus* species).

SEED PRODUCTION AND VIABILITY

Seed matures in 6 to 18 months depending on the species, and seed germination occurs in nature in moist soil from late autumn to spring. Most dryland rush and sedge species studied produce small quantities of seed (0.2 seed/culm for *Loxocarya cinerea* and *Mesomelaena pseudostygia*), with low viability. Low viability of seed is often expressed as failure of the seed to produce an embryo. One third of the decline in seed number in the Cyperaceae compared to Restionaceae species is attributable to seed embryo abortion. In wild situations Cyperaceae and Restionaceae produce 0.1 to 17.0 (mean: 5.3) and 0.9 to 960 (mean: 136.2) viable seeds per clone per annum, respectively. In the event of whole clone death or displacement many rush and sedge species are therefore unlikely to have the reproductive potential to reproduce the clone in natural habitat. However, in both families germination of seeds is only 5% except for the sedge *Cyathochaeta* which produces large

quantities of germinable seed (greater than 96% germination under laboratory conditions). For all species examined to date excised embryos (cultured in vitro) germinate more readily than intact whole seed, indicating non-embryo derived seed dormancy factors may operate.

Nutrient and moisture supplements applied to in-site field-grown plants of four species of rush and sedge failed to ameliorate factor(s) causing low seed production and viability.

PROPAGATION

Australian reeds, rushes, and sedges have not been as horticulturally important as many other Australian plants. For example there are no records of rush and sedge species being grown amongst 600 species of Australian plants cultivated in English greenhouses in the 1860's.

The reluctance of nurseries to utilize rushes and sedges may be a result of the recalcitrance of many of these plants to propagate readily and in commercial quantities. Until now traditional propagation by seed or rhizome division has met with little or no success. Even in mine rehabilitation areas though, rush and sedge species account for about 8400 plants/ha in some premined vegetation; less than 1.3% or 107 plants/ha regenerate from freshly replaced top soil containing seed.

VEGETATIVE PROPAGATION

Some success has been achieved with whole plant transplants of swamp rush species and rhizome divisions of the eastern Australian koala grass (*Restio tetraphyllus*) (G. Lamont, pers. comm).

Transplant studies into irrigated or non-irrigated field sites containing at least 3 year-old segments of wild-sourced plants show that for both rushes and sedges:

- survival improved if transplant culms are cut near ground level.
- most species transplant better if vegetative divisions are taken in mid-winter (using wild, unirrigated plants as the source of transplants)
- irrigated rather than non-irrigated plants survive transplanting better. However some species, e.g. *Lepidosperma gracile* and *Tetraria capillaris* decline if kept wet following transplanting.

In general there is 80 to 90% survival of transplants of *Cyathochaeta, Restio, Loxocarya,* and *Lepidosperma.*

Undisturbed clones of most species produce actively growing roots only from new or the immediate past season's rhizome segments. However, in some species rhizome segments up to two years old may retain active roots and produce lateral roots which

penetrate soil to 30cm deep. Disruption of this deep-seated root system during transplanting could account for the high mortality of transplants recorded for species like the little semaphore sedge, *Mesomelaena pseudostygia.*

MICROPROPAGATION

Plants have been cultured from seed embryos in 15 out of 19 rush and sedge species examined, using half strength Murashige and Skoog minerals supplemented with growth factors. Five of these species have shoot multiplication rates greater than ten-fold. In addition 11 of the 15 species have rooted in vitro and 7 species are growing vigorously out-of-flask in a peat:perlite mix under greenhouse conditions.

CONCLUSIONS

For the rush and sedge species studied to date, vegetative propagation and in vitro micropropagation are the most successful means for plant multiplication. Studies are continuing in Kings Park and Botanic Garden to define media for optimal shoot multiplication rates and for use of parent plant vegetative material as explant sources. However, the cost effectiveness and practicality of these propagation practises for commercial row cropping of these groups is yet to be assessed.

THE ROD TALLIS MEMORIAL AWARD

This award was set up in memory of the late Rod Tallis, a young Sydney nurseryman who had been very active in IPPS. The award is offered each year in the State where the Conference is being held. Young people under 25 years of age in nurseries, educational institutions, and government departments who have an interest in plant propagation are invited to apply.

The applicants, who need not be members of IPPS, must outline why they should be given the chance to attend the IPPS Conference. They also have to present a biography and outline their interest in horticulture and plant propagation.

The winner of the award attends the Conference as a guest of the Society and must prepare a paper for presentation at the Conference. The winner also receives a book award. In 1990 Leisa Armstrong won this Award and presented the following paper:

VEGETATIVE PROPAGATION OF THE WESTERN AUSTRALIAN CHRISTMAS TREE, *NUYTSIA FLORIIBUNDA*

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INTRODUCTION

Nuytsia floribunda (Labill.) R.Br. is a tree to 15m high or, rarely, a prostrate shrub in coastal areas. (6, 12) *Nuytsia* is a monotypic genus, and is one of only three root parasites in the mistletoe family Loranthaceae (9). This species is the largest known parasitic flowering plant (10). The distribution of *Nuytsia* is limited to an area from the Murchison River at the northern tip of the southwest land division of Western Australia, to Israelite Bay in the southeast (9). *Nuytsia* is renowned for its spectacular displays of orange flowers (14) during the Christmas period, hence the tree's common name of "Christmas Tree". These attributes, together with the fact that the species is virtually unavailable commercially, give the tree great horticultural potential.

Propagation by cuttings is the standard nursery practice for producing large numbers of plants from a species which is difficult or impossible to establish from seed. Although *Nuytsia* seed is not difficult to germinate (1), very few seedlings survive beyond the first year of germination (11). Cuttings are also a quick method of

obtaining plants that flower earlier (4). The vegetative material used is mature tissue.

Nuytsia seedlings undergo a lengthy juvenile phase of development. The established succulent seedling produces many xeromorphic sucker shoots. After several years the plant produces a strong dominant trunk, with adult foliage, which is capable of flowering. Sucker shoots continue to be produced by the adult tree; this is the major means of reproduction of the species. Since *Nuytsia* seedlings can take up to ten years or more before first flowering (2), determination of successful propagation methods may have commercial application.

The aim of this research was to determine a viable method, giving a strike-rate of 85% or better, for the propagation of this species by cuttings. Previous trials showed *Nuytsia* cuttings to exude a mucilage from all cut or injured surfaces. Hocking (8) suggested that soluble complex carbohydrates are contained in this mucilage. These carbohydrates support the proliferation of microorganisms which clog the xylem vessels, leading to the death of the cutting by desiccation (2). A range of surface sterilants, senescence retardants, and anti-oxidants were tested in an attempt to overcome the exudate problem but without success. Finally the technique of chilling the propagation material was employed.

MATERIALS AND METHODS

This research was carried out in the School of Biology glasshouse during 1988, on the Curtin University of Technology campus, Bentley, Western Australia. The bottom-heated propagation bench maintained a root-zone temperature of 25 $\pm$ 1.5 °C. Humidity was maintained at 90 $\pm$ 5% by a fogging device.

Cutting material was collected from a field site north of Perth (31 ° 21'S, 115 ° 35'E) that had been burned in the summer of 1985. Regrowth was vigorous with no evidence of disease or physical damage.

It had been observed in previous trials that sucker shoot tip cuttings produced less mucilage than cuttings taken from canopy material. Sucker tips, trimmed to 60 to 80mm, were used in this experiment. The cutting material was surface sterilized in 5% sodium hypochlorite solution for ten minutes and then rinsed thoroughly in deionized water.

After surface sterilization, 200 cuttings were stored at 4 ° C for three days; another 200 were treated with various hormone formulations immediately upon returning from the field. The chilled cuttings underwent the same hormone treatments post-chilling, after being allowed to warm to ambient temperature.

Refrigeration at 3 to 4° C for two to three days has proved beneficial for stabilizing cuttings of some species (13). It is known that lowering the temperature slows normal metabolic processes. This would, therefore, reduce the stress induced in taking the cutting by slowing physiological responses, possibly stopping or reducing the production of mucilage. Improved rooting of some species after storage at low temperatures may also be attributed to an induced conversion of starch into sugars and so providing more sugars for the rooting process (13). Care was taken to avoid chilling injury and desiccation, which often occurs during cool storage, by wrapping the cuttings and ensuring that free water was always available.

Indolebutyric acid (IBA) was the only rooting hormone used in this trial. Previous experiments had shown *Nuytsia* to be sensitive to the hormone, naphthaleneacetic acid (NAA). The IBA was applied at 0, 1000, 2000, 3000 and 4000 ppm. There were 20 cuttings in each treatment.

Two methods of hormone application were tested, a 10% ethanol liquid dip, and talc. Talcum powder formulations have proven more effective for cuttings of some species (7). The cuttings treated with the liquid hormone preparation were dipped as shallowly as possible for five seconds only; these were allowed to air dry for a few seconds before being placed into the propagation medium. The cuttings treated with the talc hormone preparation were also dipped as shallowly as possible for five seconds only. Excess talc was tapped from the cuttings prior to being placed in the propagation mix.

The propagation medium was comprised of 2 parts composted pine bark:1 part granulated polystyrene. All cuttings were sprayed weekly with a fungicide solution.

RESULTS

Most unchilled cuttings produced mucilage and died within a week. Those in the chilled treatments survived much longer, many finally rooting. Rooting assessment was made weekly; after 12 weeks all surviving cuttings had rooted. The results are detailed in Table 1.

The highest percentage rooting of 90% occurred in the chilled 4000 ppm IBA ethanol quick dip treatment. The chilled cuttings treated with liquid hormone dips rooted more consistently than all other treatments.

Table 1. Results of the rooting success after 12 weeks in each treatment of the propagation trial.[1]

	Talc		Liquid	
	IBA (ppm)	Percent rooted	IBA (ppm)	Percent rooted
Chilled[2]	0	0%	0	10%
	1000	0	1000	50
	2000	0	2000	30
	3000	20	3000	80
	4000	10	4000	90
Unchilled (control)	0	40	0	20
	1000	0	1000	0
	2000	0	2000	20
	3000	0	3000	20
	4000	0	4000	0

[1] 20 cuttings per treatment
[2] chilled at 4 ° C for 3 days

DISCUSSION

It appears that the main benefit of chilling was to prevent or reduce mucilage production. This mucilage is produced by the species in response to wounding (2). By chilling the cutting the physiological processes which occur in response to taking the cutting are slowed. It may also be that the healing of the base of the cutting was slowed. The production of callus is part of the healing process. Over-production of callus can inhibit rooting (5). Slowing the healing process may reduce the ultimate size of the callus produced. Callus production in the rooted cuttings appeared minimal. The superiority of applying rooting hormones as liquid dips to *Nuytsia* supports Ellyard's (3) recommendation for yielding optimum results for a number of Australian plant species.

Acknowledgements. Sincere thanks to my academic supervisor, Dr Byron Lamont, also to Mr Ray Aitken whose valuable advice and experience was always most welcome

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APPROACH GRAFTING GREVILLEAS

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INTRODUCTION

The technique of grafting Australian plants has been used with success where otherwise there have been losses due to:

- disease
- failure of more traditional propagating methods
- a lack of suitable propagating material
- failure due to climatic or soil conditions.

This paper outlines one specific grafting technique—the approach graft—whereby *Grevillea* is grafted onto *Grevillea* to produce a weeping standard.

METHOD

The distinguishing feature of approach grafting is that two independent self sustaining plants are grafted together. After a union has occurred, the top of the stock plant is removed above the graft and the base of the scion plant is removed below the graft. Sometimes it is necessary to sever these parts gradually rather than at the one time.

Approach grafting provides a means of establishing a successful union between certain plants which, otherwise, may be difficult to graft together. It is usually performed with one or both of the plants to be grafted growing in a container. Rootstock plants in containers may be placed adjacent to an established plant which is to furnish the scion part of the new grafted plant.

This type of grafting can be done at any time of the year, but healing of the union is more rapid if it is performed at a season when growth is active. As with other methods of grafting, the surfaces should be securely fastened together and covered to prevent drying of the tissues, the spliced approach method is outlined below.

Step 1. A single stemmed healthy, vigorous *G. robusta*, approximately 1.8 metres in height is used as the rootstock. The prostrate grevillea, *G.* 'Poorinda Royal Mantle' is used as the scion.

Both scion and stock should be in an active growth phase, i.e. early summer. To perform the technique the scion plant, with roots intact, is placed on shelves in the propagating unit at a height of 1.5m (see Figure 1).

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[1] Director

Step 2. With the scion material in place the rootstock is positioned so that it is directly adjacent (Figure 2). Along with the sections of stems where the graft is to occur, leaves, petioles, etc. are removed with a sanitised scalpel (Figure 3).

Step 3. The cambiums of both the stock and scion are exposed for an approximate length of 30 to 50 mm, the cuts being made by using a clean, sharp, sanitised scalpel blade (Figure 4).

Step 4. The cambiums of both stock and scion are united and tied with grafting tape (Figure 5) then placed in the shade house for some six weeks to allow a strong healthy union to form. The atmosphere is kept moist with adequate but not excessive watering of both stock and scion.

Step 5. After six weeks the graft is carefully inspected to ascertain if union has occurred; if so, the grafting tape is removed and the scion is severed from its own roots with sharp secateurs making a good clean cut directly below the union (Figure 6).

RESULTS

Once the new ''head'' begins to show vigorous growth, the top of the rootstock is removed with a clean cut directly above the union (Figure 7). As the new ''head'' slowly enlarges it is tip-pruned in order to encourage branching and create a full ''head''. Any lower leaves or branches are removed from the rootstock (Figure 7) resulting in a healthy, weeping standard grevillea (Figure 8).

DISCUSSION

The rationale for our using the spliced approach graft is as follows:

1. As a practical propagating exercise for the Corporation's 12 horticultural apprentices.
2. To propagate a supply of ''novelty'' weeping grevilleas for a landscape beautification project.
3. To assess the method under the prevailing climatic regime.
4. To obtain a ''special'' form of plant material for use in the landscape.

Many *Grevillea* spp. under cultivation have proved themselves as reliable garden subjects whereas others have proved difficult. The latter are mainly species from the drier, inland habitats which often prove difficult to propagate in southeastern Australia.

Grafting is always a possibility for grevilleas as reliable stocks, such as *G. robusta*, appear to be compatible with most species as evidenced by projects undertaken at the National Botanic Gardens (Canberra) where *G. robusta* has been used as a successful stock plant for the production of weeping *Grevillea* standards. Prostrate species such as *G.* × *gaudichaudii* have been grafted onto 2 to 3m *G. robusta* seedlings.

By this method a plant with a weeping habit was produced for use in the Hobart public landscape. Variable results are obtained by the use of this technique—some weeping trees will grow as spreading shrubs if bottom-worked, but will show the true weeping habit and form an attractive tree if top-worked onto a clear stem, as in the method outlined.

This type of graft can also be used in the production of novelty trees. This is difficult to define, but essentially they are trees/shrubs that constitute an unusual scion/rootstock combination, providing either more than one cultivar on a plant (''family trees'') or a plant providing an unusual visual effect.

The success rate in terms of union was 95% of the total number of grafts attempted. This was not unexpected considering the growth conditions of stock and scion and the summer climatic conditions prevailing in Hobart at the time—December/January.

CONCLUSIONS

As with other propagating methods there are limitations to methods of grafting, these include:

1. Methods that may require additional facilities to provide a controlled environment during the after care period, e.g. subjects propagated by bench grafting.
2. The need for reliable and skilled personnel who require training and consequently higher remuneration.
3. The additional costs involved in growing or purchasing rootstocks.
4. Problems resulting in delayed incompatibility between rootstock and scion.
5. Rootstocks that exhibit excess suckering resulting in a deterioration in the quality of scion growth over the years. This can often be prevented by:
   1) correct removal of suckers during the propagation stage,
   2) grafting lower on the rootstock,
   3) using an alternative rootstock, or
   4) removal of suckers soon after planting in the permanent site.
6. Possible changes in the normal habit growth; this can be desirable in many cases but in specialty items, such as dwarf conifers, the eventual height can be greater than originally anticipated with plants raised from cuttings.

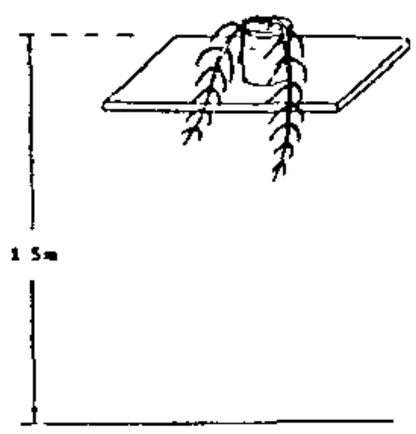


Fig 1

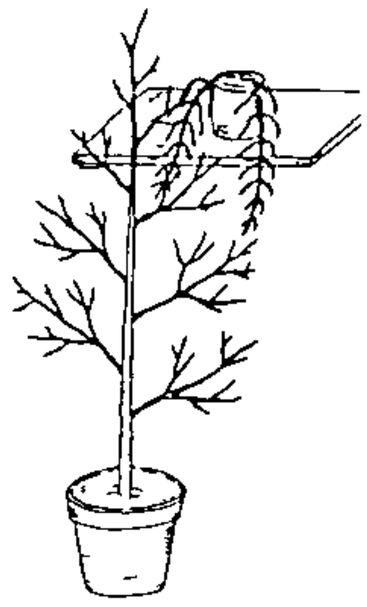
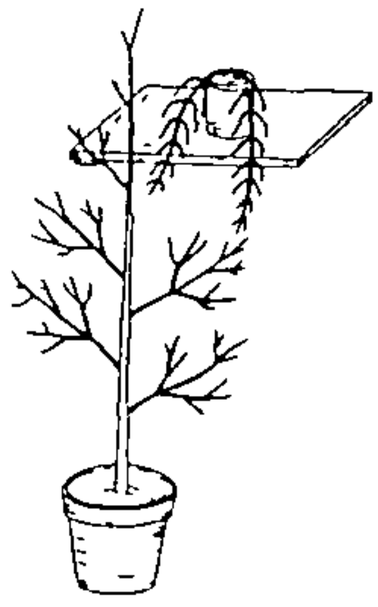


Fig 2



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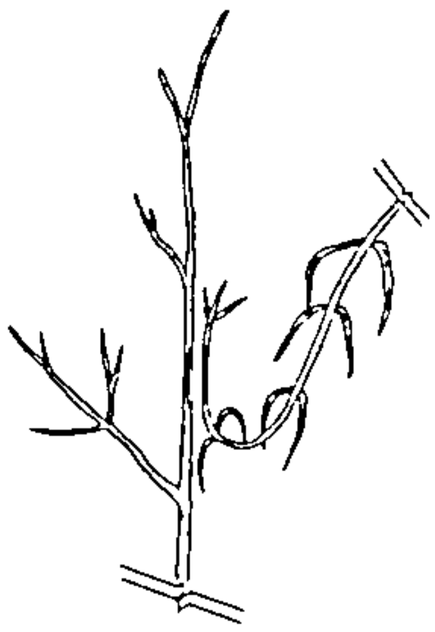

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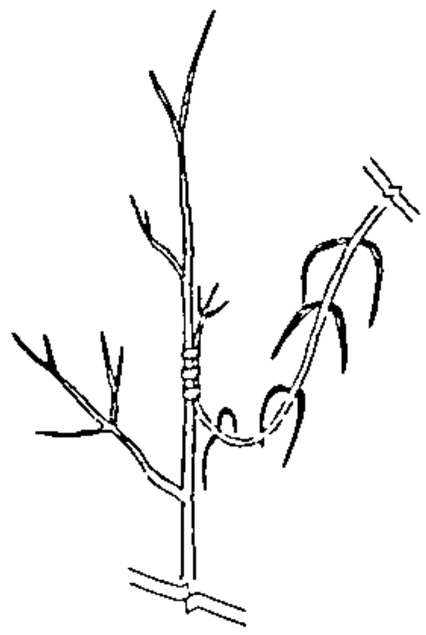

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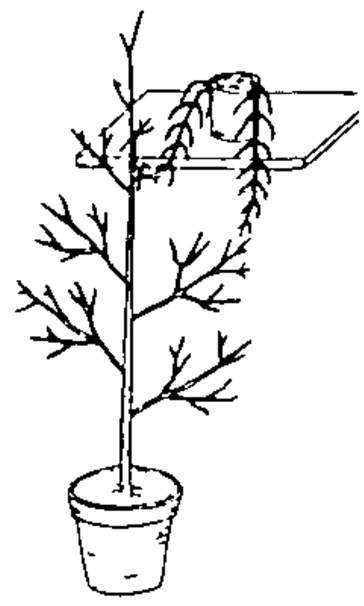

Fig 6

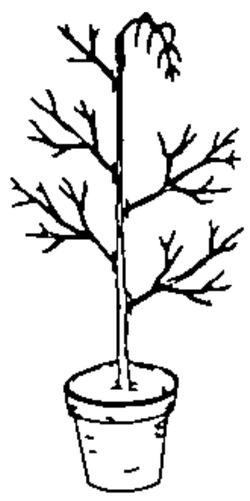

Fig 7

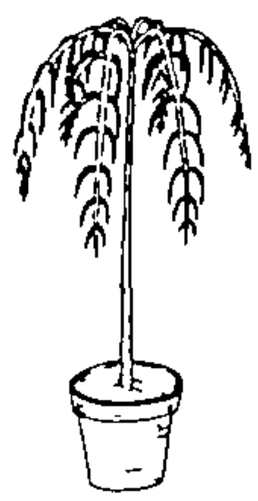

Fig 8

Figure 1-8
Steps in approach grafting grevillias

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DEVELOPMENT OF SALT TOLERANT CLONAL TREES IN AUSTRALIA

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INTRODUCTION

More than one billion hectares, or 7.6% of the world's land, consists of salt affected soils (1). Much of this area is naturally occurring saltland, such as mangrove forests, internally draining basins, and floodplains. However, an increasing proportion of land is becoming saline as the result of agricultural practices. In Western Australia about 12 million hectares of land has been classified as salt-affected, of which about 650,000 ha (5 4%) is induced salinity as a result of artificially high watertables, or as scalds caused by wind and water erosion (4).

Saltland forestry is one of the many strategies proposed for making productive use of salt affected soils. Planting trees is an attractive option because of the primary benefits of salinity control and land reclamation and the secondary benefits of wood products, livestock shelter, windbreaks, and ecological habitat construction. In many developing countries, planting trees on saltland or using saline groundwater to irrigate trees, will help alleviate chronic fuelwood shortages anticipated in the near future (2).

Salt affected soils have properties which can severely limit plant growth. High salt content and, in many cases, high sodium absorption ratios, waterlogging, and boron toxicity render saline soils very difficult to revegetate. Trees must be tolerant of high soil salinity and, where waterlogging is a problem, such as in Western Australia, plants must be tolerant of both salinity and waterlogging. Many Australian trees and shrubs have evolved in response to naturally occurring saline soils and have developed a high salt tolerance to cope with the stressful conditions In recognition of the ability of certain species to tolerate saline soils, a range of field trials have been conducted using seedlings of such species. In Western Australia the most consistently tolerant species used in field trials are *Eucalyptus camaldulensis*, *E. occidentalis*,

E. sargentii, E. spathulata, E. platypus and *Casuarina obesa*. Many other species of *Eucalyptus, Casuarina, Melaleuca, Acacia,* and *Tamarix* also show potential as highly salt tolerant species. Nearly all existing field trials of salt tolerant trees have used seedlings grown from seed collected from natural stands. Limited information is available on the variation for characters such as salt tolerance among and within species provenances. As a result, the supply of highly salt tolerant seed from natural stands, or as a result of controlled breeding programmes is virtually non-existent. Micropropagation of trees selected for their salt tolerance has been recently used as a means of supplying genetically superior salt tolerant plants for revegetation of salt affected land (3).

TREE TECHNOLOGY PROJECT

In 1986 a consortium of public and private interests was brought together to develop salt tolerant clones of Australian tree and shrub species. The group consisted of Alcoa of Australia Ltd., The University of Western Australia, Murdoch University, CSIRO Division of Forests and Forestry Products, and Plantex (Australia). From 1986 through 1988 the emphasis of the project was to collect seed, screen the seedlings for salt and waterlogging tolerance, and tissue culture the selected tolerant individuals. Seed was collected by the CSIRO Tree Seed Centre from *Eucalyptus, Casuarina, Acacia,* and *Melaleuca* species growing naturally on or near saline areas. Seedlings were then grown by Alcoa's nursery for screening experiments at The University of Western Australia. Salt and salt/waterlogging screening experiments were conducted on seedlings in such a way that only the most tolerant individuals survived the stressed conditions. Altogether eight screening experiments were conducted using nearly 17,000 seedlings from 101 species. A total of 410 seedlings, representing an overall selection pressure of 7%, were selected for tissue culture at Murdoch University and at CSIRO, Canberra. The tolerant species and provenances identified during this initial screening phase were later subjected to more intense mass screening of a much larger number of seedlings than the initial research experiments and hence a greater selection pressure was applied. From the research and mass screening experiments a total of 601 mother plants from 60 species have been selected for tissue culture research (Table 1). Each species undergoes research at the tissue culture phase to maximise shoot multiplication rates, rooting percentage, and hardening-off rates. In many instances individual lines within a species vary as to the level of hormones, etc. required for optimum clone production. Lines vary considerably in their growth rate *in vitro*, and those that perform best are selected for commercial

use. Mass multiplication of clones for field trials and further research experiments has been carried out by a commercial tissue culture laboratory, Plantex (Australia).

Table 1. Development stage of salt tolerant clones for species in the Tree Technology Project Stages of development described below

1 Salt screening (initial)
2 Superior selected plants kept as mother plants
3 Initiated in culture
4 Shoot multiplication research being done
5 Rooting research being done
6 Hardening off research being done
7. Tissue culture research complete
8 Field trails established
9. Seed orchard established
10 Second generation screening of seedlings from seed orchard

Species	Number of Mother plants	Development stage (see above) 1	2	3	4	5	6	7	8	9	10
Acacia ampliceps	3										
aulacocarpa	2										
auriculiformis	2										
brumalis +	1										
cyclops	5										
hemsleyi	2										
ixiophylla	1										
maconochieana +	6										
mutabilis ssp *mutabilis* +	2										
mutabilis ssp *stipulifera* +	2										
patagiata +	3										
pendula	2										
redolens	4										
saligna	23										
sclerosperma	1										
stenophylla	13										
Casuarina glauca	20										
cobesa	38										
Eucalyptus calycogona	6										
camaldulensis	60										
comitae-vallis	1										
coolabah	16										
exserta	2										
famelica +	0										
halophila	31										
intertexta	14										
kondininensis	7										
kumarlensis +	3										
leucoxylon ssp *megalocarpa*	1										
microtheca	31										
occidentalis	41										
pileata	2										
polybractea	3										
raveretiana	18										

Table 1 Continued

Species	Number of Mother plants	Development stage 1	2	3	4	5	6	7	8	9	10
robusta	2										
rudis	3										
salicola +	4										
sargentii	39										
sideroxylon ssp. *sideroxylon*	1										
sideroxylon ssp *tricarpa*	3										
socialis	7										
spathulata ssp. *grandiflora*	3										
spathulata ssp *spathulata*	34										
stricklandii	1										
striaticalyx	15										
tereticornis	*12*										
wandoo	17										
yilgarnensis +	6										
Melaleuca acacioides ssp *alsophila*	4										
acuminata	3										
bracteata	14										
cajuputi	3										
cuticularis	0										
decora	2										
eleuterostachya	5										
glomerata	6										
halmaturorum	12										
lanceolata	8										
lateriflora	5										
quinquenervia	2										
thyoides	5										
uncinata	13										

* Casuarina clones for field trials now produced by needle cuttings

Field trials of clonal plants have been established on salt-affected land to examine the salt tolerance of selected clonal material with unselected seedlings from the same provenance A minimum of 3 to 5 years is required to quantify the survival and growth rates of clones and seedlings in soils of varying salinity Field trials of earlier selections of salt tolerant *Eucalyptus camaldulensis* have been established since 1983 in Western Australia New selections of salt and waterlogging tolerant clones have been included in field trials

since 1988. A total of 99 lines from 17 species will have been established in field trials by the end of 1990 (Table 2). Most trials are located in Western Australia on private farms in the southwest wheatbelt and grazing districts. Trials have also been extended into Victoria, Queensland, South Australia, and New South Wales in Australia and overseas in Thailand, U.S.A., Namibia, Kuwait, Saudi Arabia, Morocco, and Mexico. The early 1983 plantings of *Eucalyptus camaldulensis* are providing useful information on comparisons among clones and between clones and seedlings. In most cases the clones are performing as well or better than seedlings and with a more uniform result as expected from clonal material. In field trials other aspects of the selected salt tolerant clones become apparent after a number of years. Characters such as growth rate, leaf area, and stem straightness are not selected for in young seedlings but vary tremendously in developing trees. While all clones may be salt tolerant they may have other characters desirable for planting such as high leaf area for water use, straight stems for fence posts, or bushy growth for windbreaks. The paper pulp quality of *E. camaldulensis* clones will also be determined when the plantations are old enough for meaningful analysis.

Table 2. Species and number of clone lines used in field trials on salt affected land

Species	Number of clones in field trials	Age of oldest trial
Acacia maconochieana	1	1990
Casuarina obesa	9	1988
glauca	10	1989
Eucalyptus camaldulensis	44	1983
calycogona	3	1989
halophila	4	1989
kondininensis	2	1988
occidentalis	3	1990
sargentii	3	1990
spathulata ssp *grandiflora*	1	1988
spathulata ssp *spathulata*	9	1988
Melaleuca bracteata	5	1989
eleuterostachya	1	1989
glomerata	1	1990
halmaturorum	1	1990
lanceolata	1	1990
lateriflora	1	1990

Forest tree improvement programs are an integral part of commercial forestry industries worldwide. From successive selections and breeding cycles, the genetic quality of the selected population is increased for the particular trait being selected. In the same manner in which commercial foresters select for economic traits such as yield, form, and stem straightness, the salt

tolerant clones developed in the Tree Technology Project are being set up so that salt tolerance will be increased in successive breeding cycles. Seed orchards of clones are planted to maximise natural crossing between clones and to allow for controlled genetic manipulation of particular clones. Isozyme analysis of the seed collected from a *Eucalyptus camaldulensis* clone seed orchard has revealed a high degree of outbreeding between clones from widely varying geographic areas (S. James, pers. comm.). The resultant open-pollinated seedlings exhibit a wide range of salt tolerance with some individuals more tolerant than the clonal parents. These second generation selections are presently being prepared for tissue culture to produce plants for field trials. It is anticipated that seed orchards will be set up for all salt tolerant clones. In the future controlled crosses may also breed into the improved salt tolerance other desirable attributes such as improved growth rates, better form, frost and disease resistance.

CONCLUSIONS

There is a vast amount of salt affected land in the world which can be made more productive by the option of saline forestry. Planting trees on saltland has many ecological and economic benefits. Salt tolerant clonal trees are being successfully grown on salt affected land in Western Australia due to a combined approach of seed collection, plant screening, and tissue culture research. The program to develop these clones is advancing from the initial research phase, to the incorporation of clonal selections into tree breeding programs and second generation selection, tissue culture, and field trials of improved salt tolerant genotypes.

Acknowledgements. Financial assistance was provided by Alcoa of Australia Ltd and by the National Biotechnology Program administered by the Commonwealth Department of Industry, Technology and Commerce

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USE OF CONTROLLED-RELEASE PESTICIDES IN POTTING MIXES

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INTRODUCTION

Controlled-release (CR) formulations of insecticides have been investigated in Australia since 1979 for control of soil insect pests such as sugar cane grub, or more recently, cockchafer beetle in turfgrass. Since some of the pesticides formulated in this fashion have been systemic chemicals, the potential exists for their use in containerised nursery stock to control sucking pests such as aphids or scale. In addition, there are several root-inhabiting pests (e.g., root mealy bug and weevil larvae) common in nursery stock that require fairly toxic, persistent chemicals for control. A product providing a safer formulation of such chemicals as well as the potential for once-only application, could have significant potential in the nursery industry.

In 1986-87, the Nursery Industry Association of South Australia (SA) and the Australian Special Rural Research Fund sponsored trialwork by our department to look at the potential application within the nursery industry of the controlled-release (CR) products currently available in Australia. Similar research was being conducted in the NSW Dept. of Agriculture on the potential use of certain CR products for controlling two-spotted mite in nursery stock.

In Australia the technology for formulation of CR products has been led by the Incitec company, Brisbane. They have cooperated with research by providing formulations developed for other agricultural industries to be assessed for nursery production. The scope of our study included testing efficacy of the chemicals in controlling targeted pests, assessing potential phytotoxicity to common nursery plant materials, and assessing the response of nursery workers to their use.

The nursery industry is a very intensive form of horticulture where the end product is of high value. The use of moderately expensive, targeted agricultural chemicals is justified as the cost of such chemicals is low relative to total production costs. With labour being the major cost component of production, slow-release fertilisers are widely accepted in the nursery industry as a labour saving practice. The potential of a protectorant treatment of insecticide granules incorporated at potting up and targeted

against specific pests, has good potential for acceptance in the nursery industry.

The following points summarise the potential benefits of using controlled-release formulations in nurseries:

- Labour saving—single application applied at potting-on stage.
- Safer to use than conventional formulations of the same active ingredient. Dust, spray drift and application problems minimised.
- Has potential to be used in integrated pest management programs as targeted pests are controlled without adverse affects to beneficial insects.
- Residual protection from pests for a desired time period.

MATERIALS AND METHODS

The first active ingredient formulated as a controlled-release product and available for evaluation was phorate (Thimet®), which has registration on field flower crops but is not generally used in pots. Rates for pot trials were extrapolated from kg/ha rates recommended for control of aphids on field-grown chrysanthemums. Chlorpyrifos (Suscon blue®) gained registration in 1985 on sugar cane and the experimental chemical, carbosulfan, was released for trialwork in 1987.

Trials were conducted at Northfield Research Labs and at four commercial production nurseries in SA. Potting media consisted of 4:1 coarse pine bark:sand at Northfield, with variations used by each nursery incorporating small percentages of peat or organic compost to pinebark/sand media. CR granules were incorporated into measured volumes of media to fill trial pots (varied from 130mm to 180mm) and young tube-stock were planted immediately in treated pots. Controls consisted of traditional formulations of the same active ingredient, and untreated pots. Trials were sited outside in open beds or shadehouses in the case of woody nursery stock, or in greenhouses for flower and foliage plants.

Growth data was collected at monthly intervals for 6 month and 9 month formulations and at two monthly intervals for 2 year formulations. Release-rate of chemicals from granules was assessed by Incitec laboratories by collection of samples from controls placed in experimental plots under the same conditions as treatment pots. Insect levels were determined by a visual rating system of infestation or, in the case of aphids, by leaf disc analysis in the laboratory. Leaf discs were collected from treatment plants, placed on petri dishes, then 20 live aphids were introduced onto the discs. Counts of aphids were made at 3 and 5 days and assessments were made by means of a rating index. Table 1 summarizes the trials at all sites.

Table 1. Summary of CR insecticide trials in South Australia

Trial plant	Chemical	Target pest	Phytotoxicity*
Outdoor			
Azalea	Phorate	Lace fly/mites	yes
Camellia	Chlorpyrifos	Weevil larvae	no
Olearia	Carbosulfan	Mealybugs	no
Eucalyptus	Carbosulfan	Psyllids	no
Greenhouse			
Gerbera	Phorate	Aphids	yes
Hibiscus	Carbosulfan	Aphids	no
Epiphyllum	Carbosulfan/	Mealybug/Scale	no
''	Chlorpyrifos	Mealybug	*no*
Pisonia	Carbosulfan/	Aphids	no
''	Chlorpyrifos	Mealybug	yes
Fittonia	Chlorpyrifos	Mealybug	yes
Syngonium	Chlorpyrifos	Mealybug	no

* Phytotoxicity to insecticides observed on some rates used in experiment

RESULTS AND DISCUSSION

PHORATE — In trialwork to control two-spotted mites, CR phorate has proved effective at rates of 200 to 400g a.i./m^3 of potting mix (1). These rates are relatively high in comparison to that needed to control mealybug (25 to 100g a.i./m^3) or aphids (80 to 160g a.i./m^3). In trialwork throughout Australia on a total of 37 species, phytotoxicity symptoms have been apparent on half of these species at rates above 100g a.i./m^3. These problems limit the use of phorate at the high rates necessary to control mites but show *potential for control of sucking pests.*

In trial work with azaleas the following results were obtained, as shown in Table 2.

Table 2. Effect of CR phorate on growth and aphid control of two azalea cultivars 4 months from treatment

Azalea	Phorate rate g a i /m^3	Mean sum lateral length (mm)	Mean aphid ratings*
'Elsa Karga'	0	51 0 a**	3 9 a
5 in pots	40	55.5 a	1 1 b
	80	48 7 a	0 9 b
	160	49 7 a	0.4 bc
	240	35.2 b	0 1 c
'Paul Schame'	0	45 3 a	4 0 a
7 in pots	40	44 3 a	2.6 ab
	80	44.3 a	0 7 cd
	160	42 0 a	0 2 d
	320	36 5 a	0 0 d

* Rating index of total aphid infestation 5 = high, 0 = nil, using leaf disc analysis
** Within columns, values not followed by the same letter differ significantly ($P<0.05$)

Suppression of azalea growth occurs only at rates of 240g a.i./m^3. Azalea would be considered to be a sensitive crop in terms of pesticide phytotoxicity problems and potential root damage with potting mix additives. Efficacy of phorate treatments was assessed in the laboratory by means of leaf disc analysis at monthly intervals utilising aphids. These results would recommend rates of 100 to 150 g a.i./m^3 to control aphids on azaleas.

A major problem when dealing with this chemical is the strong odour associated with it, and apprehension on the part of nurserymen in our study to put a hazardous chemical into potting machines. Although the toxicity of phorate is reduced by controlled release encapsulating (Oral LD50-2 mg/kg reduced to LD50-319 mg/kg) the strong odour associated with it remained. The chemical also appeared to be releasing faster than anticipated in potting mixes in comparison to soil which means the formulation would have to be adjusted for nursery use.

CHLORPYRIFOS — This broad spectrum insecticide is formulated into CR granules for suppressing soil insects. In nursery stock it would be used against pests that inhabit the root-zone during some stages of their life cycle, as there is little systemic activity

Chlorpyrifos has become a low toxicity (Oral LD50 > 1000mg/kg) alternative to the use of aldrin (a persistent organo-chlorine insecticide) for control of weevil larvae in nursery stock. Larvae of several weevil species are responsible for damage to the crown and roots of woody nursery plants. This is reported as a serious problem overseas and becoming more prevalent in Australia. In the U.K., controlled-release granules of chlorpyrifos gave excellent preventative control against vine weevil (2) for 3 to 4 months after treatment. Rates of 75 to 300 g a.i./m^3 were utilised on *Cotoneaster* and *Thuja* without damage, the higher rates recommended if persistent control is desired. In trialwork in SA, no suppression of growth occurred in *Camellia japonica* at rates of up to 800g a.i./m^3 used for control of garden weevil during nursery production.

Trials in SA assessing rates of chlorpyrifos CR granules in controlling root mealy bug on greenhouse crops showed little phytotoxicity on treatment plants up to a rate of 500g a.i./m^3 The exception was *Pisonia umbellifera* 'Variegata', a New Zealand native grown as an indoor foliage plant, which was also stunted by Chlorpyrifos sprays used as a control.

CARBOSULFAN — This is a systemic insecticide formulated in controlled release granules under the trade name Marshal/Suscon® for use in control of pests of forest trees and pastures. Two-year formulations are generally used to control weevil pests in young pine plantations. Trialwork in SA was designed to test rates and

efficacy of one-year release formulations of carbosulfan granules in woody ornamental plants during the nursery production phase. Carbosulfan significantly reduced aphid populations on *Hibiscus rosa-sinensis* at rates of 1.0 to 2.0 kg a.i./m^3 with no reduction in plant growth (Table 3).

Table 3. Results of the use of carbosulfan on *Hibiscus rosa-sinensis* for the control of aphids

Rate kg/m^3	Number leaves (6 months)	Plant height (6 months)	Aphid rating* (3 months)	Aphid rating* (6 months)
0	22 5 a**	22 5 b	4 0 a	4 7 a
0 5	21.0 a	30 6 ab	1 2 b	4 2 a
1 0	24 5 a	32.4 a	2 0 b	2 5 b
2 0	21.8 a	29.1 ab	1 2 b	2.5 b
4 0	24 5 a	28.8 ab	1.0 b	4 2 a
2 0[2]	20 5 a	35 3 a	1.3 b	5 0 a

* Rating index of total aphid infestation 5 = high, 0 = nil
[2] Dibbled
** Within columns, values not followed by the same letter differ significantly ($P<0$ 05)

A lower rate of 0.5 g controlled aphids for 3 months but was ineffective at 6 months. The dibbled treatment involved placing the CR granules in a hole formed by a dibble inserted in the potting medium after planting, which was viewed as a labour saving application method. The clustered granules were clearly less effective at providing control than those incorporated throughout the mix. No phytotoxicity was apparent at all rates tested, the poorer growth of control plants is a reflection of heavy aphid infestation.

Carbosulfan proved to be effective when used at a native plant nursery in controlling sucking pests on advanced plants grown for landscape use. On *Olearia racemosa,* after a period of 7 months, carbosulfan at rates of 0.5 to 4.0 kg/m^3 controlled a mealy bug infestation that occurred on control and dibbled treatment plants. There was no phytotoxicity apparent at any rate tested. On *Eucalyptus globulus,* rates up to 10 kg/m^3 carbosulfan safely controlled a psyllid infestation that occurred at 4 months. By 6 months, as seen in Table 4, psyllids had established on all plants.

Table 4. The effect of Carbosulfan on control of psyllids on nursery plants of *Eucalyptus globulus*

Treatment kg/m³	Psyllid infestation rating (0 to 5) (0 = low, 5 = high)		
	1 Mo.	4 Mo	6 Mo
0	0.0 a	3.3 a	4 5 a
1 25	0 0 a	1.7 bc	4.0 a
2.5	0.0 a	0 8 cd	4 7 a
5 0	0 0 a	0.3 d	3.8 a
10 0	0 0 a	0 8 cd	3 8 a
5.0 (dibbled)	0.0 a	2.0 b	3.8 a

* Within columns, values not followed by the same letter differ significantly ($P < 0.05$)

It appears that the active ingredient in this case was releasing at a faster rate than expected for a one year formulation, or higher rates are necessary for control under heavy insect pressure.

CR carbosulfan and chlorpyrifos were also tested on greenhouse-grown epiphyllum which were heavily infested with scale and mealybug. Over a four month period after treatment, CR carbosulfan at rates of 2.5 to 5.0 kg/m³ significantly controlled scale over controls but had no effect on mealybug. Chlorpyrifos CR was effective in controlling mealybug at rates of 2.5 to 5.0 kg/m³ for four months; however, sprays of the same active ingredient had no effect. Chlorpyrifos, which does not have systemic activity, had no effect in controlling scale.

RELEASE RATES

Release rates of CR granules used in nursery pots can be expected to differ from the same formulations used in soil. In organic-based potting media with high air-filled porosity, granules are more exposed to air and thus to chemical changes than those incorporated in soil. Fluctuations in temperatures are also greater in pots, particularly for woody nursery plants grown outdoors. Average temperatures in pots grown in greenhouses can be expected to be elevated over average soil temperatures, which should accelerate release rates of active ingredients. High levels of leaching also can occur through normal irrigation practices in pots with high porosity mixes. However, the organic components of a potting mix may bind active ingredients more effectively than a sandy soil.

RECOMMENDATIONS

Insecticides formulated as controlled release granules appear to have good potential for controlling common pests in nursery crops. Nurseries participating in this study were very supportive of

a product which would reduce spraying for safety and labour considerations. Many were also looking for a broad spectrum protectorant insecticide similar to Temik® , which has recently been withdrawn from the nursery trade. Those that had a specific problem pest such as weevils, were willing to use targeted treatments even if an extra step such as pre-mixing in potting mix is necessary.

Chemicals need to be of lower toxicity and without noticeable odour to be acceptable for general use in potting-on. Phorate CR appears to be limited in nursery use due to phytotoxicity and safety problems. Chlorpyrifos CR looks particularly promising in control of root weevil and mealybug, and further trialwork is recommended to establish rates on species particularly susceptible to weevil damage (e.g. *Rhododendron*, conifers).

As a broad-spectrum systemic insecticide, CR Carbosulfan appears to have many characteristics suited to use in ornamental nurseries. No phytotoxicity has been observed on a wide range of treatment plants, held both in greenhouses and outdoors. A range of sucking pests are controlled effectively to at least 6 months after application of a one-year release product. Rates as low as 0.5 kg/m^3 were effective in controlling aphids.

Further work with CR formulations of Chlorpyrifos and Carbosulfan is recommended to understand release characteristics of granules in potting media and to better define rates and periods of efficacy. It is important that the active ingredients are depleted from the nursery pot before being sold to consumers, unless the treated plants are marketed as products containing an insecticide. It is also recommended that further CR formulations of lower toxicity insecticides and fungicides should be explored for nursery applications.

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SELECTION AND PROPAGATION OF JARRAH FOR DIEBACK RESISTANCE: A PROGRESS REPORT

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INTRODUCTION

Jarrah (*Eucalyptus marginata* Donn ex Smith), a valuable hardwood restricted to Western Australia, provides two-thirds of the sawn timber from the State. Natural stands have been badly affected by dieback caused by the soil fungus *Phytophthora cinnamomi* Rands (5). It is suspected that a low, but significant number of jarrah plants may show resistance to the disease. If lines of jarrah known to be resistant were available, they could be used to replant "graveyard" areas where the disease has killed virtually all jarrah, and in reafforestation after bauxite mining.

Clones have been raised from mature trees which have survived in graveyard areas, using nodal explants from the crown of the trees. Some clonal lines showed a level of resistance to the disease (1), but the tissue culture process was very difficult. Branches from the crowns of the trees were hard to surface sterilize, shoot multiplication rate was low, shoots did not root until after a prolonged period (3), and the resultant plantlets showed the mature, rather than the juvenile leaf form (2) Consequently we have investigated the possibility of screening seedlings for resistance and cloning selected seedlings.

METHODS AND MATERIALS

Selection of "mother" trees. A number of jarrah trees were selected on the basis that they had survived in areas where dieback had killed neighbouring jarrah. Others were included because they showed dieback symptoms and were thought to be susceptible to the disease. Additional plants were selected in healthy forests to represent a particular jarrah forest site type. Open-pollinated seed was collected and seedlings from each mother tree are referred to as a "family."

Glasshouse screening of seedlings for resistance to *P. cinnamomi*. Seedlings 9 to 12 months old, grown 4 per 25 cm pot in an unheated glasshouse, were tested for resistance to

P. cinnamomi using an underbark inoculation method. An A2 strain of *P. cinnamomi* (IMI 264384), originally isolated from *Hibbertia subvaginata*, was cultured on plates of green pea agar (200g greenpeas l^{-1}) with sterile discs of polycarbonate membrane filters (pore size 8 μm) laid on the surface. When the fungal mycelium was growing thickly on the filters they were cut into squares (side approx 2mm) and a square was slipped under a flap cut in the bark of the stem. The flaps were sealed down with a smear of petroleum jelly. Care was taken to position the wounds midway between nodes, about 4 to 5 nodes from the stem apex on stems approximately 3mm in diameter. Control inoculations used filter membrane with no fungus. A brown to black lesion developed above and below the inoculation site and its extension was measured over a period of 13 days. Inoculations were carried out from January to March (summer) and repeated in July and August (winter) on a different set of plants.

Tissue Culture. Plants which were designated "susceptible" or "resistant" were pruned to remove inoculated stems and prevent further tissue invasion by the fungus, and to induce sprouting from basal regions of the plants. Shoots of 4 to 5 nodes were cut from the plants, the leaves removed, and the shoots sterilized using 2% benzylkonium chloride in 10% alcohol for 20 min. They were then rinsed three times in sterile water and nodal pieces cut and cultured in Murashige and Skoog (MS) (4) medium with 2% sucrose, 2.5 μM benzylamino-purine, 1.25 μM NAA to induce axillary sprouting (2). Sprouts were multiplied in the same medium and then rooted in a medium with ¼ strength MS macronutrients, ½ Fe, full strength micronutrients, 2% sucrose, and 10 μM IBA. Rooted shoots were potted into a 1:2.2 peat, sand, perlite mix and placed under a wet tent for 4 weeks before being hardened on a glasshouse bench.

Field planting of clones. Plants 4 to 5 months from the test tube were planted in June, 1988, on a former bauxite minesite at Dwellingup where dieback had been active prior to mining 2 years earlier. Ten plants of each of 17 clones were arranged in randomized blocks with plants spaced at 4m x 4m. In September 4 plugs of *Pinus radiata* wood inoculated with different *P. cinnamomi* A2 strains (480 R1, isolated from *Banksia*; DCE210 from *E. marginata*; SC381 from *Allocasuarina fraserana*; and 251N12 from *P. radiata*) were buried separately, around each plant. The field plantings were regularly surveyed for deaths, and the roots of all dead plants screened for *P. cinnamomi* infection by plating root pieces on selective agar (6). The pine inoculum plugs were also recovered from around dead plants and plated.

RESULTS

Glasshouse screening of seedlings. The extension of lesions differed widely among plants and between seasons. In summer, lesions grew very rapidly and often killed the shoot, yet some plants effectively contained the lesion under these conditions. In winter, lesion growth was very slow on all but the most susceptible plants. No lesions developed on the "control" plants. Best discrimination among plants was found after inoculation in January-March. "Families" were classified as "susceptible" or "resistant" according to the mean lesion lengths on the seedlings. The mother tree's appearance in the field was not always a reliable guide for predicting the performance of the seedlings, although more of the resistant "families" came from "resistant" mother trees than from other groups.

Tissue culture. Cultures were established for 40 lines Surface sterilization of material from the glasshouse was much easier than from trees in the forest. Fast-growing lines showed a multiplication rate of up to X4 over 4 weeks, and 80% rooting, but not all lines grew well. Some showed low multiplication (X1.5) and did not root. Internal contamination of many lines became apparent after 6 to 12 months in culture. This made the response in culture very variable and reduced survival on transfer to soil. Different lines showed 0 to 90% survival after transfer to soil. Plants have been produced for two field trials in 1988 and 1990.

Field trial of clones. Clones planted in the field in June, 1988, had a survival rate of 98% at inoculation in September. There were 44 deaths over the summer of 1988/89 and a further 26 in 1989/90. *P. cinnamomi* was isolated from the roots of 94% of dead plants. Clones of "susceptible" plants from susceptible "families" showed highest numbers of deaths (40 to 100%, Figure 1); clones of "resistant" plants from susceptible "families" also showed significant numbers of dead plants (30 to 70%). Two plots of clone 11.93 showed 60% and 70% deaths, respectively. Amongst clones of "resistant" plants from resistant "families" there were very few deaths; in four lines there were no deaths, and one plant died in each of the other two lines.

P. cinnamomi was reisolated from almost all pine inoculation plugs to late December, 1988, and although reisolation has become increasingly difficult, *P. cinnamomi* has been reisolated from some plugs to March, 1990, indicating that viable inoculum is still present.

DISCUSSION

Micropropagation techniques allow cloning of jarrah from mature trees of 1-year-old seedlings, but the technique is very much easier to apply to seedlings than to the mature plants. Even so, before large scale propagation can be undertaken, problems of internal contamination, low percentages of rooting, and low survival on transfer to soil remain to be solved.

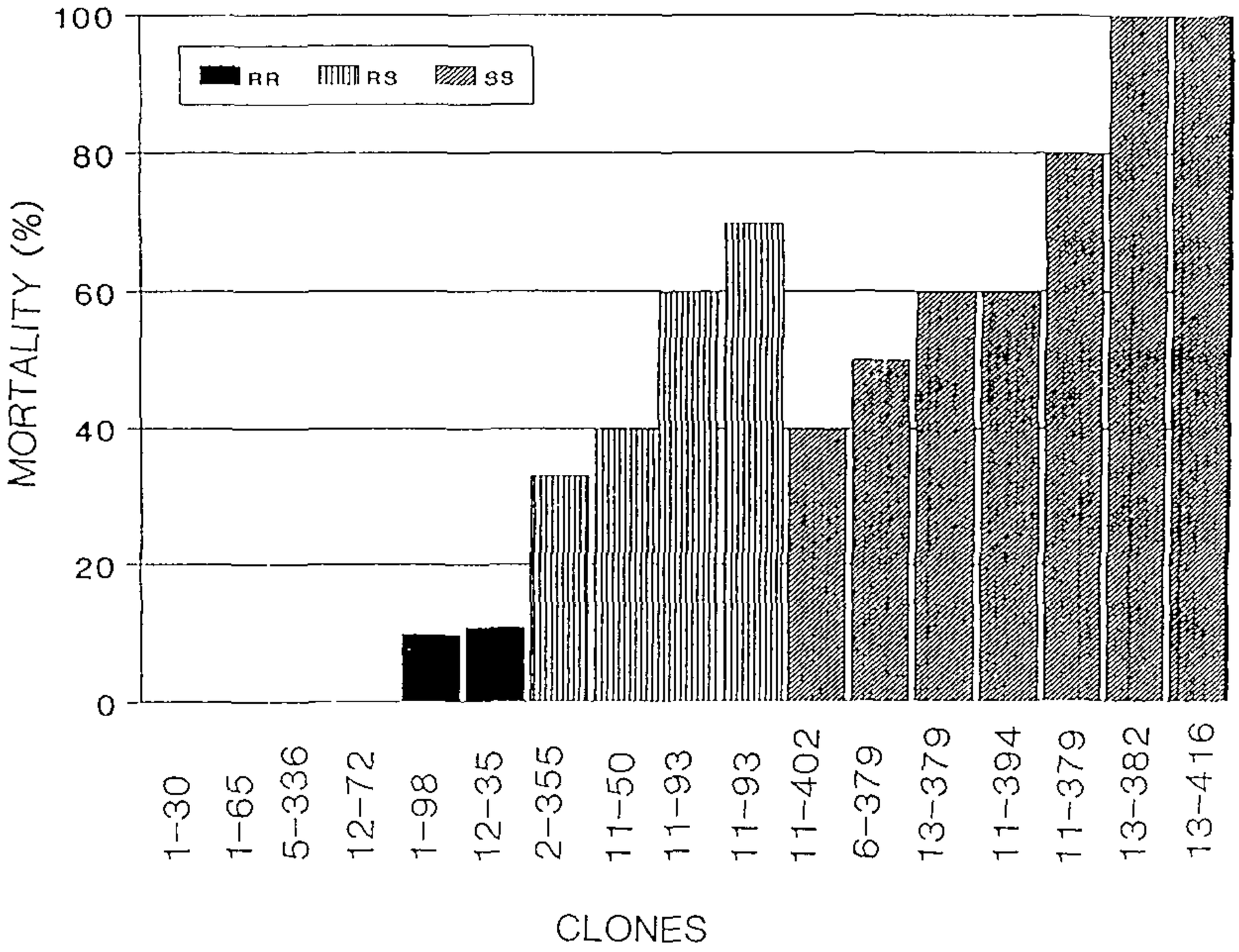

Figure 1. Deaths in clonal lines of jarrah in the field from September, 1988, to May, 1990 Clonal numbers show the family number followed by the plant number within the family RR—clones of "resistant" plants from "resistant" "families", RS—clones of "resistant" plants from "susceptible" "families", SS—clones of "susceptible" plants from "susceptible" "families"

Clones of seedlings selected for resistance to *P. cinnamomi* in glasshouse screening trials have survived in the field while exposed to *P. cinnamomi*. However, not all seedlings that appear resistant in the glasshouse maintain their resistance as clones in the field; this is particularly the case for the rare ''resistant'' individuals that appear in otherwise susceptible ''families''. It is likely that the ''resistant'' rating of such individuals is largely the result of experimental error. On the other hand, clones of ''resistant'' seedlings from ''resistant'' ''families'' all maintain high levels of resistance in the field.

Monitoring of deaths from the 1988 field planting over the summer of 1990/91 and the planting of additional clones in the winter of 1990 will be undertaken to further assess the validity of our selection of resistant jarrah.

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GIVING THE PLANT PROPAGATOR RESPECTED STATUS

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The motto of I.P.P.S. is to "Seek and Share" and the Society has done an excellent job in achieving this since its inaugural meeting in Cleveland, Ohio, U.S A. forty years ago. I, like other I.P.P.S. members, realise that in the next decade the major challenge we are going to face as a Society and industry is in attracting new propagators to our industry.

Our past International President, Mike Dunnett, recently spoke at a U.K. Conference on this very issue, whilst our present International President, Elton Smith, has identified this issue as one of the major challenges. I have had the opportunity of working in many countries with the nursery industry and the picture is the same in any country. We do not seem to be attracting the young propagators in the numbers we require and we are, in some areas, such as budding and grafting, losing the skills of propagation.

Firstly, we should ask ourselves why we are not attracting young people into propagation. The answer seems to be quite simple. To them, our profession is not attractive. As I.P.P.S., we need to get into the schools to "sell" our industry. To help us achieve this we need the material to do this professionally. The Horticultural Trades Association in the United Kingdom and The Nursery Association of South Africa have prepared videos to help sell our industry and perhaps this is an avenue we should explore further.

In the modern world, we are competing with other industries in a shrinking labour pool. This leads me to the second reason we are not attracting the right people. We must sell a career and status. In the marketplace this is what young people are now looking for and, therefore, we must sell what they require.

A career path needs to be explained to the prospective propagator at the start of his or her career Unfortunately, many prospective employees look on the job as a dead end job. We need to show the potential career structure, which should include nursery management and marketing, as well as the potential in starting their own business.

We need to promote apprenticeship schemes and a set training program either through the T.A.F.E. system or via in-house training programs.

The most important issue is that we must provide the propagator with status, and by this I don't mean a high salary and a fancy

car. I believe I.P.P.S. has a major role to play in the future in actually giving young propagators the status that they seek.

PROFICIENCY TRAINING

In the United Kingdom the horticultural and agricultural industries have a proficiency tests system that is controlled by the trade. An employee has to pass these skills tests before they are recognised as being skilled and a great deal of status is put behind such skills awards.

NATIONAL PROFICIENCY TEST
NURSERY STOCK PRODUCTION

SCHEDULE OF ACTIVITIES

NS 1	Glasshouse Frame Case } propagating
NS 2	Field propagating
NS 3	Seed propagating
NS 4	Preparing growing medium
NS 5	Planting or potting
NS 6	Pruning, staking, tying and aftercare
NS 7	Field lifting
NS 8	Packing
NS 9	Plant identification
NS 10	Tractor driving or fork lift truck or tractor
NS 11	Pedestrian controlled rotary cultivator
NS 12	Recognition and control of pests and diseases or weeds
NS 13	Irrigation
NS 14	Mechanical planting
NS 15	Mechanical potting

A proficiency test certificate will be issued to candidates who complete successfully not less than five activities comprised in this test including

One activity from

NS 9	Plant identification

Plus at least one activity from

NS 1	Glasshouse Frame Case } propagating
NS 2	Field propagating
NS 10	Tractor driving

The candidate may choose in which of the other activities he is to be tested

The training is often carried out by the colleges, but the examining is carried out by industrial examiners. Students are examined in the areas of both skill and speed, i.e. before passing the candidate has to be skilled at a set commercial speed. Once successful, the candidate is awarded a certificate.

If we are to encourage young propagators into our industry, I propose I.P.P.S. should look into the following considerations.

1) *Training Guides*
Our Society is full of skilled propagators and we should encourage those people to share their skills by producing training guides on specific propagation techniques. These could be edited by I.P.P.S. and sold as I.P.P.S. training publications.

2) *Proficiency Tests*
I.P.P.S. could set out the examination requirements for each skill in regards to the quality standard and proficiency standard that would be required in industry for a skilled operator.

3) *Examination*
Examination of such skills to be carried out by an I.P.P.S. member who is familiar with the skill. Such a person could be reimbursed for their time by encouraging candidates to pay for exams. (A practice that is not uncommon in other countries or other professions).

4) *I.P.P.S. Diploma*
Successful candidates should be awarded an I.P.P.S. Diploma on completion of a set of propagation skills.

I am sure some people are feeling this is a revolutionary proposal that looks like hard work. I believe it is part of the evolutionary process of I.P.P.S. and that we as a Society and industry must get more aggressive in selling our profession to young people if we are to recruit the appropriate calibre people in the required numbers.

I hope that this paper will help in the discussions of how we attract the people we should and that valuable skills are being lost. If some of these principles are accepted, it would give the Australian Region the opportunity to lead the way.

PROPAGATION OF SOME FRUIT CROPS IN THE 1990s

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INTRODUCTION

The two crops to be discussed in this paper are apple (*Malus*), and chestnut (*Castanea*). Both are deciduous and are grown in the cooler regions of Australia.

The public demand for the fruits of these crops has a direct effect on the nursery production of the trees. Should a particular cultivar of apple or chestnut become hard to sell in the market place then the grower will cease to produce the fruit and demand for the nursery-grown trees will diminish. It is important, therefore, that the growers and the nurseries communicate with one another for future requirements.

Both apples and chestnuts are introduced crops to Australia, and are basically of European origin. Since the introduction of apples there has been a number of chance seedling cultivars discovered throughout the production regions.

Today and throughout the 90's the introduction of new cultivars, particularly in apples, is going to be of great importance to the nursery industry. Breeding programmes are carried out overseas to find superior cultivars which cater for people's ever-changing tastes. These cultivars are being imported through Plant Variety Rights and other means.

THE PAST/PRESENT/FUTURE

The propagation of various apple cultivars has taken place using seedling rootstocks for many years but the popularity of clonal dwarfing rootstocks has increased since the early 1960's.

Current trends in Australia are to use mainly 'Northern Spy' rootstocks, Malling Merton (M.M.) 106, M.M.111, and some seedlings.

In the early years, trees were grown at wide spacings 7.25m. x 7.25m., (187 trees/ha.) and generally an intercrop was grown between the trees.

Currently, apple trees are planted at much closer spacings, 5m. x 3m. (680 trees/ha.). The future will see spacings even closer, 4m. x 1.5 to 1m, and in a 2 or 3 row bed system creating anything from 1000 to 1500 trees/ ha.

For these very high density plantings to be successful, dwarfing rootstocks must be used, enabling a very compact tree to be grown, which produces high quality fruit very early in its life, i.e. in years 2 to 3. Dwarfing rootstocks include: 'M.27' (most dwarfing), 'M.9', 'M.26', 'Ottawa 3', and '793' (New Zealand). The economics of

growing apples today and the public's desire for a better quality product has necessitated change. The nurseries, therefore, must keep abreast of these changes. Apple cultivars of the present and future:

Present	*Future*
Red Delicious—'Starking'	Red Delicious—'Red Chief'
—'Hi Early'	—'Hi Early'
—'Royal Red'	
—'Richared'	
—'Royden'	
'Granny Smith'	'Granny Smith'
'Golden Delicious'	'Red Fuji Naga Fu2'
'Jonathan'	'Royal Gala'
'Delicious'	'Golden Delicious'
	'Bonza'

During the 90's there is going to be ever-increasing pressure applied to all forms of agriculture and horticulture and the way they interact with the environment. Reduced applications of insecticides and fungicides will become a necessity. Research is currently being undertaken at the Institute of Horticultural Research, East Malling, England, to develop cultivars that have resistance to apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera*). Should this ever be achieved then it will mean a big saving to the grower and the environment. I see the development of cultivars on their own roots as a distinct possibility, as this could result in a cheaper tree from the nursery, which is an advantage to the grower when planting densities are increased.

With the constant change in cultivars and rootstocks it is important that the nurseries can compete. They must look at their propagation techniques and outputs.

With chestnuts, however, the situation is a little different. These trees are strong growing and require plenty of room to grow and develop. Nuts are produced only on the current season's growth, therefore the greater the tree canopy, the greater the crop load. Final tree spacings can be up to 20m. square, but it is possible in the early years to plant trees a lot closer.

The propagation of all chestnut cultivars takes place on seedling stock and this is likely to be the case in the foreseeable future. There has been some work done with hardwood cuttings with only limited success.

As with apples, the public's demand for a quality product is increasing. Currently, the size of the nut is a crucial factor relative to the growers' return price. The future will also see a greater emphasis on eating quality. Again, it is important for the nurseries to keep these factors in mind when deciding what cultivars to propagate.

Chestnut cultivars grown in northeastern Victoria that are currently suitable for today's market and on into the 90's include:

'King of the Valley'; 'Sword'; 'Wandiligong Wonder'; and some privately named cultivars.

Some fruit tree propagation methods of the 90's are: stool or mound layering; hardwood cuttings; micropropagation.

Stool or mound layering and hardwood cuttings can be said to be the traditional methods used for raising apple rootstock material and will, no doubt, continue to be used for some years to come. However, with increased technology the use of micropropagation (1) will advance very quickly. Some reasons for this are:

a) The change to dwarfing rootstocks, of which some are difficult to produce under traditional methods, e.g., 'M.26.'
b) To bulk-up large quantities of stock quickly.
c) To take advantage of a mutation or selection of a cultivar quickly if it has possibilities commercially.
d) A means by which to export plants to other parts of the world.
e) Improved performance in the orchard situation.

Some interesting research has been carried out at the Institute of Horticultural Research—East Malling, England, into the micropropagation of fruit trees where the rejuvenation *in vitro* causes vigorous growth in the field of the rootstock/scion combination of apple trees. Composite trees of apple, large enough for orchard planting can be produced routinely within three months of grafting at any time of the year. Trees of the cultivar, 'Greensleeves' were produced in 1985 on 'M9', 'M27', and 'M25' rootstocks by grafting producing 25cm. tall micropropagules. The various rootstock/scion combinations are now larger than the corresponding combinations of apple trees produced by conventional budding.

CONCLUSIONS

Development of new cultivars is a slow process, taking from ten years onwards. It is, therefore, necessary when a new cultivar is released that the maximum benefit from it be developed as quickly as possible. The techniques of micropropagation are then essential to nurseries and growers alike. To be successful in any area, from the propagation of the tree through to the selling of the fruit produced, will require a great deal of integration among the involved parties.

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TOMATO GRAFTING

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Crop producers worldwide are constantly searching for cultivars with resistance or tolerance to pests and diseases. Plant breeding has always been the most common method of producing such cultivars with techniques ranging from simple hybridisation to the more complex genetic engineering processes of today. All these methods are relatively slow and pests and diseases often mutate and develop different strains faster than plant breeders can produce resistant or tolerant cultivars.

Chemical control of pests and diseases is being questioned increasingly as people pay more attention to their health and the environment. Previously accepted chemicals for the control of particular problems are now being questioned, re-tested, and withdrawn from usage in many instances.

Consequently there is a growing need to find—or return to—alternative methods of protecting plants against pests and diseases.

Grafting scion cultivars onto rootstocks has been a common practice in fruit and ornamental horticulture for many years. Clonally propagated and seedling rootstocks are used to influence overall plant growth, to induce uniformity, to affect flowering or fruiting and to confer resistance or tolerance to certain pests, diseases and soil conditions.

The use of grafted plants in vegetable crop production is very limited but there are examples where the technique is used to allow tomatoes and cucumbers to be grown where soil-borne pests and diseases are difficult to control by any other means.

The technique of grafting tomatoes was developed in Holland during the 1950's when there were severe problems with crops being damaged by nematodes, corky root fungus, *Fusarium* wilt, *Verticillium* wilt, and tobacco mosaic virus. Resistant cultivars had not been developed at that time and the standard method of eliminating soil-borne pathogens was to pasteurise or sterilise soils using steam or chemicals, respectively. Neither method was totally satisfactory and there was always a carry-over of pathogenic material from one season to the next in dead and decaying plant material in the soil.

It was shown that several wild species in the genus *Lycopersicon—L.pimpinellifolium, L.hirsutum, L.peruvianum* and *L.glandulosum*—had resistance to the pathogens in question

but it was a very slow process to transfer this resistance into acceptable cultivars of the commercial tomato—*Lycopersicon esculentum.*

F_1 hybrid rootstocks were produced by crossing long established greenhouse cultivars—'Ailsa Craig' or 'Moneymaker'—with a wild sub-species—*L. hirsutum* ssp. *glabratum.* A number of rootstocks were produced by this means so that resistance was avilable to one, some, or all of the pathogens. Rootstock resistances were given code letters as shown:

K—Corky root: N—nematodes: V—Verticillium wilt.
F—*Fusarium* wilt: Tm—tobacco mosaic virus.

An appropriate rootstock could then be used for each situation; for example, rootstock KN gave protection against corky root and nematodes, while KVFN was used against everything apart from tobacco mosaic virus.

The tomato rootstock used today in Australia is TmKNVF Hires which gives protection against all five pathogens.

Plant breeders have produced many new fruiting tomato cultivars over the last 30 years, most of which have resistance or tolerance to tobacco mosaic virus and *Verticillium* and *Fusarium* wilts. Problems still exist in this country with nematodes and the susceptibility of old, traditional cultivars to virus and wilts. Consequently there is only a limited place today for the use of grafted tomatoes by commercial growers. Grafted plants are produced, however for sale in garden centres. Garden soils are often heavily contaminated with the pathogens in question and home gardeners do not have access to most of the crop protection materials used by commercial growers. Most people would not want to use them anyway especially in the enclosed environment of a home garden.

THE METHOD OF PRODUCING GRAFTED TOMATO PLANTS

Sowing. Poor germination can occur with rootstock seed and it is also slow to emerge. Consequently the rootstock seed should be sown ahead of the cultivar that is to be grafted. A time lag of 10 to 14 days may be needed in late winter but that can be reduced to 6 to 8 days later in the year, or when temperatures are higher. It is important to have rootstock and scion cultivar seedlings with stems of similar diameter at the time of grafting.

Seedling culture prior to grafting. Scion and rootstock seedlings should be pricked out as soon as they are large enough to handle. An ideal method is to transfer them to plastic or polystyrene cell trays. Seedlings should be set towards the edge of the cells since this makes the grafting process easier.

Seedlings are generally ready for grafting at a height of 10 to 13 cm and a stem diameter of 3.5 to 5.0 mm. The plants should not be too soft although it is better for them to be a little soft rather than too hard.

Preparation of seedlings for grafting. The cotyledons and true leaves are removed up the stem to a height of about 6 to 8 cm. Some authorities favour cutting the stem of the rootstock about 5cm above the point at which it will be grafted. Our experience is that plants are easier to handle if they are kept intact until after the graft has taken.

Grafting. A simplified tongued approach graft is used and it works very well with tomatoes. Razor blades or scalpels are ideal tools for cutting into the soft stems.

Rootstock and cultivar seedlings are moved into adjacent cells in a tray and can then be grafted *in situ*. The cuts are made on the sides of the stems nearest to the edge of the cell so that the two seedlings can be brought together.

A *downwards* sloping cut is made into the rootstock seedling at the point of graft. The cut should be about 10 to 12 mm long and pass just over half way through the stem. An *upward* cut of the same dimensions is made into the fruiting cultivar seedling. The cuts must match each other, being an equal height above the original soil level and of similar length and depth.

The stems and cuts must be accurately matched so that a close fit is obtained.

Grafting should not be done in direct sunlight as the soft tomato plants are likely to collapse or wilt.

Hold the two joined seedlings together carefully and bind them together around the graft using adhesive tape or a special grafting clip. Self-adhesive medical tape, such as Micropore® , works very well. Grafting clips are also satisfactory but are much more expensive. The tape should be wrapped around all edges of the graft and a small amount should overlap to form a handle with which to pick up the grafted seedlings.

The grafted seedlings should remain in the trays in the growing house and be watered carefully to avoid wetting the graft area.

After-care of the grafted plants. Initially the plants should be kept out of direct sunlight to reduce stress. The humidity should be high with the temperature maintained around 20 to 25 °C. Plants must be watered as necessary and misted over if they show any signs of wilting. During the first two weeks from grafting the plants can be gradually introduced into direct sunlight.

Tomatoes are very easy to graft and they unite quickly. The grafts should take in about 14 days and the plants should then be potted up. Since the rootstock and scion cultivar are growing in adjacent

cells it is easy to take them out and pot them into a single pot. The grafting clip or adhesive tape can be removed as soon as the graft has taken and strengthened.

The root of the scion cultivar can be severed any time after the graft has securely taken Simply make a cut through the stem between the graft union and the base of the cultivar stem. When the plants are destined for soils known to be infected with tobacco mosaic virus, *Verticillium* or *Fusarium* and the fruiting cultivar is susceptible to these diseases then the scion root must be severed otherwise the diseases may be transmitted up to the cultivar via the scion roots. After the scion root system is severed the plant may suffer a temprorary setback. It may be preferable to postpone the severing until just after planting out so that plants retain both root systems during propagation and sale and are accordingly more robust.

A slight hardening of the plant occurs due to a grafting check but it should be remembered that grafted plants have a vigorous, spreading root system in conditions where nongrafted plants have limited roots. Consequently the grafted plants should grow vigorously after planting.

Associated problems:

Virus: Grafting is an ideal method of spreading sap-transmitted viruses and attention to hygiene is very important. Washing hands and tools in a 3% solution of tri-sodium orthophosphate between grafts is a sensible precaution.

Magnesium deficiency: Grafted plants may show magnesium deficiency symptoms in some soils where nongrafted plants remain quite green. In such cases foliar applications of magnesium sulphate can help to correct the problem.

The steps in producing grafted tomato plants are shown in Figure 1.

CUCUMBERS

Grafting fruiting cucumber cultivars onto rootstocks of the Malabar gourd (*Cucurbita ficifolia*) is a control measure for *Fusarium* wilt and also allows crops to be grown in soils infected with black root rot (*Phomopsis sclerotioides*). This technique is particularly important when cucumbers are to be grown in infected greenhouse or polyhouse soils where pasteurisation using steam is not possible since *Phomopsis* is not controlled by any other method.

The grafting method is very much the same as that described for tomatoes.

Grafting tomatoes or cucumbers onto disease-resistant rootstocks is unlikely to be a technique for field producers since many of today's commercial cultivars—especially of tomatoes—have been

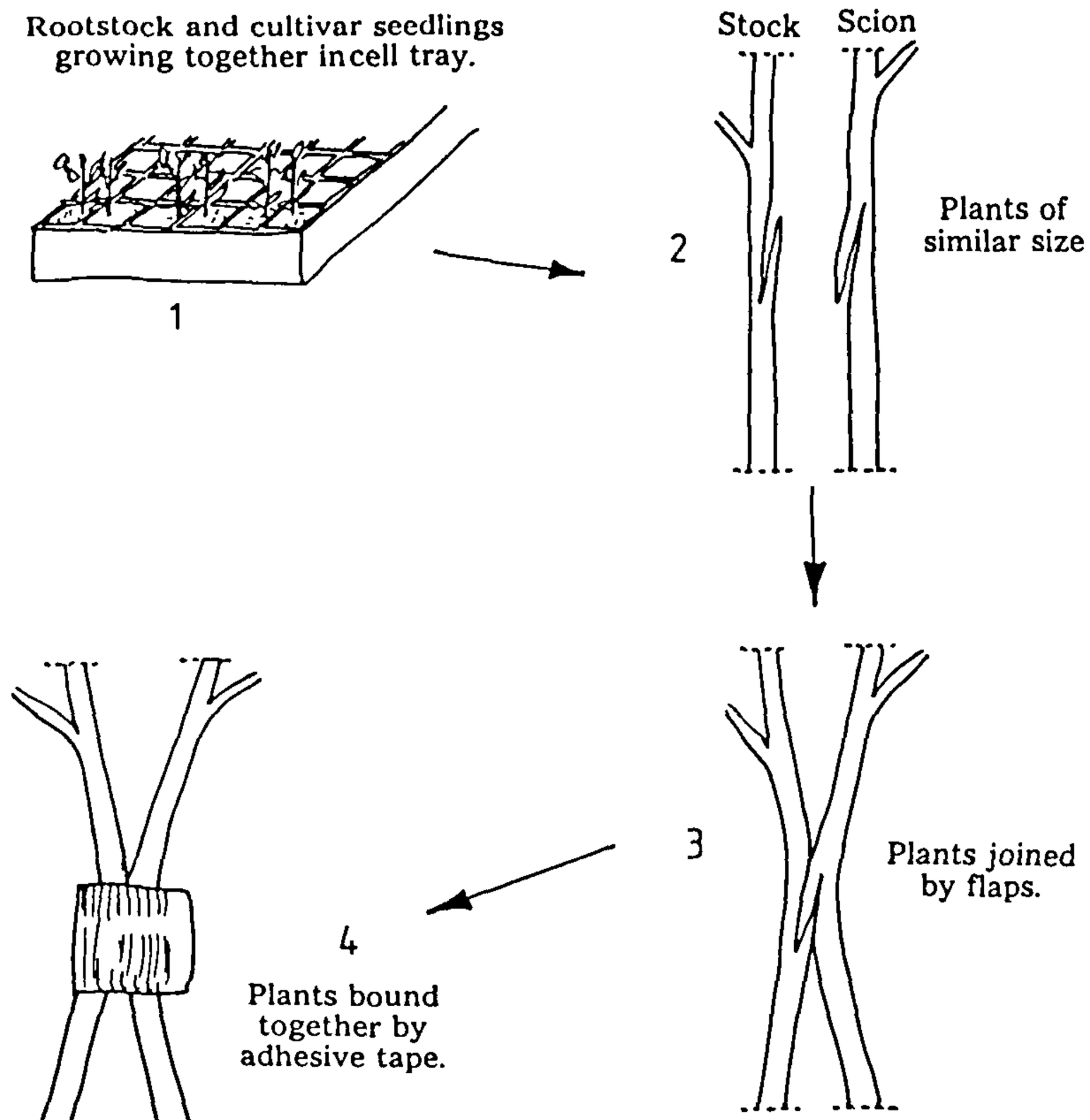

Figure 1. Stages in grafting tomatoes

bred with resistance to soil-borne problems The situation may change, however, and new strains of the pathogens may appear to which the cultivars are susceptible Legislation and/or public opinion may not permit the use of chemical treatments in this new situation and growers may need to resort to alternative methods of growing healthy crops.

With greenhouse or polyhouse crops the situation is different since growers do not have the option of rotating their plantings onto other areas of land. Consequently the use of grafted plants may become a very important method.

The production of grafted plants for the domestic market will continue and it is important that the general public is given full and accurate information on the use of these plants

IMPROVING AUSTRALIAN DAISIES BY BREEDING

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We have been involved in plant breeding for almost 12 months, concentrating on the Australian Asteraceae and, in particular, on the genera *Brachyscome* and *Helipterum.*

The project evolved after trips to Europe and the U.S.A. revealed a strong interest in Australian daisies for use as "indoor potted colour" and "balcony plants," as well as for landscape use

Traditionally, daisies such as chrysanthemum and gerbera have been amongst the top four sellers in both the pot-plant and the cut-flower markets throughout the world. Australian daisies are quite different from these and their unique nature, beauty, and suitability for pot culture have particularly excited overseas growers. For example, Prof. W.U. von Hentig of the Geisenheim Institute in West Germany has developed a form of *Brachyscome multifida* for the European market and this plant now commands sales of about 6,000,000 units per annum in that market place.

Plant breeders in Holland, Germany, and the U.S A. are aware of the opportunities in breeding Australian daisies and thus the development of a breeding program in Australia is of prime importance if this country is to share in some of the benefits to be gained in the marketing of our flora in other countries

After studying the overseas markets and trends we have developed a set of objectives for a breeding program. The prime objective is to breed an on-going supply of desirable new Australian daisies which can be protected by Plant Variety Rights.

These new plants should satisfy the following criteria.

1. Be suitable for use as "Indoor Potted Colour" and as "Balcony Plants" in a range of climates including low light areas.
2. Have attractive form and habit.
3. Come in a range of colours suited to fashion needs of particular countries or areas.
4. Have good cultural characteristics. They should be
   i) easy to clonally propagate by either cuttings or tissue culture
   ii) easy and quick to grow as a uniform flowering crop
   iii) relatively pest and disease resistant.
5 Have good shelf life and shipping characteristics.

With these objectives and criteria in mind, Plant Growers Australia (P.G A.) established a collection of Australian daisies covering 21 genera and over 120 species and forms from a wide

range of different climatic and geographic areas. From the collection we selected the genus *Brachyscome* and the genus *Helipterum* for our initial breeding program.

Having targeted the species for improvement and set some specific criteria for selection, we then developed some detailed breeding programs and commenced trial work. In the main, our methods involve the standard controlled cross-pollination, both within and between species, which is a feature of most traditional plant breeding practices. To achieve satisfactory results, we feel that a glasshouse is essential, and ideally the house should be used exclusively for breeding purposes. It should be well sealed, to prevent drafts and insects interfering with pollination and preferably have a provision for lighting and heating to extend the flowering season. Watering is best carried out by drip irrigation. A well designed and managed glasshouse will result in healthier and more vigorous plants and consequently the production of ovules and pollen will be improved. At P.G.A. we have adapted a plant quarantine glasshouse with a dual chamber for insect exclusion, and this has proved most effective.

While pollination can be regarded as a simple process, controlling the event to achieve a desired result can be complex and often very difficult, depending upon the plant in question. In the Asteraceae, controlled pollination is complicated by the nature of the inflorescence which is a capitullum, or aggregate of small flowers (florets) arranged in a head. On any one capitullum, there can be male, female and bisexual florets and some may also be sterile. The outer florets on the head open first and are often more fertile than the innermost florets which open last.

The Asteraceae also shows a diversity of compatibility systems. Some are self compatible while others, such as many of the brightly coloured "Paper Daisies" are strongly self incompatible. To develop an understanding of the pollination mechanisms involved, we have taken great care to conduct controlled pollination trials on isolated florets which have been emasculated. Where self incompatibility can be proven, as has been the case with all *Brachyscome* species tested, the need to emasculate female parents prior to cross pollination is eliminated.

At P.G.A. our breeding programs have involved both intra-specific crosses and wide crosses between different species. To date, only some of our inter-specific crosses have been successful and from these we are presently growing on a number of F_1 *Brachyscome* seedlings. We have found that even within a species such as the *Brachyscome multifida* group, which is represented by more than a dozen different forms, some crosses have been easier to make than others. Inter-specific hybridisation

has been more difficult in both the *Brachyscome* and *Helipterum* and our task over the next twelve months is to develop techniques which may overcome the barriers to hybridisation. Such techniques may involve treating the stigma, either physically or chemically, to aid fertilization; or adopting embryo rescue where embryo abortion is the problem. Preliminary examinations of stigmas, ovaries, and pollen tube development should indicate where the barrier exists and which technique would be most applicable.

With only limited experience in plant breeding we feel that it is appropriate for us to apply fairly basic plant breeding principles and to identify and overcome problems sequentially rather than to adopt expensive technologies at the onset. Nevertheless, modern breeding methods cannot be overlooked and we will use tissue culture techniques to enable us to carry out *in vitro* culture and maturation of embryos, *in vitro* seed germination, and mutation breeding by means of gamma irradiation of plant tissue. These techniques will be used if and when the need arises. We believe that with this philosophy, and with well organised and committed breeding programs, there is a great potential in using plant breeding as a tool to improve many Australian native species for ornamental use.

SELECTING WESTERN AUSTRALIAN WILDFLOWERS FOR EXTENDED FLOWERING TIME

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When plants are being selected from the wild we can select various characteristics for different purposes. These may include suitability for pot culture, cut flowers, compactness for gardens, long straight stems for export flowers, and for different flower colours.

It is generally regarded that any species of a Western Australian wildflower will only flower for a short time but, within a single species, there may be many hundreds of variations of flowering times. Flower colour, foliage, and the size of the plant will also vary. In most books reference is made to a species flowering at a certain time, but a knowledgeable plant person would know that by selecting from a wide area on which a species grows the variations can be great. To a nurseryman, landscape architect, botanist, horticulturist, or cut flower grower, a more accurate flowering time is important.

Many species have plants in the wild that flower at different times, and if one makes many visits into the field and observes many thousands of plants it is possible to select certain clones that will greatly increase flowering times. One can extend the flowering season for a species over three months with three different clones, and there may also be three different colours for each month. With even more selection this period may be extended to six months.

With Geraldton wax (*Chamelaucium uncinatum*) we have selected six clones that flower from May to December. There are three colours, pink, white, and purple, giving 18 clones of the one species without even breeding. This makes it a very exciting plant, and increases plant sales over a longer period. This is particularly important for the export of flowers. The flowering period will change with different clones geographically, producing earlier or later flowers on different latitudes. This can vary as much as four weeks in some cases.

Field Selections for Cloning. I have been involved in this area for many years and have worked with several experts on Western Australian wildflowers. I have introduced several select cultivars from this unique flora into cultivation over the past 16 years. These include·

Chamelaucium uncinatum 'Purple Pride' was selected in 1974, and introduced into the trade. It is now the most cultivated Geraldton wax, and is one of the best cut flowers in Western Australia. Up until this time Geraldton wax had been picked from the wild. This clone gave the flowering stem consistently required by the flower exporters and the customers. It has also been an excellent pot and garden plant.

C. uncinatum 'Burgundy Blush' was my next selection. It has a larger flower than 'Purple Pride' and flowers later. This plant is not suited to flower picking due to its pendulous habit, but is an attractive pot plant and shrub.

There are now a large number of selections of Geraldton waxes. We now have a pink form which flowers in May. I am currently selecting flowering clones of white, pink, and purple that will flower in Australia in September, October, November, and December. These will all be available by 1991. These clones along with others being produced by plant breeders make *Chamelaucium* an exciting genus.

Lechenaultia biloba 'Autumn Blue' is another clone I have selected for its flowering "out of season." *L. biloba* normally flowers in August/September, but 'Autumn Blue' flowers from March to September. This deep blue selection is excellent for pot culture and as a garden subject. Using this clone as a parent I hope we will see many beautiful hybrids which will flower for much of the year

Grevillea obtusifolia 'Gin Gin Gem'. Gardens have become smaller and ground covers are in more demand. *G. obtusifolia* is a very popular shrub which normally grows about 2 metres high and up to 4 metres across. I made a selection of a prostrate form and called it 'Gin Gin Gem' as it came from Gingin. This clone is now possibly the most popular ground cover used in the Western Australian landscape.

G. crethmifolia 'Rapid Raider'. Normally grows about 2 to 3 metres high but I selected 'Rapid Raider' as a prostrate form, and have promoted it over the past 16 years. This plant is widely used in Western Australia for freeways and road verges, especially in limestone soils.

Scaevola striata 'Pink Perfection'. This is another ground cover selected from *S. striata*, which is normally blue. 'Pink Perfection' has a deep pink flower which flowers over a very long period of time.

Eucalyptus ficifolia 'Autumn Selection'. Normally *E. ficifolia* flowers in Western Australia in December/January but 'Autumn Selection' flowers in March to May. This tree has consistently been flowering at the same time every year. This selection comes true

E. calophylla var. *rosea*—Autumn/winter selection. This tree flowers in late autumn to winter (April-June) whereas *E. calophylla* normally flowers in February. This tree has consistently flowered at the same time each year for many years. Propagation is from seed, or by budding or grafting.

CONCLUSIONS

My aim is to have a clone flowering in each season, i.e. four clones a year for as many species as possible. Selection from the wild in Western Australia can give an immediate result compared to growing seedlings and selecting from them.

These selections will benefit the plant breeders of the future as I will have presented them with genetic material that has already done some of their work. Hopefully they will be able to enhance flower size and colour. This is a very exciting area of floriculture.

THE RONNEBY APPROACH FOR GROWING BETTER TREES

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The bulk of nursery trees in Australia are grown in containers that range from tubes to 300mm pots. There are specialist nurseries that provide more advanced trees. There are two methods used for the production of advanced trees, either (one) above the ground in containers, or (two) in the ground.

Both of these methods have disadvantages. Plants grown in containers have problems. Because of the higher aeration levels at the outside of the container, 80% of the roots occur in a sheath near the container wall, with the remainder of the soil acting as ballast.

The size of a container limits growth, the stock must either be sold, be re-potted, or be thrown away when roots become too limited. The third option is rarely taken due to the high cost of production of advanced trees.

The other method of growing advanced trees is in the ground, and this method has been used since man first grew trees.

Even though this method results in a tree with good vigour and root growth, there are several disadvantages. Trees can only be lifted and transplanted for about four months of the year, and there is considerable damage done to root systems Great care has to be taken in lifting, handling, transporting, and planting them to avoid excessive damage to roots.

Most of the fine roots are destroyed during these processes, and there is little root activity until bud swell. This tends to limit trees suitable for this process to those which are strong enough to take a lot of stress and can recover rapidly. Even with care and good techniques the species are limited to deciduous trees or plants which have a dormant period.

Preceding any discussion of solutions to these problems an insight into relevant aspects of plant physiology is necessary. The distribution of carbohydrates within a tree is important, with about 80% going to growing shoots, 15% to the stems, and only about 5% to the root system. It is also of note that any stored carbohydrates will be moved to flowers and fruits rather than to other plant parts (1).

If there is significant root damage and loss during digging, the tree may have sufficient carbohydrates to produce a good flush of new leaves and shoots early in spring, but there may be very little root

growth. Often this new growth cannot be sustained because of insufficient roots, and the new growth may wither. This causes a further lack of carbohydrate production, and a further decline of the tree. In extreme cases the tree may die.

Our nursery, the Ronneby Tree Farm began growing advanced trees a decade ago, when the recognised method was to ball and burlap the root system ready for sale and transport. However, we were not entirely satisfied with the ongoing vigour and performance of trees planted out. Ronneby then looked for an alternative method of producing a tree which had a more vigorous recovery after planting.

On a trip to the USA Ronneby's were introduced to "Root Control Bags" (RCB) by their inventor, Dr. Carl Whitcomb, at a plantation in the sands of Florida. These root control bags combine the advantages of growing a tree in a container with the safety and practicality of field grown trees.

The bags are made of a fabric similar to the filter fabrics used in engineering drainage, and have the appearance of felt. The roots grow outwards and downwards when the plant is initially planted in the container and they come into contact with the wall of the container. The inner surface of the fabric is "bearded", i.e. there are loose fibres on the surface which prevent the roots clinging to it, and this encourages them to grow through the container wall. As the root diameter is very small at this stage there is no restriction of the root.

Because the fabric has tremendous physical strength it resists the expansion of the roots and, as the roots grow out into the surrounding soil and increase in diameter, the fabric constricts or girdles the root.

At some point in the girdling process the so-called "apical dominance" of the root begins to decrease. This "apical dominance" usually prevents lateral root development. As this dominance decreases lateral roots develop, and these laterals will grow out through the container wall, and they themselves will be constricted.

Because the root pruning process is gradual, trees must be left in the container long enough for root restriction and pruning to occur or little benefit will be gained. The larger the diameter of the fabric containers the greater the time required to build an excellent root system, as the roots have to grow further before contacting the fabric.

Water and nutrients are almost exclusively absorbed at the root tips, and these are transported to the stem and leaves through the xylem, which is in the inner part of the root.

Carbohydrates, however, are produced by the leaves and moved down to the root systems via the phloem, which is in the outer part

of the root. These carbohydrates, which are the energy source of the plant for future root growth, are largely prevented from moving out of the container by the fabric. A swelling occurs on the root on the inside of the fabric and a ''nodule'' forms. This ''nodule'' is packed with carbohydrate and is made up of many small cells with thick walls. As a result they are not easily damaged, and are less likely to be affected by dehydration than other root cells.

When the trees are planted from the containers, the fabric is sliced vertically in 150mm strips and torn downwards, thus removing all the roots which are on the outside of the fabric. There is a tremendous burst of new root growth from the ''nodules'' which have large reserves of stored starch. It is not known whether there are root primordia in the nodules; however, the extremely rapid production of new roots following transplanting suggests this, when compared to the several weeks taken to produce new roots from the end of a cut root on plants which are conventionally open root grown and transplanted. The root control bag produces more rapid root development, and a very different and more responsive root system than the conventional method.

The original root control bags were imported from the USA but, after several trials, inherent faults were found. In particular, some had glued bottoms that simply dropped out. Others were stitched with cotton which decayed and permitted roots to escape, thus defeating the purpose. The major fault was with the fabric itself.

Recognising that the principle was good, Ronnebys have improved the design. The stitching method and thread have been improved by using a non-degradable thread, and a ''burst resistant'' base has been included. Finally a superior fabric has been selected which performs, as required, to the high standard set by Ronnebys. Research is still continuing, however, to improve the root control bag and its performance

With a system that now allowed a tree to be grown with the best of both worlds—in ground and containerised, Ronnebys then turned their attention to the quality of the stock that was placed in the root control bags.

It soon became obvious that the standard method of transplanting evergreen stock from 2 in. tubes or liners into a 6 or 8 in. pot left a lot to be desired, with respect to the formation of the root system.

Potting on of tube stock into a larger sized container is not always done when it is convenient for the plant. This often results in a root-bound plant being placed in a 6 or 8 in. container for sale. Examination of the root system of the plant in the 8 in. container may only reveal new white roots and give an impression of a good healthy root system. If the root ball is further examined it is often found this is not so. In the vast majority of cases, particularly with

shrubs, this does not cause great problems further down the line with time.

However, as the production of some trees may take up to five years, root circling can show up even at this early stage of the plants life. The real problem lies in the ongoing performance, as the roots start to girdle each other. The vigour of the tree declines, and the client may never attribute this decline to the supplier.

Ronneby's felt that their obligation to their clients necessitated the production of the best possible stock and they, therefore, looked at another of Dr. Carl Whitcombe's inventions—the "Root Maker Pot".

For many years it has been known that increased root branching stimulates plant growth. More recently it has been found that if roots branch close to the base of the stem, growth accelerates and health of the plant improved. The key is to force roots to branch close to the base of the stem (2).

The "Root Maker Pot" is 2.5 in. square and 4 in. deep (Figure 1) and these dimensions are ideal for stimulating root formation at the stem base.

When a seed germinates it sends down a strong tap root. If the tip of the tap root is air pruned secondary branching of the root forms, but only a short distance back from the point of pruning. The root maker container stimulates the formation of secondary lateral roots on the main tap root and, in turn, the secondary lateral roots are air-pruned on the sides of the container to accelerate root development at and near the base of the stem. Because of the unique design of the container roots do not wrap or curl.

Using these methods has allowed Ronnebys to produce high quality trouble-free trees. It gives a better product to grow on in their root control bags.

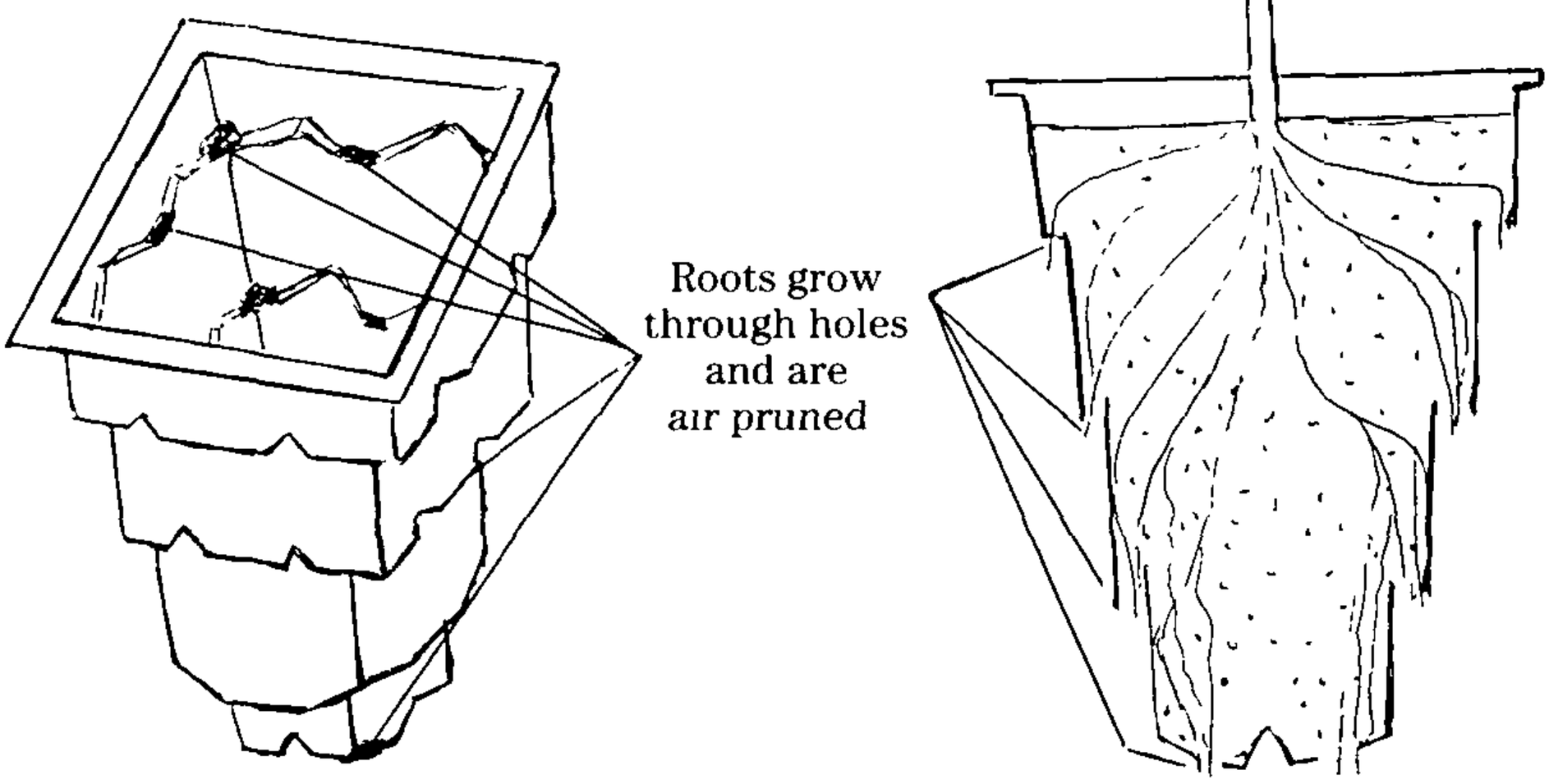

Figure 1. "Root-Maker Pot" Three dimensional (left) and cross-sectional (right)

A new problem arose—how to store the trees once they had been dug from the ground. The conventional method using a 200 litre plastic bag, although good in the short term, creates problems of weight, and stress on the root system if movement is attempted too early. The trees have to be left until the root system has formed sufficiently to withstand movement and handling.

Most of the results accomplished up to this point by Ronnebys would have been undone if the trees were then placed in a smooth sided container where root curl would result This problem led to the development of the "Spring ring."

This consists of an 18 in. (60 litre) container which has 600 hexagonal shaped funnels in the side wall and these are open at the tips. As roots grow outwards they are directed into the funnels and are air-pruned at the openings. Since roots contacting the sidewalls are directed into the funnels, no root curling occurs. This builds a superior root system compared to a conventional container.

After the strong spring flush of growth is complete the trees function as if container-grown. This eliminates the hardening/ acclimatisation process necessary when the trees are dug during the growing season.

This container is especially compatible with the root control bags that build a superior crown, stem, and root system on trees grown in the field. By removing the root control bag and placing the tree in a spring ring, the root ball size can be increased to be more proportionate to the top, and the appearance of tree is improved.

The extensive root system developed from a root-maker pot produces a tree with the capacity to establish quickly in a limited volume of soil. This allows a much larger tree to be harvested and transplanted successfully with a smaller and lighter root ball than is required using conventional methods and techniques. It is not the size of the root ball but rather what is in the root ball that counts. The combination of more roots and more energy to produce new roots sets this system apart from all the others.

In essence the "Ronneby Approach" is to produce trees that are as close to perfect as technology and current methods will permit.

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DEVELOPMENTS IN PROPAGATION AND HYBRIDISATION OF *ANIGOZANTHOS* AND *MACROPIDIA* (KANGAROO PAWS)

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INTRODUCTION

Kangaroo paws occur naturally only in the southwest part of Western Australia. They are fairly new to cultivation, only having become widely grown since the 1970's, but they are now grown in many countries and are now well established in the international cut flower trade. They are also being sold as container plants and used in landscaping and amenity horticulture.

Kangaroo paws have bizarre, colourful, uniquely beautiful bird-pollinated flowers that are covered in a velvety "fur" which, together with the strange, but attractive shape of the inflorescence, makes them a widely appreciated and highly desirable plant to grow. Growing kangaroo paws has not always been easy, many species are difficult to grow from seed and many species are short-lived and are also subject to attack by debilitating fungal diseases that usually prove to be fatal in susceptible species. Long-lived hybrids have been developed that have good resistance to the fungal diseases and micropropagation methods have been developed to reproduce these hybrids.

I will review some species and hybrids, developments in raising plants from seed, and developments in micropropagation techniques for reproducing hybrids and species.

Species and hybrids. There are 12 species of kangaroo paws, 11 of which are placed in the genus *Anigozanthos,* with the other one being placed in the genus *Macropidia,* the "black kangaroo paw".

Within the genus *Anigozanthos*, the three most important species horticulturally are *A. manglesii, A. pulcherrimus,* and *A. flavidus.*

A. manglesii is the most famous and well known kangaroo paw and is the floral emblem of the State of Western Australia. It is commonly red and green but also comes in many other colours.

A. pulcherrimus is the most widely grown species for the cut flower trade. It is reasonably disease tolerant and easy to grow, has brightly coloured yellow or orange flowers, has excellent wilt recovery, and is easily dried, bleached and dyed. The very similar and closely related *A. rufus* provides various red shades.

A. flavidus is noted for its vigour, hardiness, adaptability, disease resistance, and longevity. It is generally considered to be one of the

least attractive of the kangaroo paws, nevertheless there are some attractive forms of this species in cultivation, but these have rarely been used as cut flowers.

All of the other species of *Anigozanthos* have been hybridised with A. *flavidus* to obtain hybrids that show varying degrees of vigour and disease resistance, and hybrids with *A. pulcherrimus, A. rufus, A. manglesii* and *A. humilis* are quite common, while hybrids with *A. preissii, A. onycis, A. viridis* and *A. bicolor* are also well known. Hybrids between *A. flavidus* and *A. kalbarriensis* and *A. gabrielae* are very rare

All attempts to cross the black kangaroo paw, *Macropidia fuliginosa* with species of *Anigozanthos*, have failed up to the present.

When *A. flavidus* is crossed with *A. pulcherrimus, A. rufus, A. onycys* or *A. preissii*, (all of which are in the same subgenus), the hybrids are slightly fertile. However, when *A. flavidus* is crossed with *A. manglesii, A. viridis, A. humilis, A. bicolor, A. kalbarriensis* or *A. gabrielae*, all of which are placed in a different subgenus, *Haplanthesis*, then the hybrids are highly sterile. This low fertility in the former case, and sterility in the latter, has been overcome by the production of fertile allotetraploids from the interspecific hybrid diploids. These fertile allotetraploids have been further crossed among themselves and some of the current hybrids are very complex crosses.

All of this hybridisation has resulted in a good variety of vigorous, hardy, disease-resistant, long-lived hybrids which come in many sizes, forms and colours, and this process is continuing at a rapid pace. Some well known hybrid kangaroo paw series are my own "Western Star" series and the "Bush Gems" and the "Southern Aurora" series.

One problem with the use of these hybrids for cut flowers has been that the flowers do not have the same wilt recovery as the widely grown species, *A. pulcherrimus*. This has been overcome by suitable post-harvest treatments. The stems are pulsed by standing them in a solution of 2.5 grams of 8-hydroxyquinoline sulphate and 200 to 2,000 grams of sugar per 10 litres of water for a minimum of 12 hours, (Adrian Bowden, Linda Manning, pers. comm.), or by the use of similar treatments.

The hybridisation of kangaroo paws has been covered much more fully elsewhere. (8, 10).

To sum up, then, it would be fair to say that hybrid kangaroo paws are now well established, both within Australia and overseas, and are gaining widespread acceptance, both by the general public and by professional growers. This trend is expected to continue, as the obvious advantages of hybrids are enhanced, and any

disadvantages are minimised by further careful breeding and selection.

Raising Kangaroo Paws from Seed. Seeds of many species are difficult to germinate and often results have been low or even nil. Various methods have been tried to overcome this problem including burning paper or leaves on top of planted seeds; stratifying (1): sulphuric acid treatment (9); hot water treatment (9); weathering the seed in the sun over summer (4); a combination of treatments including sulphuric acid, hydrogen peroxide, hot water and gibberellic acid (GA_3) (12); embryo excision (11); and germination in vitro (Bowden pers. comm.).

I also produced strong evidence in 1989 that low day/night temperatures are a requirement for good germination of mixed hybrid seed, (max 20 °C.—min 10 °C.), although the occasional seed does germinate in quite high summer temperatures.

With the possible exception of the methods of Watkins and Shepherd (12), the above methods have not always proved to be convenient, consistent, or reliable and obviously some rigidly controlled trials are needed to give us some understanding of the process of germination, and provide reliable methods for the propagator.

Some work along these lines has been done by Professor John Considine and Mr. Nipat Sukhvibul at The School of Biological and Environmental Sciences at Murdoch University, and it is hoped that when this is extended to cover all species (and hybrids) germination problems will be solved. Some indication of the scope and results of this work are given below.

The influence of stratification, plant growth regulators, and various scarification treatments on the germination of *A. manglesii* seed were studied

METHODS

Stratification—The seeds were placed between two layers of filter paper in a petri dish and moistened with 5 ml water mixed with a 1 g/l Benlate fungicide solution. They were wrapped in plastic and stored at 4 °C. for periods of 0, 2, 4, 8 and 12 weeks and moistened with water every 7 days during the storage period. Four replicates of 20 seeds each were stored for each period.

Scarification with sulphuric acid—The seeds were submerged in 50% v/v sulphuric acid for periods of 0, 5, 10, 15, 20 and 25 min. at room temperature, with gentle shaking during the entire treatment. The seeds were then washed in running water for 30 min.

Scarification with potassium hydroxide—Seeds were immersed in a 5M potassium hydroxide solution for 10 min. at room temperature and then washed in running water for 30 min.

Scarification with sodium hypochlorite—Seeds were gently shaken in a 6% sodium hypochlorite solution (available chlorine approximately 62 g/l at room temperature for 10 min. and then washed in running water for 30 min.

Gibberellic acid treatment—Seeds were placed on double filter papers soaked with 10 ml GA_3 solution for 24 hours at room temperature. GA_3 concentrations of 0, 0.3, 1.0, 3.0 and 10.0 mM were used. The seeds were then rinsed twice with distilled water.

GA_3 and cytokinin, [6 Benzylaminopurine (BA)] treatment—Same as for GA_3 treatment except that the solutions were also 0, 0.03, 0.1, 0.3 and 1.0 mM in BA.

Hot Water Treatment—The seeds were immersed in water at 60° C. for two hours.

Germination—Seeds were placed between two moistened filter papers in a petri dish which was wrapped in plastic and placed in an incubator at 22° C. Seed was kept moist by additions of water weekly.

RESULTS

Both stratification and hot water treatments proved to be ineffective, and seeds with these treatments did not germinate.

Soaking the seed in the aqueous GA_3 solutions increased germination. The addition of BA reduced this GA_3 promotion of seed germination.

Chemical scarification with either sulphuric acid or potassium hydroxide also led to increased seed germination. The effect of these treatments was in addition to, and independent of that of the gibberellic acid.

Total germination increased with longer scarification time with 50% sulphuric acid—up to about 30 to 60 min.—as well as with the concentration of gibberellic acid, up to 10 mM, the limits tested in this study.

A treatment of about 30 to 60 min. in 50% sulphuric acid followed by a treatment of 24 hours in 10mM gibberellic acid provided the most effective enhancement of both total seed germination and speed of germination. This combined treatment gave germination of 55 to 91%, with germination beginning in 10 days. This was compared to 5 to 7% germination obtained with the controls.

Most seed in this study was germinated in the dark in a controlled temperature incubator set at 22° C., which appears to be quite satisfactory. Seeds in trials in the light at room temperature germinated more slowly.

CONCLUSIONS

A full discussion of the extent or implications of this work cannot be given here but it is hoped that this work will be published in full soon and that the work will be extended to cover all species and fertile hybrids.

TISSUE CULTURE OF KANGAROO PAWS

This has been developed and documented in references (5) and (6), but a greatly improved technique has been developed at the Plantex Australia Pty. Ltd. Laboratories (2). This is briefly outlined below.

Sterilisation of young unopened flower buds gives approximately 80% clean explants of which approximately 30% directly produce adventitious shoots. Cultures multiply within 12 weeks of sprouting.

Potting out of plantlets—Rooted shoots are removed from the agar, washed, then potted into a mixture of 50% polystyrene beads, 40% sphagnum peat, and 10% crushed rock. Plants are placed in a misthouse at 80% humidity and watered by overhead mist for 10 sec. every 15 min. Plantlets are treated with Previcure fungicide once a week. After two weeks the mist is reduced, and after four weeks the plants are transferred to a normal glasshouse for four to six weeks.

Explants may be rapidly and easily obtained from selected clones of kangaroo paws while they are in flower without damage to the plant, and with a minimum of contamination problems, by the use of this method.

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BREEDING NEW CARNATION CULTIVARS

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Carnations are dichogamous, i.e. the male and female flower parts are present in the same flower, but they mature at different times, thus preventing self-pollination.

When the anthers ripen first it is known as protandry, and when the stigma is receptive first, it is known as protogyny. The carnation is protandrous as the pollen is mature when the flower opens.

When breeding anything, whether it is plant or animal it is generally accepted that the final result will be as in nature, that is the strongest will be more dominant and eventually the most successful. So the first lesson comes from nature.

Selection for breeding. When selecting carnations for breeding, pick strong and vigorous plants. Usually the pollen-bearing male plants contribute more to the physical make up than the female plants, but they both contribute to the progeny.

The things to look at in carnation parent stock are:

a. resistance to disease, particularly rust.
b. a strong and lengthy stem.
c. a flower to look you in the face.
d bluish type greenery—this is generally healthier.
e. quality of plants.
f. flowers when YOU want it, e.g., I breed for winter flowering.

Cross-pollination. Once the parents have been selected it is essential to prevent interference from insects, such as bees. A tent or greenhouse is necessary for pollination, but I would recommend a glasshouse or polyhouse as it also aids in the ripening of the pollen. I have tried using pot covers and outside tents with little success compared to the process inside the glasshouse. Wind is a big factor when working outside as it blows the pollen around.

Inside the glasshouse the cross-pollination can be carried out in still air without fear of contamination.

I recommend that the stripping of most of the petals from the flowers be done, as this ensures that the ovaries area does not hold any excess moisture, as well as making the styles more accessible.

Collection of the pollen is best done in early morning from the just-opened flowers. The pollen is taken from the flowers by the fingers, and put in a carefully labelled small jar. The pollen is still in lumps when taken from the anthers, but will dry to a powder in a couple of hours. The jar must be kept in a warm and dry place and must not be sealed

The carnation's male parts mature in the first few days of the flowers life, and the female parts are not ready for fertilisation until

the last few days of the flower. Late morning or early afternoon are the best times to carry out the cross-pollination process.

A fine camel-hair brush is used to apply the pollen to the stigmas of the old blooms. The stigmas are located on the upper most ridge of the styles; generally there are two styles. Holding the stigmas uppermost, the pollen is applied to the very end which is curled. It is best to use one hand to straighten out both styles together so the pollen is applied evenly to both stigmas. More than two styles to a bloom generally does not give good seed.

After fertilisation, it helps to open out the calyx to allow the pod to ripen and to ensure it dries out particularly around its base, as any fungal infection in this area can damage all the seed in the pod.

Harvesting. The pods can be harvested when the top of the pod starts to split. The pod is allowed to dry out for a few weeks then the black, viable seeds are collected. Seeds will keep for six months or more in dry storage.

Seed germination. Seeds are sown into trays using a slightly acid, sterile, sandy U.C. mix. The mix is well watered before sowing, then, after sowing, the seed is covered with a light sprinkling of the same mix. The trays are then left for four or five days without any water. They are then placed under mist until the seed has germinated and the seedlings are growing well. They are then put under light mist before hardening-off a month later. The seedlings are ready for planting out after about two months.

Planting out. The seedlings are planted into the open ground about 2 in. apart, in rows about 18 in. apart. Unwanted plants are removed with a 2-in. hoe.

The testing process. Out of 5000 seedlings we get about 100 we consider worth testing further. Three replicates of these 100 selections are planted and grown for another year. Out of that 100 we may get about 12 that we will test the following year. From these 12 we may select three or four for final testing over the next three years. These are now tested in the glasshouse for duration of flowering, disease resistance, general appearance, etc.

The average successful carnation cultivar occurs about one in 30,000 seedlings, so patience is indeed a virtue for the successful breeder. The 'Granny Smith' apple would have taken around a million seedlings to produce, using this process, and the 'Sim' carnation even more.

The future. New cultivars will always be required, and genetic engineering may be used in this process Tissue culture may be used to propagate huge numbers of a cultivar, but plant breeding to change the genetic make-up is essential to produce new ones.

"If I believed that I alone made this wonderful fruit, then, indeed, it would be for nought."

Ed Note This article was originally published in Vol 39, but due to the omission of an important paragraph is republished in its entirety here

THE BEGINNINGS OF THE I.P.P.S. IN THE WESTERN REGION

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The great attendance we always have at the annual meetings of the Western Region of the International Plant Propagators' Society is glowing testimony to the high regard with which we hold it. Today we are going to take a look at its origins. . . . who conceived it, who gave it life, energy, direction, and character.

At that first organizational meeting at Asilomar on October 14, 1960, the discussion was lively and sometimes even a bit heated. Fred Real and I remember it well even though we were mere boys at the time.

To better understand the seriousness of the discussions it is necessary to take a look at the origins of the Plant Propagators Society itself. The forward to Volume I of the Proceedings of the first meeting in 1951 reveals the following: that an earlier propagators' society went out of existence back in 1934. The depression and the lack of experienced propagators who were willing to share information caused it to fail. But this need still existed and the thought of reviving the old organization began to flicker again. Attended by about 100 people, an organizational meeting was held November 8-9, 1951, in Cleveland, Ohio. The Plant Propagators' Society was reborn.

Jim Wells of Redbank, New Jersey, was the keynote speaker. He likened plant propagators to the craftsmen of the old world who banded together in trade guilds. The guild was a fraternal organization, one which chose its members carefully. Full membership should be an honor, a prize a person has won, not something handed out on a platter. It established high standards of experience, skill, and ethics. The guild established the number of years of training for an apprentice before he became a journeyman and finally a master of his trade. He should be prepared to improve the craft by demonstrating a willingness to share his experience with others.

Which of these factors should be considered most important? A willingness to share with others would quickly show whether knowledge and experience were there, while the very act of sharing should suggest integrity. Wells thought that this last should be considered of paramount importance. He was adamant that propagators overcome secretive practices and open their greenhouses to fellow members. He also felt strongly that we should take every possible precaution to see that people who are mainly

concerned with what they can get out of the organization, and not one bit concerned with what they might contribute, should be rigorously excluded.

These radical ideas set forth by Jim Wells formed the basis for membership requirements of a resurrected plant propagators society. It was re-established in 1951 with Jim Wells as president. Dr. L. C. Chadwick, Department of Horticulture, Ohio State, vice-president; and Dr. Ed Scanlon as secretary/treasurer.

The organization met annually in the Cleveland area. The membership roster of 1957 lists the following westerners:

Percy Everett—Rancho Santa Ana Botanic Gardens
Ted Frolich—Subtropical Horticulture, U.C.L.A.
Ray Hartman—Leonard Coates Nursery, San Jose
Dr. Hudson Hartmann—Dept. of Pomology, U.C. Davis
O A. Matkin—Soil and Plant Laboratory, Orange, Calif.
Dr. George Ryan—Subtropical Horticulture, U.C.L.A.

A junior member was a graduate student of Dr. Chadwick, Phil (now doctor) Barker. Phil came to the University of California, Davis, from Ohio State University in summer 1957. He had interrupted his graduate studies under Dr. Chadwick to take a one-year appointment at UCD to teach identification and ecology of landscape plants. California was new to him as were most of the trees and shrubs about which he would be teaching.

He tells me that it was comforting to dwell on past experiences which were particularly memorable as guideposts to his future. One such experience was attendance at the annual meeting of Plant Propagators Society in Cleveland, Ohio, in 1955. It had been such a stimulating meeting particularly because of the very forceful dialogue among venerable plant propagators. In the belief that there ought to be far more than the twelve plant propagators in western United States who would attend a western meeting rather than make a 2000-mile trip to Cleveland, he went into action and called on Dr. Hudson Hartmann, UC Davis, co-author with Dale Kester of a recently published text on plant propagation. Hudson, in his usual easy-going manner, gave a reassuring and positive response and they immediately became a team in pursuit of a common goal. Together, they wrote a letter to the 12 western members of the Plant Propagators' Society and others, requesting their opinion about the merits of a western organization of plant propagators. The response was wholeheartedly favorable. (1).

Copies of all the replies were referred to the Executive Committee of the Plant Propagators' Society, with a request that approval be given for establishing a western chapter. At its annual meeting in Cleveland in December, 1958, a motion was passed "to establish a West Coast Section of the Plant Propagators Society

which would be under the direct control of the parent body. In March, 1959, the Society's president, Roy M. Nordine, named a Committee for Intersectional Affairs to suggest a revision of the constitution that would allow for a western section. The committee consisted of Richard Fillmore as Chairman, Hugh Steavenson, and Hudson T. Hartmann. At the 1959 annual meeting in Philadelphia, the Society approved a recommendation that a Special Educational Meeting of the Society be held in California. It also authorized $1,000 for travel and other incidental expenses. Phil Barker and Hudson Hartmann then called a meeting at Davis June 24, 1959. Twenty-two attended. Again real enthusiasm was shown; Dr. Hartmann was asked to chair the organizational committee. He was unable to do so as he was going on sabbatical leave to Australia.

This group was unanimous in wanting a chapter that would be an autonomous part of the Plant Propagators Society. Autonomy was not a lukewarm concept. Hudson, Phil, and the others felt autonomy would be a key element in future efforts to organize western meetings. In this important fundamental issue we see the first seeds of conflict with the Eastern Region.

Don Hartman was elected to chair future meetings, Herman Sandkuhle, vice chairman, and Dick Harris, secretary. Several more meetings were held that summer. Much of the effort was devoted to formulating a program, selecting a meeting site, and announcing the event.

The committee assembled an impressive array of speakers. It was intended to stimulate interest and insure a significant turnout for the founding meeting. It was also intended to impress the Eastern Region with our quality and content.

The first meeting was held the weekend of Oct. 14-16, 1960, at the famous religious conference center at Asilomar on the picturesque Monterey Peninsula of California; 150 plant propagators registered. This was twice the number the organizing committee had hoped to attract.

The information-filled meeting began Friday night with a discussion of grafting techniques using mechanical devices. The Department of Viticulture and Enology of UC Davis sent two of the evening's speakers—Drs. Lloyd Lider and Curtis Alley. Dr. Thomas Terry, and S.J. Novitiate of Los Gatos, described their practical experiences with bench grafting of grapes using the machines, and the advantages of this method over field budding. Gordon Kershaw, Medford, Oregon grower, detailed his firm's efforts with mechanical bench grafting of fruit trees. Registrants were permitted to inspect various types of grafting machines displayed at the meeting.

Chairman Don Hartman opened the Saturday morning session by introducing the Society's first and second president, Jim Wells.

Jim proceeded to tell us how important we were as plant propagators. He told of the early days of the Society and the need for such an organization. He emphasized the importance of the plant propagator, declaring all horticulture and floriculture and the huge garden supply industry is directly dependent upon the ability of the propagator to produce the plants which motivate the business of gardening.

"In our early days, plant propagation was a secretive business, but due the Plant Propagators' Society, this belief is dying out." As I looked back in the Proceedings, Jim Wells was quoting from the same speech he had given at the original meeting in Cleveland in 1951! He went on to proclaim "we have established a formula that has proven quite successful."

Jim Wells was followed by a star-studded symposium on seed propagation techniques. It was moderated by Dr. Verne Stoutmyer, Horticulture Department chairman, U.C.L.A.

Dr. Dale Kester from U.C. Davis discussed seed dormancy.

Dennison Morey, Research Director at Jackson-Perkins Roses, covered seed stratification in roses.

William Stuke, Stuke's Nursery, dealt with walnuts.

Eastern Region Past President Hugh Steavenson revealed field production techniques. Gerd Schneider of Saratoga Horticultural Foundation dealt with seedling production of liquidambar, pistacia, gingko, magnolia, and *Quercus* in containers. In all, it was a pointed fact-filled discussion.

In true Plant Propagator Society fashion, the afternoon session concentrated on one plant, *Pistacia chinensis*. The panel was moderated by Louis LeValley from Fresno State University. Lloyd Joley, Director of the U.S.D.A. Research Station, Chico, California, and Dwight Long from the City of Modesto, California dealt with budding, grafting, and root training. Dwight was a real character. His uninhibited and witty presentation made his remarks memorable.

Bob Weidner, Buena Park Greenhouses, finished off the session with a hard-hitting talk. He believed you made money propagating plants that were healthy. He was a total believer in the U.C. System: clean greenhouse practices, healthy mother plants, mist propagation, and light weight UC soil mixes. This was radical, exciting new ideas at that time.

It was completely logical that the final papers on Sunday morning should deal with mist propagation and the thoughts of a group of horticultural heavyweights. The question? How to bring plants out of the comfortable womb of the mist-filled propagation house to the hard realities of life in a greenhouse or, worse yet, the field.

It was a real privilege to be allowed to share the thoughts and experiences of such propagational All-Stars as Bob Tichnor, North Willamette, Oregon, Experiment Station; Martin Usrey, Monrovia Nursery; Will Curtis of Wil-Cris Acres, Sherwood, Oregon; and those of one of the Society's Founding Fathers, Jim Wells.

At the Saturday night meeting in the chapel at Asilomar, Phil Barker introduced members of the inter-regional affairs committee composed of leaders from the Eastern Region Each spoke on the philosophies, practices, and rules of the Plant Propagators' Society that were unique, sometimes even radical These set this organization apart from all others.

The first was Dr. John Mahlstede from Iowa State, Editor of the Proceedings. This is a unique organization. It integrates science with practical commercial know-how. Here you have research men that are doing the actual experimentation. They report to you; many growers go home and try these ideas. The next year they come back and tell him he is crazy; it doesn't work. Now you can get down and actually get out a good workable solution.

Phil Barker introduced Mr. Hugh Steavenson who graduated from Iowa State University. During the last decade, he has been running Forrest Keeling Nursery at Elsberry, Missouri, and was president of Plant Propagators in 1957-58. "I was not one of the originators, but I am indebted to those who set up this excellent organization. I attended the second meeting. I wanted to get going on a vegetative propagation program, which we had not yet set up very well. I thought I would stop in and see if I could pick up a little dope. The thing that amazed me at the time and always has since, is the intense participation in the meetings. All of us go to various other nursery meetings. There may be more people out in the corridors or in the bars than at the sessions But there was not a soul in the corridor, nobody was in the bars; everybody was at the meeting, paying keen attention to what was going on. That is the way it has been at every meeting. I know of no similar meetings of nursery people that have been so enthusiastically attended or received."

We have a wide spectrum of members, we have Ph.D's and we have the horny-handed propagators that never set foot in a school of higher learning. The man who has grown up with the propagating knife in his hand can be just as valuable as the one who has his training in the academic hall.

Mr. Barker introduced Richard Fillmore. He received a Masters Degree in Ornamental Horticulture from Cornell. He was third president of the Plant Propagators Society. He is the Aristotle of the organization. "I was the plant propagator at the Arnold Arboretum at Jamaica Plains, Massachusetts, an institution that has 6,500 to 7,000 species and cultivars of woody plants. It was my

business to put roots on them if they didn't have roots. I was very much interested in the formation of a Plant Propagators Society.

"I have experienced considerable professional loneliness. The diamond cutters all congregate in New York City and in Brussels, but the plant propagators are spread out. In smaller institutions and in smaller nursery firms, it is common for the propagator to work pretty much alone. Now, when I have problems, I can freely write to any one of a half-dozen persons who are obligated to me through mutual membership in the Plant Propagators' Society to give me a prompt and thorough answer."

Fillmore continued, answering questions from the floor: What is the policy if two or three members of the same firm apply? "Membership of any category is strictly a personal matter between one individual and this organization. A member may bring two guests each year. This means a manager may bring two of his people as guests. If these two people decide to apply for membership, they start on the same footing as their boss. In the meeting they are his complete and entire equal. They are not obligated to him in the meeting; they are only obligated to the organization. This has had a tightening effect on the self-respect of the plant propagator as a craftsman and as an individual in his own right."

Question from the floor: Fillmore: "How widely do you interpret plant propagation?" It is often widely interpreted. In many organizations, many people function as executives. If they draw up production schedules, are a good host when visitors come, do not have locked greenhouses and phony secrets, if they have executive authority extending over five years and directly or indirectly supervise propagation, they would be eligible for membership."

Mr. Wells: "Membership is by invitation. We do reserve the right to "not invite" some. This is not a Society where one applies in the usual sense. You must recognize that a few individuals do not understand fully the implications of membership in relation to the exchange of information. Any individual who receives a request for information from another member should immediately reply in full. if he does not, he should be *drummed out.*"

At the business meeting Philip Barker introduced the proposed re-organization plan to incorporate the Western Group into the Plant Propagators' Society. Revision of the present Constitution will be considered at the annual meeting in Cleveland.

In general the plan provides that:

1. There shall be *one* Plant Propagators Society.

2. It shall be organized with two major groups, one comprising the Eastern Region and another the Western Region.

3. The activities of each Region shall be governed by bylaws adopted individually by each regional group.

4. The Society shall be under the direction of an International Board with representation from both regions.

The Board of Directors are to meet annually, alternating the meeting place between the two regions.

These proposals were set up in the hope that the Eastern group, which is already an organization, will modify their Constitution so that we can be part of their organization.

Mr. Herman Sandkuhle emphasized that the object of this plan is that we will have our own *autonomy*, but within a master organization.

Mr. Richard Fillmore: "We Eastern folks have hesitated to interfere or unduly influence your meeting out west. As committee members, we will present and support a proposal for the inclusion of the Western group. However, if we are to get the Constitution modified to admit the Western group, work and effort will be required. Our job at Cleveland will be easier after your Region is established and is contributing funds and ideas to the central organization."

Mr. Morey: "I move that the name be the Western Region Plant Propagators' Society." The motion was seconded.

Mr. Wells: I feel strongly that the original name of the Society be retained and suggest that it be known as the Plant Propagators Society, Western Region. This change was accepted by Mr. Morey and the second of the original motion. The motion was passed unanimously.

With this official action the Western Region was ready to request the Eastern Region to include them into the plant Propagators' Society.

The Tenth Annual Meeting of the Plant Propagators Society convened on December 1, 1960, in Cleveland, Ohio, President Harvey M. Templeton Jr., Winchester, Tennessee, presiding. The registration fee for the meeting was set at $11.00!

The Society was reminded that arrangements were made last year to promote a Western Regional organization of the Plant Propagators Society. Dick Fillmore was the chairman of the committee sent to Asilomar to help organize the Western Region.

Mr. Richard Fillmore: "I believe that in our Western Regional endeavors we were very successful. I made a statement to the Western Regional Joint Committee at Asilomar that while it is true that we can give the Western Regional group an honorable name, one well recognized throughout this country and even throughout the world, we can also give them the benefit of ten years of very successful experience in operating an organization of this kind. They, however, can do more for the Society than we can do for them."

At their organizational meeting at Asilomar they had some 150 persons in attendance. These numbers reflect interest and enthusiasm on the part of the western group. There was a very great deal of spontaneity and ingenuity in evidence. These people have the incentive to go ahead, organize a meeting, and to do things.

The Eastern committee all feel also that these people are willing to learn. They were respectful of our eastern experience and anxious to profit by it. Jim Wells was the keynote speaker at the Conference and concurs with the western group's enthusiasm and the respect.''

A motion was proposed to approve the constitutional re-organization plan. This provides for a single Plant Propagators' Society with Eastern and Western Regional organizations and creates an International Board of Directors.

Past president Ed Scanlon spoke on the motion as follows: ''I question seriously the wisdom of organizing this Western Region. It seems to me that for a period of two to three, or maybe five years, it should be strictly on a chapter basis, and that other considerations should be given along that line rather than taking this group in. I am not questioning any of their integrity or anything of that sort, but I think that our organization has been established for a period of ten years, and it has established itself very firmly, and that we consider a trial period of three to five years before establishing the thing.

Mr. Chairman, ''I would like to add a few remarks about the addition of the word ''International.'' I think that in ten years the name ''Plant Propagators Society'' has become quite an honored name in the profession of horticulture, and I see nothing to be gained by the addition of a 13-letter word that would mean absolutely nothing.''

President Templeton recognized Jim Wells, who said,

''I think the name of International Organization is splendid and I would be tickled to death to accept a European region and Australian region, and any others that might crop up. I was very fortunate, indeed, to go to California, and have the most wonderful three days I have had in a long time. I met a lot of splendid people who, except for the color of their hair or the shape of their nose, could be any one of you, the people that have met together for ten years. They think the same, they act the same, they look the same, they are the same. Therefore, I would like to make a motion that we accept the report of the Executive Committee with all that it implies with relation to the incoming western group.''

Mr. Richard Fillmore: "While I know that Ed Scanlon certainly has the best interests of the Plant Propagators' Society at heart, and out of all respect for him, I believe personally that the Executive Committee has exercised good judgment in the presentation of this motion as you have it before you on the floor "

The question was called, the motion was adopted to approve the organization plan for the International Plant Propagators Society.

President Templeton then introduced Mr. Don Hartman, President of the Western Regional group as follows. "Don Hartman is a partner with his brother and father in the Leonard Coates Nursery of San Jose, California. His father, Mr. Ray D. Hartman was one of the original 65 who came to the first Plant Propagators' Society meeting here in Cleveland."

Mr. Don Hartman then spoke saying, "This is certainly a momentous afternoon, and this I do not feel is only for the Western Region of this new Plant Propagators' Society, but it is certainly for the good of the International Organization

"We had what we felt was an excellent meeting on the West Coast. We patterned it after the ten years' experience that you gentlemen have had here in your own meetings. It was made a better meeting by having your Eastern Region representatives attend our meeting.

"Our attendance figures show that we had 150 at the first meeting, and I know that it will not be but one or two years before we will have a membership of over 300.

"I would like to assure Ed Scanlon that the states beyond the Rocky Mountains are still within the borders of the United States and if we continue to follow what you have done in the past you will be proud of the Western Region, not only in five years but in the very near future.

"I would like to thank you again for your solid support. I know from this standpoint that we will not only go ahead from here in the Eastern Region but in the Western Region and in all parts of our International scope."

They appointed Bill Snyder to work up a new Constitution that would take in both areas and still be able to give each area its autonomy. They called it the Constitution of the *International* Plant Propagators Society, Inc.

Hopefully, now we can understand more clearly how and why our energetic, creative predecessors fashioned such a dynamic organization—one that advocates such radical ideas. Ideas such as: seek and share, open greenhouses, boss and employee are equal, were almost revolutionary in those days.

One of our Past Presidents, the irrepressible late Stan Sorenson asked me to give the invocation at the I.P.P.S. banquet in Hawaii

in 1982. It seems to sum up a lot of the principles of I.P.P.S. Here it is for the record.

Dear Lord,

We are grateful to be alive and we thank you, Lord, for the gift of life that you have given to each of us We are grateful for these, your beautiful islands, which we have been allowed to share We have seen your wonderful work in the mountains, the sea, the shore, and the forests of your islands. We thank you for allowing us to be together tonight to share this food and the friendship that spans so many years

We thank you for this fellowship of International Plant Propagators who are pledged to seek and share We know that you have all the answers, Lord Please help us to find the wisdom to ask the right questions about plants and the ways to make them grow And as you reveal the answers to us through our hard work, research, and good luck, remind us to share your revelations with one another, in your name Amen

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THE NURSERIES OF YESTERYEAR

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I feel very fortunate to have been born in an era of drastic changes in the nursery industry, during an era that transcends from the "dark ages" to a period of practical tissue culture, gene splicing, and computers to sophisticated seedling and cutting propagation. I also feel most fortunate to have been born into a nursery family, a family that has been actively involved in plant production from just prior to the turn of the 20th century, (the year 1897 to be exact).

The California horticulture industry, which includes general ornamentals: shade, fruit, nuts and vines, potted plants, cut flowers, bedding plants, and others, is a billion dollar farm gate value industry. It ranks number 4 or 5 following livestock, dairy, and hay. It is difficult to assess its ranking at the retail level as there are no means of accumulating this data.

Though the industry enjoys its share of "corporate giants" the nursery industry is primarily sole ownership although there are many family enterprises. During the late 1970s, and into the 1990s, names such as Weyerhauser, AMFAC, and American Garden Products flexed their "muscle" into the horticulture industry. Today all have deserted the industry except for Weyerhauser and even they are eagerly seeking a "buyer" for some of their selected facilities.

With air freight and refrigerated trailers, our products are shipped from California and the west coast to the national market place. Flowers and propagative stock finds its way to the international market place. Some products from Florida are sold in the European common market and have grown from zero dollar export to more than 20 million dollars in less than five years.

Florida trails California in the production of horticultural products followed by the state of Texas. National weather conditions have a tremendous impact on California producers. A deep freeze in the southern states can mean feast or famine to California producers. Weather conditions in the great triangle containing a concentrated mass of people (roughly Chicago, Boston, and Richmond, Virginia) during the narrow gardening season can also spell disaster.

During the last decade flower imports from our neighboring countries to the south has greatly impacted our California flower producers. It is difficult to be competitive in an international market place where wages are a dollar a day plus very few fringe

benefits. There is no OSHA and there are no restrictions on pesticide usage or environmental laws and restriction.

A visit to the world's largest flower market in Aalsmeer, Holland, is a shocker. Horticultural products sold are from Denmark, Germany, Israel, South Africa, Australia, Colombia, Mexico, and other countries. One wonders, have the U.S. producers become uncompetitive because of our wage and salary and fringe benefit structures in addition to our many regulations and restriction in labor, pesticide, and environmental laws? With this brief overview, I like to tell you about Oki Nursery and about our industry of yesteryears.

My father, Magoichi Oki was involved in the production of fruit and nut trees, grape vines and citrus in the Fresno, California, area. Fancher Creek Nursery, the forerunner of the California Nursery, and Kirkman Nursery were some of the nurseries where my father had the privilege of learning the "state of the art" in fruit, nut, citrus trees, and vine production.

In 1907, Mr. Oki moved to the Perkins area of Sacramento and began his own nursery, principally in the production of fruit, nut, and citrus trees and grape vines which were in tremendous demand as new orchards and vineyards were sprouting all over northern California. In the 20s, Oki gradually turned to ornamental plant production to satisfy the increasing demands to landscape new homes and housing tracts that were being developed during this era. The depression of the late 20s and the 30s had a tremendous impact on the nursery industry as demand for fruit trees dwindled with the deepening depression. Fortunately, not everyone was a victim of the stock market and there were numerous avid gardeners who ventured to our nursery to purchase nursery stock for landscaping, beautification, home orchards, and color.

I can only recite to you some of my personal experiences as a five-year-old when I became aware that we were in the nursery business and quite different from my numerous truck farming and tree fruit orchard, strawberry, vineyard farming family friends. During summers and when not in school I would travel with my father on his delivery or purchasing of nursery stock for his wholesale and retail trade. Some of the names I recall are Louis Vistica Nursery, Kent Nursery, Miller Nursery, Lindo Nursery, Capital Nursery, Lilly Stribling, Sanger, F.W. Chambers, California, Linwood, Ragath, Bell Conservatory, East Lawn, and Lagomarsino, to name a few.

Sanitation was minimal and consequently plant losses were quite high Nutrition program, if one can call it that, was mostly organic and, sometimes, commercial fertilizer was used. It was common to mix loam, peat moss, and chicken manure in most of our container mix. Chicken manure was plentiful as there were numerous poultry

and egg ranches in the area north of Sacramento known as Rio Linda. I would venture to guess that B & B or balled and burlap nursery versus container production was 90% B & B, or field production, to 10% container. Most of the container production was limited to camellia, azalea, rose, and other seasonal species that could not survive as a B & B plant heeled in wood shaving bins.

Chicken manure was also used in our field production of general ornamentals and in the production of fruit, shade, nuts, citrus, and grape vines. Commercial fertilizer was also used to enhance the growth of trees and vines. Field Irrigation is one thing that hasn't changed very much over the years. Flood or furrow irrigation was commonplace. Spinner or Ross type sprinklers were used to water B&B plants in wood shaving bins.

One can view plant propagation during this era of the 30s as unbelievable judged by today's standards. Coarse sand in flats were used and cuttings were stuck using Rootone or other hormones. Since mist propagation was still an unknown state of the art, rooting percentages were far from ideal. In order to compensate for these relatively poor rooting percentages, more cuttings were put in to obtain the quantities needed.

As we approached the 40s and the economic arena gradually improved, more ornamentals and shade trees were required to landscape the growing housing market. Many nurseries of northern California purchased lining out stock from Coolidge Rare Plants of Pasadena, California. I can almost picture Ms. Elizabeth Cox (I believe that was her name) in a turtle back coupe with her samples of liners. Orders were placed with her and in 3 to 4 weeks many wood apple or orange boxes arrived at the Railway Express station in Sacramento. Each of the liners were taken out of the pot and carefully packed in moist newspaper cut in strips of 6 to 8 in. These lining out stock were planted in the field for production requiring one or two years Plants were then graded for size and dug with a ball spade and wrapped with the suitable size burlap and tied with a sisal binder twice. The B&B plants were then heeled in shaving bins for moisture retention for a later shipping date.

It was customary every summer to have two sales persons call on us to take orders for November delivery from Portland, Oregon. Avery Steinmetz, and later, Paul VanAllen of Portland Wholesale Nursery, and Paul Doty made their annual visit. In November several rail cars came to Sacramento with pooled shipments of nursery stock to several Sacramento nurseries. All of the nursery stock were carefully stacked in multiple tiers and carefully packed with moist shingle tow Looking back it was an amazing feat to unload several box cars of Colorado spruce, Norway spruce, Alberta spruce, Mugho pine, skimmia, pieris, Japanese maple, *Daphne odora*, and a host of other plants from Oregon. Bare-root trees of

Norway maples, hawthorn, mountain ash, red and pin oak are some of those that arrived in these packed box cars. Can you believe a perfect shaped Colorado blue spruce 42 to 48 in. tall retailing somewhere between $3.50 and $4.50 in 1939?

One other person that called at the nurseries every summer was Ron Kausen of Cottage Garden from Eureka, California. He and his wife made their annual trek to Sacramento to take orders for rhododendrons. Yes, rhododendrons came B&B, too, in size from 12 to 15 in. to large specimens of 42 to 48 in. size. These, too came in packed box cars from Eureka. Rail freight during this period was the most reliable and economical method of shipping.

I also understand that many pooled box cars of container grown nursery stock were shipped to the Bay Area nurseries from Southern California. If memory serves me correctly the name Pederson and Augsberger comes to mind as the principal plant broker that shipped 1 gal., 3 gal. and 5 gal. ornamental nursery stock to many northern California nurseries.

As the economic condition continued to strengthen there were more demands for general ornamentals and trees. In order to fulfill this growing demand, container-grown ornamentals became more in demand. I can recall using beer can openers to punch the bottom drainage holes in the gallon, 30 lb. frozen food cans, and the square 5 gal cans: 7 gal. and 15 gal. containers were also used for planting specimen trees and shrubs. But the tin can container rusted quickly and something had to be done to preserve the containers. Roofing asphalt was used, thinned with paint thinner, which greatly improved the longevity of the tin can.

With the bombing of Pearl Harbor which plunged America into a world conflict both in Europe and in the Pacific there came a severe shortage of tin can containers and field production again flourished. The subsequent internment of all Japanese Americans from the west coast left a tremendous void in the production of nursery stock and flowers, since people prospered in the war time economy and had money to spend to improve the landscaping of their homes and business places

It was not until March, 1947, that I returned to the postwar Oki Nursery. My parents returned to Sacramento in the fall of 1945, built a house, dug a well and started a nursery again Fortunately, with our parent's old business ties, business flourished and demand for nursery stock continued to grow. It was during this time a man from Los Angeles, a Frank Higashi, came in to purchase our first crop of fruit, shade, and nut trees. Many truck loads of bare-root nursery stock were taken to Los Angeles and the Allied Nursery Exchange in West Los Angeles. For return hauls 1 gal. can ornamentals were purchased, some at incredibly low prices of

20 cents each. Soon we were making empty runs into Los Angeles to purchase 1 and 3 gal. container ornamentals. We were getting increasing demands for bedding plants and opened up a completely new market.

A semi-truck was purchased in 1949 to haul 1100 flats of bedding plants and thus began a lasting relationship with Union Nursery and Henry Ishida. It was through this relationship that we learned of U.C. Manual 23, the Soil and Plant Laboratory, and O.A. Matkin. This combination revolutionized the nursery industry in the 50s. Continuous feed programs accelerated plant production and products were ready for the marketplace in incredible short production time.

The U.C. System, advocating sanitation, nutrition, soil mix, mechanization, and irrigation did much to launch the nursery industry into the 21st century. During this period Richard Oki designed and had built a mechanical 1 gal. planting machine. I can recall the all time record of more than 21,000 planted containers in one 8 hour day. He also designed a screw type dibble plunger to plant gallons to fives, and the same design is in use today in many planting machines.

In March, 1959, a young man fresh out of the U.S. Army and California State Polytechnic University—Ed Kubo—came to work for Oki Nursery, an association that has weathered more than 31 years. It was during this period we learned about a society in the East called the International Plant Propagators' Society and we were able to attend a meeting in December, 1959, the first of many meetings that we attended in subsequent years in the East. We met many interesting personalities, Drs. Charles Hess, John Mahlstede, Ken Reisch, Tom Cannon, Marc Cathey and, in the nursery section, Harvey Templeton, Case Van Hoogendorn, Martin Van Hof, and Jim Wells, to name a few. The papers presented a host of new ideas, systems, and for the first time secret barriers began to fall.

In 1961 a Western Region was chartered with their first meeting in Asilomar, California. I can remember many personalities such as Joe Solomone, Jiro Matsuyama, Ted Van Veen, Bill Curtis, Henry Ishida, Drs. Hudson Hartmann, Curtis Alley, Howard Brown, J. Harold Clarke and Steve Fazio, to a name a few. At an early meeting in West Linn, Oregon, I think I was the influencing force to move the meeting from Asilomar to El Rancho Hotel in Sacramento. I believe everyone can recall that the facilities in West Linn and Asilomar in those days was not first class. I was privileged to assist in the programming with Bob Boddy V.P. to stage the Third Western Region meeting. Following this meeting I was sworn in as V.P. of the California Association of Nurserymen at Hobergs and the beginning of my many years of involvement and commitment to the California nursery Industry.

In the spring of 1963 I was pondering how I could develop statistical data of the quantities, cultivars, pricing, and our customers. We attempted to count through invoices generated during a certain week in March, only to find it an impossible task.

In June of that year a young man, Alan Platt appeared at our office, introduced himself representing IBM and said, "I have a system to help you with your invoicing, standardize your accounting system, do payroll, and developing statistical data for later analysis." This system is known as the IBM 403 Unit Record System. The basic system utilizes 3 pieces of equipment, the key punch, sorter and the 403 unit record machine and printer.

The rest is history now but we are proud that we were one of the first to launch the nursery industry into the use of computers. From the 403 Unit Record System we then went through IBM System 3 unit record to disk file storage and to the IBM system 38. When we launched into the IBM system 3 we were talking 16K's of memory where today a 1 megabyte memory can be found in some of the smallest systems. An amazing change in 20 years.

The bedding plant industry is a very important integral segment of the nursery industry. The production practices of the 20s, 30s, and 40s had not changed during this era. Seeds were sown in nurse flats and transplanted singularly and manually. Many of you can recall cutting a dozen plants and placing them in baskets or paper carry-out trays. Most bedding plant producers of this era were family enterprises although there were a few giants in the Los Angeles and Bay areas. Most fertilization was done with blood meal and hoof and horn meal. Many secret formulas for soil mixes were used and were coveted like gold by many producers.

With the advent of University of California Manual 23 and the UC soil system, many coveted soil mixes boiled down to a single mix. Fine sand, peat moss, and light sized aggregates, as pumice or perlite were used. Steam pasturization of the soil placed in flats became a standard practice. Liquid constant-feed became a standard of the industry. It was a common practice to see transplanted seedlings be ready for the market place in a week to ten days.

In 1949 a couple of enterprising young men, the Mertz Brothers, and American Plant Growers, Lomita, California, introduced "pony pak". This novel idea was taking a molded papermache tray roughly 4 × 7½ in., which held a dozen bedding plants; eight of these trays were placed in a 18x18 in. dimension flat. This simple idea revolutioned the bedding plant industry. In 1950 Oki Nursery entered into contract to be the exclusive Northern California distributor but the venture turned out to be a fiasco because we both failed to recognize weekly seasonal sales and provincialism. We did not recognize that pansies sold in mid-January, peaking in

sale in March, tapered off in demand by May. In addition, public gardeners were not about to change from their old method of cutting out their dozen plants as they always have done. This taught us that more data was required as well as public gardening education.

Aluminum foil paks were next introduced, a giant step forward from the papermache. With the improving technology in vacuum plastic molding the bedding plant industry enjoys an array of plant pak sizes for the sophisticated gardener of today There has been an increasing trend towards larger plants and we produce a 90 plant 15 pak, a 36 plant 6 pak, and a 16-4 in. pot in a specially designed vacuum molded plastic tray. Gallon can size finished flowering plants, 10 to 12 in. hanging plastic baskets, and decorative clay planting pots have been enjoying an increasing demand.

The bedding plant seeding machine and the ''plug'' technology, coupled with the rolling bench technology from Holland and Denmark is already changing our bedding plant industry. There are now a handful of nurseries using these technologies and some of these I have seen are not nurseries per se but sophisticated material handlers. Several embryo plant transplanters have been produced, though with many imperfections; it, too, will become history as man with the aide of robotic science will produce this machine. What an exciting era we live in.

There is a metamorphosis occurring in our industry and it is difficult to see and evaluate as the changes have been so subtle and gradual. For instance, there are very few Japanese-American gardeners today as they have gradually retired, giving rise to Hispanic gardeners who were formerly their helpers. We also see larger service maintenance companies to accommodate the large corporate and condominium type complexes.

Many growers and retailers are retiring, having sold their places of business at a very handsome profit as their children fail to accept the challenge of business. The chain and mass marketers have strengthened their position in the retail market place There are fewer corner or neighborhood nurseries as in yesteryears

What about the future, well, your guess is as good as mine. But it is perfectly clear its not business as usual, with new environmental rules and regulations, drought conditions, or to just satisfy our ever-increasing population for demands on water, the nurserymen and farmers alike must seek new methods to grow our product in the complexities of our society to provide beauty and the ability to feed and cloth ourselves. There is no room for alarmists, but doing things as we have in the past will not and cannot be permitted if we are to leave our world in a better condition than before we inherited it. The world is greener today

than ever before, think how green is our greater Sacramento-San Joaquin Valley as we have transformed desert and wastelands into productive farms. The planting of trees, lawns, and flowers to beautify and to pursue our American dream continues. We are meeting the challenge, but my only with is that our state legislatures and national congressmen and regulatory agencies provide us with more opportunities.

America's might and its strength is derived not from its military strength or advance in technology, though very important, but from its ability to clothe and feed its people. From time immemorial, the great dynasties, empires, and kingdoms have become extinct, the Egyptians, Babylon, the Kahn dynasty, the Greek and Roman Empires have all disappeared for failure to recognize this delicate balance of people and nature, together with the abuse of agricultures. Let us hope that our leaders and the American people recognize that our food and clothing does not come from the supermarket and clothing store but from American farms, the basis of our civilization.

PLANTS NO LONGER AVAILABLE, BUT SHOULD BE

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I wish to emphasize the changing fashions in ornamental plants. Perhaps this is because we now have a choice of so many garden plants and we like to have new ones from time to time. But this desire creates the fashions, making some plants more popular while others are neglected, thereby causing nurseries to discard those not asked for. Then there is a trend in the nursery industry for the larger wholesale nurseries to mass-produce, using their efficient methods for production of those plants most saleable. This results in the neglect or elimination of many useful garden plants. Fortunately, we have a number of smaller nurseries that propagate those plants that have gone out of fashion. In addition, botanical gardens, through volunteer propagators and plant sales, make available plants not to be found commercially. Both of these sources should be encouraged.

The British, who have had a similar problem, have begun to solve it through the formation in 1979 of the National Council for the Conservation of Plants and Gardens. It was organized through the cooperation of the Royal Horticultural Society, which sponsored publication of a conservation guide to garden plants. The book, *The Vanishing Garden*, calls attention to the loss of many good plants. It describes endangered garden plants in eighty genera and gives steps that can be taken to safeguard them. Recently I learned of what may be a comparable American organization, The Garden Conservancy, founded in 1989 and may accomplish a similar purpose for us. From their brochure it sounds as though the Conservancy may be more interested in saving gardens than plants; however, the first two gardens, which it chose to sponsor, are in California. They are Ganna Walska's Lotusland, Santa Barbara, and the Ruth Bancroft Garden, Walnut Creek, both known for their fine plant collections, including some interesting and unusual plants.

For today I have selected a few of the many good garden plants once available. Some were never common but can still be obtained. I wish to acknowledge the suggestion of some plants by my good friend, Philip E. Chandler, well known horticulturist and garden designer of Santa Monica, who has an extensive knowledge of garden plants.

The dates of introduction for a few of the plants discussed are from the unpublished list (dated August, 1964), *Dates of Introduction of Trees and Shrubs to California*, compiled by Harry

M. Butterfield, formerly Horticultural Specialist, Extension Service, University of California, Berkeley. He based the listed dates on his remarkable collection of nursery catalogs that go back to the earliest nurseries in California.

I hope that the following discussion will leave you with the thought that some plants once available should be used again, today, and in the future.

Antigonon leptopus. Mexican creeper. Coral vine. Polygonaceae (buckwheat family). Scrambling to strongly climbing vine. Leaves alternate, entire, heart-shaped, to 4 inches long. Flowers brilliant rose-pink in short racemes that end in a tendril. A striking vine, the bright flowers lasting for months. Native to Mexico.

Angophora costata (synonym *A. lanceolata*). Myrtaceae (myrtle family). *Angophora* is related to *Eucalyptus*; it differs in having separate petals, while in *Eucalyptus* the petals are joined with the sepals to form the bud cap. *Angophora costata* is a tree 30 to 40 feet or more tall, trunk smooth with bark peeling leaving the trunk with pink- to orange-brown spots. Flowers usually in 3s, white, petals 5, stamens many. Native to eastern Australia.

Chonemorpha fragrans. Apocynaceae (dogbane family). Robust vine with milky sap. Leaves opposite, large, up to 9 in. long. Flowers many, white, said to be fragrant, corolla about 3 in. long, lobes twisted to the right. Native to warm parts of Malay Peninsula. Belongs to the same family as oleander and thevetia, to be mentioned later.

Crotalaria agatiflora. Canary-bird bush. Leguminosae (legume family). Large shrub. Leaves composed of 3 leaflets. Flowers in long and showy racemes, petals canary-yellow, typically sweet-pea or papilionaceous in shape, the largest petal, the banner, reflexed. Native to eastern Africa. Has been in California since about 1900. I first saw it at Evans and Reeves Nursery, West Los Angeles, in the 1930s.

Eucalyptus calophylla. Myrtaceae (Myrtle family). Commonly called marri in Western Australia where it occurs in a limited area. Tall tree, bark rough, persistant, fibrous. Leaves alternate, with fine, more or less obscure parallel veins almost at right angles to the midrib. Flowers 3 to 7 in umbels, white to pink, showy. This eucalypt is similar to the red-flowered *Eucalyptus ficifolia* but its flowers are in pastel shades and its large, woody capsules are more deeply constructed at their apexes, forming a "neck."

Lonicera hildebrandiana. Caprifoliaceae (honeysuckle family). Giant Burmese honeysuckle. Vigorous evergreen vine. Leaves opposite, to 6 in. long. Flowers few in loose clusters, corolla to 6 in. long, slender, tubular, 2-lipped, yellow. This unusual honeysuckle has the largest leaves, flowers and fruits of any

honeysuckle. Native to Burma, Thailand, and southern China. In California since the 1930s, it was listed by Evans and Reeves Nursery in 1934.

Loropetalum chinense. Hamamelidaceae (witch-hazel family). Evergreen shrub, 5 to 6 ft. tall, branches slender, somewhat crooked. Leaves to 3 in. long. Flowers white, otherwise like those of the witch-hazel, with narrow, strap-shaped petals, each about ¾ in. long. Striking shrub when covered with numerous flowers; does best in shade.

Luculia gratissima. Rubiaceae (madder family). Large deciduous shrub, to 16 ft. tall. Leaves opposite, to 8 in. long. Fragrant flowers in dense terminal clusters, to 8 in. across; corollas pink, about 1 in. long. Native to the Himalayas. This attractive shrub was never common but has been available.

Magnolia denudata. Yulan. Magnoliaceae (magnolia family). Deciduous tree, flowers numerous, erect, large, showy, white. Native to China, cultivated there for more than 1300 years. Introduced into California in 1854, an early introduction. Probably the finest Chinese magnolia for southern California. It is one of the parents of *Magnolia* × *soulangeana*.

Mandevilla laxa (synonym *M. suaveolens*). Chilean jasmine. Apocynaceae (dogbane family). Deciduous vine with milky sap. Leaves to 6 in. long. Flowers showy, fragrant, corolla white, to 2.5 in. long. Native to Bolivia and northern Argentina. Probably never common. In California since at least 1935 when Evans and Reeves Nursery listed it.

Montanoa arborescens, M. bipinnatifida, M. grandiflora. Tree daisies. Compositae (daisy family). All have large, showy, daisy-like flower heads. Plants are large shrubs or small trees to about 20 ft. tall, with opposite, sometimes large leaves. Attractive and unusual because of its tree-like habit. The daisies are white.

Oxera pulchella. Royal climber. Verbenaceae (verbena family). An unusual member of this family because of its large flowers. Evergreen vine, leaves opposite, to 5 in. long. Flowers pendulous with white, trumpet-shaped corollas to 2 in. long and exerted stamens. Native to New Caledonia. Never common but in California since 1893. Evans and Reeves Nursery listed it in 1935.

Pandorea jasminoides. Bower vine. Bignoniaceae (bignonia family). Evergreen vine climbing without tendrils. Leaves opposite, composed of 5 to 9 leaflets, each to 3 in. long. Flowers few in clusters, corollas white, dark centers, 2 in. long. Two cultivars, 'Alba' and 'Rosea'. Native to Australia. An early introduction into California, listed first in 1858.

Pandorea pandorana. Wonga wonga vine. A vigorous, often pendulous climber, is related to *Pandorea jasminoides* but has many flowers and smaller corollas, less than 1 in. long. Young growth deep bronze. Native to Eastern Australia and New Guinea.

Philadelphus mexicanus. Hydrangeaceae (hydrangea family) but has been placed in the Saxifragaceae. Evergreen, scandent shrub, with long arching branches. Leaves opposite, to 3 in. long. Flowers solitary, fragrant, yellow-white, to 1-1/2 in. across. An attractive shrub, makes a good bank cover. Native to Mexico. Coolidge Rare Plant Nursery, Pasadena, California listed it in 1923.

Pileostegia viburnoides. Hydrangeaceae (hydrangea family). Like the preceding, also placed in the Saxifragaceae. Evergreen vine, climbs 20 to 30 feet into trees or may be a prostrate shrub. Flowers very small, white, numerous in dense, attractive, showy clusters. Native to northeastern India, western China, and Taiwan. Introduced from China by E. H. Wilson. Can be espaliered. In California since 1936.

Prunus campanulata. Taiwan cherry. Rosaceae (rose family). Deciduous, small tree, to 30 feet, with attractive deep rose, very colorful flowers in hanging clusters, during late winter, often February. Leaves alternate, to 4 in. long. One of the few cherries well adapted to southern California. Native to southern China and Taiwan.

E. H. Wilson brought it to the Arnold Arboretum in 1915.

Reinwardtia indica (synonym *R. trigyna*). Linaceae (flax family). Subshrub, about 3 ft. tall. Leaves alternate, die back in summer. Flowers bright yellow, 1 to 2 in. across, petals overlapping, very showy and attractive, but fall early. Probably never common. Evans and Reeves listed it in 1935.

Rondeletia cordata. Rubiaceae (madder family). Evergreen shrub to 7 ft. tall. Leaves opposite, to 5 in. long. Flowers pink, in large terminal clusters, corollas to ½ in. long. Evans and Reeves Nursery listed it 1935. This and *Rondeletia amoena*, also with large clusters of pink flowers are equally attractive shrubs. Both native to the American tropics.

Sutera grandiflora. Purple glory plant. Scrophulariaceae (snapdragon family). Subshrub, 3 to 4 ft. tall, stems sticky hairy. Leaves mostly alternate, sometimes opposite, 1 to 2 in. long. Flowers with phlox-like corollas, about 1½ in. long, lavender to rose. The flowers, said to be fragrant, are seen throughout most of the year. Now being grown at San Marcos Growers, Santa Barbara, California, test garden.

Thevetia thevetioides. Apocynaceae (dogbane family). Oleander, and chonemorpha mentioned earlier, are in the same family. Shrub or small tree to 15 ft., with milky sap, evergreen. Leaves linear-lanceolate, to 4 in., leathery, veins conspicuous. Flowers several

together, corolla funnel-shaped, yellow, to 2 in. across. Can be grown in full sun or reflected light, but not in the desert. It is fall flowering. Native to Mexico.

Thunbergia grandiflora. Blue clock vine. Sky vine. Acanthaceae (acanthus family). Evergreen twining vine, rampant grower. Leaves opposite, to 8 in., angular lobed or toothed. Flowers large, few in drooping clusters, corolla blue, to 3 in. long. This attractive vine flowers from October to December.

BASIC PROPAGATION METHODS (OR HOW I LEARNED PLANT PROPAGATION IN THE OLDEN DAYS)

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No paper concerning one's own early work experiences is possible without talking about mentors, and being able to thank them personally for all the help that was received is often just not possible. Before relating some of my own experiences as an apprentice propagator, I should like to pay a tribute to those who were so valuable as mentors to me as a beginner.

Alfred Fordham, former propagator at the Arnold Arboretum near Boston is Mr. Plant Propagator and will always be known by that title, I am sure. During all the years that he was with the Arnold Arboretum, Alfred shared his knowledge with any and all who asked for his help and was on the other end of the telephone when anyone called for his assistance. (Just think what we could have done with a Fax machine and Alfred!!) He is among those who have presented many papers to the International Plant Propagator's Society, and, though he has been retired for some time, is still willing to talk with new members as well as old friends on his favorite subject of plant propagation, including seed germination and seed dispersal in particular.

Immediately after his retirement from the Arnold Arboretum, Alfred came to work as a consultant with us at Weston Nurseries in Hopkinton, Massachusetts, where I was assistant propagator at the time. Al was hard at work on the propagation of *Kalmia* by stem cuttings and wanted to continue that experimentation work. It was my privilege to be able to spend most of each day working with Alfred. I believe that he taught me more about the nature of cuttings, timing, root inducing compounds, and plants than I could have ever learned by myself. It was from Alfred that I developed a fondness for seeds that will always be with me. That seed mystique, which is the tiny package containing all that is needed to produce a plant, is remarkable, mysterious, and fascinating. Thanks, Alfred, for all the times you helped me.

The person to whom I owe my career as a horticulturist is the late *Ed Mezitt* of Weston Nurseries. He was the person who decided that I had, perhaps, at least the faint glimmering of a plant person and set about to prove that he was right in that regard. I worked as his assistant for nearly ten years and to him I owe my biggest vote of gratitude. He instilled in me the love of plants, especially the lepidote rhododendrons-which persists to this day with me, even

though I have been in the Midwest for a long period of time where rhododendrons are scarce. Ed taught me the rudiments of plant hybridization, and an appreciation of the results of crossing and back crossing (even though we would throw out hundreds and hundreds of plants each year, there was always the quest for the future success).

It is this quest for the future that keeps us—in this plant business—going. We will always be planting seeds and sticking cuttings even though the results may not be seen for many years and we, ourselves, may never see the results of this work.

AND NOW TO THE WAY WE USED TO DO THINGS

Seeds, cuttings, and grafting are the basics of plant propagation and, although the methods seem to change and be refined, in this industry we are still after the same results: the least expensive plant in the largest quantities possible that can be sold in the public market for the most profit.

Seeding is done today in very much the same manner—using the techniques proven to be successful: Direct seeding into a prepared seedbed, covering the seeds with a fine layer of soil or other material to help keep in the moisture and prevent birds from taking all the seeds away...these methods are all still in use today. We have refined these techniques, learned how to use chemicals to help with the weed problems, and have mechanical assistance in the harvest.

The seed work done at Weston Nurseries, at the time I was propagator there, started primarily with a large group of numbered packets of seeds collected from the plants that had been hand pollinated, as well as from many open pollinated plants. Most of the seed sowing was done just before, during, and just after Christmas week. The seeds were sown into 6 × 3 ft. copper pans at the end of a glass greenhouse (south facing). A 6 in. clay tile was placed in each corner of the pans to monitor the water level in the pan and to enable us to drain the pans. (There was no drainage hole in the pans). The pans were ''bottom watered'', that is the water was put in with a hose and left in the pans just long enough to saturate the medium and then siphoned out. The medium was a mixture of leaf mold from the forest floor that had been finely screened and then mixed with perlite plus a small quantity of sand. The pans were leveled and the medium was firmed but not packed. There were no divisions between the seedling blocks other than a slight indentation in the soil. As soon as the seedlings were large enough to survive, transplanting was begun. Many thousands of seedlings were produced in that fashion and the success is very visible today in some of Ed's hybrids that are on the market.

Propagating plants from stem or leaf cuttings is another very popular method of plant propagation that is practiced all over the

world, much the same way today as in the past. However, we have the added advantages of mist, plastic, soilless mixes, time clocks, etc. Techniques have been refined and honed to a science, but the basics remain the same: plants in active growth, and a medium to support the cuttings. Once again, nurserymen have adapted different materials to their own needs, making the rooting of cuttings as easy and inexpensive as possible.

The methods that I used for rooting cuttings at the nursery, as well as the botanical garden, are much the same as elsewhere in the industry. Mist heads, time clocks, soilless mixes (although sand was still used when I started at Weston) and cuttings taken from plants in full summer growth are the basics. In both places, bench propagation was used and, in the nursery situation, outdoor sand beds were also used. Root inducing compounds are about the same now as when they were introduced into the trade, but further developments are still underway.

Each nursery has developed systems and methods that serve their particular line of plant materials and labor force the best. Many nurserymen design and build their own equipment when nothing that is on the market will do the job. Many nurserymen are inventors when it comes to working out systems that will do the best job for them. Innovation seems to be a part of the nursery business.

In closing, I would like to say to all IPPS members, Please be certain to help the new members who are coming along. Remember that we were all beginners once and were afraid to talk to the more experienced propagators for fear that they would laugh at our questions. I will always remember that formidable "front row" of the Eastern Region, Case Hoogendoorn in particular. To be "dressed down" in front of the group by him was a memorable event, but it was Case who recommended that I give my first paper, and it was my privilege to help him read his last paper to the Eastern Region.

Some of the best ideas that the Eastern Region have had for their meetings came from the new members who were asked for their input. We have a first night "get-together" that is just a gathering space for everyone to get together and talk. There is no formal discussion, but there is plenty of talk going on. All the members are wearing a name tag, the Executive Committee is introduced, and so are the new members. This meeting has become a regular event in our annual meetings and came into being because a new member told me that she was afraid to go up to the long-standing members and introduce herself. The next year Kim Hines herself ran this function and it was so successful that it is now in the regular schedule.

Always remember that our motto is "To Seek and To Share" and try to live up to this.

EARLY PLANT PROPAGATION TECHNIQUES THAT STILL WORK TODAY

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While serving my apprenticeship in a tree and shrub nursery during the aftermath of the war-ravaged Germany of the early 1950s, we did not have any fancy machinery or any sophisticated equipment. We did not have a single greenhouse. We did all of our propagation in cold frames outdoors, without foggers or misters. Considering Germany's temperate climate with frequent cool and rainy summers and moderately cold winters, careful preparation of the cold frames was a necessary step to ensure success.

The cold frames were 150 cm wide. At the lower end they were 20 cm high and at the upper end 30 cm high. They were covered by glass windows 100 cm in width. The length of the frames could be variable. Every 100 cm a wooden lath was nailed like a cross beam to the frames, to give them stability and to support the windows. At that time all our frames were made of wood.

In the bottom of the cold frames first came a layer of horse manure (to provide the heating), which was covered with sifted compost tamped down with a strong wooden board. On top of that came the actual propagation medium, a mixture of 3/4 fine sand and 1/4 sifted peat (we did not have perlite or vermiculite at that time). For ericas and other acid-loving plants we increased the peat content to 50%. Each of these layers was about 5 cm thick. The propagation medium was very carefully flattened by moving a thin lath repeatedly over the surface which was then tamped down lightly. Then we watered heavily and let the lot settle for some time before tamping it down very firmly. Now the frame was ready to receive the cuttings.

We used a piece of lath with a set of equidistant nails to punch holes for an entire row of cuttings, which were then inserted rather shallowly and firmed into the mix. For very small-leaved material we used a lath without nails and cut a narrow trench with an old, blunt knife, so the cuttings could be put closer together.

Then the cuttings were watered in thoroughly and the clear glass frames put on. No shade cloth was rolled on until sufficient heat and steam had been generated within the frame which, of course, depended on the day's weather. The condition was checked by simply lifting the glass frame and inserting the hand for temperature and moisture control. Naturally it took some time for

a novice to gain the necessary experience, but it worked very well, primitive as the method was.

When deemed right, the cuttings were given a quick dousing from a small watering can, then the shade cloth rolled on over the glass frames. That procedure was repeated several times during the day, depending on the weather. Every morning they got a good watering to prevent the rooting medium from drying out. Then everything was repeated for the next four to six weeks until the cuttings were rooted.

To harden the cuttings off, a notched piece of wood was put under the frame cover to allow air to enter, first only a centimeter or two, then gradually the windows were lifted higher, and finally they were taken off and only the shade cloth was rolled on when necessary.

The layer of compost under the propagation medium supplied enough nutrients to the young plants initially, so transplanting could be delayed if necessary. We only used auxins in difficult cases, like certain evergreen *Berberis*, for example, and for conifers.

In winter we took a great many hardwood cuttings. The long water shoots were cut in the afternoons, when it was relatively warm. The following morning we cut them to length in a heated workroom, where they were bundled together with thin willow branchlets. The labeled bundles were then wheeled out to a large sand pile where they were buried upside down and covered with a thin layer of sand, topped by a thick layer of leaves, to prevent the sand from freezing. After the spring thaw the callused cuttings were taken to the field and planted directly into long rows.

We also grafted dwarf conifers. The rootstock was planted in clay pots and the grafts were tied on with cotton strings. (To accommodate such larger size plants in the cold frames we used two frames, one placed on top of the other). Before putting the grafts into the frame the pots were thoroughly watered, then plunged into wet peat in the frame. The pots were inserted at a diagonal angle, with the grafted scions facing up. Then they were covered with the glass frames. The frames were lifted every morning, to allow the condensation to run off, so that no water droplets could fall onto the grafts. These frames were shaded in the same way as the cuttings, but no daily watering took place. Only when necessary did we dampen the peat. The grafting took place in late summer and very early spring.

Our success rate with grafts, as well as most of the cuttings was generally very high, whether softwood or hardwood. This shows that one does not need to have sophisticated equipment to get ahead. What we did have, were tools of the highest quality. Shears

and knives we used were always the top of the line, as available at the time.

These simple techniques, as primitive as they may be, work very well in situations where the application of high-tech methods is not feasible, but they are very labor intensive.

THE CONTAINER TREE NURSERY MANUAL— AN EXPERIENCE IN TECHNOLOGY TRANSFER

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THE NEED FOR EFFECTIVE TECHNOLOGY TRANSFER

As Western Nursery Specialist for the United States Department of Agriculture—Forest Service, one of my primary responsibilities is to provide technology transfer to forest nurseries in the western United States. ''Technology transfer'' is one of those terms that is widely-used, but can be most practically defined as the sharing of information. The motto of the International Plant Propagators' Society—''To Seek and to Share''—is an excellent example of technology transfer in action.

Technology can be transferred in a variety of different ways ranging from individual personal contacts, such as telephone inquiries and nursery visits, to group approaches, which include workshops and publications (Table 1). All of these technology transfer methods can be effective, but I have found that they are not equally efficient in terms of specialist-to-user time. Nursery visits are one of the best ways to provide technology transfer because they allow personal contact and address specific cultural concerns, but they are relatively expensive in terms of time and travel costs. Because my territory includes the 17 U.S. western states and island territories, I soon found that it was impossible to make regular visits to all the nurseries in my area. And, because I work with all different types of nurseries (federal government, state government, forest industry, and private), I found that it was difficult to provide the same amount and quality of technical assistance to each nursery and avoid any preferential treatment.

Table 1. Comparison of Different Technology Transfer (TT) Methods

T.T. Methods	Type of Contact	Program Impact Time	Cost	Specialist[1] Efficiency Ratio	Effectiveness Period
Telephone Inquiries	Individual	Low	Low	Low	Short-term
Nursery Visits	Individual	Medium	High	Low	Short-term
Newsletters	Group	Medium	Low	High	Short-term
Workshops	Group	High	Medium	High	Short-term
Journal Articles	Group	High	Low	High	Long-term
Technical Manuals	Group	High	High	High	Long-term

[1] Specialist-to-User ratio, assuming that a ratio of one specialist to many users is most efficient.

I also noticed that after several years of nursery visits, I found that I was repeating myself quite a bit—explaining the same principle or procedure to different growers. This led me to the conclusion that group methods were the most effective and efficient way to provide technology transfer to forest nurseries, and so I initiated several different publications. Starting in the early 1980s, I developed a newsletter called Forest Nursery Notes, which provides a news and literature service to nurseries, and also helped organize workshops and training sessions. Both of these activities have relatively short periods of effectiveness, however (Table 1).

After further analysis, I came to the conclusion that the best way to provide technology transfer to a large audience was through technical manuals or handbooks. These large publications are relatively expensive in terms of specialist time and publishing costs but these must be amortized over the functional life of the manual, which is one of the longest of all the technology transfer methods (Table 1). An additional benefit of a technical manual is that it can be used to increase the efficiency and period of effectiveness of other technology transfer methods, such as workshops or technical assistance visits.

One of my first technical writing projects was to help produce a handbook for growing forest tree seedlings in bareroot nurseries. Working with Mary Duryea of Oregon State University, we published the *Forest Nursery Manual: Production of Bareroot Seedlings* in 1984. After that project was completed, I began working on a counterpart for propagating tree seedlings in containers. The only comprehensive technical manual had been out of print for several years, and so there was an obvious need for an updated source of technical information for container nursery managers.

THE CONTAINER TREE NURSERY MANUAL

The writing team consisted of Richard W. Tinus, Stephen E. McDonald, and James P. Barnett, all of whom have been involved with nursery research for the USDA Forest Service, and myself. We spent a considerable amount of time planning the new *Manual,* and decided on a different emphasis—to stress basic concepts of plant propagation rather than try to develop a "cookbook" that merely lists a sequence of nursery operating procedures.

Our objective in writing the *Container Tree Nursery Manual* was to discuss the concepts of plant propagation as they apply to forest tree seedling production, as well as document existing cultural techniques. Several sources of information were used to develop the *Manual*. We searched the published literature to find the most relevant information relating to tree seedling culture, using articles

from both the forestry and horticultural fields. We also circulated a detailed questionnaire to container tree nurseries in the United States and Canada to determine the current state-of-the-art in nursery culture, and we documented many new practices that were not reported in the published literature.

We decided to use some innovative formats for the *Manual*, such as publishing it as a series of separate volumes to allow for ease of updating. This would allow the volumes to be accumulated as a complete nursery manual or they could be used separately, by specialists needing information on a particular subject. The *Manual* will be printed in the standard 8.5 x 11 inch format, so that the books would fit onto bookshelves and into files. The series of seven volumes (Table 2) are organized around a numerical indexing system that helps the reader to easily locate information and refer between different volumes. Finally, we used numerous tables, line drawings, and color photographs to illustrate cultural concepts and also break up the text and make it more readable. The color photographs are particularly useful for illustrating seedling disorders such as mineral nutrient deficiencies and nursery pest problems.

Table 2. The seven volumes of the *Container Tree Nursery Manual, Agriculture Handbook No. 674,* and their planned publication dates

Volume No.	Title	Publication Date[1]	Stock Number and Price
One	Container Nursery Planning, Development, and Management	(1991)	
Two	Containers and Growing Media	(1990)	
Three	Container Nursery Environment	(1991)	
Four	Seedling Nutrition and Irrigation	1989	001-001-00635-1 $15 each
Five	Biological Influences: Nursery Pests and Mycorrhizae	1990	001-001-00633-5 $30 each
Six	Seedling Propagation	(1992)	
Seven	Seedling Processing, Storage, and Outplanting.	(1992)	

[1] Dates in parentheses are estimated publication dates

The seven volumes of the *Container Tree Nursery Manual* are being serially published as *USDA Agriculture Handbook No. 674* (Table 2). One very unusual practice is that the different volumes are being printed out of numerical sequence—much to the dismay of librarians. This idea originated from the container nursery survey

in which nursery workers indicated what subject areas they considered most critical. This emphasis on nursery priorities resulted in *Volume Four: Seedling Nutrition and Irrigation* being published first, followed by *Volume Five: The Biological Component, Nursery Pests and Mycorrhizae. Volume Two: Containers and Growing Media,* is currently at the printers and will hopefully be published in 1990. The remaining four volumes will be released over the next few years, barring complications in funding or printing delays (Table 2).

ORDERING INFORMATION

We feel that, because we have emphasized the basic concepts of nursery culture, the *Container Tree Nursery Manual* will be of interest to many members of the International Plant Propagators' Society. The USDA Forest Service has purchased a limited supply of the Manuals for distribution to cooperators. Contact me at the following address if you would like to obtain one free copy of each of the volumes that have been published so far:

Thomas D. Landis
USDA Forest Service, CF
P.O. Box 3623
Portland, OR 97208-3623 U.S.A.

PHONE: 503-326-2727; FAX: 503-326-5569

Additional copies of the *Manual* can be ordered using the stock numbers and prices listed in Table 2; contact the U. S. Government Printing Office:

Superintendent of Documents
Government Printing Office
Washington, DC 20402-9371 U.S.A.

PHONE: 202-783-3238

The availability of the remaining volumes of the *Container Tree Nursery Manual* will be announced in my *Forest Nursery Notes* newsletter.

Response to the first volumes of the *Manual* has been quite favorable, and copies have been mailed to nursery managers all over the world. We hope that the *Manual* proves to be an effective technology transfer tool and helps bridge the gap between pure science and practical application.

AN ENTOMOLOGIST'S PERSPECTIVE ON POTENTIAL INSECT PROBLEMS

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There are two different ways to approach the question of potential insect problems. The first is probably the most obvious: introduction of new insect pests into the areas where plants are either produced or used. The second is less obvious, but potentially more complicated to approach. That is, the shift in public attitudes and the regulatory environment may limit the tools available for insect pest management, and consequently, insects that are now of minor importance because they can easily be controlled may become serious management concerns in the future. Solutions to these potential problems will require creativity, consumer education, and flexibility on the part of the industry.

INTRODUCTION OF EXOTIC INSECTS AND PLANTS

California is blessed with a diverse climate that is hospitable to a broad range of plant species. The horticulture industry has introduced a tremendous variety of ornamental plants that have become integral parts of the landscape. The urban forest that we now enjoy in southern California is primarily ornamental and comprised of a mix of native plants, plants introduced from other parts of the state, plants from other parts of the continent, and plants from all over the rest of the world. Fortunately, many of the introductions have been carefully made so as to avoid also introducing insect pests or diseases.

However, despite the obvious care made at the time of introduction, there has been reestablishment of pests with the plant. In many of the cases in which we are now familiar, the pests were introduced without the associated natural enemies. For example, eugenia psyllid, pepper tree psyllid, ash whitefly, and eucalyptus longhorned borer are rarely or only occasionally reported as pests unless the biological control agents in the endemic systems are disrupted. These biological control agents, both predacious and parasitic insects, are important factors in reducing the pest numbers in the native range of the pest.

Not every introduction results in the establishment of new pests, but those that are adapted to the new environments or to new plant hosts in those environments can build up to damaging levels. Sweetpotato whitefly has been introduced into California and

has moved onto several new host plants that are economically important. Similarly, native insect species can shift onto newly introduced host plants and cause damage. There are occasions where insect populations build up on non-economic hosts or in non-economically important environments because of specific or unusual environmental conditions (e.g. drought) and then move into other areas or onto other hosts and cause injury. These outbreaks are difficult to predict and will continue to occur.

However, although the damage caused by outbreak pests can be severe, the injury caused by chronic pest complexes is more critical to control. Production of any horticultural plant requires managing a suite of pests on a regular basis. The plant qualities associated with efficient production (e.g. uniformity of shape and form, narrow range in development or maturation time, patentability) may work against reducing pest populations. That is, the plants are selected for their commercial success and for the ease of production with a minimum amount of genetic variability. The narrow genetic base could result in a limited amount of variation in resistance to insect pests; furthermore, variation in the insect pest population combined with the tremendous reproductive potential of many pests can effectively overcome the plant resistance within a very short period of time.

Obviously, one of the best ways to limit the injury caused by the introduction of new insect pests is through sanitation. Movement of infested plant material expands the geographic range of pests or reestablishes infestations in otherwise clean growing areas. The state and federal inspections at borders and international points of entry are designed to reduce the movement of infested products into the country. Insects are capable of dispersing over large areas once established and that is why there is such a major emphasis at preventing establishment.

PUBLIC PERCEPTION AND REGULATORY PESTS

The problems associated with pest management are no longer confined to the boundaries of the commercial enterprise. Regulation of pest management stems from a growing environmental awareness on the part of the general public. Consequently, the regulatory environment will have a major impact on potential insect problems. Specifically, chemical control options and materials are being removed from the market, either voluntarily by the manufacturer, by direct governmental regulation or, in California as a specific case, are never offered for sale. Without the tools that have been relied upon in the past, insect pests that have been relatively easy to control may present new problems, and key pests may become very difficult to manage.

In addition to the problems associated with regulation, the public attitude appears to be growing increasingly intolerant of pesticide residues. The primary focus has been on food safety and pesticides applied to food crops. Some retail food stores have contracted with pesticide testing services to check produce and certify it as pesticide-free in order to improve their market image and sales. Similar public attitudes toward pesticide residues are becoming apparent in the structural pest control industry, with new and novel non-chemical control strategies for termite control finding an increasing share of the market. It is highly likely that the ornamentals industry will also feel pressure to supply pesticide-free products for the market. Depending on how strongly and how quickly this trend develops, the industry may find itself with new insect problems as it tries to develop compatible control alternatives.

POTENTIAL SOLUTIONS AND MANAGEMENT ALTERNATIVES

While insect and disease resistance of ornamental plants has been used only minimally to date, it has been an important pest management tool in other horticultural production. The use in ornamentals has focused on tree resistance to insects and diseases (e.g. elms for resistance to Dutch elm disease and ficus resistant to Cuban laurel thrips). The role of host plant resistance needs to be increased for two primary reasons. One, the resistance will improve the ability of producers to grow clean plants. Secondly, and possibly more importantly, resistance will help maintain the market for the plant material. In situations where plants have been put into the landscape and have continually been plagued with problems, the demand for that species has declined. The current problems with eugenia and eugenia psyllid, or ornamental pears and ash whitefly are good examples. Admittedly, there are problems with expanding the genetic variation among individuals and increasing the importance of resistance over characters associated with plant form, synchrony, or production ease, but these may be technical obstacles that can be overcome.

Biological control will also become increasingly important. It may be very possible to rely on the use of natural enemies for control of insect pests during part of the growing cycle of the plant. That is, there may be times during production when the plants can tolerate a minor amount of injury, enough of a pest population to support a population of natural enemies and to prevent the pest population from building up above the threshold levels. However, this requires development of realistic threshold levels of injury that can be tolerated. At other times, particularly as the plants are nearly marketable size, other pest management approaches may be appropriate.

In addition to the use of biological control within the fence lines, the industry must expand its horizons to rely on biological control to reduce movement of pests into production areas. Most producers maintain low pest populations within the growing areas because there is strong incentive to do so. In the landscape, usually much higher pest densities are tolerated. The outside areas become sources for infesting populations. Specifically, for the insects that have been introduced into California without their complement of natural enemies, this influx of insects from the landscape has been the primary source of production problems. Introduction of natural enemies into the landscape through the support of classical biological control programs is a principal way of reducing the influx into the production sites. That is, the natural enemies contribute to the control of the pest insect populations, but not just those in the nurseries. The nursery industry within the state has been very foresightful in supporting these types of biological control programs, knowing that general releases of natural enemies will, in a short time, have a direct benefit to their production.

If several of the broad spectrum insecticides are removed from the market, other materials may become available for use. Several companies are developing a new generation of insect growth regulators that kill insects by disrupting the physiological processes of development. These chemistries often have less mammalian toxicities and are safer to use. In addition, there is increasing interest in properly applied feeding deterrents, desiccants, soaps, and oils. Some biological materials not traditionally classed as pesticides but are applied in the same manner include the bacteria, viruses, nematodes, and fungi that can be integrated into a pest management program. Commercial development of these products was stalled following the introduction of relatively cheap and highly effective synthetic pyrethroid insecticides but has increased dramatically in recent years because of public demand for non-chemical control alternatives.

Innovative techniques for cultural management of insect populations are also being developed. Row covers of spun polyester are used to protect young plants from aphids and whiteflies. New screen technology is currently marketed for weed control and to prevent entry of insect pests into glasshouses. Barriers or bands of sticky material can be applied to trap moving insects. For example, plastic sheeting coated with a sticky material has been marketed to be placed below a growing crop to catch and kill thrips pupae. Pheromones are being tested to either mass trap, confuse and prevent mating, or inhibit insects from arriving on susceptible hosts. These chemicals are released in tiny quantities and are usually specific for one insect species.

There are many combinations of alternative management approaches available to develop an integrated pest management system tailored for production of a specific crop. The ornamentals industry has an opportunity to capitalize on a new and environmentally aware market. Their primary product is plants that enhance the environment of the consumer and can be sold as products grown in an environmentally sound, or "green", manner. However, this will require education and creativity on the part of the industry to develop acceptable products. It will also require education of the consuming public so that they will appreciate the efforts of the industry and increase the demand for "green" products to improve everyone's environment.

NEW PLANT DISEASE PROBLEMS ON ORNAMENTAL PLANTS IN CALIFORNIA

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A title such as the one above might be misleading in that it could suggest that disease organisms frequently are being brought into the state. This probably is true due to the huge amount of plant materials imported to supply the ornamental plant industry. However, many of the organisms are not new and have been found and reported as occurring in the state. Control measures frequently have been worked out for such organisms. Occasionally, organisms new to California are brought in or, sometimes, organisms already here are found to be infecting new hosts. Perhaps some of the hosts have had the problem for some time before it is detected.

Although none of the new diseases reported here are as potentially threatening overall as a problem such as the ash white fly, to individual growers they can be a serious problem.

Anigozanthos spp. are interesting Australian plants grown for cut-flowers and recently as a potted plant. Following its introduction into California for cut-flower production, a leaf spot was found on plants from the San Diego and Watsonville areas. The causal fungus is a species of *Alternaria* (4) and is in a group of fungi that tend to be host specific. Infection results in round or elliptical black spots on the leaves. The size of the spots varies and in a susceptible species such as *A. manglesii* D. Don, can be an inch or longer and may develop in streaks. Control measures have not been developed yet nor has the host range in the genus been completed.

Recently *Anigozanthos* hybrids have been developed for use as potted plants. These are being produced in large numbers using tissue culture. Recently some of these plants in a nursery in the San Francisco Bay area developed blackened areas in the leaves. These started as small spots and rapidly enlarged, sometimes covering the width of the leaf and also extending up and down the leaves so that sometimes nearly the whole leaf became black. Culturing failed to reveal the cause of the problem but free-hand sections of infected materials revealed the presence of a foliar nematode. This was identified as *Aphelenchoides fragariae* (Ritz.-Bos.) Christie (9) and presently, studies are in progress to determine if this is a common or specialized form of that nematode. Studies also are in progress to determine the susceptibility of other *Anigozanthos* spp. "Vidate" as a foliage spray may give control.

Several years ago a leaf spot was found during the winter months on calendula in central coastal California. The fungus killed the

leaf tissues resulting in somewhat angular spots up to ½ in. across. Small black spots were found on the stems (6). The fungus, also an *Alternaria* was found to infect *Calendula* spp., and of 20 species inoculated, all were found to be susceptible, although 2 species were only moderately affected. When inoculated, *Dimorphotheca pluvialis* Moench and *Osteospermum calendulaceum* Harv., which are in the same tribe as calendula, were found to be susceptible. An *Alternaria* sp. infecting *Calendula* was reported from Denmark (3) but that fungus has a different host range than the fungus in California. Iprodione was found to give good control in experiments here.

Another *Alternaria* has been found on annual and perennial candytufts. Though reported in Europe (3) and in Florida (10) only recently has it been reported in California (6). The fungus has been identified as *Alternaria brassicae* (Berk.) Sacc. and has been reported on many members of the Cruciferae (2). Following inoculations with the fungus, candytuft, broccoli, Brussels sprouts, cabbage, cauliflower, radish, and 16 species of *Iberis* were found to be susceptible. In candytuft, infection results in small black spots on the leaves, stems, flowers, and fruits. Infected leaves yellow and drop. Severely infected plants have only a few leaves at the top and do not produce saleable flowers. Most *Alternaria* species do not infect flowers. In candytuft, the fruits also were infected and as a result, might be seed-borne.

Several years ago, leaves of pansies in several central California nurseries turned pale green to yellow. This was found to result from infection by a downy mildew (8). Although two downy mildews have been reported in the U.S. (2, 11), one of which also has been reported in Europe (1), the fungus in California is a different genus than the others. Why is this new form in California and where did it come from? The fungus has not been observed since although excellent control has been found using several metalaxyl sprays.

A new disease on marguerite daisies appeared two years ago in central coastal California. The disease results from infection by a species of *Ramularia*; symptoms appear as angular brown areas on the leaves which can become 1½ in. across. Small circular spots appear on the stems. In shipping, infected leaves become invaded by secondary fungi resulting in a destruction of the foliage. Although new, the fungus has spread through much of the marguerite growing area. Experiments are in progress to find a control.

In the production of miniature roses in greenhouses, a crown and root rot problem has developed. The fungus *Cylindrocladium scoparium* Morg. has been isolated repeatedly and has been reported on roses before, but not in California, and not on miniature

roses. The fungus causes a cutting rot but also produces crown and root rot on young plants. Some cultivars are more susceptible than others. Experiments are in progress to find an effective fungicidal control.

Eustoma grandiflora (Raf.) Shinn., or lisianthus is a new crop being grown as a bedding plant or for growing in pots. The plant has been found to have several problems associated with the roots and crown. *Pythium, Phytophthora,* and *Rhizoctonia* have been isolated from infected roots. A crown rot resulting from *Fusarium solani* (Mart.) Sacc. has been found. Recently a vascular wilt resulting from infection by *Fusarium oxysporum* has been reported (5). The plant seems to have lost some of its popularity, possible because of disease problems.

Time limits this to only a few of the problems which are new on ornamental plants in California. Others, such as twig and branch die back in oaks, new leaf spots on dichondra, ivy, *Lychnis*, and baby's breath, powdery mildews on a number of plants, and many root rot problems could be included.

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THE IMPACT OF TISSUE CULTURE ON *FICUS* SPP. PROPAGATION AND PRODUCTION

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Plant propagation through tissue culture is continuing to expand as commercially sound laboratory production systems are developed. While commercially successful tissue culture propagation has occurred in the landscape, cut flower, small fruit, flowering pot and seed parent areas, the greatest impact of tissue culture in the U.S. continues to be in the interior foliage market where over forty million tissue culture propagules are used annually. The interior foliage industry has benefited from one of the most recent commercial successes with the advent of large-scale production of tissue-cultured *Ficus* spp. propagules.

Ficus species are tropical woody shrubs and trees that play a significant role as interior foliage plants. It is estimated that some 20,000,000 *Ficus* plants are produced annually in the U.S. for interior use. Size ranges from large-scale trees to small containers with either single or multiple stems. The bulk of U.S. production is currently being done in south Florida where plants are container-grown in full sun or in Saran houses.

Typically, *Ficus* is propagated readily from tip cuttings or air-layers with growers either maintaining their own stock or buying rooted cuttings from off-shore producers.

In the mid-1980s, Twyford Plant Laboratories began its *Ficus* program with the goal of establishing tissue culture propagation as a cost-effective, reliable alternative to conventional propagation. To become successful, the product had to offer unique benefits to the growers who were accustomed either to a readily available supply of inexpensive off-shore cuttings or easily rooted tips from their own stock plants.

In spite of this formidable competition from conventional propagation, the potential size of the market, as well as early indications of favorable laboratory performance, gave impetus to the project.

The program was developed around three criteria considered to be essential to successfully commercializing *Ficus* tissue culture.

Reliability. A tissue culture product cannot have a significant sales volume without a reliable and timely stream of product. The inability of tissue culture labs to produce on schedule is as significant a factor as are high unit costs in limiting the expansion

of the tissue culture industry. With *Ficus*, attention was paid to developing sound culture handling techniques that were extremely reproducible with an associated minimal product mutation rate. An important additional factor was the development of storage techniques for lab cultures which enabled excess inventory to be carried at a minimal cost. This "culture warehouse" created a safety net which could be drawn upon in the event of production shortfalls or increased sales demand. The development of a computerized data collection system that enabled ready monitoring of crop performance targets against actual results was another significant component of the program.

Product Performance. Uniform, vigorous, disease-free liners are a must if tissue culture is to be an alternative to low-cost conventional propagation. Tissue culture is well known for its role in producing high-health stock; *Ficus* is no exception. In fact, it is rare for a grower to experience any disease problems with tissue-cultured *Ficus*. Vigor is outstanding with plugs rapidly establishing in containers, even when they are planted directly in full sun in south Florida. Other factors attributed to the "invigorating" effect of tissue culture include a more vigorous root system and resistance to cold temperature stress. It has been noted that tissue-cultured *Ficus* remains green while cutting-produced plants turn off-color during exposure to low temperatures. In addition, there have also been reports of significantly reduced leaf drop from tissue culture derived *Ficus* maintained in interior environments.

Product Quality. Aside from the uniformity and disease-free aspects of tissue culture plugs, the major factor in producing what the grower perceived as a high-quality *Ficus* plug was the development of a multiple-stemmed plug. All plugs in Twyford's 72-cell tray are produced with a minimum of five shoots resulting in a full, compact finished plant from only one plug rather than multiple conventional cuttings. The grower thus realizes the additional benefit of being able to rapidly plant into containers without pre-plant grading of cuttings.

Careful attention to laboratory processes and grower needs has resulted in a significant new product from tissue culture that has benefited the grower and consumer with a higher quality product without higher cost. Currently, Twyford Plant Laboratories offers a complete line of tissue-cultured Ficus cultivars that are soil-established in 72 cell plug trays. Cultivars include:

Ficus benjamina 'Wintergreen'*
Ficus benjamina 'Spearmint'*
Ficus lyrata 'Everglades'*
Ficus elastica 'Robusta'
Ficus elastica 'Cabernet'*

* Registered Trademark of Twyford Plant Laboratories

As technology continues to develop, many more "old standards", as well as new unexploited cultivars will become available through tissue culture propagation in all areas of plant production. Steady but significant advances in culture system and cost reduction will greatly enhance the role of tissue culture propagation in the 1990s.

ANALYSIS OF GREENHOUSE CURTAIN SYSTEMS FOR SHADING, COOLING, AND HEAT RETENTION

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INTRODUCTION

Curtain systems have been used for environmental control in greenhouses for over 10 years. When they were originally installed, their main function was either:

—to reduce heat loss at night
—for photoperiod control (blackout) of chrysanthemums
—daytime shading of crops

Over the last 10 years, there has been a dramatic improvement in the level of environmental control that can now be achieved in a greenhouse with environmental control curtain systems. This is due mostly to improvements in:

1) the curtain system fabric, which provides better cooling and greater heat savings at night.
2) more dependable curtain system mechanics; i.e. systems that can be automatically controlled so that an operator does not need to be present to monitor the movement of the system.
3) more sophisticated controls for the curtain systems, i.e. computers.
4) growers now having a better understanding of how to use the curtain systems to maximize environmental control and consequently their crop quality.

Now, when growers install an environmental control curtain system, they usually do it to achieve *more than one* of the following:

—shade plants *only* during periods of excessive light levels.
—help cool the greenhouse in the daytime, i.e. reduce both plant and soil temperature.
—reduce nighttime heat losses.
—photoperiod control (blackout)
—control crop height using DIF, (cool days, warm nights, cold shocking the plants in the morning)
—reduce costs associated with watering the plants, i e.
  —reduced water usage
  —reduced cost of hand watering
  —reduced fertilizer usage
—reduce electrical costs associated with using fans.

—control the nighttime escape of stray light from supplemental lighting.
—reduce temperature variations throughout the greenhouse at night.
—increase the quality, color, and shelf life of grown vegetables.
—humidity control for vegetables (i.e. tomatoes, cucumbers) grown hydroponically or in rockwool.

A properly designed environmental control curtain system should by definition "provide the ability to react to changing outside environmental conditions by maintaining *optimal, uniform* conditions inside of the greenhouse, while minimizing the energy inputs spent to provide this control."

In addition to the roof, the sidewalls and gables affect the light and temperature fluctuations that occur in the greenhouse. When we are discussing light and temperature control within a greenhouse using curtain systems, we are not only referring to curtain systems to control the roof of the greenhouse, but we are also referring to rollup curtains to control the sidewalls and gables.

When analysing which curtain system is suitable for your application, the analysis should include the following categories:

1) Fabric selection
   i.e.—should a polyester, polyester and aluminum, acrylic, or polyethylene film be used?
2) System configuration
   i.e.—do covers travel from truss to truss or from gutter to gutter?
3) System design
   i.e.—how is the fabric moved?
   —how does the system support the fabric?
   —is the fabric laying on top of and dragged across nylon wires, or is the fabric suspended from hooks that slide on wires?
4) System controls
   i.e.—is the curtain system controlled manually, by a timeclock, light sensor, or a computer?

Throughout this analysis, we will be referring to what effects the curtain systems can have on the greenhouse environment. All of the examples concerning the use of curtain systems inside greenhouses in this analysis, are based on using aluminized fabrics on the curtain systems. These fabrics are usually made from alternating strips of aluminum and polyester.

Table 1 compares some of the fabrics that can be used on the curtain systems for shading, cooling, and nighttime heat retention.

Table 1. Comparison of fabrics available for daytime shading and nighttime heat retention.

	"LS" Fabric Alum & Clear Strips	White 100% Polyester Fabric	100% Polyester C W Alum Strips Laminated on	Black Polypropylene Shade Fabric
Percent of Range	22% to 99 9%	30% to 76%	60% to 99 9%	30% to 95%
Reflects Light For Better Cooling	Yes	Some	Yes	No
Pliability	Good	Average	Average	Poor
Resistance to Dirt Adhesion	Good	Very Poor	Very Poor	Good
Cleanability	Good	Very Poor	Very Poor	N/A
Diffusion	Yes	Some	Some	None
Re-Reflection	Yes	Some	Some	None
Controls Night-Time Radiant Heat	Yes	Some	Yes	Minimal
Heat Retention	Good	Good	Good	Poor
Resistance to Mechanical Abrasion	Average	Good	Good	Good
Price	High	Low	High	Low
Resistance to Algae Growth	Good	Poor	Poor	Very Good
Suitable for Nylon Wire Suported Peaked Truss to Truss System	No	Yes	No	Yes

Due to the custom nature of curtain systems, we will not be addressing the various curtain system designs or curtain system controls. Should you have an interest in the curtain system designs and controls, they should be discussed first hand with the various curtain system manufacturers.

DAYTIME SHADING

If daytime shading is required, a shade factor between 30% and 85% is typically used. The actual shade percentage that you select will depend on:

—maximum daytime light intensity for your area
—maximum foot candles the crop can tolerate
—light transmission of the greenhouse and covering

When needing to shade a greenhouse, there are five basic alternatives:

1) whitewash the greenhouse roof.
2) black shade cloth fastened semi-permanently over the greenhouse roof.
3) black shade cloth fastened semi-permanently inside the greenhouse.
4) automatically controlled curtain system inside of the greenhouse.
5) retractable shading system *above* the greenhouse

The following is a brief summary of the pros and cons of the five alternatives mentioned above.

1. Whitewash the greenhouse roof

—is economical to buy
—can be difficult to remove
—may need to be reapplied after a rainstorm
—shades crop even during low light levels (i.e. early morning, late afternoon, overcast days) even though the crop could tolerate all available light at those times, thus *reducing the crop's growth and quality.*
—is a yearly expense to buy, spray on, and wash off.
—can permanently reduce the light transmission of your greenhouse covering.
—can introduce chemicals into your ground water runoff either from the whitewash, or from chemicals used to remove the whitewash.
—cannot be used to reduce heating costs in the winter

2. Black shade cloth fastened semi-permanently over the greenhouse

—shades crop
—is economical
—can be dangerous to install
—wind can cause shade cloth to have abrasive effect on poly (may void warranty on poly?)
—shades crop even during low light levels, thereby reducing crop growth, and quality
—stops light from entering the greenhouse, thereby reducing heat build-up inside the greenhouse
—cannot be used to reduce heating costs in the winter

3. Black shade cloth fastened semi-permanently inside the greenhouse

—is economical to buy
—is easier to install and remove than black shade cloth fastened over the greenhouse.

—does not affect roof covering
—shades crop even during low light levels
—can shade crop even more during the early morning and late afternoon. Shade cloth can generate a level of shade higher than its rating when the light comes from a low level of incidence, i.e. early morning and late afternoon.
—cannot be used to reduce heating costs in the winter
—Can actually increase crop and soil temperature.

A test was done in southern Florida to determine the effect on plant and soil temperatures of using black shade cloth inside a greenhouse. Plant and soil temperatures were first monitored in a freestanding, 35 ft. wide, double poly covered greenhouse without any black shade in it. The greenhouse had open sidewalls to ensure maximum air movement. After that, 65% black shade cloth was installed in the greenhouse at the bottom cord level. Plant leaf and soil temperatures were again monitored and it was noted that the plant leaf and soil temperature increased by 5° F. instead of decreased. This is contrary to what one would have expected.

4. Curtain system inside the greenhouse
—minimum yearly labor cost with respect to shading.
—does not affect the light transmission of, nor have an abrasive effect on the greenhouse covering.
—does not use paint or chemicals.
—can be used to reduce heating costs in the winter
—will positively affect the quality of light that the crop receives, i.e.:
a.—diffusion of light
—using the fabric with the clear strips between the aluminum ones, will create additional diffusion of incoming light.
b.—re-reflection of light
—using the fabric with the aluminum strips will help increase the amount of diffused light that your crop receives. Some of the light that enters the greenhouse is reflected back up off of the plants, benches and walkways. The aluminum underside of the fabric reflects some of this reflected light back down towards the crop. If you had black fabric inside the greenhouse above your crop, this reflected light would be absorbed rather than reflected.
c.—Ensures that you are only shading the crop when it needs to be shaded. Retracting the fabric during low light levels maximizes plant growth by maximizing the light that the plants receive.

5. Curtain system above the greenhouse

—provides similar benefits of retractable shade as the curtain system inside the greenhouse

—is not efficient for heat retention ·

—is better at cooling than a curtain system inside the greenhouse.

Given that the primary difference between a curtain system inside or above the greenhouse is daytime cooling, it will be addressed in more detail in the following section titled "Daytime Cooling."

When analysing these alternatives to daytime shading, the analysis ultimately centers on the use of either "fixed" or "movable" shading. One grower in California did a test to monitor the amount of light that plants received in a greenhouse that was shaded with whitewash versus plants located in a house with an automatic shading system. The results were as follows:

—the plants in the whitewashed greenhouse received approximately 6 hours of sunlight at an intensity sufficient for plant growth.

—in the house with the automatic curtain system, the plants received an average of 9 hours of sunlight at an intensity sufficient for plant growth.

—consequently it can be said that the crop under the automatic curtain system received *50% more hours of light sufficient for growth than the crop inside the house that had whitewash on the roof.*

—considering that plants can only process into growth a limited amount of light (if they receive too much light then the plants either burn or "shut down" due to overheating, (heat stall) then it appears that if you want the plants to grow faster, it is better to increase the number of hours in the day that the plants get sufficient light to grow, rather than to try to give them more light than they can tolerate.

To help you understand the concept of fixed and retractable shade, there are three graphs in Figure 1 that show the difference in the amount of light that the plants would receive depending on whether fixed or retractable shade was used.

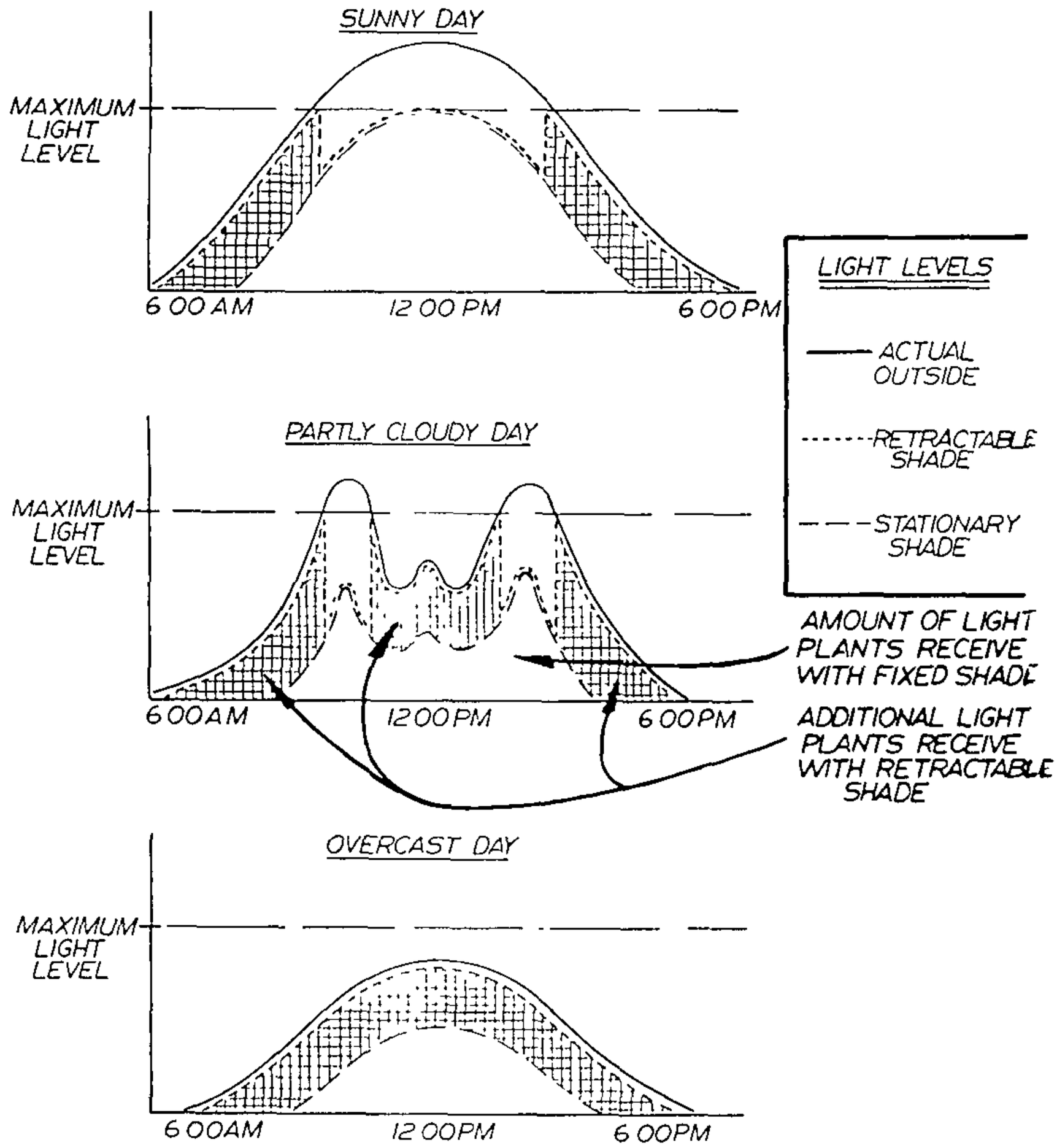

Figure 1. Comparison of light levels inside the greenhouse using stationary shade vs a retractable shade/cooling curtain system

DAYTIME COOLING

When trying to cool a greenhouse, there are five basic alternatives and combinations thereof:

—fans and cooling pads
—fans and side vents
—fog
—roof vents (natural ventilation)
—curtain systems

Normally, a greenhouse already has some sort of ventilation system, either roof vents or side vents. A curtain system is then typically never installed in a greenhouse without some sort of ventilation system already in place. Consequently, it can be said that the curtain system will always be used for cooling in conjunction with a ventilation system.

As mentioned in the "Daytime Shading" section, when it comes to cooling, the most important aspect of the curtain system is the fabric selection. The level of cooling that you will achieve with a curtain system is mostly dependent on your selection of fabric. This is comparable to the idea that the greenhouse covering is what primarily determines the environment inside the greenhouse.

Both the greenhouse covering and the fabric used on the curtain system have an effect on:

—light transmission
—light diffusion
—heat retention
—cooling
—humidity

Since an aluminized fabric is one of the best fabrics for reflection, (and the higher the reflection, the better the cooling), the following discussion concerning the use of curtain systems *inside* greenhouses for cooling is based on the using of an aluminized fabric.

When new, white fabrics can also have a high degree of reflection, but they tend to get dirty faster and, consequently, they become less effective in cooling a greenhouse the longer that they have been installed.

See "Daytime Shading" section for a discussion of why black shade fabric should not be used inside a greenhouse for shading and cooling.

One of the major benefits of using a retractable curtain system for cooling instead of fixed shade is as follows. When you install fixed shade for shading and cooling, whether it be whitewash or shade cloth, the right shade factor must be selected. If, for example, you choose 50% shade, the problem arises that 50% may not be quite enough for proper daytime cooling. However, 50% shade *is too much shade* in the early morning, late afternoon, and during overcast conditions. To select a 65% shade for the sake of better

cooling would definitely slow the plant growth down too much, so one would probably stick with the 50% shade. With fixed shade, one could say that the plant is never getting the right amount of light. Not enough in the morning, too much in the middle of the day, and not enough in the late afternoon.

With a retractable curtain system for shading and cooling, a fabric with a 65% shade could safely be used. The system is retracted during the early morning, the late afternoon, and during all overcast conditions. Finally, when the sunlight is excessive, the curtain system is closed, shading the plants with a 65% shade thus cooling the plants sufficiently to maintain growth.

CURTAIN SYSTEM INSIDE GREENHOUSE

The following is a summary of the benefits of what some greenhouse operations have achieved by using an interior curtain system for daytime cooling.

Increases cooling efficiency of ventilation system.

A curtain system reflects a high percentage of incoming light back up, thereby minimizing the amount of light that accesses the plant level. This reduces the amount of heat at the plant level that the ventilation system has to expel from the greenhouse.

At one greenhouse operation in San Antonio, Texas, the following was observed on a summer day (in a double poly gutter connected range, with and without a 50% shade aluminized curtain system), when the outside air temperature was 100° F.

Air temperature:

—inside air temperature, using pad and fan cooling, WITHOUT curtain system: 95° F.

—inside air temperature, using pad and fan cooling, WITH curtain system: 83° F.

Soil temperature:

—soil temperature WITHOUT curtain: 90° F.

—soil temperature WITH curtain: 85° F.

Consequently, an air temperature drop of 12° F and a soil temperature drop of 5° F was realized simply by closing the curtain system.

Shading and cooling of crops are not only required in the south. There are greenhouse operations in the northern U.S. States, and Canadian Provinces, where soil temperatures of 100° F. have been observed. In Ontario, Canada, a glasshouse with pot mums dropped the soil temperature 5° F. when the curtain system with a 50% shade aluminized fabric was closed.

The monitoring of the soil temperature is becoming even more critical with the number of crops being grown in flats and 4 in. pots. The less soil in a container, the faster the soil temperature will rise,

the faster the plant will shut down from overheating, and consequently the greater the need for proper cooling.

Reduces power consumption.

Using a curtain system to assist in daytime cooling can also help reduce your electric bills by reducing the number of fans that need to be operated to attain a certain level of cooling. During periods of maximum heat loading, the curtain system will help maintain cooler temperatures while the fans are running at maximum capacity. As the temperature drops, the cooling system will drop to a lower stage of cooling, thus shutting off several banks of fans. This not only will reduce electrical costs but also extend the life of the fans.

Reduces water consumption.

From the greenhouse operation in San Antonio to a greenhouse in Michigan, operators have experienced between a 40 to 50% drop in water consumption in the houses where they installed a curtain system and used it for daytime shading and cooling.

This not only reduces the cost to buy water, but it also:

—reduces the amount of fertilizer that is used

—reduces the potential for groundwater contamination

—reduces the cost associated with hand watering

—can allow for expansion if on a limited water supply

Increased employee comfort and productivity.

Employees tend to be happier and more productive in an environment where there are cooler temperatures (by greenhouse standards) and where the lighting conditions are less intense, i.e. diffused light. Greenhouse owners in the southern states can now have their employees work for a full day in the greenhouse without excessive fatigue. As the labor force continues to get smaller and more expensive, it is becoming even more important to provide better working conditions.

CURTAIN SYSTEM ABOVE THE GREENHOUSE

In the southern climates, it has been apparent that most growers have a bigger problem trying to cool their greenhouses rather than heat them. In these cases, a curtain system above the greenhouse usually makes more sense than a curtain system inside.

The primary benefits of a curtain system above the greenhouse instead of inside are as follows:

1) **Maximum cooling.** Sun is prevented from getting access to the greenhouse roof covering, consequently the solar gain is minimized.

   The air space between the curtain and the roof covering minimizes the radiant heat transfer. When black shade cloth is fastened on top of the roof covering, the radiant heat transfer into the greenhouse can be very substantial.

Fabric is porous to the air so that the heat that does build up underneath the fabric can pass through and escape.

Reduces cooling problems created by bug screening vents. Bug screening drastically reduces air movement necessary for cooling. The curtain system above the greenhouse stops a large percentage of heat from entering the greenhouse. This will reduce the amount of air flow required to maintain a given level of cooling.

Due to the air space between the shade system and the greenhouse roof, black shade cloth can be used on the curtain system while still maintaining adequate cooling. If required, an aluminized fabric can still be used for even better cooling. This is especially effective in high heat, high humidity locations where pad and fan, and fog are not as effective.

The distance between the shade and the plants is maximized, (it could be 2× greater than a curtain system inside a greenhouse.) This allows for twice as much air volume that must be heated up before the air at the plant level heats up.

2) **Reduces humidity.** This method reduces reliance on evaporative cooling. During periods of marginal cooling the cooling pads or fog can be run at a lower stage of cooling since the curtain system above the greenhouse is reducing the amount of heat that enters the greenhouse, and consequently the amount of heat that needs to be removed.
3) **Extends the life of the roof covering.** The curtain system above the greenhouse shades the roof covering everytime there is high U.V. exposure, which is when you need the curtain system closed for cooling. The fabric from a curtain system never touches the roof covering so that the roof covering will never suffer any mechanical abrasion, unlike when shade cloth is fixed on top of the roof covering.

Unfortunately, the existing greenhouse designs only allow for the curtain system to be installed above two types of greenhouse structures, gutter connected sawtooth style greenhouses, and free standing quonset greenhouses. This is due to the fact that the curtain system needs a member above the greenhouse. As the greenhouse structure designs develop over time, there may be designs of gutter connected greenhouses that are not sawtooth that may accommodate these curtain systems. In any event, if you are planning to build a greenhouse with a curtain system above it, clear the structural design with the curtain system supplier before you build the greenhouse.

NURSERY EQUIPMENT—PAST, PRESENT, AND FUTURE

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This presentation is on equipment. What has been used in the past, what is being used presently, and a peek into the future. Colorama is a color grower and therefore this presentation will be slighted toward such but, nevertheless, will give you food for thought when and if you decide to mechanize/automate.

PAST

In the past we have seen many types of greenhouses—some makeshift—but mostly wood-framed with glass. Seeding was done in any type of container available. Soil mixing was done by hand until loader buckets for tractors came out. Potting was all by hand as was fertilization until later studies indicated the benefits of soil incorporation of fertilizers. Material transport within the nursery was mostly by hand, again with help from push cars, wagons with horses, or wheelbarrows. The transplanting of seedlings was definitely by hand, a tender touch being needed. Spraying was by hand sprayers; a lot of times weed hoeing was pursued. Product delivery was by any means available.

PRESENT

As our industry progressed further, greenhouses are presently being manufactured out of durable lightweight materials, with coverings of plastics of various forms lasting for many years. Glass and aluminum houses are being constructed over the world using better glass, and are becoming more and more popular due to the ultimate longevity of the materials. Automatic shading systems are currently being used along with automated blackout curtains for daylength sensitive crops. Computerized climate controls are becoming popular, but the big push on automatics has not started as of yet. HID-lites are coming into their own now, allowing growers to maximize daily growth. Seeding is definitely moving towards plugs, aided by the use of automatic seeders capable of sowing over 140,000 seeds per hour on manifold type seeders and over 500,000 seeds per hour on rotary drum type seeders. Soil mixing will stay at the present time with tractor type mixing, cement drum mixers with a move towards complete systems that start out with raw ingredients at one end and at the other end comes a complete,

chemically correct mix. Potting presently is still done manually, but some growers are utilizing pot filling machines, flat fillers, automatic potting machines that have the capacity to singulate, fill, dibble 6,000 4 in. pots per hour. Fertilizers will remain presently with soil incorporation and injectors, both electronic hybrid type and piston type injectors. Slow release fertilizers are coming back strong due to nitrate runoff problems.

Material transport within the nursery now is by electric carts with racks, small tractors with wagons. Some nurseries utilize trailers that accommodate the actual shipping racks, loaded directly onto the trucks—less handling of product. More and more moving belt type conveyors are being used, faster, reliable, less labor.

Transplanting now is still done by hand in some nurseries, in others the use of robotic transplanters is coming in. Additionally, moving belt transplant stations are being utilized. Machines that set the pace, cut labor costs.

Spraying presently is still done by hand, using current equipment. The improvement I see here is in the chemicals themselves, not necessarily the equipment. Although, electrostatic sprayers, foggers, and low volume mist (LVM) units are being tried as we speak.

Product delivery I touched upon briefly on material transport with a more concentrated effort being pursued with rolling racks and lift gates. These eliminate the need for a helper to go with the driver, plus the driver does not work as hard.

FUTURE: *THESE ARE THE EXCITING TIMES!!*

Greenhouses will be totally climate-automated, computer-controlled, ebb and flow irrigated. Longer lasting glazings will become available.

Seeders will be faster, more precise placement of seed. A move toward direct seeding in finished product size. More growers converting to plugs, either purchased or self-produced. Soil mixing will head towards self-contained full line mixing units. Potting will see improvements on the present machines via electronic scanners coupled to robots.

Fertilizing will be coupled with recycling systems, all being run by computers that will adjust all chemicals, pH, and EC levels, also sanitizing the water with heat or ultraviolet tunnels.

Material transport within the nursery will be improved by more moving tables, more conveyors, and trolley systems plus robots to go directly into the beds to retrieve an order—all computer aided.

Futuristic transplanting is here now. These automatic/robotic transplanters take the plug (seedling) out of the plug tray and plant directly into finished product size. The only improvements seen are

the addition of electronic scanners to sort transplants and to give faster operation.

As far as spraying equipment, more interest and movement towards electrostatics and low volume mist (LVM), although there are concerns of air pollution with the LVM units.

Lastly, product delivery will be improved by use of computers to route shipment, especially in high traffic areas. The times of known congestion can be programmed into memory, then the computer can route accordingly, giving time and fuel savings.

In conclusion, our industry has grown by leaps and bounds; it is time we ask ourselves how a certain piece of equipment can save us money. The right equipment can do a uniform job and save money on labor, thereby keeping costs down. The flip side to any piece of equipment is who is going to run it, who is going to service it? How long will this machine run until repairs are necessary, to name just a few. Ultimately, do I really need this particular piece of equipment and will I always have a plentiful supply of labor available? But remember, just because you have automated, does not mean you do not have to periodically check everything.

VOICE: This is to Richard Vollebregt. I would like to know if there are any differences in the light transmission qualities among the different greenhouse covering materials you discussed.

RICHARD VOLLEBREGT: The light transmission of Dynaglas is 92%. All of these materials have been tested in light chambers, but the real test is after they have been on the greenhouse roof for many years. Dynaglas has been on greenhouses for about 5 years in California with excellent results. The twin-wall polycarbonate has 89% light transmission. It has a warranty for 10 years, but I believe you will see 20 years useful life from it, but dropping to 72% light transmission in its later years. Polycarbonate is flame retardent with self-extinguishing properties.

LOREN OKI: Question for Richard Wilson. On your fog applicators for pest control substances in greenhouses, are you able to use them for general applications or only for specific substances?

RICHARD WILSON: We do not have that system as yet. But in that particular unit you can run both powders and liquids but the

powders become very abrasive. Basically any emulsifiable concentrate can be used, but I would not buy one yet until the EPA considers this system for a while due to air pollution possibilities.

VOICE: Question for Richard Vollebregt. Would you clarify the situation you mentioned in how moveable shade cloth controls the temperature in large shade houses?

RICHARD VOLLEBREGT: I am talking about a 1, 2, or 3 acre shadehouse. With open side walls and a fixed-roof you tend to get hot spots in the center. The cooling effect from the sidewalls will only go so far before the temperature increases, but by having retractable shade on the roof, you can expose all the plants in the entire shade house to exactly the same environment, so you get uniformity throughout the entire shadehouse range.

VOICE: Question for Richard McMann. On the new clear plastic, what is its life expectancy? Not the double wall material.

RICHARD McMANN: They are both polycarbonate materials, and both have ultraviolet inhibitors. They both have a condensation control built on the lower side of each panel. Both should last about the same length of time, at least 10 years.

RICHARD CRILEY: All speakers have touched upon the advantages and positive aspects of these shading systems. What kind of problems have arisen with them?

RICHARD VOLLEBREGT: Problems encountered are: (1) How does the system treat the fabric when the curtains are opening and closing. (2) Limit switches that stop the travel in either direction. The latest type is one that counts revolutions of the drive shaft and starts or stops by this method rather than by contacting something at the end of the run. (3) Problems with chain drives or cables that stretch over time. But, today, with well designed and engineered equipment, the curtain shade systems are very reliable, and all can be controlled by computers.

MIKE POYNTER: Could one of the speakers cover some of the considerations for using retractable exterior systems for heat retention and frost control, particularly the height of the posts?

RICHARD VOLLEGREGT: The closer the curtain system is to crop the better the heat is held to the plant, but the system must be high enough so as not to be hit by fork lifts, trucks, etc. The higher the

curtain the better the summer cooling, but the lower the curtain the better the heat retention in winter.

STEVE McCULLOCH: We are interested in automatic transplanting machines. How many are now available and what are the inherent problems?

RICHARD WILSON: There are only two that I know of in the U.S. and they are just coming into production. There is one model in Holland, but you have to buy all the related equipment—plug trays, etc. Someone in your organization must be knowledgeable of the equipment adjustments. It sells for $40,000 but will pay for itself in 5 months, replacing 10 workers.

VOICE: Can these machines tell the difference between a cell with a plant in it and an empty cell?

RICHARD WILSON: No, they cannot, but in a year or two scanners will be added to give this capability, but it will slow down the pace.

INTERNATIONAL CITRUS NURSERY PRODUCTION AS IT RELATES TO *PHYTOPHTHORA*, VIRUSES, AND GROWING MEDIA

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Several important factors must be considered before growing citrus nursery stock in the world. Climate and available useable irrigation water are critical. Most citrus is grown between 20° and 45° latitude N, and 20° and 40° latitude S. To propagate and grow citrus, two of the most significant challenges have been *Phytophthora* diseases and citrus viruses. The threat of *Phytophthora* can be reduced by using tolerant rootstocks when possible, and practicing preventative sanitation.

Phytophthora diseases of citrus (gummosis, root rot) attack the root system and/or the trunk. Depending on soil, moisture conditions, and treatment, the affected tree may die quickly, or make periodic attempts at regrowth. Contaminated citrus seed can be a source of *Phytophthora* infection. The extracted seed needs to be heat-treated in agitated water at 52° C (127° F) for 10 min. The seed is then dusted with a protective fungicide and stored in poly bags at 3° to 7° C (35° to 45° F).

Growing media used in the nursery must be free of *Phytophthora* organisms harmful to citrus. It has been proven that decomposed pine bark affords some antagonistic effects on the development of various plant pathogenic fungi, including *Phytophthora* species (3). Media can be fumigated under plastic tarps with methyl bromide to kill fungal organisms. Aerated steam could also be applied.

Contaminated river water used for irrigation of nursery stock must be decontaminated of plant pathogenic fungi and nematodes by extensive filtration and chlorination (3).

Copper-containing footbaths at the entrances of various sections of the nursery and greenhouses can limit spread of *Phytophthora*. Vehicle-tire-drive-thru-copper-containing troughs can limit outside contamination.

Citrus rootstocks selected for their high degree of tolerance to *Phytophthora* continue to play an important role. 'Carrizo' and 'Troyer' citrange, *Citrus* × *macrophylla*, and trifoliate orange have shown high tolerance to *Phytophthora*.

Use of the systemic fungicides, methalaxyl (Ridomil) and efasite aluminum (Aliette), have been proven to be effective at controlling gummosis and root rot of citrus caused by *Phytophthora*. Neither chemical should be used as a substitute for soil fumigation in the

nursery. Using systemic fungicides in nursery stock known to be heavily infected with *Phytophthora* will probably result in healthy-appearing nursery stock, but will only serve to distribute *Phytophthora*-infected plants to growers (5).

California has a long-standing concern for the protection of citrus. It was the State of California that enacted in 1881 the first law establishing a plant quarantine. The first registration program for citrus, by the California Department of Food and Agriculture (CDFA) was started in 1937 for trees inspected and found free of psorosis. Prior to this time, very little was known about citrus virus diseases (1).

The discovery in 1939, of a quick-decline disease of sweet orange on sour orange rootstock in southern California, ushered in an era of concentrated attention and research on citrus viruses. Quick-decline has its most serious effect on sweet budded to sour orange. Young trees may wilt and die within a few months after infection (quick-decline) when tristeza-infected budwood is used—or will linger for a number of years, making poor growth before death. Extensive indexing by the CDFA in the 1950s revealed that tristeza (quick-decline) had been spread by vector and transported by budwood or nursery stock to most commercial citrus areas in the Los Angeles area. As a result, the psorosis program was amended to include indexing for tristeza and another virus disease, veinenation.

Recognizing the fact that citrus was highly vulnerable to several diseases spread by budwood and insects, the Citrus Advisory Committee asked the University of California to assume responsibility for developing and maintaining a foundation-variety planting of scion and rootstock cultivars that would be virus-free and true-to-type. The University accepted this challenge, and in 1957 inaugurated the Citrus Variety Improvement Program (CVIP). In 1977 the program was renamed The Citrus Clonal Protection Program (CCPP), to more accurately reflect the activities of the project.

Citrus selections to be placed in the program, are very extensively tested or indexed for all known citrus viruses before they are cleared for planting in a Foundation Block at the U.C. Lindcove Field Station near Visalia, California. If the desired selections are found by indexing to be virus-infected, they are subject to either shoot-tip grafting or heat treatment, to obtain virus-free plants. Following 2 to 3 years of fruiting by the newly-propagated trees, usually at about 5 to 6 years of age, the individual trees are registered and can serve as source of scionwood for propagation of nursery-increase blocks, mother-block trees, or propagating certified nursery stock directly. Figure 1 shows the flow of a citrus selection through the CCPP to the nursery and to the grove.

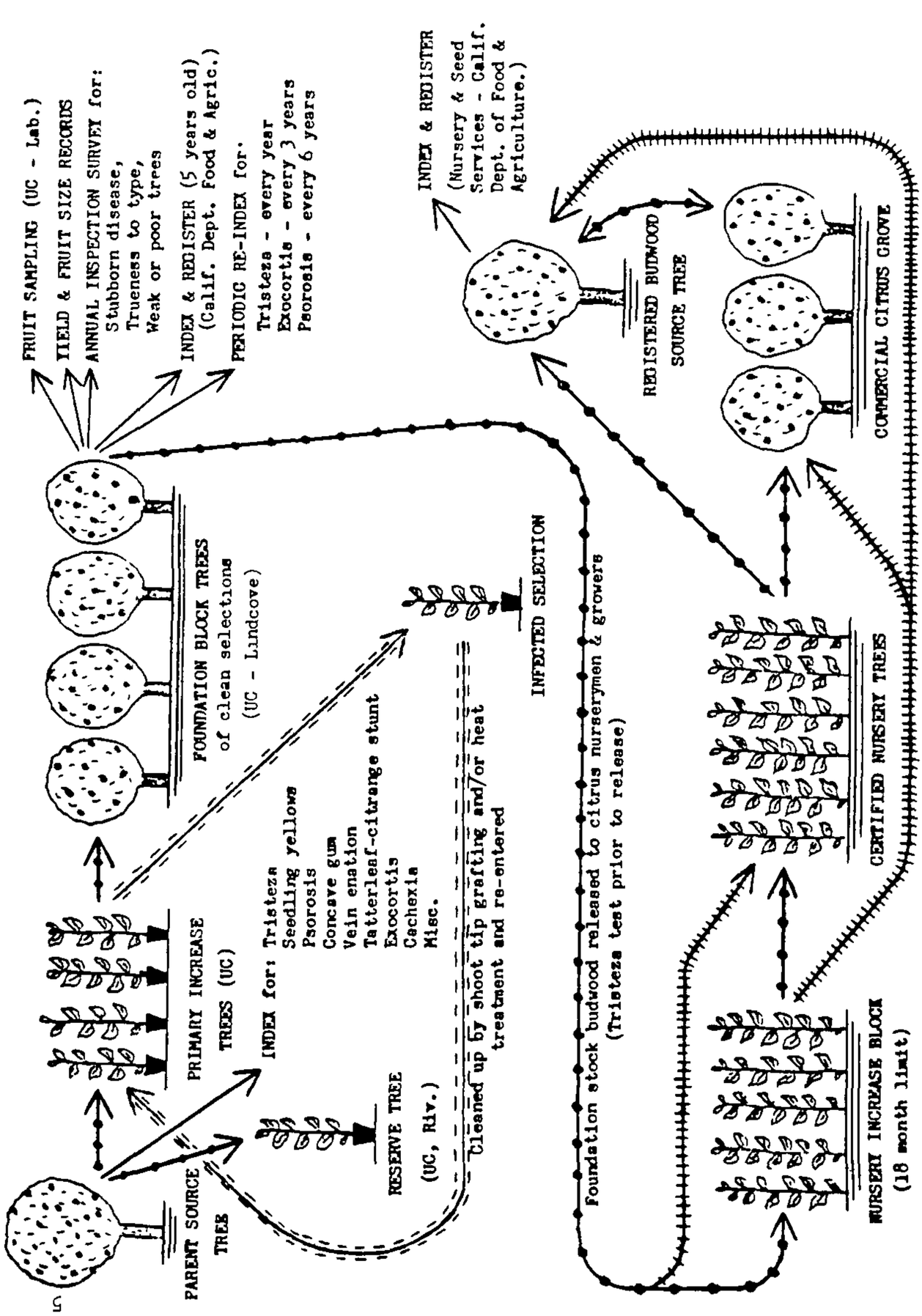

Figure 1. The California citrus clonal protection program. Diagram of Steps and Procedures

As a direct result of this integrated program of research and services, psorosis has been virtually eliminated from California. Exocortis is declining rapidly, especially in new plantings, and one of the major tristeza-free areas of the world has been maintained in the Central Valley of California.

World-wide, citrus nursery stock has historically been field-grown and either bare-rooted or field-dug with soil attached to root ball. The past 10 years have shown a trend from field to container growing.

Since container-growing is a trend, and since we are exclusively growing citrus in containers at our nursery, my focus will be on that challenge.

An ideal growing medium should fulfill certain physical and chemical requirements. Most California nurseries use a mixture of pine or fir bark with coarse sand or decomposed granite. Bark fulfills the majority of good growing medium components. In addition, it can be milled to the required particle size distribution and is extremely light. The main disadvantage of bark is that if it is not correctly composted, toxicities due to water-soluble tannins or organic acids can occur, resulting in growth stunting and, in severe cases, even tree dieback (4).

Composting causes these tannins to be bound in forms not soluble in water For composting to take place water, nitrogen, and air are required. The media should be turned at 4 to 6 weeks, and ready for use in 2 to 3 months Composted media at least half bark (by volume) has moderate (desirable) cation exchange.

The moist, hot, oxygenated conditions in an active compost pile are just right for killing plant pathogens. They are either killed outright by the heat, or they become food for other microbes. Most weed seeds are also killed if the temperature is high enough (2). The pH should be between 5.5 and 7.0.

The air-filled porosity (AFP) of a growing medium is the percentage of its volume that contains air after it has been saturated with water and allowed to drain. AFP is a measure of how much air is available to the roots and is, therefore, an excellent means of determining the suitability of the physical properties of a growing medium. Citrus, when grown in coarse sand, reacts favorably to AFP ranging from 12% to 20%, while lower values are more suitable to early seedling growth.

The water-holding capacity (WHC) of a growing medium is the volume of water retained just after it has been saturated with water and allowed to drain. WHC should range between 150 and 250 ml/l of media.

A growing medium should have a good balance between AFP and WHC. This ensures sufficient oxygen for root respiration without

dieback due to desiccation. If drainage is impaired, not only will an environment be created which is conducive to *Phytophthora* and *Fusarium* root rots, but root growth will also deteriorate (4).

World citrus growing currently covers 3.2 million hectares. With an expanding output of 60 million metric tons, citrus ranks second only to grapes (64 million tons) in world fruit production. While citriculture is carried out in more than 70 countries, only 20 account for 90% of total yield. Only about 10 countries have a budwood program, controlled with virus-free buds available.

Brazil has recently taken over top ranking in citrus production from the USA, whose industry has dropped to second place due to diseases, freezes, and ever-increasing urbanization; these have brought American citrus growing to a standstill.

Brazil (650,000 hectares of citrus; 12.2 million tons produced) mainly exports concentrated orange juice. Nurseries are growing some 18 million trees annually, at about $1.50 per tree. Government control of budwood sources started with the revival of the citrus industry after tristeza rampaged through orchards in the late 1930's. The time had come to recognize nucellar selections. Recently, the disease, ''declino'' is killing 8 to 10 million trees per year in Brazil at age 15 or 16 years. Rootstocks have changed from Rangpur lime (resistant to drought; high-quality fruit) to Sweet orange and Cleo mandarin.

Brazil has maintained research stations that produce clean budwood to satisfy the tremendous requirements for their expansion of citrus growing.

The major citrus-producing states in the USA are California, Arizona, Texas, and Florida. Each state has a good program of maintaining blocks of virus-free budwood (except tristeza in Florida, which is wide-spread). Strict quarantines regulate movement of budwood between states.

Florida is losing about 3% of its citrus each year due to blight (this disease is not well understood).

Spain, 3rd in world production, (254,000 hectares, 5 million tons) exports 80% of its production of fresh fruit. Because of tristeza, sour orange as a rootstock has been restricted since 1972, except as a stock for lemon. To date, approximately 10 million trees have been killed by this virus, now controlled in new plantings with resistant rootstocks.

Spain conducts one of the world's model programs AVASA, the Association of Nurserymen, produces clean budwood at a farm outside the regular citrus area, where it is free from tristeza. The new disease-free orchards in Spain contrast with the poor old groves. Since 1983, a quarantine program based on *in vitro* studies exists.

Because of severe strains of tristeza and good vectors Africa and Australia pre-immunize their bud source trees with a mild strain of tristez. The severe strain, known as stem pitting in South Africa, when attacking grapefruit shortens the tree's life by 20 years (total tree life 12 to 15 years). Both countries have government-indexed budwood sources, optionally available to nurserymen.

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PROPAGATION OF *CARICA PENTAGONA*

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INTRODUCTION

Carica pentagona belongs to the same group of plants as the papaya. It has a thick, fleshy trunk. Its leaves and fruit alike are held on stalks from the trunk. The plant itself looks very tropical with its heavy green trunk and palm-like foliage. It grows as a single trunk unless pinched or nipped by a heavy frost. It then becomes multiple, having as many as four or five trunks. Although it seems very tropical, when grown properly, *Carica pentagona* seldom dies from a winter freeze in Southern California. More than likely problems will be related to heavy soil or excessive moisture in the winter months.

Unlike most tropical papayas, *Carica pentagona* does not need male and female plants and requires no cross pollination. The small fruits are already set as the flower opens. Ripe fruit can reach a weight of up to six or seven pounds. It can be left on the plant to ripen, or picked when the fruit just begins to turn yellow and ripened indoors. Another attribute is that the fruit is seedless and has no hollow center cavity. To become palatable, sugar, honey or other juices should be added to enhance flavor.

Little is known about the origin of *Carica pentagona* in its native Ecuador [a synonym is C. × *heilbornii* V. M. Badillo var. *pentagona* (Heilborn) V.M. Badillo]. It was discovered in the early part of the century by explorers in the remote high altitude valleys of the Andes Mountains where, until then, it was known only by the Ecuadorians. In the 1950's, the plant was brought to New Zealand, where it found great acceptance and thrived in the sub-tropical climate. Sometime in the early 1970s, *Carica pentagona* found it's way to California, where it was grown by a handful of rare-fruit growers.

PRODUCTION OF STOCK PLANTS

For optimum cutting production, it is beneficial to grow stock plants in containers. This allows the versatility of moving plants into the greenhouse for the winter and to the shadehouse for the outdoor growing season. Greenhouse-grown cuttings do not root as well as the fresh spring and summer shade-house growth. It is also important to use a light, fast draining mix and feed frequently as *Carica pentagona* is a heavy feeder.

CUTTINGS

Cuttings should be prepared 3 to 5 in. in length. Ideal cutting stock will be 3/8 to 3/4 in. caliper; however, *Carica pentagona* stumps can be rooted almost as large as they can be found. Cuttings from the perimeter of the plant with short internodes tend to root better than growth from the inner shaded structure. Tip cuttings as well as internodal cuttings can be rooted, but should be stuck in separate flats because tips tend to sprout before they root and should be treated separately. For best results, cuttings should be completely defoliated, leaving only a short petiole of ¼ in. If foliage is left on the cuttings, the petioles are very long and tend to drop almost immediately and rot in the flat. Cutting flats should be new or cleaned of all debris and sterilized. Standard plastic propagation flats are recommended. Rooting media should consist of approximately ten parts coarse perlite and one part peat moss. Cuttings have also been successfully rooted in straight coarse perlite. Hormone powder containing 8,000 p.p.m. of IBA is recommended. Results with liquid IBA are varied, as it seems that many of the carrier solutions are too strong and tend to burn the base on the soft, fleshy cuttings.

ENVIRONMENT FOR ROOTING

The best environment for rooting is a plastic covered bench inside a shaded greenhouse. Temperature should be kept between 75° and 85° F. Cuttings kept too hot or too cool do not respond as well as cuttings kept within this 10 degree range. After cuttings are set into the bench, a light solution of captain W 50 and Benlate is recommended as a fungicidal drench before closing the cover. Relative humidity should be maintained between 80 and 90%. Under these conditions callus begins after 5 to 7 days and healthy roots are noted after three weeks.

PLANT PRODUCTION

After cuttings are rooted and removed from the tents, they are hardened up for one to two weeks before potting. A 4 in. pot is used, which provides adequate room for rapid foliage and root development. Plants are moved out to the shade house after two weeks or so and shortly thereafter, are ready for field planting for fruit production or shifting into a larger container for sale to the retail trade.

SUMMARY

Carica pentagona is a unique new fruit. Oftentimes it is misunderstood when the fruit is treated like that of a Solo papaya or Mexican papaya. Ornamentally, the plant is quite beautiful. When the fruit is prepared properly, *Carica pentagona* will be met with great acceptance in Southern California as well as in other subtropical areas where it can be grown.

SOME FACTORS AFFECTING ROOTING OF CUTTINGS

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Within the past 60 years, there has been tremendous advances made in the field of plant propagation. During this time, we have seen the isolation and utilization of auxin (IAA and others), the development, with all of its modifications, of the intermittent mist system, the use of polyethylene plastic, growing plants in containers, and many physiological/biochemical research findings in plant growth and development. Because of this, today we root many of our species, cultivars, and clones by cuttings, which years ago were unrootable.

Plants are rooted from cuttings to preserve the genetic (clonal) characteristics, is a fast method of increase, is relatively cheap, and is relatively simple (6). Many plants today are grown from cuttings. Factors affecting the rooting of cuttings fall into three very broad categories; one is the anatomical relationships of where the new (adventitious) roots emerge; another is the physiological or biochemical aspects of the internal workings of the cuttings, which causes it to root or not to root; the third is the environmental aspects, which are the cultural and environmental manipulations performed on the plant before, during, and after the cutting is stuck. Root initiation and development is the interaction of many factors.

Juvenility. Woody perennial plants go through a juvenile phase before maturing and going into flower. This juvenile phase may last 40 or 50 years. Juvenile wood usually roots much easier than wood from mature plant parts. On a plant that has reached maturity, the more mature branches will be nearer the top of the plant. Lower branches tend to be more juvenile and have a tendency to root with greater ease.

The following methods have been shown to retain juvenility in a plant and therefore could increase the rootability of cuttings.

1. Very hard pruning or heading cuts: The resulting branches may be rejuvenated. The cuttings of these generally form adventitious roots much easier.
2. Adventitious buds will produce shoots that are more juvenile in character. This can be buds sprouting from around large pruning cuts or buds sprouting from roots or root cuttings.
3. Grafting a mature scion onto a juvenile rootstock may cause the scion to revert to more juvenile characteristics. This can be done in serial fashion.

4. Tissue cultures, especially when a number of subcultures are made, will eventually provide very juvenile (very easy-to-root) shoots. (For a more complete discourse on juvenility, see Hackett (4, 5).)

Etiolation and Banding. Etiolation is growing plants in either total darkness or very heavy shade. Banding is the use of 2 to 3 in. wide tape around the base of the cutting to etiolate or blanch the stem. It has long been known that etiolation and/or blanching can increase the rooting of some difficult-to-root plants (3, 7, 8).

Stock Blocks. Stock beds for the sole purpose of supplying cuttings and scionwood for propagation materials are used in Europe more than in the United States or Canada. While stock blocks may take space away from production, they can increase efficiency in the production of plants and uniformity of the plants themselves. Advantages of stock blocks include:

1. Ease of management, particularly when timing of cutting taking is critical.
2. Plants may be managed so cuttings are uniform and, therefore, subsequent crops may be more uniform.
3. Ease of monitoring the plants' health.
4. History of plant and management procedures of the stock plant is known.
5. Stock block plants may be maintained to produce the type of cutting wood needed and when it is needed. These procedures may not be the same as those used on production plants.
6. More juvenile, easier-to-root, cuttings may be produced.

Cutting Water Status and Rooting of Cuttings. Cuttings when taken are detached from and devoid of any root system, thus they develop water deficits. The greater the deficit, the less likely the cutting is to root. Control of water deficits within the cutting should be one of the prime objectives in any propagation scheme. The relatively recent development and use of polyethylene film and intermittent mist system has lessened some of the internal water deficit problems in cuttings and has greatly expanded the scope of the plants which can now be propagated by cuttings.

Some of the factors affecting water loss from cuttings are:

1. *Temperature:* Temperature increases around the cuttings can decrease the relative humidity. Higher temperatures may also increase respiration rates, which may deplete carbohydrate reserves and retard the rooting processes.
2. *Humidity:* At high relative humidities the humidity gradient between the leaf and the surrounding air can be small. Propagation systems, i.e., polyethylene tents, mist, humidifiers, etc., attempt to keep the humidity around the cutting leaf/stem as close to 100% as possible.

3. *Foliage wetting:* The wetting of cutting foliage has certain advantages and certain disadvantages. Evaporation from the leaf surface cools the cutting, reducing respiration. Water may be absorbed through the leaves, reducing water loss from the leaf surface, and may reduce evaporative demand from the leaves, thus conserving internal water. Excessive watering can leach needed nutrients from cutting leaves. Excessive water can also lead to increased disease incidence from a wet, poorly aerated rooting medium.

Root Promoting Substances. The naturally occurring root promoting substance, auxin (indole-3-acetic acid or IAA) was first reported in 1934 (9). Later, indole-3-butyric acid (IBA) and 1-naphthaleneacetic acid (NAA), two synthetic compounds, were shown to have root inducing activities on cuttings. Since IAA is naturally occurring, the plant has the ability to endogenously synthesize this hormone and also has the ability by enzymes to destroy this material. Because IBA and NAA, other derivatives of these two, and a few other compounds with root-inducing properties are synthetic or foreign to the plant's biosystem, the plant cannot destroy these as readily as IAA. Therefore, the effect of the synthetic root-inducing substances in generally considered to be longer lasting. Except for physiological research and tissue culture, IAA is now used very little as a root-inducing substance.

IAA, IBA, and NAA, plus their derivatives, are essentially insoluble in water and are usually dissolved in an organic solvent such as alcohol (methyl, ethyl, or isopropyl) or an alcohol water solvent. The potassium (K) salts of IAA, IBA, and NAA are water soluble and are as effective as the organic acids (1).

Relatively new compounds with root-inducing properties include some aryl and thioaryl esters of IBA. These have the advantage of being synthetic, are just as effective as IBA, and are considerably less toxic than IBA. (1, 2).

There are three methods of application of root-inducing substanccs to cuttings to enhance adventitious root formation. These are:

1. Root-inducing substances thoroughly mixed and suspended in an inert material, such as talc. While this method is effective, it can be messy. The amount of root-inducing substance actually applied is also variable, as this depends on the degree of wetness of the cutting and physical characteristics of the cutting (smoothness, hairiness, roughness, etc.).
2. Concentrated Dip: The cutting is dipped into a solution of the root-inducing material. The solvent is usually organic or at least partially organic. The advantages of this method is uniform application with some penetration into the stem tissue. The

range of application concentration is about 500 to over 10,000 ppm.

3. Dilute Soak: The cutting is put into a very dilute solution of the root-inducing substance for a period of six to 24 hours. Concentrations range from two to about 200 ppm. The dilute soak method is seldom used but may be beneficial for rooting of small batches of cuttings or extremely difficulty-to-root plants.

The rooting of cuttings has taken giant leaps forward in the last fifty or so years. We are now rooting plants that used to be impossible to root. Knowing some of the basics, observing plant growth and behavior, and gathering as much information as possible beforehand, can lead to rooting of many plants which are now considered difficult.

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WESTERN REGION CURTIS J. ALLEY AWARD OF MERIT

Presented by Joseph Solomone, Western Region President

The recipient of the 1990 Curtis J. Alley Award of Merit was born in 1927 in Seward, Nebraska. He was raised on a farm, graduated from Seward High School in 1943, then attended University of Nebraska, College of Agriculture, Graduating in 1947. His first work after college was as County Extension Agent from 1947 to 1951. He left to serve in the United States Air Force for four years, returning to the Extension Service in 1954. He owned and operated a farm supply for two years before relocating to Oregon in 1957 and taking a position as Marion County Extension Agent in Urban Horticulture for Oregon State University. His job scope changed to include Land Use Development and County-wide zoning programs, in addition to horticulture.

In 1963 he took a sabbatical leave to obtain his Master's Degree in Agricultural Extension at Purdue University, then returned to Oregon to continue his career and spend more time on nursery and greenhouse programs.

He became Staff Chairman of Marion County Extension Office in 1974 but retained his program work with nurserymen as well.

In 1984 he became Secretary-Treasurer of IPPS Western Region while doing consulting work in the field of horticulture and teaching classes at a community college on Plant Identification, Nursery Certification, and Landscape Maintenance. Under his guidance, IPPS Western Region experienced outstanding membership growth, sound financial management; the meetings were well-attended as well as informative. Our award winner has very good communication and guidance skills in working with the officers, directors, and committee members. We, especially his fellow officers and committee members, can really appreciate how valuable and indispensable he is as the best ever "Watchdog of the Western Region".

He also serves on the Board of Directors of Berry Botanic Garden in Portland, Oregon, and is an active member of the Native Plant Society; he is also on the advisory board of Cecil & Molly Smith Rhododendron Garden.

In addition to his many career pursuits, he has made time for a photography hobby, (which helps with presentations for teaching and entertainment of various community groups), has 26 years perfect attendance at Keizer, Oregon, Rotary Club, sings with the Salem Madrigal Singers, is an active member of the First United Methodist Church, and plans to publish a Bluhm family history during 1991 after many years of genealogy research and writing.

He and his wife, Mary, of 37 years have 3 adult children and 3 grandchildren.

Please join me in congratulating Wilbur L. Bluhm, winner of this year's Curtis J. Alley Western Region Award of Merit.

WESTERN REGION LIFETIME HONORARY MEMBERSHIP AWARD

Presented by Joseph Solomone, Western Region President

One of the highest honors an IPPS Region can give is to award one of its members a "Lifetime Honorary Membership". This evening I have the pleasure of making this presentation.

This "Honorary Membership" category is for those individuals who have made outstanding contributions to the field of plant propagation, and who have made equally outstanding contributions to our Society for at least 10 years.

Our Awardee has become a worldwide leader in tissue culture production of woody plants. His research to develop a tissue culture laboratory has set the groundwork for further experimentation and innovation in plant production systems.

Innovation exemplifies his commitment to the future of the nursery industry. He is an excellent reminder that the learning process is not confined within university walls. He has spent a lifetime being inquisitive. If he needed an expert, he found one. He has surrounded himself with strong young minds full of new ideas.

Development of the woody plant tissue culture technology and the tissue culture laboratory at his nursery is an excellent example of his commitment to develop, adapt, and integrate research information into a small business. He enlisted Dr. Wilbur Anderson of Washington State University, in cooperative research that led to a breakthrough in woody plant propagation through tissue culture. He notes that the last 10 years have seen tremendous refinements in the tissue culture process, but believes tissue culture will go up many avenues that have not yet been explored.

He has openly and enthusiastically shared information from his research. Since beginning his tissue culture research and production program in 1964, he has published over 20 research reports in publications ranging from the *IPPS Proceedings* to *Acta Horticulturae.*

He is internationally recognized as a leader in the nursery industry. He has been President of the IPPS Western Region; he has

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been an International President of the IPPS; he was named "Man of the Year", and presented the "Outstanding Service Award" by the Washington State Nurserymen's Association; the "Service Award" was presented in recognition of his many years as chairman of the Washington State Nursery Association Legislative Committee. He has served on the boards of the Horticultural Research Institute, National Germplasm for Ornamentals, Rhododendron Species Foundation, University of Washington Arboretum, and the Washington Agriculture and Forestry Leadership, from whom he received the Distinguished Service Award. He has also served on practically all of the committees that the IPPS Western Region has to offer.

As if he has not done enough, he is presently much involved in water issues. I guess one can keep on going, so at this time it gives me great pleasure to present to Bruce Briggs an "IPPS Western Region Lifetime Honorary Membership Award."

PLANT PROPAGATION IN THIRD WORLD COUNTRIES

O. A. "JOLLY" BATCHELLER[1]

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Claremont, California 91711

August and September, 1989, my wife and I served as volunteers in Western Samoa. The Peace Corps had requested a practical horticulturist to assist them with two botanic gardens in this country. Volunteers in Overseas Cooperative Assistance (VOCA) contacted me to go there in what they call the "Farmer to Farmer" program.

Western Samoa is an independent Republic about the size of Rhode Island. It is located half way between Hawaii and New Zealand 300 miles south of the equator. There are two major islands; it has a population of 163,000, imports are $38 million and exports are 17 million in U.S. dollars. The per capita income is $616 US and there is a literacy rate of 99%. It is a truly tropical island with a rainfall of over 100 in., most of which comes between October and June.

With the stream bed dry and no piped water in the 11 acre Botanic Garden when we arrived, I turned to my second objective—that of training workers. Even though the Samoans depend on their agriculture, there are no life sciences taught in the schools. The Samoan's have their own language although most understand a little English. Their language has no words for such terms as cambium, xylem, phloem, auxins, or hormones. As the workers are not fluent in English my lectures and all my notes on the black board had to be translated. This required four or five words for each one I spoke and took a lot of time. This sure threw my usual rapid-fire lectures into chaos.

Machetes were the only tool issued to the crews, until I introduced hand pruners. In discussing plant growth and its control I likened the hormones to the traffic officer in the street intersection. He would not let the cars get out of line. If we removed him out of the intersection then the side buds would grow

Fortunately, three weeks before I had tied several 15 ft shoots of poinsettia to the horizontal. All of the 80 nodes had responded with new shoots, and the students could see that instead of just one blossom at the tip, the shoot would have many blossom. With the pruning shears, saw, and loppers we gave the garden a real pruning job.

Our office was located at the Forest Nursery site where seedling trees were grown in plastic bags for reforesting. It had dependable

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[1] Professor Emeritus, California Polytechnic State University, Pomona, California

water, and a Saran house we could use. When I suggested that we should propagate some plants to be ready when the rains came, I was informed that we could not propagate during the dry summer.

I had been experimenting at our cottage with a "Mickey Mouse Mist System". I had found that water dripped from a height of 5 ft. onto a convex surface would splatter an area about 15 in. across. On the local trash heap between houses I found a quart plastic vodka bottle. With a hot needle I burned a small hole in the bottom. I plugged this with a tapered piece of coconut fiber. By pushing in or pulling out I could control the rate of drip. I found that 8 drops a minute would keep the cuttings moist and the water would last for 6 hours. When I demonstrated this to the workers and showed them the roots on cuttings in 7 to 9 days, you would be surprised at the number of dripping containers that appeared.

When I found that they only got 50% rooting with their cuttings, I made the following suggestions:

1) about two weeks before making their cuttings to girdle the stem at where the basal cut will be made;
2) split or wound the bottom of the cutting;
3) use hormones;
4) in all cases put 3 in. of coarse sand in the hole before placing the cutting.

I understand that where the suggestions have been followed that the rooting response had greatly improved.

There was much interest in budding and grafting, so we began to water stock plants heavily so that we could be sure of an active cambium. Here I might mention that in the Peace Corps you must use A.T. "Appropriate Technology". One cannot use material that is not readily available to the native people. Rubber bands and grafting wax was out. We wrapped the buds and graft unions with toilet paper and either watered daily, or arranged a drip system to keep the buds and graft unions moist at all times. We got surprisingly good results until the local people tore the grafts and bud apart to find out what we were doing. I even grafted *Plumeria,* that has bloomed twice and withstood a disastrous hurricane that swept the island.

Our second experience in a Third World Country was from May 20 to July 20, 1990. North Yemen Arab Republic is 1/3rd the size of California. It is located south of Saudi Arabia, bound on the west by the Red Sea and on the East by the Great Desert. It has high plateaus and mountains to 12,000 ft. It is located 1000 miles north of the equator and has 7.8 million people. Imports a total value of $12 billion US, with exports worth $10 million U.S., mostly agricultural commodities.

The major crop is *Catha edulis*, qat or khat (pronounced gat), a plant whose leaves contain amphetamine (like an "upper"), sold only locally. Per capita income $550 U.S. Literacy is about 20% nationally but just 2% for women. It is amazing that 80% of the country is terraced to catch and hold all of the rain that falls and allow it to get into underground aquifiers. North Yemen is in a serious drought and water tables are dropping fast, about 15 to 20 feet a year.

The soil is mostly a fine clay from calcarious material, alkaline in nature and with water that ranges in pH from 7.4 to 8.5. I was working in the capital, Sana'a, at an elevation of 7,200 ft. The climate was not unlike that of Palm Springs, California, little humidity, and with a nearly constant drying wind.

I held a series of three different lectures and demonstrations of two days each. It was the first time I have lectured to women who were completely veiled. I visited eight government nurseries, seven private nurseries, and seven demonstration farms. All were directly related to deciduous fruit crops. Since 1984 the importation of deciduous fruits has been restricted as the country wishes to become self sufficient in the production of these crops. Rootstocks are either imported or grown from stool beds. With limited water, winds, low humidity, and lack of sawdust, the stool beds dried and plants became sunburned so that rootstock production was less than two plants a foot.

Two government nurseries had crops other than deciduous fruits. One had about 500 rose cuttings planted in plastic bags. Less than 1% rooted. It appeared from the looks of the cuttings that they had not been callused before planting. The other nursery had hardwood cuttings of bouganvillea and quince. These had been stuck in ground beds in a Saran house. The beds were below the walk level so that any surplus water drained onto them. Again, less than 1% had rooted. I was really amazed to find that the budding techniques for chip buds and T-buds were exceptionally good. It was the aftercare that showed lack of understanding of plant requirements

It appears to me that the greatest problem is the literacy situation. I had several of the official bulletins regarding pruning translated, and then with their horticulturists, tried to figure out what I was supposed to do. We could not The drawings in the pamphlet were very artistic, but in no way resembled how plants actually grow. The fruit growers are so scattered that work shops are not practical. The rich owners are not interested and the workers merely follow instructions of the poorly informed owners.

Although the Government Nurseries were supervised by "College Graduates", of the nine supervisors who attended my lecture demonstration sessions, I found all to be really lacking in basic

information of how plants grow and the basic principles of pruning. It appeared to me that the Horticulture section of the Agricultural Ministry lacked strong leadership and drive. Perhaps it was the problem of combining the offices of the two Yemens (as the North and South recombined on May 24, 1990), things were still in a state of transition. Perhaps in a couple of years the situation will get straightened out and a better organization will develop.

One final statement. It surprised me that in the libraries of both countries, copies of *Plant Propagation: Principles and Practices* by Hartmann and Kester, 4th ed., were available.

HYBRIDIZATION OF PLANTS NATIVE TO CALIFORNIA AND BAJA CALIFORNIA IN THE GENUS *DIPLACUS*

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Mildred E. Mathias Botanical Garden
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Diplacus is a genus of about one dozen species or botanical varieties of small shrubs that are native to California and adjacent Baja California and Oregon. As members of the family Scrophulariaceae, they are close to *Mimulus*, but differ chiefly in their woody character. Known as "bush monkey-flower", they often attract attention by their abundant flowering on roadcuts or in recently burnt areas. With one exception the species are freely interfertile so that hybrids, both wild and from plants in cultivation, have long attracted the attention of horticulturists. Past workers have included Van Rensselaer (Santa Barbara Botanic Garden), McMinn (Mills College), Sexton (U.C. Davis) and Lenz (Rancho Santa Ana Botanical Garden). My work began in about 1965 and continued to 1980, with a great burst of activity during the final four years, being supported by a grant from the Elvenia J. Slosson University of California Endowment Fund for Ornamental Horticulture.

SPECIES AND VARIETIES USED IN THE PROGRAM

Diplacus longiflorus is the most common species in southern California. It is characterized by being densely pubescent, and has rather large pale orange flowers that, as in all species of the genus, are produced in pairs—one from the axil of each of the opposite leaves. It tolerates garden conditions as well as any of the others. D. l. var. *rutilus* is found in a few localities and has deep velvety red flowers. D. l. var. *calycinus* is more compact and has pale yellow flowers. It is found higher in the mountains (to 7,500 ft.) and, though not used, should provide cold hardiness to future workers. *D. aurantiacus* ssp. *australis* is similar to *D. longiflorus* but is glabrous and has slightly smaller flowers. It is found in parts of San Diego County and Baja California. With a similar distribution is *D. puniceus*, which has small red flowers and, on some of the offshore islands, grows the closely related *D. parviflorus*, which seems to be well adapted to cultivation. Two species which offer important characters to the hybrids are *D. grandiflorus*, with its extraordinarily large flowers (over 4 cm. across) and *D. clevelandii*, with its golden yellow flowers that have rounded lobes and red dots

in the throat. Hybrids with the latter species have reduced fertility which can be overcome in later generations.

METHODS USED IN BREEDING WORK

To make as rapid progress as conveniently possible, the plants were treated as annuals. Seed was sown in a greenhouse in October or November and, in most years, the seedlings (when about 2 in. tall) were moved bareroot directly into outside raised beds in February. These beds has been prepared by rototilling and fumigating with methyl bromide. The seedlings were watered and fertilized routinely until the end of June, by which time they were in full flower. When the plants were in bloom, it was often necessary to spray with malathion to control flower thrips which, if left uncontrolled, would cause the anthers to abort. Depending on the weather, the plants were watered about once every week or 10 days until the end of July, after which watering was greatly reduced.

Crosses were made, usually in mid-morning, by removing the selected pollen bearing flowers that had opened that morning and squeezing the anthers so that the pollen dropped directly onto the desired stigma. The stigmas of *Diplacus* and related genera are composed of two flattened lobes that close on contact. If they have been successfully pollinated, they remain closed, and, therefore, it is not necessary to emasculate the flower. If it were not for this characteristic, much time would have been necessary to emasculate and bag flowers, and the project would not have been possible. Each flower was tagged after pollination, and the resulting seed was collected in August and September. The pods open primarily with the fall rains, and seed collecting time is not critical. After all seed was collected, the plants were removed to make the beds ready for the following year.

GENETICALLY CONTROLLED CHARACTERISTICS

The objective of the breeding program was to develop a wide variety of plants that combined good growth habit with large well-displayed flowers in a broad spectrum of desirable colors. As the work proceeded, new traits were noted, some desirable and others not. New potentialities were revealed, particularly in bicolored flowers, that future workers can strive to reach. Some of the traits selected for are noted briefly below.

Color. As described by Van Rensselaer (1), a great diversity of flower colors beyond anything seen in the wild is soon revealed in second generation crosses. Attempts to stabilize some of these colors so that they come true from seed was successful in some

instances, while others await future work. Pure white flowers were obtained by combining traits from several near-white wild mutant individuals. An F_2 population from a cross between *D. parviflorus* and a near-white mutant of *D. longiflorus* yielded the whole range of colors seen, but not all of the more subtle shades. Included in this was a yellow that was as intense as that found in *D. clevelandii*.

Flower size. The large size of the *D. grandiflorus* flower can be recovered in a few generations, and some progenies had flowers that were seemingly larger than those in wild plants, but actual measurements were not made.

Width of petal lobes. Two species, *D. parviflorus* and *D. clevelandii*, have broad petal lobes, a characteristic considered desirable.

Margin of petal lobes. *D. longiflorus* and *D. aurantiacus* ssp. *australis* have irregular petal margins, while those of *D. clevelandii* and *D. parviflorus* are entire. In this project selection was generally for entire margins, but some very interesting flowers with irregular margins appeared. *D. grandiflorus* has each petal lobe deeply divided into two narrow segments, a character that was selected against, but could be used to develop interesting flowers.

Throat openness. The throat of *D. clevelandii* is strongly constricted within the tube, a character considered undesirable.

Flower color fading. Some red colors fade strongly in one or two days, while others do not, but no studies that I know of have been made on *Diplacus* pigments. Interesting multicolored effects can be seen on a plant with fading colors.

Nectar guide size and color. At the bottom of the throat there is usually a pair of nectar guides, which varies in width and in color from yellow to dark orange. *D. clevelandii* has a nectar guide composed of red spots, and it may be possible to develop broad red nectar guides.

Color around mouth of throat. An irregular area around the throat entrance may be colored differently from the rest of the petal. There are two patterns that are apparently genetically separately controlled—one that is diffuse and another that is very abrupt. The color of this area may be red, yellow, orange, or white. Through the manipulation of these traits, exceptionally interesting flowers can be developed.

Added flowers. Normally there is a single flower at each leaf axil. Plants have appeared that have a second or even third flower beneath the normal one, these additional flowers opening several days after the original one. This character appears only during periods when the plants are growing and blooming vigorously. By breeding from these plants, the percentages of such individuals in the progenies has been increased, but the inheritance mechanism of this character seems to be very complex.

Short internodes. The internode length varies considerably, and by selecting from individuals with very short internodes, extremely compact plants have been developed that should be useful for bedding purposes.

STATUS OF THE BREEDING PROGRAM IN 1980

At the end of the Slosson grant period in 1980, it became necessary to devote the botanical garden space to other purposes, and bed space in another part of campus was soon to be obliterated by new buildings. At this time significant results had been achieved that are briefly described below:

1. True breeding strains with large flowers in colors of red, orchid, and white had been developed.
2. Sterility barriers of the yellow strains derived from *D. clevelandii* had been overcome, and progenies with a high percentage of large yellow-flowered individuals were obtained, although some orange-flowered plants were still present.
3. True breeding strains with very small compact plants in several colors were developed.
4. Plants that have large white flowers with yellow or orange nectar guides and yellow or orange rings around the throat had been developed, although the strains were not true.
5. Plants that have large white or yellow flowers and red rings in the throat had also appeared.
6. An unusual new clear pink color was developed in a number of plants.
7. Crosses between color strains were yielding a broad diversity of color shades and combinations.

FUTURE WORK

Although time and space do not permit me to continue with this project, work on *Diplacus* breeding, selection, and propagation is continuing both by Mike Evans at Tree of Life Nursery in San Juan Capistrano and by Steve Morgan at the Botanical Garden, University of California, Riverside. Seed stored in the refrigerator since 1980 was planted in 1988 and 1989 and germination was excellent. At Riverside current work is concentrated on selfing plants to concentrate desirable characteristics, propagation, and irrigation regimes. At Tree of Life Nursery, clones have been selected, named, and are being propagated for sale. Future workers should go back to the species to develop such characteristics as increased longevity in the garden, drought and cold tolerance, and additional flower characters and colors.

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COLLECTION AND INTRODUCTION OF BRITISH COLUMBIAN NATIVE PLANTS TO THE NURSERY INDUSTRY

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A new phase of the University of British Columbia Botanical Garden Plant Introduction Scheme (PISBG) has now commenced and will concentrate on selecting and introducing relatively unknown, as well as superior forms, of native species into commercial production for use in the urban landscape. With over 2000 species in the province, there is a rich and varied flora from which to select. The current commercial success of *Arctostaphylos uva-ursi* 'Vancouver Jade', with over one million a year being propagated, has shown the value of selecting improved forms of native plants. Also, there is an increasing interest in using native plants in the landscape as replacements for some non-native species and cultivars.

With support from the B.C. Nursery Trades Association, the Botanical Garden was fortunate in receiving funding of $136,000 (Can.) for a three year project, commencing in 1988, to systematically collect plants showing potential from various areas in the Province. This funding came from the Canadian ARDSA project, a joint federal-provincial program to stimulate new agricultural and horticultural projects showing direct commercial potential. Dr. Wilf Nichols came on staff to undertake this work.

The first objective was to work with industry to determine "target species" of both woody and herbaceous perennial plants—particularly where there is known to be significant genetical variation. These include *Arctostaphylos, Cornus, Anemone, Aquilegia, Balsamorhiza, Draba, Eriogonum, Fragaria, Geranium, Lupinus, Penstemon, Lilium, Phlox, Ribes, Mitella, Rosa,* and *Polemonium*. There is an increasing demand for perennials in North America and particular emphasis will be given to collecting and selecting superior forms of such plants.

This program has a monitoring committee consisting of members from nursery growers, Agriculture Canada, and the Provincial Ministry of Agriculture. However, it is the advice being received by the committee from the B.C. Department of Highways that could be a major factor in its success. This department is a large user of landscape plants, and it is vital that they are included in the

program. The advice they provide is on plants to select, where plants would be used and, more important, the estimation of numbers which would be required in future years. This information is invaluable for growers in planning their production schedules.

Well over 1,000 documented collections have been made from diverse locations in the province. These include northern and eastern B.C., coastal mountains, Vancouver Island and the Gulf Islands, and the Okanagan and Kootenay areas.

Following collection, the plants, cuttings, or seeds are returned to the Botanical Garden's nursery for evaluation and propagation. Among the criteria for selection and potential introduction are:

(1) Overall market potential across North America and for overseas export.

(2) Hardiness, particularly for broadleaved evergreens.

(3) Pest and disease resistance.

(4) Ability to successfully establish and grow under nursery conditions, e.g., to respond to fertilization programs, potting mix, and overhead irrigation. Two very promising plants, *Lupinus lepidus* and *Douglasia laevigata*, have not responded well, thus more research is required as to their cultural requirements. Many species, particularly some herbaceous perennials, come from dry arid areas and are unable to respond to the extremes of climatic conditions in coastal nurseries.

(5) Appearance at point of sale, e.g., herbaceous perennials need to be floriferous particularly during April-May (the major period for retail sales) and compact and tidy after flowering. Clean foliage and compactness are other major considerations.

(6) Successful establishment in the landscape, particularly in areas where water is a limiting factor. Also, they should not become invasive and weedy, which can occur when introducing a dryland plant into moister coastal situations.

The current plant introduction scheme has some seven test sites in Canada and six in the United States. These test sites will provide invaluable information for the performance of ARDSA plants in cold winter conditions and in hot-dry and warm-humid summers.

CLONAL SELECTION AND PLANT BREEDING

Clonal selection is being shown to be an important aspect of this program. The benefit of this was previously shown with *Arctostaphylos uva-ursi* 'Vancouver Jade' which was selected for its vigor, flower and leaf quality, tolerance to foliage diseases, hardiness, and ease of rooting. Prior to this introduction, B.C. nurseries were selling variable quality material obtained by collecting cuttings or saving seed from plants in the wild—the percentage success of rooting was particularly variable.

Vaccinium ovatum is another plant with great variation. Selection is being made on color intensity of the reddish-brown new growth, profusion of flowers and habit. Similarly, *Paxistima myrsinites*, another native evergreen shrub, is being selected for habit and leaf color. Two golden forms and one variegated form have resulted as part of this program. The variable *Rosa woodsii* is a popular shrub for highway planting—an interesting, relatively compact, large, bright pink-flowered form shows considerable promise. The two native *Phlox, P. diffusa* and *P. douglasii*, generate considerable color variation from seed, so distinct colored forms will be selected and named for future vegetative propagation.

A number of hybridization programs will develop under the coordination of Dr. Gerald B. Straley, Research Scientist and Curator of Collections. One cross already carried out has been the native *Philadelphus lewisii* with *P. delavayi* f. *calvescens*, the latter noted particularly for its attractive purple calyxes.

Penstemon fruticosus 'Purple Haze'. Part of the ARDSA program agreement was that the Botanical Garden had to ensure the release of a plant for introduction to its participator nurseries within the three year term of the project. To achieve this, it was necessary to utilize a selection from existing collections in the Native Garden component. With the current enthusiasm for compact, evergreen, purple-blue, spring-flowering container plants, a priority selection was that of *Penstemon fruticosus*, which has received wide acclaim from visitors and growers. Its ease of production and growth habit meant that it was a ''natural'' for the program's first release. This is now being readily propagated in British Columbia nurseries and will be available for public release on March 1st, 1992. (See Appendix A for botanical description, propagation, culture, uses in the landscape, and sales potential.)

In conclusion, the success of this project will largely depend on the Botanical Garden staff working with industry and seeking advice from other interested parties. Increasing awareness of the environment means that native plants for landscape use will become ever more important. Part of the marketing plans is that great emphasis will be placed on packaging and labeling at retail garden centres which, combined with media promotion, will encourage the home gardener to use these plants for their gardens as alternatives for the more standard items. In addition to these collections being important for the Botanical Garden's Native Garden, they will provide a source of valuable genetic material for plant breeding and other related research programs.

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APPENDIX A

PENSTEMON FRUTICOSUS 'PURPLE HAZE'

BOTANICAL NAME: *Penstemon fruticosus* (Accession #11772-284-75)

CULTIVAR: 'Purple Haze'

FAMILY: Scrophulariaceae

COMMON NAME: shrubby penstemon

ORIGIN:
The original plant was collected in 1975 at Nairn Falls, near Pemberton, B.C. by Al Rose, former curator of the B.C. Native Garden, UBC Botanical Garden. It is a common and variable species of dry parts of southern B.C. to Oregon, Montana, and Wyoming.

SOIL REQUIREMENTS: Average, well-drained, slightly acid soils.

GENERAL DESCRIPTION:
An evergreen or partially evergreen sub-shrub to 20 cm tall and 60 cm wide. Opposite pairs of dark green toothed leaves are 2 to 3 cm long and 0.5 to 1 cm wide. Plants are covered with mauve-purple tubular flowers 3 to 4 cm long in late spring, forming a solid mound of colour for several weeks. The mounded form of the plant is attractive throughout most of the year.

EXPOSURE REQUIREMENTS: Full sun. Tolerant of extended summer drought.

PRUNING:
Little needed, but may be lightly pruned from time to time to keep more compact. Should be sheared following flowering during the nursery production schedule.

USE IN THE LANDSCAPE:
Excellent for cascading over rock walls, on well-drained, sunny banks, and in alpine gardens. Useful with other spring-flowering perennial ground-covers such as *Aurinia, Aubretia, Arabis,* and *Iberis.* Should be planted 20 to 30 cm apart when massed in the urban landscape.

HARDINESS: Hardy to USDA (Canadian) Zone 3-4

PROPAGATION:
Readily roots from softwood and semi-hardwood cuttings from June through September. Rooting hormone not necessary, but if rooting should prove erratic, then 0.3% IBA in talc will be beneficial. Use a well-drained rooting medium, e.g., 1:1 peat and perlite. Avoid excessive misting and also remove from propagation facility as soon as rooted to avoid cutting deterioration.

SALES POTENTIAL:
This plant will be an excellent product for impact retail sales during spring, particularly in one gallon containers and upwards. Its hardiness means it will have appeal in many locations in North America. Also, when massed it will provide instant appeal for the urban landscape and on arid roadside conditions. Its mauve-purple flower color is particularly effective with associated yellow or white flowering plants.

VOICE: This is to David Verity. In your talk about *Diplacus*, you explained some of the dwarfing due to short internodes. Did you also include in your work *Diplacus aridus*, which is naturally dwarfed?

DAVID VERITY: This species occurs in the desert here in San Diego county and in Baja California. It is naturally dwarfed and is a very drought tolerant plant. I did make some crosses with it and the results are being grown at the Tree of Life Nursery, San Juan Capistrano, California. *Diplacus aridus* is a species that should be used more for its many good characters.

VOICE: Bruce, about the *Penstemon fruticosus* 'Purple Haze' that you showed, do you think it would grow well in Southern California?

BRUCE MACDONALD: It is difficult for me to say. It would do well in Washington and Oregon. This selection came from Pemberton in British Columbia. It might just burn up in Southern California, but I really don't know.

VOICE: Question for David Verity. Do you know of any species of *Diplacus* that do not have the sticky leaves that tend to limit their use?

DAVID VERITY: I do not know of any species that do not have glutinous leaves. I was hoping to find one. I have grown all the species and they all have it. One could search through all the *Diplacus* plants growing in the wild and possibly find one, then select from that. This is the only way I can think of to get rid of that character.

VOICE: Bruce, How long do you leave your new introductions in the ground for trialling? Secondly, have you had any new plants escape and become a weedy problem?

BRUCE MACDONALD: We like our native plants to be in our collection for seven years, unless there is something unique about it, and we already know quite a bit about it, and the nursery industry wants it. On your second question; yes, we had one *Rubus* from China that became a problem; the birds like the berries and move it around so it can tend to become weedy.

VOICE: My question is to Kathy. What is your connection with the people in Australia so that you can bring in plants?

KATHY: There are a variety of ways that we use. The University of California Santa Cruz Arboretum has been one of the major routes in bringing in plants. Then we introduce them to Southern California. There are other people doing this also. We also get plants directly from Roger and Gwynn Elliott from near Melbourne in Australia. They have their own nursery, the Australian Tube Plant Nursery. Their's is one of the main nurseries promoting Australian plants, especially for overseas trade. Many plants I get are from seed exchange lists from botanical gardens. We have also had plants sent to us from commercial nurseries in Australia. So there are many good sources of plants from Australia.

(Ed. Note — One can contact IPPS Australian Region officers as to sources and contacts for obtaining starts of Australian plants).

ANN KYTE: My question is to Dr. Verity. You said you were treating some of the *Diplacus* (or *Mimulus*) as annuals. By implication, are all of the *Diplacus*, and *Mimulus*, annuals or perennials?

DAVID VERITY: *Diplacus* plants are perennials. I treat them as annuals so as to make more rapid progress in breeding. But they will live for 10 or 15 years. With *Mimulus*, some species are annuals and some perennials.

NEW TECHNOLOGY IN PLANT HEALTH TESTING

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The production of healthy, pathogen-free plant materials is a key objective in propagation operations, but one that is not easily achieved. There are many avenues through which pathogens can infect nursery crops, with one of the most insidious being through the plant material itself. There are numerous examples of viral, fungal, and bacterial pathogens being carried on or in apparently healthy plant tissues. Sensitive methods for detecting pathogens in seed or vegetative propagating materials are necessary to insure high standards of plant quality.

While there have been many advances in virus detection over the years, the methods for detecting bacterial and fungal pathogens are much the same today as they were 100 years ago. Detection usually involves some form of culture-indexing, which can be slow, and may require both specialized laboratory facilities and personnel skilled in taxonomic identifications. These constraints have limited the effort and success of screening programs for fungi and bacteria. But recent advances in biotechnology have led to the emergence of relatively simple, highly effective detection methods, which will undoubtedly form the foundation of future screening programs (4, 6). These methods are quickly moving from laboratory phenomena to commercial realities.

IMMUNOASSAY METHODS

Chief among the new technologies is serodiagnostics. This is a familiar approach to pathogen detection, since antibodies have been used to detect viruses in plants for many years. But the application of serodiagnostics to fungi and bacteria has been far more difficult to accomplish (3). This is because fungi and bacteria are far more complex antigenically than viruses. The antigenic complexity of these organisms has made it very difficult to develop antisera with desired levels of specificity and affinity using conventional methods. However, the recent development of monoclonal antibody procedures has largely eliminated these problems (3, 6), while at the same time enabling large-scale commercial production of a highly uniform antibody product. The utilization of highly specific monoclonal antibodies in sensitive ELISA test formats, has enabled the development of detection kits which are simple to use, and which provide rapid, accurate

detection of their target organisms. Some kits now available require *no* special laboratory facilities and can be performed in a matter of minutes.

While antibodies have been developed recently for a variety of important fungal and bacterial pathogens (e.g. 1, 9), as well as for viruses (e.g. 7) only a few have been commercialized into test kits at this time. I have been evaluating prototype kits produced by Agri-Diagnostics Associates (Cinnaminson, NJ) for the detection of *Phytophthora* spp., *Pythium* spp., and *Rhizoctonia* spp. in nursery plants. These kits are genus-level tests intended to provide broad detection capability. I have found the phytophthora kit to be as effective as culture-plating in detecting several *Phytophthora* species (5). The Pythium and Rhizoctonia test kits appear promising for nursery crops, but will need refinement before they can be used and interpreted effectively in areas outside of propagation.

While monoclonal antibody-based tests offer advantages in speed and simplicity, they also have limitations. For example, some pathogens (e.g. potato spindle tuber viroid) are so simple that they possess no antigenically active components and are impossible to detect by serological methods. Also, antibodies that work well in one assay format, may not work well in another (6), or pathogens may produce different levels of the detected antigen in different hosts or under different environmental conditions. And since the ELISA reaction intensity varies along a continuous scale between "none" to "very strong", one must determine what constitutes a positive test result (8). Background "noise" is common and may vary among plant species and test conditions.

NUCLEIC ACID PROBES

Another detection method that is becoming more common involves techniques of nucleic acid hybridization. Nucleic acid "probes" are developed by extracting and fragmenting nucleic acid (i.e. DNA) from pure cultures of the target organism. A nucleic acid fragment can be inserted into the genome of a bacterium, where it is replicated along with the transformed bacterial genome. Nucleic acid extracts from transformed bacteria are used in hybridization tests to detect the complementary gene in the target pathogen. If the selected gene is unique to the target organism, the probe can be a highly specific detector (2). Furthermore, because the transformed bacteria are typically grown on media amended with ^{32}P to produce radioactive nucleic acid probes, they are much more sensitive detectors than immunological tests. Very little target nucleic acid is required to yield a detectable positive result.

Because of their high degree of specificity, nucleic acid probes can be less subject to background "noise" than serological tests,

but they introduce their own problems. These tests require well-equipped laboratories and radioactive materials can only be used in licensed facilities. There have been efforts to tag nucleic acid probes with enzymes or fluorescent markers to enable wider use, but this invariably degrades test sensitivity. To retain optimum detection capability of the potato spindle tuber viroid in potato seed pieces, Agdia (Mishawaka, IN) has established a centralized testing program, wherein samples are collected in the field, spotted onto membranes and mailed back to the laboratory for radioactive probe analysis. This approach may become more common in the future.

SUMMARY

There are many other diagnostic procedures being developed to simplify and improve the accuracy of pathogen detection, but ELISA tests and nucleic acid probes will clearly dominate the field in the coming years. But even as new diagnostic techniques improve detection capability, they raise questions for which there are few answers. Chief among these is test interpretation. What constitutes a positive test result? Does the presence of a target organism at extremely low levels always indicate a potential disease situation? If reactions are very weak, how can we be sure it is the target organism at low levels, or some other organism which, coincidentally, may have antigens or nucleic acid sequences in common with the target? How can one be sure the tests are detecting a viable pathogen and not residual degradation products of a killed organism? As tests become ever more sensitive, scientists may have to decide if there are acceptable levels of target organisms in plants, much as there are acceptable levels of certain chemicals in human food or water supplies. These are questions which have not been answered because we have never previously had tests *sensitive enough to make them an issue, and researchers have not* had wide access to the tests needed to undertake the necessary experiments.

It also must be kept in mind that these tests are essentially "recognition" reactions. A mutation in a single antigen or nucleic acid sequence in the pathogen could render a test ineffective long before anyone recognizes the failure. But even with their potential ambiguity and fallibility, these tests are far superior to current culture plate methods. This is an area of increasing research activity, and one which will significantly affect those involved in plant health testing over the next decade

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APPLICATION OF MOLECULAR BREEDING TO CROP IMPROVEMENT

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INTRODUCTION

Since the latter part of the 1970s, scientists have proposed that genetic engineering, based on the new recombinant DNA technology, would have a profound impact on plant breeding. Indeed, even more today than a decade ago, technological advances in the field of plant molecular biology make it possible to consider seriously the role molecular genetic techniques will play in commercial breeding programs. This paper presents a brief review of plant breeding strategies and discusses the feasibility of incorporating recombinant DNA technology into conventional plant breeding programs.

BREEDING STRATEGIES

Classical Breeding. Breeding strategies differ for ornamental plants that are seed propagated and ones that are vegetatively propagated. For seed-propagated species the genetically improved cultivar must be either a true breeding inbred or a hybrid cultivar comprised of inbred parents. Breeding programs of these types typically include years of backcrossing and/or selfing to obtain true breeding parents. Hybrid seed production usually is more advantageous than inbred seed as the hybrid is protected from further sexual propagation and generally has more vigor. However, the production of hybrid seed cultivars can be labor intensive and thus costly.

Vegetative propagation is also labor intensive and costly; however, the high cash value of the crops often insures economic feasibility for this mode of propagation. Whereas seed propagation requires true breeding parents, this is not necessary for vegetatively propagated plants. Vegetative propagation leads to a perpetuation of the same genotype with great precision, and an indefinitely large number of genetically identical plants can be obtained irrespective of the degree of heterozygosity. This manner of breeding makes it possible to screen many thousands of highly heterozygous plants in order to find the single most desirable phenotype from a cross and evaluate it in performance trials. A limitation of this manner of breeding is that, due to the high degree

of heterozygosity, it is difficult or impossible to produce isogenic lines.

Classical breeding methods have been very successful in providing the market with a great variety of ornamental species with beneficial attributes. However, in spite of the achievements, classical breeding has limitations. Foremost among these is that the breeder is unable to alter traits in a directed manner; genotypes are seriously disrupted by crossing. Breeders cannot manipulate genes independently; and, if linkage is tight, the breeder may never be able to backcross in a certain cultivar to achieve a particular phenotype.

Another limitation confronting the breeder is the limited number of traits within the gene pool of any species. For example, no plant species possesses the genetic capacity for producing the full spectrum of flower colors nor resistance against all diseases. There are some traits which the breeder will never be able to manipulate through a sexual cross.

Mutation Breeding. Mutation breeding has been used as an approach to introduce new traits by changing a single gene or a few genes (1, 8). The spontaneous mutation rate in nature is very low, on the order of 10^{-6} to 10^{-7}, for any particular gene. Although in some cultivars the spontaneous mutation frequency can be high enough to find sports or naturally occurring mutations. Chemical and physical techniques are used to increase the mutational frequency to a level that permits detection in a manageable number of populations. Chemical mutagenesis has had limited success and is most useful with seed-propagated species rather than vegetatively propagated species. Ionizing radiation, Xrays, and gamma rays have been used successfully for mutation breeding in vegetatively propagated crops. The majority of commercially successful introductions in the ornamental industry have been flower color mutants and form and size mutants.

Despite the successes of mutation breeding, the method is not always reliable nor predictable. In many instances the high frequency of deleterious mutations, the presence of chimeras and the widespread occurrence of gross chromosomal changes has made the establishment of stable breeding lines difficult and time consuming. Somaclonal variation has been suggested as an alternative to mutagen use (3). Plants regenerated from somatic cells via tissue culture can express genetic variability, either transiently (epigenetically) or in a stable fashion. If the mutations are stable and desirable, they could be used in a breeding program.

Molecular Breeding. Molecular breeding, the application of recombinant DNA technology to conventional breeding, is seen as the means to introduce more precision into plant breeding

programs. Recombinant DNA technology permits direct gene transfer and enables the breeder to introduce single genetic changes into superior cultivars and to preserve intact the elite genotype. For seed-propagated crops this capability may possibly decrease the number of years, which is typically 10 to 15 years, needed to produce superior cultivars. This molecular approach would eliminate linkage problems and allow the breeder to cross sexual barriers in search of new genetic variation.

Technology advancements make direct gene introductions feasible, but there are significant limitations to molecular breeding, one of which is the expense of the technology. While significant progress has been made in gene isolation and manipulation, there is a paucity of cloned and characterized genes that would have a direct impact on such major agricultural issues as disease and pest resistance, stress resistance, control of maturity and flowering, control of morphological traits, and yield. With classical breeding techniques it is possible to manipulate a large number of genes (polygenic traits) simultaneously. This is especially important when breeding for inheritance of genes that control quantitative traits such as yield, vigor, and maturity. With molecular breeding it is an impossible task to manipulate multiple genes; current technology constraints limit molecular breeding to single gene changes.

The number of economically important crop species that can be efficiently transformed and regenerated is limited at this time. However, the transformation and regeneration of recalcitrant plant species will most likely be accomplished in the near future by one or more of several recently developed technologies such as microprojectiles (6). The recent report of *Agrobacterium tumefaciens*-mediated transformation and regeneration of chrysanthemum (9) demonstrates that molecular breeding may be practical in the future breeding of important ornamental crops

Traditional plant breeding has already been impacted by molecular techniques with the advent of restriction fragment length polymorphism (RFLP) analysis. The development of RFLPs offers a tremendous potential to construct detailed linkage maps, to identify quantitative trait loci (QTL), to analyze genome organization, and in cultivar fingerprinting as a means of identifying and protecting proprietary germplasm (4, 7). An application of this technology to floriculture is the construction of an RFLP linkage map in rose (5).

IMPORTANT TRAITS FOR CROP IMPROVEMENT

In general, the most valuable phenotypic traits in ornamental species include resistance to diseases and pests, productivity, plant growth and habit, flowering response, flower color and shape, and

postharvest physiology attributes. Resistance to diseases and insect pests is undoubtedly the phenotypic trait that is the most important to the industry. For the ornamental industry the aesthetic quality of the plants is the measure used to gauge yield. Chemical control is becoming increasingly more scrutinized by both regulatory agents and the public. In the future the industry may be limited to a much smaller number of chemicals with reduced effectiveness. The establishment of effective integrated pest management programs and the breeding of resistant cultivars is essential to the industry.

Increased resistance to several plant viruses has been demonstrated by the engineering and expression of viral coat protein in transgenic plants (13). *Bacillus thuringiensis* (BT) toxin expression in transgenic plants is seen as a means to control those insect pests which are affected by the toxins (2). Both of these technologies could be extremely useful in ornamental plants as a means to effect virus and insect control.

Phenotypic traits such a senescence, flower morphology, flowering, and growth habit are controlled in part by plant hormones. The biochemistry and physiology of hormonal responses are not well documented. Among the many hormone biosynthetic genes only 1-aminocyclopropane-1-carboxylic acid (ACC) synthase has been cloned (12). In those plant species in which senescence is controlled by ethylene, it may be possible to extend vase life by engineering ethylene resistance.

Flower color manipulation is the area that molecular breeding in ornamental plants may have an immediate impact. The reason for this is that the biochemistry and genetics of the anthocyanin pathway have been well characterized. In addition several genes in the pathway have been cloned and characterized. Several successful approaches for manipulating flower color in *Petunia* × *hybrida* have been reported (10, 11, 14).

SUMMARY

Since the beginning of this century plant breeding programs have introduced a tremendous amount of genetic diversity into crop species from which superior genotypes have been selected. Molecular breeding is not envisioned as an alternative to conventional breeding, rather, it is perceived as yet another tool for the breeder to create and analyze genetic diversity in a more directed fashion. Clearly there are still technological hurdles that limit the role of molecular techniques in ornamental breeding programs. A decade ago plants could not be transformed routinely, yet the past ten years have witnessed significant technological achievements that give hope that this technology will have a role in future plant breeding programs

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MYCORRHIZAL INOCULATION OF CONTAINER PLANTS

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INTRODUCTION

The majority of the work reported here took place at Tree of Life Nursery, which produces about 300 species of California native plants for both horticultural and revegetation purposes.

With the revegetation plants, especially, we are concerned that they leave the nursery in a condition that will allow them to survive the rigorous conditions of a land restoration job. Those conditions include no irrigation except natural rainfall, little or no fertilization, and minimal help against weeds and herbivorous animals. For that reason we have established a program of inoculation with mycorrhizal fungi.

WHAT ARE MYCORRHIZAE?

Roots of most field-grown plants are found to contain fungal tissue. The fungi may form a cloak around the root, or may exist as individual strands (hyphae) among the root cells, but in each case the fungus extends from the root into the soil. These fungi are known to be beneficial for the plant. The association that they form with roots is called mycorrhiza. The word "mycorrhiza" refers to the association of both organisms, not to the fungus by itself. The plant is called the "host plant," and the fungus is referred to as the "*mycorrhizal fungus.*"

Mycorrhizae of several types differ from each other in the kinds of fungi that enter the root and the details of the fungus-root-interface. Two of the several kinds of mycorrhiza are most likely to be of concern in the nursery. These are ectomycorrhizae (ECM) and vesicular-arbuscular mycorrhizae (VAM).

ECM mycorrhizae are found primarily in the dominant trees of temperate forests and in a few genera in the tropics. Among California natives, examples of ECM host plants include chamise, oaks, pines, willows, and cottonwoods. The fungi form a layer around short side roots, and ectomycorrhizae can often be seen with the unaided eye. Many of the fungi of ECM produce mushrooms or other large fruiting structures.

The most widespread type of mycorrhiza is vesicular-arbuscular mycorrhizae (VAM). This kind of mycorrhiza was named for two kinds of characteristic structures: vesicles, which are globular oil-

storage organs, and arbuscules, which are finely-branched fungal networks within the cells. In the arbuscules, the fungus passes phosphorus to the host plant, and receives carbohydrates from the plant. This mutually beneficial exchange is the fundamental feature of the mycorrhizal symbiosis.

VAM are found in most crop, ornamental, and native plants, and their fungi are the most abundant microorganisms in many soils (8). The fungi can infect a very wide range of host plants. The same species of VAM fungus may be associated with liverworts, ferns, and maple trees; thus one or a few species of fungus may serve an entire plant community. Host species among California native plants include grasses, *Ceanothus* spp., most members of the legume and rose families, and many others. VAM are not normally visible without special staining and magnification.

Other kinds of mycorrhiza are found in the Ericaceae, Orchidaceae, and several small tropical families. California native plants with their own kinds of mycorrhizae include *Arctostaphylos* spp., Madrone, and *Rhododendron* spp. Harley and Smith (7) gave detailed descriptions of the known kinds of mycorrhiza.

It is clear that most kinds of plants, when growing in their natural habitats, are host to one or more of these kinds of mycorrhiza. Although numerous accounts have been published of the mycorrhizal status of various plant species, the list is far from complete.

The most important kind of mycorrhiza for the nursery trade is VAM, because it is by far the most widespread type, and because the natural dispersal of VAM fungi is slow. Ectomycorrhizal fungi often are carried by the wind, but the very large VAM fungal spores must move by animal vectors or movement of soil. These fungi must be intentionally introduced if the plants are to benefit from the mycorrhizal symbiosis.

WHAT ARE THE BENEFITS OF MYCORRHIZAE?

The growth response that can be brought about by mycorrhizae is legendary. Inoculated plants commonly show growth rates double or more those of comparable uninoculated controls. The increased growth rate is the result of enhanced mineral nutrition.

Mycorrhizae greatly improve uptake of phosphorus (and probably zinc and copper) because of spatial distribution of the hyphae; the fine, branched fungal filaments. The root removes phosphorus quickly from a zone near the root surface, but because phosphorus moves through the soil very slowly, a zone of depletion forms around the root. The mycorrhizal hyphae cross the depletion zone and take up phosphorus that is beyond the reach of the unaided root (20).

The special ability of mycorrhizae to take up phosphorus is of interest in the nursery. Not every nurseryman is aware that soilless mixes, unlike natural soils, allow phosphorus to be leached out. Not many modern nurserymen would consider rock phosphate for serious nursery use, but Graham and Timmer (6) showed that within the first five weeks of a 16 week experiment, rock phosphate was a better source of phosphorus than superphosphate.

To be efficiently used, rock phosphate has to be added in large amounts. Rock phosphate is inexpensive when purchased in bulk, and can be safely applied in large quantities. However, it must be used in combination with mycorrhizae. The mycorrhizal fungi make the otherwise unavailable rock phosphate useful to the plant (6). In our experience, osmotically-coated slow-release fertilizer has provided a steady supply of phosphorus, and has been compatible with mycorrhizae. A low-P, slow-release formulation with a long release time, combined with vesicular-arbuscular mycorrhizae inoculation has solved some phosphorus-related problems that have plagued us seasonally for several years.

It is difficult to avoid a boom-and-bust cycle when highly soluble phosphorus is used, because the superphosphate is leached out with irrigation. While a mycorrhizal program is necessary when rock phosphate is used, a mycorrhizal program is very difficult with superphosphate, since the high initial phosphorus concentration inhibits mycorrhiza formation. Later in the cycle, soilless media cannot retain even the relatively low concentration of phosphorus needed by mycorrhizal plants.

There have been reports of mycorrhizal benefits other than improved phosphorus nutrition, including better tolerance of transplanting (2, 13) and higher drought resistance (17, 18). Mycorrhizal plants perform better in saline conditions (14), and may be more resistant to pathogens (19). Some of these "non-phosphorus" effects of mycorrhizae may actually be side effects of improved phosphorus nutrition.

Mycorrhizae do not enhance the uptake of nitrogen (4), but do aid nitrogen fixation by improving the phosphorus supply. Both leguminous (9) and actinorrhizal (16) nitrogen fixers have been shown to perform markedly better when mycorrhizal.

Mycorrhizae have important effects in the soil, beyond their effects on individual host plants. Mycorrhizal fungi are important agents of soil structure (21) because their hyphae bind soil particles into aggregates.

Mycorrhizae have brought about important advantages in the nursery, such as relief from phosphorus-induced stunting (10). However, the main focus of a nursery's mycorrhizal program should be the performance of the plant after it goes into the ground.

Inoculating in the nursery improves the chances of good transplant recovery and early growth. It also insures against a complete lack of native mycorrhizal fungi at the site, as occurs on recently graded or severely eroded ground.

WHAT IS MYCORRHIZAL INOCULUM?

Inoculum is material that carries viable propagules of mycorrhizal fungi. This usually means a combination of fungal spores, root fragments, and mycelium. Inoculum may be purchased from a commercial supplier, produced in-house by a nursery (5, 12), or collected from the wild. Commercial sources of mycorrhizal inoculum are generally the most sensible option. NPI of Salt Lake City, Utah produces a VAM product called "Nutri-Link." Mycorr Tech, Inc., of Pittsburgh, Pennsylvania, produces several ECM fungi in liquid culture. Other suppliers of each kind of inoculum have been in production at various times. Tree of Life Nursery is producing inoculum for in-house use, and is considering offering several isolates for use by other nurseries.

VAM inoculum can be produced in-house, although the process brings with it several unexpected difficulties. The fungus must be grown with a living host plant, usually in greenhouse cultures. Host plants for this purpose are most commonly fast-growing tropical grasses, which produce abundant spore crops in summer conditions. Lower quality inoculum can be produced in winter greenhouse conditions, but only by shifting to a host (such as celery) that tolerates short photoperiods. The container medium must be relatively low in nutrients to encourage the spread of the fungus rather than rapid top growth of the plant. It is very important that the amount of phosphorus be low in relation to the supply of cations and micronutrients. The balance between phosphorus and nitrogen, which can also be inhibitory to mycorrhizae, is particularly sensitive.

The culture medium should be steamed since the cultures have to be free of unwanted soil organisms. The mix must be formulated with components that are free of "autoclave toxicity," toxic forms of manganese and other factors that can greatly reduce plant growth.

Container-grown inoculum is harvested after two to six months, depending on conditions, and may be chopped up for storage and handling. Inoculum is usually stored in a refrigerator, where it may be expected to retain most of its viability for several months. If the inoculum has been mixed with nursery potting medium, the bulk mix must be sheltered from harmful conditions. Deleterious influences include extremes of temperature, such as may occur in a mix made with "green" organic matter. The inoculum should not

be allowed to dry to extremely low moisture content, or to experience excess moisture, which will encourage the growth of pathogens.

INOCULATION IN THE NURSERY

To initiate a mycorrhizal inoculation program, the nurseryman must make several important decisions:

- Which plant species are to be inoculated?
- What kind of mycorrhiza do they normally support (ECM, VAM)?
- What species of mycorrhizal fungi are appropriate for the intended uses for the plants?
- At what stage will the inoculation be carried out?
- How will the inoculation be carried out?
- How much inoculum will be required for each plant?
- What special care should be exercised during growth of the plants?
- Will the grower "certify" mycorrhizal plants at the time of sale?

CHOICE OF PLANTS AND FUNGI

Pines, oaks, willows, and a few other groups of plants are ECM hosts, and members of the family Ericaceae have several specific kinds of mycorrhizae. Most plants have the VA type of mycorrhiza; thus a plant of unknown mycorrhizal status should be assumed to be a VAM host.

The fungi should also be chosen with care. Every species of mycorrhizal fungus has a range of tolerance for each environmental variable, and it follows that some fungi will be preferable to others in any given set of conditions. The most important considerations determining suitability of the fungi are pH and other soil properties. Since the primary objective is performance after outplanting, mycorrhizal fungi should be chosen for conditions in the field rather than the nursery.

In the final analysis, most nurseries will have to choose fungi primarily on the basis of availability. A commercially available VAM fungus known to occur naturally in slightly acid soils is *Glomus etunicatum*. For neutral to slightly basic soils, *Glomus intraradices* is available commercially. As demand for mycorrhizal plants grows, other fungi may become available for unusual or difficult conditions. Our own objective is to pre-inoculate container plants with a mixture of fungi native to the vicinity of the intended planting site.

MECHANICS OF MYCORRHIZAL INOCULATION

Inoculation may be carried out at the germination or rooting stage, at an early transplant, in the final container, or at the time of outplanting. The earlier stages are preferable because maximum benefit is realized from inoculation of plants early in their lives. Most host plant seedlings can support mycorrhizae as soon as lateral roots have appeared. Inoculation in the seed or cutting flat would give the best early boost to plant growth, and can hasten development of roots (1, 11, 23). However, inoculation at that stage may be impractical if fungicides must be used to control damping-off. After performing several tests on timing of inoculation, we have found that the first transplanting is the most practical time to inoculate.

Highly concentrated inoculum, such as that available from commercial sources, may be mixed throughout the potting medium, or a small amount of inoculum may be introduced separately to each pot. The amount required per pot is a function of the quality of the inoculum and should be based upon the supplier's recommendation. For VAM spore inoculum about 300 spores per plant has been effective (5), but hyphal and root fragments are often more important propagules than spores. The inoculum is placed in the center of the pot, just below the roots. The roots should be in contact with the inoculum as the soil is pressed in place.

Larger plants already in their final containers may be inoculated in place by cutting into the root zone, where future growth will carry the roots through the inoculum.

Inoculation in an outdoor nursery bed can be carried out by banding (introducing inoculum into a slit cut in the soil beside a row of growing plants). Riffle and Maronek (15) discussed various means of inoculating ECM fungi with basidiospores, which can be applied in hydromulch, mixed into soil, dusted onto seedlings, or pelleted with seed in a clay carrier.

CARE OF MYCORRHIZAL PLANTS

In order to assure that mycorrhiza formation proceeds smoothly, certain key steps in plant growing are modified to accommodate the symbiosis.

The conditions of light, temperature, and moisture that promote photosynthesis and root growth in host plants are generally the conditions that promote colonization by mycorrhizal fungi. However, mycorrhizal plants are sensitive to fertilization. Close control has to be maintained on concentrations of nitrogen and phosphorus during the establishment phase. One form of fertilization that has worked well is resin-coated slow release

fertilizer, such as Osmocote 18-6-12 (Sierra Chemical Company, Milpitas, CA). Comparable products rated for eight or more months are likely to work as well. The fertilizer should be incorporated at the manufacturer's lowest recommended rate. Supplemental feeding may be carried out as needed by top-dressing with the same slow-release material, or with soluble nutrients if the immediate needs of the plants are not exceeded. Nitrogen and phosphorus are both potentially inhibitory. No sacrifice of growth rate need be accepted, but it will be necessary to apply fertilizers with precision.

Sometimes the nursery's potting mix will have to be modified for compatibility with mycorrhizae. Media consisting only of organic materials, or solely of soil conditioners such as sand, perlite, or vermiculite, have often been unsatisfactory (3), but any of these can be useful as components of the medium. At the liner stage, we have successfully used a medium consisting of about 40% organic materials (bark, shavings, and sawdust of redwood, white fir, or pine) and 60% inorganic amendments (#2 and #3 perlite, vermiculite, and sand). Peat moss is a common source of trouble, with some peats giving good results and others inhibitory to the symbiosis. Soil or clay components in the potting mix appear to improve colonization, but are not required. Any soil components should be tested for toxicity that may develop as a result of steam pasteurization. The pH of the mix must be adjusted to match the optimum pH of the mycorrhizal fungus. Most commonly used VAM fungi will colonize roots if the pH of the medium is near pH 6.5.

Many pesticides can be inhibitory to the symbiosis (22); care should be taken in selecting and applying any pesticides that must be used. Fungicides are generally the most damaging. A few examples of fungicides that are thought to be compatible with ectomycorrhizal (ECM) fungi are benomyl, captan, and subdue. Examples of fungicides that appear to be compatible with vesicular-arbuscular mycorrhizal (VAM) fungi are copper sulfate and subdue. Because conditions and dosages vary considerably, tests of each pesticide should be carried out in-house before large-scale pesticide applications are undertaken.

Another potential problem is soil temperature, especially when plants are grown outdoors without shade. Mycorrhiza formation may be reduced or inhibited by high temperatures in the growing medium.

CERTIFICATION OF MYCORRHIZAL PLANTS

Certification of mycorrhizal plants is a valid concern when mycorrhizal container plants have been specified for a restoration or revegetation job. Certification requires an independent laboratory that is prepared to evaluate the mycorrhizal status of

sample material. We have approached a commercial soil laboratory about a certification program, but at this writing the program has not yet been in place.

CONCLUSIONS

The result of our mycorrhizal work has been routine production of mycorrhizal plants, focusing on a few key species. The best approach for each nursery, and the means for solving practical problems will depend on the grower's objectives and on the specific circumstances. The important generalities about a mycorrhizal program at a commercial nursery can be summarized:

- Mycorrhizae are natural part of the life of most plant species.
- Mycorrhizae aid uptake of nutrients and enhance drought resistance, thus helping to make plants less dependent on irrigation and fertilization.
- Mycorrhizae may provide immediate benefits in the nursery, but the primary objective of the program should be performance of the plants after outplanting.
- Mycorrhizal inoculation can be incorporated into a nursery's routine, but may require some accommodation in cultural procedures.

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VOICE: I have a question for Dr. St. John. Do you know what mycorrhizal organisms are in ''Nutri-Link'', and could you elaborate on the circumstances where it could be used successfully in a nursery production situation?

T.V. ST. JOHN: Right now in ''Nutri-Link'' they are marketing two fungal species, *Glomus intraradicas* and *Glomus etunicatum.* They are using these two species after test screenings showed that these give a good response with a number of hosts under a variety of conditions and a range of climates.

Plants that grow very poorly until they are planted out in the ground indicate a mycorrhizal problem. There are some plants where it is nearly impossible to give them enough phosphorus without a symbiot—without mycorrhizae; *Liquidambar* is an example of this. Certain forest tree seedling nurseries show spotty growth. This may be due to uneven distribution of mycorrhizae. More even growth may be obtained by intentionally introducing mycorrhizae.

VOICE: How specific are these mycorrhizal fungi?

V.T. ST.JOHN: The ones people work with are quite non-specific but for some ectomycorrhizal fungi there are cases where they are quite host specific.

BRUCE BRIGGS: In order to prevent the loss of phosphate, if you use aluminum in a non-soil medium what would be the effect on mycorrhizae?

V T. ST.JOHN: Aluminum is quite toxic, but it is not soluble until the pH is very low, too low to be used. The main effect is that it would bind up the phosphorus—the phosphorus is there but the plants can't get it.

ANN KYTE. Carolyn, I am wondering if you have published on your work with molecular plant breeding

CAROLYN NAPOLI. Yes, it has been published in the April, 1990, issue of the journal, *Plant Cell*, which can be found in most university libraries.

VOICE: Dr. MacDonald, you mentioned ''Agro-Diagnostics'' kits for the detection of certain fungus species. Are these easy to use and how expensive are they?

JAMES MACDONALD: They are really very simple to use. Anyone could do it. In regard to expense, they are still doing marketing studies—whatever the market will bear. They want to go commercial with a *Phytophthora* test kit in the winter of 1990-91. I am sure you will hear more about the costs in the future.

VOICE: To Dr. MacDonald—I am wondering if you have done any work on preventing *Phytophthora* and a cure for it.

JAMES MACDONALD. In terms of chemical control, there are many pesticides that can be used. One of the problems with these is that you must detect the pathogen at the very earliest possible stage. By the time you can see the problem in the crop the pathogen is very well established, which limits the effectiveness of these materials. Given the current political climate against the use of pesticides, it is very fortuitous that we have these early diagnostic aids coming along for very early detection of the fungi.

WHATEVER HAPPENED TO PLANT TISSUE CULTURE?

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There are, still, many unrealistic expectations that growers bring to tissue culture labs almost every week.

I hope to cover three areas: what we expected of tissue culture, what we thought we were getting, and what we really got.

The 1960's saw a dramatic conquest of the major problems confronting orchid propagation The orchids were slow to propagate vegetatively and were almost universally infected with viruses that caused a dramatic shortening of the shelf life of the flowers. Morel (6) described the methods for producing virus-free *Cymbidium* orchids and how to use tissue culture for clonal propagation of orchids. Scully (10) described clonal propagation of *Phalaenopsis*. Sagawa and Shoji (9) described clonal propagation of *Dendrobiums*. Scully (10) wrote about meristem culture of *Cattleya* orchids.

So here, after decades of steady but slow improvement in vegetative orchid propagation, tissue culture burst on the scene successfully. Where did this put our expectations? Why, we were ripe to hear news of the rosetta stone of propagation.

Now, the 1970's produced literature that made us think that we were getting a complete tissue culture system that was cheap, fast, and would shortly be universally applicable to all plants, (kind of like Eisenhower's 'Atoms for Peace', where nuclear power would be so cheap we wouldn't even have to meter it).

I wish to review some of the early literature to demonstrate where these impressions began. These papers on plant tissue culture "puffed" in three distinct areas.

1) Cost of production.

2) Numbers of plantlets possible (which concurrently implied speed and ease).

3). Plant cultivars that could be propagated.

Anderson (1) has a worksheet showing the cost of producing a plantlet in culture plus the added costs of normal bench handling The tissue culture plantlet costs out to 11.6 cents each. However, then there is a figure shown of 3.8 cents for the costs of establishing this plantlet in soil Lauderdale (3) summarizes a presentation given by Bruce Usrey showing costs for liners in new beds. Using 3 cents each for the cuttings, the final cost was 28 cents each, based on a volume of 12 million cuttings. If Anderson had used his 11.6 cents

lab costs and had taken the data from Lauderdale for the costs for growing on, Anderson's tissue culture plant cost projections would have been 36.6 cents. Thus, growers looking at the tissue culture projections saw a final cost of 15.4 cents compared with 28 to 36 cents for the probable cost. Obviously, many would have been much more pessimistic given an almost 100% discrepancy in these cost projections.

The initial numbers of plantlets projected from tissue culture sounded too good to be true. Murashige (8) suggests that it is premature to claim commercial feasibility without extreme care and followup testing. Murashige lists, however, hundreds of plants under the heading ''Plants with demonstrated potential for clonal multiplication through tissue cultures''. These papers both appeared in the same year.

In a similar vein, Earle and Langhans (2) wrote that ''the amount of sterile manipulation involved may make it unrealistic to use this technique for large scale propagation''.

However, all of these authors immediately make reference to tantalizing large numbers of plants that can be produced by repeated division of multiple plantlets from shoot tips in sterile culture. Earle and Langhans (2) show that chrysanthemum propagation in vitro could lead to over 200 million plantlets per year from a single tip. This is followed by Miller and Murashigi (5) who translate these numbers into multiples, stating that the chrysanthemum procedure is actually an increase of plants 3 million times faster per year.

Not to be outdone, the California Association of Nurserymen in their 1975 research notes take the Earle and Langhans data and state that, (based on an initial data for only 1000 mum plants on the greenhouse bench), this system could in actuality produce 90 billion plants within a year! (This is a number that is *significantly larger* than all of the plants ever vegetatively propagated by human beings!)

Finally, if one examines a current table of contents for '*Plant Cell Reports*' No. 2, 1990, it can be seen plant tissue culture is alive and well, but quite far from the early concepts.

So, from the work with orchids, we expected a complete breakthrough in propagation through tissue culture. From the literature it seemed that we had reached that point. However, what we really got was—using Linsmaier/Skoog salts and modifications thereof—a system that does a good job propagating many herbaceous plants. Additionally, it provides a platform for further development and evolution of tissue culture systems. We didn't get the rosetta stone, but it would have been surprising if we had.

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ORNAMENTAL PALM PROPAGATION AND CONTAINER PRODUCTION

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Palms are playing an ever increasing role in the overall sales of retail and wholesale nurseries. In warmer climates these plants provide a tropical feel to the landscape. As interior plants many palms are unsurpassed for their durability and low light requirements. Many of the more common landscape palms are being recognized for their drought tolerance—a factor that is becoming more important in urban areas with water shortages.

Palms are arborescent or shrubby monocots. Related plants in this monocot group are plant families such as the bamboos and grasses, bananas, strelitzeas, aroids, and lilies. In addition to their ornamental value, palms are very important economically in the world. Coconut and African oil palms are widely grown for their tropical oils and other food products. Date palms are grown for their production of the edible date fruit. Many new palm plantations have recently been established in tropical areas for the production of hearts of palms, a gourmet delicacy.

Nursery production of palms generally falls into two categories. Field production of balled and burlaped palms (or boxed palms) for the landscape, and container shade production of interior palms. A few large interior palms may start out as field-produced plants and, likewise, some landscape palms are strictly container-grown, but these are generally exceptions to the standard practice.

PROPAGATION OF PALMS

The primary method for propagating most palms is by seed, even though advances in tissue culture techniques have made it possible to asexually propagate a few important palm species (8, 9). Germination of palm seed can require from several weeks to over a year (3) and methods of accelerating palm seed germination have been investigated. Presoaking seeds in gibberellic acid (GA) is known to accelerate germination of Macarthur palm (*Ptychosperma macarthurii* (H. Wendl.) Nichols), Alexandra palm (*Archontophoenix alexandrae* (F.J. Muell.) H. Wendl and Drude), and areca palm (*Chrysalidocarpus lutescens* H. Wendl.) (5, 6, 7),

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but in the case of areca palm, GA presoaking caused excessive elongation of seedlings and resulted in unattractive plants. Cleaning or removal of fruit pericarp also improved germination percentage and decreased germination time of areca palm seed (1).

Seed quality, as affected by fruit maturity at harvest and postharvest handling, can greatly affect germination percentage of palm seeds. Areca palm seed picked green germinated very poorly if cleaned, but almost as well as mature seed if not cleaned (1). Improper storage of areca palm seed prior to planting also greatly decreased germination percentage (1).

Fruit maturity at harvest has a significant effect on time required for germination of some palm seeds, but may not always affect final germination percentage. Seed presoaking generally hastens germination time and final germination percentage. Cleaning queen palm seeds greatly improves final germination percentage. With this palm, the highest germination percentage was obtained when cleaned mature green or half-ripe seeds were used. This contrasts with results obtained for areca palms where cleaned ripe or half-ripe seeds had the highest germination percentage and required the least time for germination. The fact that ripe queen palm seeds germinated more slowly and that very few uncleaned seeds germinated suggests the presence of a germination inhibitor in the pericarp of ripe fruit.

As a general rule, one should plant fresh, fully mature seed. The maturity of palm seed can be determined in most cases by a softening of the fleshy fruit surrounding the seed and an associated color change of the fruit (green to red, etc.). Although there are exceptions, as noted above, fresh, mature seed requires less germination time and seedlings emerge more uniformly.

Although the best way to obtain fresh seed is to collect it yourself, this is not always feasible. When obtaining seed from commercial seed sources always request freshly harvested seed. If improperly stored, palm seed can lose its viability in just a few weeks. If the seed has been stored, ask what method was used. The following storage method will often extend the viability of palm seed to one year or longer (1).

Storing Palm Seed. Cleaned palm seeds are spread out in shallow containers and conditioned for two days at 85 to 90% relative humidity. A greenhouse or propagation house generally provides this humidity. The seeds are dusted with a seed-protectant fungicide (such as thiram), tightly sealed in heavy polyethylene bags, and stored at 23 $\pm$ 1°C (73°F). This method is different from the storage of most seeds in two ways. Usually seeds are dried and then stored under cool, dry, refrigerated temperatures. Palms require just the opposite; high humidity and warm temperatures.

Since this environment can encourage fungal growth it is important that a seed-protectant be used.

Germinating Palm Seed. Once good, clean seed is obtained it should be soaked in water for one to two days. Some propagators will add a wide spectrum fungicide to the water. Some also add insecticides. For large numbers of seed a wooden frame is usually constructed of exterior plywood. Dimensions will vary depending on the number of seed. The depth should be about 30 cm (12 in.). Good drainage is necessary.

A loosely fit piece of black plastic should be placed in the bottom of the bed. This will prevent the seedlings from rooting deeply into the soil and thus make pulling them for transplanting much easier. The frame should be filled about 4/5 full of the germination medium. Tests have shown that a medium composed of sphagnum peat and perlite in a 1:1 ratio gives the best results (4). Avoid using topsoil or other components that may introduce insects or disease organisms into the germination bed.

The soaked seed is placed in a single layer on the prepared bed. Depending on the size of the seed, an additional 1.3 cm (1/2 in.) to 2.5 cm (1 in.) of medium is placed over the seeds. Water-in the seeds thoroughly and then cover the bed with clear plastic. You can staple the plastic to one side of the frame and then attach the other end to a long wooden stake. This will allow you to rollup the plastic to water the bed and pull seedlings. It may also be necessary to roll up the plastic slightly to allow some of the heat build-up to escape. If rodents are a problem you may have to attach hardware cloth to the top of the germination bed. If you are germinating smaller amounts of seed you can use a deep container to hold the seed. Avoid shallow flats because it is very difficult to keep the medium watered properly.

Temperature, to a large degree, determines how fast and how even the seeds will germinate. Try to maintain the temperature between 29° and 35° C (85 to 95° F). At 21° C (70° F) *Chamaedorea seifrizii* required over 12 months to germinate while at 29° C (85° F) this same seed source germinated in four months. Similar results were found for queen palms.

The endosperm of most palm seed provides enough nutrients for the seedling until 2 to 3 juvenile leaves have been produced. At this time the seedlings are generally transplanted. If fertilization is required before transplanting, apply a weekly liquid fertilizer application at 200 ppm nitrogen of a soluble fertilizer with a 3:1:2 ratio. Resin-coated granular fertilizers with the same nutrient ratio have also been used successfully.

Container Soils for Palms. One of the most important factors in the successful production of container palms is the soil (less) medium used. This must hold the water, provide the nutrients, and support the plant. Most basic horticulture courses teach the fundamentals of plant physiology and give us a pretty good understanding of a plant's root system. But what is often forgotten, and extremely important to nurserymen producing container-grown plants, is the effect the growing medium has on the root system and how this information can be used to maximize plant survival and growth.

All ''soiless'' mixes for interiorscape palms require the addition of certain nutrients to insure proper plant growth and maintenance. Dolomitic limestone (dolomite) is a combination of calcium and magnesium carbonate and often the sole source of magnesium (Mg), a macronutrient required by plants, particularly palms. While many feel the addition of dolomite is necessary for pH reasons, it is far more important as a source of Mg. Container soils require about 8 lbs of dolomite per cubic yard. A finely pulverized material that is 12 to 20% Mg is recommended.

Micronutrients are also incorporated into palm soil mixes. Research has shown that the sulfate forms of micronutrients remain available to plants for over 18 months (2). A material such as Micromax (Sierra Chemicals) should be incorporated at a rate of 1½ lbs. per cubic yard.

Many ''textbook'' soil recipes include superphosphate in container mixes. Their reasoning is that since phosphorus is important in the growth of new roots it should be a component of the soil mix. Unfortunately, this recommendation is not based on research results, particularly with palms. Superphosphate ties-up certain micronutrients and can lead to serious deficiencies.

The medium used must be water retentive yet well drained. The fairly unaggressive root system of most palms, in addition to the length of time they must exist in the same container, requires a soil resistant to degradation by the interactive effects of nitrogen fertilizers and microbial action.

A good mix consists of 25% (by volume) small bark pieces (graded to about ¼ to ½ in. sizes), 25% coarse sand (such as trap sand), 30% Canadian peat, and 20% scoria. Horticultural grade perlite can be substituted for the scoria—but avoid styrofoam soil amendments.

It is important that the Canadian peat be the coarse ''chunky'' grade. For each cubic yard of this material incorporate 8 lbs of dolomite (for magnesium) and 1½ lbs of Micromax (Sierra Chemical). **No** superphosphate should be incorporated into the mix.

Another ''recipe'' that excludes the sand, makıng the mix physically lighter but still very good for ınterior palms ıs:

1 part scoria (or perlite): 1 part bark· 2 part sphagnum peat

Example:

1/2 cu. yd. scoria (or perlite).
1/2 cu. yd. bark (1/4 in.)
1 cu. yd. coarse sphagnum peat (fluffed)
16 lbs dolomite lime
3 lbs Micromax

This makes two cu.yds. of the mix. Note that 1 cu.yd. of sphagnum peat is equivalent to about 7½ cubic feet of **compressed** peat. Peat is usually purchased in 4 or 5 cubic feet (compressed) bales. This mix will work well with all interior plants, is very well drained, and difficult to overwater.

Most palm seedlings are transplanted directly to 10 cm. (4 in.) or 15 cm. (6 in.) containers. The fairly fragile root system should be handled with care. Planting depth is critical. Planting seedlings too deeply (for seedling stability) is a common mistake that can lead to many problems. Establishment of young palms requires a structure that provides 55 to 63% shade. After 2 to 3 months the young plants can be moved to their final growing destination. Interiorscape palms require 63 to 73% shade while landscape palms should be grown in full sun.

Palm Fertilization. There are two methods of fertilization commonly used in palm productıon. In southern California or other arid areas it is probably preferable to liquid feed using a fertilizer ınjector durıng every irrigation. Use a fertılizer with a 3:1:2 ratio of N, P, and K. Irrigate with 200 parts per mıllion (ppm) N three times a week.

In areas with more rainfall and subsequent leaching, notably Florida and Hawaıı, it ıs probably better to use a slow release (resin-coated) fertilizer with the same 3:1:2 ratio. Studies in Florida indicate that the most efficient method of applying resın-coated fertilizers is a modified type of dibbling. First, in these tests a small amount of soil (2.5 cm (1 in.) or more, depending on the container size) was placed in the container. The fertılizer charge was then broadcast evenly on the soil. The palm being transplanted was put into the container at the proper depth and the container filled with soıl. This method of fertilization almost eliminates soil degradation from bacterial breakdown.

The only step left ın growing container palms is to transplant them to larger containers as they grow. Most palms require transplanting

every 12 to 18 months. If the palms are being transplanted to a field nursery they should be set-out as established plants in at least 15 cm (6 in.) containers. The best time to plant them in the field is in the spring or early summer. This allows them to develop an established root system before the cooler winter months. Fertilization in a field nursery can be liquid fed through the irrigation system, or by top-dressing around the young palms with granular fertilizers. The preferred ratio of N, P, and K are 2:1:2 (such as a 10-5-10), but a good high grade turf fertilizer will also work. Liquid and granular fertilizers that contain micronutrients should be used. It may be necessary to supply magnesium in the form of magnesium sulfate (Epsom salts) as a top dressing to the palms.

Growing quality palms is easy if you follow the above recommendations. Just remember, start with fresh, cleaned seed, a good soil mix, and the proper nutrients.

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IMPROVED GERMINATION OF *ROSA CORYMBIFERA* 'LAXA' SEED USING A COMPOST ACTIVATOR

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Abstract. Autumn-harvested achenes of *Rosa corymbifera* 'Laxa' can be successfully germinated in the following spring if pretreated with a proprietary compost activator and stored under controlled conditions. The pretreatment used is 10g moist achenes, 25g moist vermiculite, 0.5g * ''Garotta'' compost activator, before storing at 20° C for 12 weeks and then at 4° C for 12 weeks. A series of experiments is described which shows that the time of harvest, rate of compost activator, proportion of vermiculite and storage temperatures can all be varied within given limits.

INTRODUCTION

Seeds of many rosaceous species show marked dormancy. This is a particular problem in the production of the rose rootstock, *Rosa corymbifera* 'Laxa' where dormancy results from a series of factors including a hard pericarp, chemical inhibitors, and physiological immaturity. Under natural conditions the achenes, (single-seeded fruits often referred to as ''seeds''), can take up to 18 months to germinate. Rootstocks produced in this way have a very variable grade-out because of erratic germination. Blundell and Jackson (1) were able to show that dormancy of the achenes could be broken if the pericarp was partially removed by scarification using concentrated sulphuric acid. Achenes treated with acid consistently had above 90% laboratory germination.

Commercial production of 'Laxa' rootstocks is now largely by acid scarification and is described in a U.K. Ministry of Agriculture leaflet (3). It is a complex process which initially involves separating the rose achenes from the hips and air drying. The achenes are then treated with concentrated sulphuric acid to remove most of the woody pericarp. After washing, the moist achenes are stored for 4 weeks at 20 to 24° C, followed by 12 weeks at 3 to 4° C. (These warm and cold temperature treatments probably facilitate physiological changes including the breakdown of inhibitors).

The process of acid scarification does require a degree of expertise. During the acid treatment, samples of achenes have to be sectioned and the end-point carefully assessed. The temperature of the acid-achene mixture also has to be carefully controlled as the heat generated can damage the living seed inside the achene. Thus,

* ''Garotta'' is produced by Sinclair Horticulture and Leisure Ltd, Firth Road, Lincoln LN6 7AH.)

although this method is useful for large-scale production of rose rootstocks, it is unlikely that the propagator, requiring relatively small numbers of seedlings, would employ the acid scarification technique. Natural stratification would be used as an alternative, where achenes are stored in moist sand and exposed to ambient temperatures for 12 to 18 months. The germination rate after natural stratification is low and varies from approximately 7 to 15% (3).

When rose achenes are dispersed naturally the hard pericarp is exposed to microbial decay in the soil, causing the pericarp to be weakened and inhibitors to be degraded or leached. Acid scarification probably mimics parts of this process. Normally the rate of microbial decay will vary among achenes but will be greatest in the warmer months of the year when microbial activity is higher. Achenes dispersed naturally in the autumn may not start to decay appreciably until the following summer, thereby accounting for the erratic field emergence observed.

As an alternative to acid scarification investigations in both the laboratory and field were undertaken to see if the microbial decay of the achenes could be advanced by storing the moist seed at warm temperatures and adding a proprietary compost activator (our trial used "Garotta") to encourage microbial action. The normal cold temperature treatment of 12 weeks at 3 to 4 °C was then given. For this method to be considered successful a useful percentage of achenes harvested in autumn should germinate when sown in mid-March of the following year. If sowing is delayed to later in the spring then the higher seedbed temperatures prevailing at the time of sowing may induce secondary dormancy (2).

MATERIALS AND METHODS

All achenes used were harvested from *R. corymbifera* 'Laxa' stock plants grown at Writtle Agricultural College. The hips were crushed before being left to soften in water for about one week. Sieves were used to separate the achenes. Achenes were not normally dried before use. During all treatments the achenes were mixed with moist vermiculite (medium grade) prepared by adding 400 ml deionised water to 250g vermiculite and stirring thoroughly. Normally 25g moist vermiculite was used for each 10g 'Laxa' achenes and the compost activator was added as required. The mixture was stored in a polythene bag, tied loosely to admit air, and then weighed. Each week during both the warm and the cold treatments the bags were shaken to aerate the contents and returned to their original weights by adding deionised water.

Following a cold storage treatment, laboratory germinations were determined by placing the achenes in Petri dishes containing

moist filter paper. These were maintained at 15 °C and germination (radicle emergence) was recorded regularly. Field emergence was measured by sowing achenes into a seedbed treated the previous autumn with the soil-sterilant, dazomet, then covering with a layer of 4 to 6 mm gravel to prevent capping.

All treatments had four replicates and the laboratory germination and field emergence tests were fully randomised. Resulting data were subjected to an analysis of variance.

EXPERIMENT 1: Effect of the compost activator on moist achenes:

Harvest date:	25 September 1986
Treatments commenced:	2 October 1986
Treatment 1	10g achenes + 25g moist vermiculite, 12 weeks at 20° C then 12 weeks at 4° C
Treatment 2	10g achenes + 25g moist vermiculite + 0.5g "Garotta" 12 weeks at 20° C then 12 weeks at 4° C
Treatment 3	10g achenes + 25g moist vermiculite + 1.0g "Garotta" 12 weeks at 20° C then 12 weeks at 4° C

Treatments completed: 17 March 1987—then laboratory germination and field emergence measured (see Tables 1 and 2 of Results).

EXPERIMENT 2: Effect of harvest date on compost activator treatment

Harvest dates:	24 September 1987. (Treatment 1) 21 October 1987. (Treatment 2) 19 November 1987. (Treatment 3)
Treatments commenced:	30 September 1987. (Treatment 1) 28 October 1987. (Treatment 2) 25 November 1987. (Treatment 3)
Treatment 1	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 12 weeks at 20° C then 12 weeks at 4° C
Treatment 2	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 8 weeks at 20° C then 12 weeks at 4° C
Treatment 3	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 4 weeks at 20° C then 12 weeks at 4° C

Treatments completed 25 March 1988—then laboratory germination measured (see Table 3 of Results).

EXPERIMENT 3: Effect of temperature during warm treatment

Harvest date:	21 October 1987
Treatment commenced:	28 October 1987
Treatment 1	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 8 weeks at 20° C then 12 weeks at 4° C
Treatment 2	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 8 weeks at 25° C then 12 weeks at 4° C
Treatment 3	10g moist achenes + 25g moist vermiculite + 0.5g "Garotta"; 8 weeks at 30° C then 12 weeks at 4° C

Treatments completed 25 March 1988—then laboratory germination measured (see Table 4 of Results).

EXPERIMENT 4: "Commercial" treatment of achenes with a compost activator at normal and half-rate of vermiculite

Harvest date:	24 September 1987
Treatments commenced:	30 September 1987
Treatment 1	500g moist achenes + 1250g moist vermiculite + 25g "Garotta"; 12 weeks at 20° C then 12 weeks at 4° C
Treatment 2	250g moist achenes + 313g moist vermiculite + 12.5g "Garotta"; 12 weeks at 20° C then 12 weeks at 4° C

Treatments completed 25 March 1988—then laboratory germination measured (see Table 5 of Results).

RESULTS

EXPERIMENT 1: Effect of the compost activator on moist achenes

Table 1. Laboratory germination of 25 achenes/replicate after 13 days, from treatments with and without the compost activator.

Replicate	1	2	3	4	Percent
Treatment 1 (control)	1	0	1	0	2 (a)
Treatment 2 (0.5g Garotta)	21	20	15	20	76 (b)
Treatment 3 (1 0g Garotta)	21	21	20	21	83 (b)

(a) and (b). Different letters indicate significant difference at 99% confidence.

Table 2. Field emergence of 100 achenes/replicate after 2 months, from treatments with and without the compost activator.

Replicate	1	2	3	4	Percent
Treatment 1 (control)	32	21	23	28	26.0 (a)
Treatment 2 (0.5g Garotta)	39	36	42	69	46.5 (b)
Treatment 3 (1.0g Garotta)	47	39	38	51	43.7 (b)

(a) and (b) different letters indicate significant difference at 95% confidence.

EXPERIMENT 2: Effect of harvest date on compost activator treatment

Table 3. Laboratory germination of 50 achenes/replicate after 14 days, of achenes harvested at different dates with the compost activator.

Replicate	1	2	3	4	Percent
Treatment 1 (harvested Sept.)	48	47	43	45	91.5 (a)
Treatment 2 (harvested Oct.)	46	33	48	47	87.0 (a)
Treatment 3 (harvested Nov.)	43	47	40	40	85.0 (a)

(a) same letter indicates no significant difference.

EXPERIMENT 3: Effect of temperature during warm treatment

Table 4. Laboratory germination of 50 achenes/replicate after 14 days from achenes given different warm temperature treatments with the compost activator.

Replicate	1	2	3	4	Percent
Treatment 1 (20° C)	46	33	48	47	87.0 (a)
Treatment 2 (25° C)	46	48	49	47	95.0 (a)
Treatment 3 (30° C)	44	46	49	38	88.5 (a)

(a) same letter indicates no significant difference.

EXPERIMENT 4: "Commercial" treatment of achenes with a compost activator at normal and half-rate of vermiculite

Table 5. Laboratory germination of 25 achenes/replicate after 14 days from "commercial" treatment of achenes at normal and half-rate of vermiculite

Replicate	1	2	3	4	Percent
Treatment 1 (Normal Rate Vermiculite)	25	23	19	21	88.0 (a)
Treatment 2 (Half Rate Vermiculite)	23	20	23	21	87.0 (a)

(a) same letter indicates no significant difference.

DISCUSSION

The use of a compost activator to enhance the germination of *R. corymbifera* 'Laxa' achenes gives results broadly comparable to published results for acid scarification (1). Although the time of treatment is longer when a compost activator is used there are two stages fewer than are needed for acid scarification, i.e. air drying plus acid treatment. In addition, the experiments described above show that the technique does not require particular expertise or exact conditions. The time of harvest, rate of compost activator, proportion of moist vermiculite, and storage temperature can all be varied within the limits shown without a profound effect on the success of the technique. At Writtle *R. corymbifera* 'Laxa' rootstocks are produced by harvesting achenes in late September, and treating them in the proportion of 10g moist achenes, 25g moist vermiculite, 0.5g "Garotta", before storing at 20° C for 12 weeks and 4° C for 12 weeks. Achenes are then ready to be sown in late March. Figure 1 shows that this method has produced consistent results over a four year period.

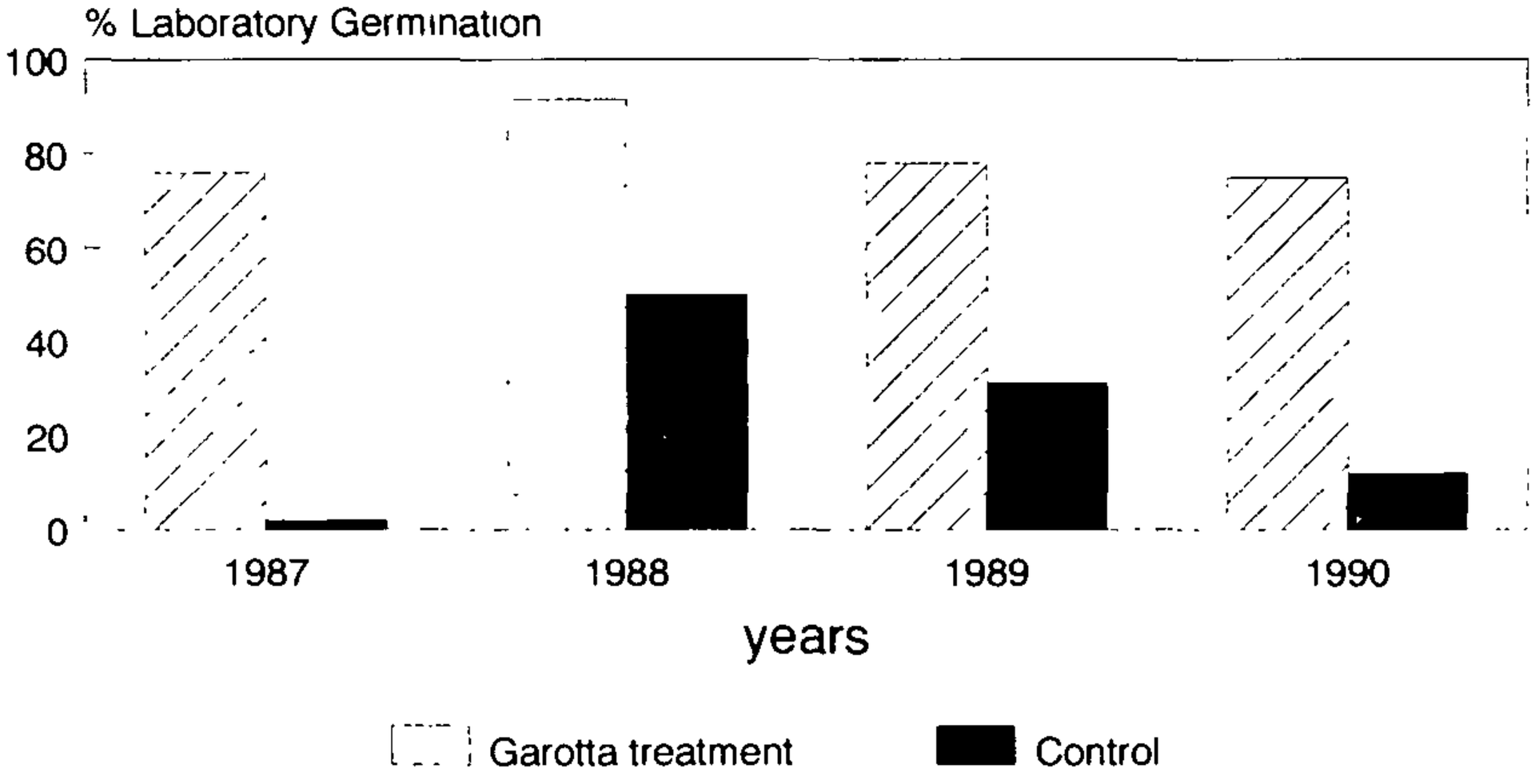

Figure 1. Laboratory germination (14 days) of "Garotta"-treated achenes compared to warm and cold-treated achenes over a 4 year period.

The action of the compost activator on the achenes has yet to be fully investigated. Achenes treated with "Garotta" darken more quickly and have a softer pericarp by the end of the warm treatment. The composition of "Garotta" is a "trade secret". Possibly the achenes could be supplied with a nitrogen source to encourage microbial activity. However, this product is widely available in the United Kingdom and it is the authors' belief that this technique could readily be used for production of *R. corymbifera* 'Laxa' rootstocks.

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ROSE ROOTSTOCKS

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INTRODUCTION

The creation of the Research Centre for Ornamental Plants marked a new era in the history of cultivation of ornamental plants in Belgium. This Centre is an amalgamation of three experimental gardens: for Floriculture, Nursery Stock, and Cut Flowers. The Experimental Horticultural Station B.V.O., established at Wetteren (Ghent) in 1954, now also forms part of the Centre. The Research Centre for Ornamental Plants is situated in Destelbergen (Ghent), right at the heart of the ornamental plant-growing region. Both the amalgamation and the location of the Centre have enhanced its function as a research and information agency, improving the two-way flow if ideas.

On 1 October 1988, one year after building work began, the buildings and facilities of the Ornamental Plant Research Centre were ready for occupation. On 16 September 1989, the Research Centre was officially opened. The Ministry of Agriculture, the Flemish executive, and the Growers Association itself have all made a considerable contribution towards the completion of this project.

The non-profit association, East Flanders Business Information Service Horticultural Research Station (abbreviated to B.V.O.), has been operating in Wetteren since 1954. In the B.V.O.'s early days, it provided information and carried out research for a variety of sectors of horticulture. In the mid-1960s, the service began concentrating on the ornamental plant sector, with the emphasis on applied scientific research. Funds were received from the I.W.O.N.L. (Institute for the Promotion in Industry and Agriculture).

Research into general nursery stock, azaleas, and potplants was carried out at Wetteren. A director is responsible for the Centre's day-to-day management, ensuring that the administrative side functions properly; he also supervises the budget, the research programmes to be carried out, and the work of the Centre as a whole.

The work carried out in the Experimental Garden is jointly formulated and supervised by the Experimental Garden Manager. In the Research Station for Horticulture B.V.O., the Works Manager is responsible for the execution of the research programme and

coordinates the day-to-day work with an assistant. In the Costent-park cooperative, all work is done by paid staff and supervised by the Director of the PCS and the Manager of the Experimental Garden for Nursery Stock.

EXPERIMENTAL GARDEN FOR NURSERY STOCK

Our activities are: Container cultivation, container plants, wintering of container plants in small tunnels, and open-ground cultivation.

Each year, new rose cultivars are worked on different rose rootstocks and are assessed for compatibility and growing strength.

The grafting and inoculation demands a high professional capability. They both are very labour intensive activities. The following steps are necessary: preservation of rootstocks and grafting material, breeding, and after-care. This specialisation is of great importance. Breeding of cut- and bush roses is still very popular but even in this sector *in vitro* culture, and culture by cuttings are becoming more important. Nevertheless, much research still has to be done.

Experiment 1: Propagation by root cuttings of *Rosa nitida*.

Root cuttings were tried as a potential system for container production.

Rosa nitida is a low shrub (40 to 60 cm) with small oblong leaves and light pink flowers. It is suitable for hedges and gives a beautiful autumn colour. From a cross between *R. nitida* and *R. rugosa*, a strong grower, *R.* × *rugotida*, was developed. The leaves are like those of *R. rugosa* but a little smaller. The flowers are pink like those of *R. nitida*. The Darthuizer Nursery introduced in 1971 the 'Dart's Defender', a hybrid of *R. nitida* and *R. rugosa* 'Nansa'. It is a strong grower with purple-red, half-full flowers.

Culture Programme:

14/01/1986	Root cuttings in Jiffy 4's in a frost-free glasshouse.
27/02/1986	First new growth tips visible.
03/06/1986	Potting out in 3 litre bags and 1.6 litre pots (and pinched).
29/10/1986	Pots placed under plastic tunnels.

During production, a few pinches are necessary (the longest shoots were shortened). The growth in 3 litre bags is not significantly better than in 1.6 litre pots. To become a good saleable product, we have to pinch the plants at least one time in the second culture year.

24/02/1987	Pruning of *R. nitida* (second culture year) in pots under plastic.
15/06/1987	Saleable flowering plants.

Experiment 2. Rootstocks and cultivars.

We are looking for an alternative to *Rosa corymbifera* 'Laxa' as a rootstock because of its susceptibility to nematode infestation.

These rootstock cultivars were used in replicates of 1,400 plants each:

Rosa canina 'Inermis'; *Rosa canina* 'Pfander'; *Rosa canina* 'Pollmer'; *Rosa canina* 'Smith's Ideal'; *Rosa canina* 'Superba'; and *Rosa corymbifera* 'Laxa'.

Plants were delivered on January 29, 1988, and stored at 2 °C until planting on April 27, 1988. Plants were harvested on November 11, 1989. Results are shown in Table 1.

Table 1. Numbers of harvested roses per rootstock and per cultivar in 1989. (second culture year); 1400 plants per rootstock cultivar.

Flowering Cultivar	Rootstock					
	R. corymbifera	*R. canina*				
	'Laxa'	'Inermis	'Pfander'	'Pollmer'	'Inermis'	Total
New var. RVS (Euro 92)	72	70	69	62	64	337
New var. RVS 330 rose (Melflor)	74	70	60	56	57	317
'Melglory'	73	70	62	61	57	326
'Queen Elizabeth'	71	69	72	68	71	351
'Wettra'	72	71	64	60	64	331
'Nina Weibull'	79	68	65	67	69	348
'Nicky'	69	69	69	59	69	335
'Kanegem'	72	69	62	66	69	338
'Dame de Coeur'	83	79	73	71	65	371
'Sabine'	88	73	71	67	70	369
'Gravin d'Alcantara'	83	78	66	64	71	362
'Pierrot'	82	72	69	65	69	367
'Joro'	81	73	66	78	61	359
'Joro'	66	69	70	73	78	356
'Reina'	65	85	78	70	72	370
'Nina Weibull'	79	62	69	70	59	339
'Melglory'	77	74	68	69	73	361
'Melglory'	63	80	62	65	75	345
Total	1349	1301	1215	1194	1223	6282

Rosa corymbifera 'Laxa' produced the highest number of saleable roses, with a 96% take.

The experiment was repeated the following year including a new rootstock cultivar, *R.* 'Schmidt's Ideal'. This performed better than *R. corymbifera* 'Laxa' for that year as Table 2 shows.

Table 2. Number of harvested roses per rootstock and per cultivar in 1989 (second culture year). 1200 plants per rootstock cultivar

Flowering Cultivar	Rootstock						
	R. corymbifera 'Laxa'	*R Schmid's* 'Ideal'	*R canina.*				
			'Inermis'	Pfander'	'Pollmer'	'Superba'	Total
'Euro 92'	68	65	75	64	61	58	391
'Melflor'	78	83	71	72	45	58	407
'Nina Weibull'	60	69	60	63	37	54	343
'Wettra'	52	53	61	59	35	59	319
'Melglory'	42	45	50	51	35	46	269
'Nicky'	52	68	62	61	55	57	355
'Kangegem'	64	63	50	59	52	59	347
'Joro'	61	53	60	65	56	61	356
'Reina'	66	66	53	60	60	62	367
'Queen Elizabeth'	68	74	67	67	65	64	405
'Sabine'	61	64	52	69	67	65	378
'Dame de Coeur'	73	69	54	53	61	65	375
'Gravin d' Ale'	71	72	50	67	58	63	381
Rosa climbing 'Wettra'	66	67	78	59	71	67	408
	882	911	843	869	758	838	5101

WEANING AND GROWING-ON OF MICROPROPAGATED ROSES

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The technique of micropropagation is now proven for many types of nursery stock—especially roses of all types. Micropropagated roses are easy to prune; have no wild suckers; more flowers and, for the grower, make container production easy. These attributes have ensured the adoption of the technique for roses.

Two difficult stages in the production of micropropagated roses are weaning and growing-on. This paper will discuss how we at Micropropagation Services carry out the weaning and some of the recommendations we make following trials on the growing on of young plants. I will also discuss some of the problems of weaning and growing-on and how to overcome them.

WEANING

Many of the problems of weaning can be overcome by good horticultural practices and a propagator's attention to detail.

The quality of shoots produced in the lab, including the type of shoot, how it is handled, culture media, etc. all affect how the plants will grow on later. A good quality robust shoot 1 to 2cm in length with 2 to 4 well developed leaves has a good chance of survival even if the weaning conditions are not ideal.

Stage of transfer to compost is also critical in the same way as potting-on can be with conventional cuttings. Shoots are put on culture media containing a rooting hormone for just long enough to initiate roots but not long enough for them to grow, otherwise they can be damaged on transfer to compost.

A free-draining compost is essential to avoid waterlogging as well as a low nutrient level to prevent checking. Some nutrient is required as soon as roots have developed and liquid feed should be applied as soon as possible.

The weaning environment is critical, but does not need to be anything very special. We use conventional mist successfully, but timed/solar control with regular manual adjustment is so far the only way we have been able to obtain satisfactory control. Basal heat, 20 to 24 °C and air temperature of over 20 °C, works well and, for year-round production, supplementary lighting is needed to maintain a 16-hour day. In fact, conditions are used that are much the same as for rooting many softwood cuttings.

Disease control must be good, and a regular routine preventative spray for *Botrytis* is needed together with powdery and downy mildew control, once weaned. For *Botrytis* control we use a number of standard fungicides (i.e. Rovral, Benlate, Captan), used in rotation. The weaning process takes approximately 2 weeks under mist plus a further 6 to 8 weeks in a heated glasshouse and at least 2 weeks hardening off in a cold house—a total of 10 to 12 weeks. At that stage the weaned plant should have a well established and ideally "rootbound" plug, and a slightly woody and robust stem. The propagule is then ready for the rigours of the average nursery.

GROWING-ON: GENERAL

Successful growing-on of micropropagated roses needs attention to the following points:

A high quality propagule is most important. The young plant should be fully hardened-off after weaning with a good root ball to ensure that once potted it grows away vigorously and is not susceptible to root rots. It should be slightly woody so that if a cold spell is encountered soon after potting the plant is strong enough not to succumb to *Botrytis* or other moulds.

Compost for potting-on should be free-draining and have a high nutrient content, preferably supplied at least in part by a slow release fertilizer (see compost formulations, Tables 1 and 2).

Pests and diseases need to be carefully controlled. Roses are susceptible to a number of both but all can be adequately controlled with a routine preventative spray programme aided by good horticultural practices. Mildews will be difficult to control under protection if ventilation is poor. Aphid and red spider mite can also be problems when growing under glass, but are usually not so serious once plants are moved out onto nursery beds. Under high humidity conditions, inside or out, preventative measures against downy mildew need to be taken. This disease can cause stunting or spindly growth and lack of vigour, even without showing the obvious symptoms of leaf drop and purple/yellow spots on leaves. These spots will be angular, often bordered by the leaf veins.

Downy mildew is often mistakenly identified as blackspot, but because of the initial clean status of micropropagated roses any leaf spotting is more likely to be downy mildew unless there is already a source of blackspot infection close by. (More details of identification of these diseases can be seen in a paper at this Conference by David Rowell).

Preventative sprays for downy mildew are essential when growing roses intensively as, at present, there are no effective curative treatments and, like all diseases, prevention is easier and

better than trying to cure. Adequate control can be easily achieved by the correct preventative spray programme (e.g. Fongarid or Fubol).

Growing on as liners.

The best micropropagated roses in 3 litre pots are produced by potting into a liner pot first—(7cm square or 9cm round). If a final product in less than a 3 litre pot is desired, direct potting can be successful.

Liners are best potted under protection. September to April under cold glass or polythene tunnel, in May to September a shade tunnel, or just a sheltered area on the nursery is sufficient. Micropropagated roses respond to a compost with a high nutrient status, which is best provided by slow-release fertilizer with additional liquid feed after potting and at times when release is not fast enough. Our compost recommendation is shown in Table 1.

Table 1. Compost formula—liner stage

Ingredient	Quantity
Irish moss peat, medium grade	
Cambark 100	10% to 25% by volume
Magnesium limestone	2 4Kg/m^3
Fritted trace elements	0 3Kg/m^3
Osmocote (Ficote), 5-6 months	4Kg/m^3
Wetting agent (Aquagro)	

NOTE High level nutrient Additional liquid feed may be needed as a ''start up'' and at times of rapid growth

It is very important to pot deeply at each stage of potting, this reduces wind rock and encourages the production of a ''crown'' below the compost surface, ensuring frost hardiness. It also assists the natural bushiness of micropropagated roses. After approximately 8 weeks of reasonable growing weather the liner will be ready to pot on; it is best moved on promptly to prevent any check in growth. However, if desired, the liner can be held for quite a long period until a more convenient time for potting (e.g. over-winter). Micropropagated roses flower at a young age, even in liner pots—this has allowed a new market to be developed—the sale of roses as pot bedding.

Growing-on as container plants in pots of 3 litres or more.

Again a high nutrient compost is required (see Table 2). Pruning may be required at potting, cutting back to 4 to 6 in. to prevent wind rock. Containers should be placed on well-drained nursery beds or capillary beds, if available.

Micropropagated roses will at this stage start to show their natural bushiness with the production of numerous basal shoots. Saleable flowering plants can be expected 8 to 10 weeks after potting from liners. The two selling seasons, spring and late summer/autumn, are catered for by: 1) spring/summer potting of plugs, producing saleable plants for late summer/autumn or early the following spring, or 2) late summer/autumn potting into liners (over-winter liners), potting-on in early spring for late spring/summer sales.

Table 2. Compost formula—container stage

Ingredient	Quantity
Irish moss peat, medium grade	
Cambark 100	20 to 30% by volume
Grit	10% by volume
Magnesium limestone	2 4Kg/m³
Fritted trace elements	0 3Kg/m³
Osmocote (Ficote) 12-14 months	6-8Kg/m³
Wetting agent (Aquagro)	

NOTE· High level nutrient. Additional liquid feed may be needed as a ''start up'' and at times of rapid growth.

FIELD GROWING

Initial trials on field planting of well-rooted plug plants has shown that a substantial plant can be produced within 12 months. This opens up the possibility of producing roses for the established traditional markets as ''bare root'' and/or ''root wrapped'' plants, or containerized field-grown plants. The latter may seem a retrograde step, but it may be economically advantageous to do so. The fibrous roots of micropropagated roses would lend themselves to being containerized rather better than those of the woody, non-fibrous roots of conventional budded roses.

GARDEN PERFORMANCE

If micropropagated roses are grown in the garden and pruned in the traditional way, they look, perform, and survive as well or better than budded plants. If, however, they are pruned more vigorously, by hedgecutter, flail mower, etc. they grow back more vigorously with more shoots and more flowers. Of course, micropropagated roses have the added advantage of not producing root suckers, and so they are much easier for the gardener, and/or landscaper to handle.

UNUSUAL WAYS TO USE MICROPROPAGATED ROSES

Pot-bedding. The property of micropropagated roses to flower at a young age, even in liner pots, has allowed a new market to be developed—the sale of roses as ''pot bedding'' plants. The vigour of micropropagated roses ensures good establishment and the gardener/landscaper will have fully established rose plants in the second season. All types of roses can be sold at this young size and perform very well.

Mail-Order. Micropropagated roses can be sold mail-order from a size of 3 to 4 in., allowing the maximum benefit of cheap distribution by post.

Hanging Baskets. Many of the new ground cover types make excellent hanging baskets when produced by micropropagation which maximises bushiness.

PESTS AND DISEASES OF ROSES

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Many pests and diseases can affect roses but relatively few have serious consequences for the commercial grower.

INSECT PESTS OF ROSES

The two most important insect pests on roses are aphids and two-spotted spider mites. The rose grain aphid (*Metopolophium dirhodum*) is the aphid normally found on roses. It is very variable in colour, from pale green to pink. Large colonies of aphids can build up very quickly and if not controlled can seriously weaken the bushes. Infestations can start very early following mild winters and aphids were found on many crops in February this year (1990). The specific short term aphicide, pirimicarb, will give control and is a good choice environmentally. However, many growers still prefer to use the broader spectrum and more persistent organophosphates or pyrethroid insecticides.

In most seasons the two-spotted spider mite (*Tetranychus urticae*) is not a serious problem on field-grown roses. However, in hot summers and on container-grown and glasshouse roses it can cause serious damage. Growers need to be aware of the characteristic signs of damage such as speckling and leaf bronzing and to use acaricides if necessary. Acaricides that are available are all contact-acting materials that require high volume penetrating sprays on both the upper and lower leaf surfaces. All too frequently poor control may be blamed on resistance when the real cause is poor spray application.

Of the other pests that affect roses, leaf webbing caterpillars (*Tortrix* spp.) can often be found but rarely justify spraying. Free-living soil eelworms (*Pratylenchus, Longidorus,* and *Xiphinema* spp.) can cause damage on glasshouse roses but are not significant as field pests under normal circumstances in Britain. However, when crops are grown on very close rotations, especially on light soils, numbers can build up to damaging levels. *Xiphinema* can also spread the virus diseases, strawberry latent ringspot, and Arabis mosaic.

DISEASES OF ROSES

The three most important diseases of roses affecting the commercial grower and the general gardening public alike are

rose rust, powdery mildew, and black spot. Routine fungicide programmes are applied to rootstocks mainly to control rose rust and mildew and to the maiden bushes to control all three diseases. The problems these diseases cause in gardens has been one of the factors involved in the decline in popularity of roses in Britain.

Rose Rust is caused by species of the fungus, *Phragmidium*. The most common species found in the UK are *P. mucronatum* and *P. tuberculatum*. Rust infection can have a number of different effects.

i) Infection in the rootstocks can cause early defoliation which may affect bud ''take'', reduce growth of the rootstock, and can affect grade-out of the maiden bushes in the following season.

ii) Infection in the maiden bushes seriously reduces grade-out.

iii) Some susceptible rose cultivars such as 'Blue Moon', 'Pink Peace', 'Queen Elizabeth', and 'Picadilly' develop stem cankers that can even kill the bushes.

Rust spores are spread by wind and infect leaves through stomata. Optimum temperatures are 18 to 21 ° C and continuous moisture for two to four hours is required for establishment of infection. The pustules are orange in colour in spring and summer but in autumn the black overwintering pustules develop.

Routine fungicide spraying for rust normally starts in early June and continues at 10 to 14 day intervals until autumn. The fungicides oxycarboxin, benodanil, or myclobutanil can all give good control.

Powdery Mildew is caused by the fungus, *Spaerotheca pannosa* var. *rosae*. The disease is a worldwide problem but is present in many different races. The fungus attacks young leaves, flowers, and stems, giving disfigured growth and reduced vigour of the bushes. In commercial production it can also attack rootstocks but is normally a much more serious problem on the maiden bushes.

The disease can overwinter on infected buds and stems and on fallen leaf debris. The spores of the disease are spread by wind. Optimum conditions for infection are warm nights with 90% R.H. or more, and day temperatures of 20 to 25 ° C with 40 to 70% R.H. The normal life cycle is usually completed in seven days but, exceptionally, can be as short as three days.

Routine spraying at 10 day intervals with fungicides such as bupirimate, triforine, or myclobutanil will normally give an acceptable degree of control for the grower.

Black spot. The characteristic feathery edged spots all too commonly found on roses are caused by the fungus, *Diplocarpon rosae*. The disease also causes severe leaf yellowing and defoliation. Although black spotting on leaves is the most obvious effect it can also attack young stems. The disease overwinters in infected stems and buds and on fallen leaves. The spores are spread by watersplash on the expanding young leaves. The spores must be continuously

wet for at least seven hours for infection to occur. Development takes place most rapidly at 19 to 24° C and the life cycle can be completed in as little as 10 days. Warm, wet weather in August can trigger an epidemic.

As the disease is spread by water rather than wind the introduction of infected plants into rose beds is a significant factor in disease spread.

The fungicides, triforine or myclobutanil applied at 10-day intervals will give reasonable control of black spot.

Other Rose Diseases. There are many other diseases that can affect roses and some of these can cause significant losses on individual nurseries given circumstances which favour the disease. These include downy mildew, stem canker on *R. rugosa*, black mould, and virus diseases.

A) *Downy Mildew (Peronospora sparsa)* has become a much more serious problem on roses because of the increase in rose production in containers and in the use of micropropagated roses. It is very much a nursery disease and does not normally cause problems in the garden. Close plant spacing on container nurseries with localised high humidities and overhead irrigation provide ideal conditions for the disease. The symptoms on many cultivars are of dark purple leaf spots with leaflets sometimes turning yellow. The disease can cause rapid defoliation and, because of its symptoms, may be confused with black spot. The spores of the disease are only formed on lower leaf surfaces and can develop and spread rapidly under humid cool conditions.

Fungicides give only partial control of this disease and unless nurseries modify their growing conditions this disease is likely to become even more serious.

B) *Stem Canker* on *R. rugosa*. Since the early 1980's batches of *R. rugosa* stems imported from Holland have suffered from purple/black stem lesions resulting in losses of up to 50%. Two fungi, *Gnomonia rubi* and, in 1990, *Phomopsis mali*, have been found causing the lesions. These diseases, and a general dissatisfaction with the quality and cost of imported stems, have stimulated interest in the home production of stems by budding onto R.laxa rootstocks.

C) *Black Mould (Chalaropsis thielaviodes)* is a wound-infecting disease which, on rare occasions, can cause almost total losses through budding failure. The heavy black growth of the fungus prevents union of the stock and bud. In cases investigated in Britain it appeared that the disease had built up on rootstocks that had been poorly stored, so that the disease was widespread when budding took place.

D) *Virus diseases* do not appear to be widespread on bushes budded onto seed-raised *Rosa corymbifera* 'Laxa' rootstocks. However viruses can sometimes cause trouble on bushes grown on vegetatively propagated rootstocks. Some cultivars from the USA and New Zealand budded onto vegetatively propagated rootstocks have been infected with *Prunus* necrotic ringspot virus. In Britain cultivars such as 'Pascali', 'Fragrant Cloud', and 'Peace' have been severely stunted when budded onto *R. rugosa* stems infected with strawberry latent ringspot virus.

DISEASE RESISTANCE AND ROSE BREEDING

Rose cultivars vary widely in their susceptibility to rust, powdery mildew, and black spot. The factors involved in resistance are largely unexplained, although anti-fungal substances on leaves, cuticle thickness, and chemical substances within leaves have all been suggested as being involved in black spot resistance.

Most rose breeders do not specifically breed for resistance, but they do screen their seedlings for susceptibility and weed out those that are obviously susceptible. Unfortunately, even if a cultivar begins its life being resistant to disease, new races can develop that can overcome the resistance.

Some breeders have deliberately sought to introduce resistance from wild species such as *Rosa wichuraiana* and *Rosa roxburghii,* which are highly resistant to black spot, with good results.

Unfortunately, scientific research into identifying the genes responsible for disease resistance would be extremely expensive and difficult to justify.

WEED CONTROL FOR FIELD-BUDDED ROSES

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Abstract. A range of residual herbicides and a straw mulch were applied to newly planted *Rosa dumetorum* 'Laxa' rootstocks Visible damage in the form of leaf scorch was seen following applications of oxadiazon (Ronstar liquid) and a transient chlorotic leaf blotching was seen after applications of diflufenican plus isoproturon (Javelin) The best weed control was given by oxadiazon (Ronstar) plus simazine (Simazine 50 FL). Good weed control was also given by straw mulch, atrazine plus terbuthylazine (Gardoprim A 500 FW) plus metazachlor (Butisan S), simazine plus metazachlor, metazachlor plus isoxaben (Flexidor) plus propyzamide (Kerb 50W), and oxadiazon (Ronstar) plus diflufenican plus isoproturon (Javelin)

INTRODUCTION

The residual herbicides, atrazine and simazine, were first marketed by J.R. Geigy S.A., (now Ciba-Geigy), in the late 1950s and have been widely used by U.K. rose growers since the 1960s. Rose crops usually receive three applications of residual herbicide. after planting, after budding, and after heading back. Simazine has a lower water solubility than atrazine and has, therefore, been favoured for use on light land where root uptake of atrazine has led to crop damage. On heavier soils, atrazine has proved safe on roses and its contact activity against small annual weeds has been a boon to growers where there has been a delay between planting and residual herbicide application.

Tolerance of the triazine herbicides, the group that contains atrazine and simazine, by weeds that were previously susceptible, first appeared in the United States in the mid-1960s (3) By the early 1980s incidents of triazine-tolerant *Senecio vulgaris* (groundsel) and *Poa annua* (annual meadow grass) were reported from various locations in the U.K. Triazine-tolerant *Senecio vulgaris* is now fairly widespread and, in common with producers of fruit and other field ornamentals, rose growers have had to seek alternatives to triazines alone. The Dutch intend to discontinue using triazine herbicides in 1991 for environmental reasons (1). If, in the future, a similar approach is taken in the U.K., rose growers will need replacements for triazines rather than, as is currently popular, triazines used in combination with other non-triazine residual herbicides This trial screened a range of triazine and non-triazine herbicidal combinations for weed control and, to date, visual phytotoxicity symptoms.

MATERIALS AND METHODS

Rosa dumetorum 'Laxa' rootstocks of 5 to 8mm hypocotyl diameter grade were hand-planted on a heavy loam of the Bishampton series at Pershore College between 26 and 30 March, 1990. The site had previously been a long term grass ley Crop spacing was 20cm in rows 90cm apart. The stocks had been overwintered in an open frame and were at an advanced bud burst stage at planting. The crop was earthed up manually following planting and irrigated to aid establishment.

Treatments. The following herbicidal treatments were applied on 11 April in dull, calm weather. No irrigation was applied following treatment application.

1. Atrazine applied as Gesaprim 500 FW at 3.4 litres/ha.
2. Oxadiazon and diflufenican plus isoproturon applied as Ronstar liquid at 4 litres/ha, plus Javelin at 2 litres/ha.
3. Oxadiazon and diflufenican plus isoproturon applied as Ronstar liquid at 4 litres/ha, plus Javelin at 1 litres/ha.
4. Oxadiazon and simazine applied as Ronstar liquid at 4 litres/ha, plus Simazine 50 FL at 3.4 litres/ha.
5. Untreated Control.
6. Untreated Control.
7. Simazine and metazachlor applied as Simazine 50 FL at 3.4 litres/ha plus Butisan S at 2 5 litres/ha.
8. Pendimethalin and matazachlor applied as Stomp 330 at 6 litres/ha plus Butisan S at 2.5 litres/ha.
9. Propyzamide and metazachlor applied as Kerb 50 W at 1.7 kg/ha plus Butisan S at 2.5 litres/ha.
10. Atrazine plus terbuthylazine and metazachlor applied as Gardoprim A 500 FW at 5 litres/ha plus Butisan S at 2.5 litres/ha.
11 Isoxaben, propyzamide and metazachlor applied as Flexidor at 0.25 litres/ha, Kerb 50 W at 1.7 kg/ha plus Butisan S at 1 25 litres/ha.
12. Wheat straw mulch at 7.5 cm depth, equivalent to 18.5 T/ha, topdressed with additional ammonium nitrate at 300 kg/ha.

With the exceptions of treatments 4 and 11, oxadizaon (Ronstar liquid) plus simazine (Simazine 50 FL), and isoxaben, (Flexidor), propyzamide (Kerb 50 W) plus metazachlor (Butisan S), all formulations were applied separately. Treatments 4 and 11 were applied as fresh tank mixes All applications were made by knapsack sprayer in 830 litres/ha water equivalent

RESULTS

A foliar scorch was recorded on the three treatments that had combinations containing oxadiazon (Ronstar liquid). This persisted

until late May after which recovery appeared to be total. The two treatments containing diflufenican and isoproturon (Javelin) produced a chlorotic blotching on new crop foliage. This symptom was more severe on plots treated with Javelin at 2 litres/ha than those treated at 1 litre/ha. The chlorotic blotching was associated with an apparent reduction in early growth but foliage symptoms did not persist after 21 June. Subsequent crop growth was good. Results of weed counts are shown in Table 1.

No other treatment produced visible phytotoxicity symptoms and all other crop growth suppression appeared to be linked directly to the level of weed infestation.

DISCUSSION

The weed spectrum was typical of the area except for the absence of *Stellaria media* (common chickweed).

Triazine tolerant weeds were not apparent on the area. All of the herbicidal treatments gave good weed suppression in comparison with the untreated control. The performance of oxadiazon plus simazine (Ronstar liquid plus Simazine 50 FL), atrazine plus terbuthylazine, and metazachlor (Gardoprim A 500 W plus Butisan S), and the straw mulch was outstanding.

The combination of oxadiazon and simazine had performed well in an earlier trial at Luddington Experimental Horticulture Station* and, at present, has a label recommendation for application to established dormant roses.

Atrazine plus terbuthylazine (Gardoprim A 500 FW) are both triazines. Gardoprim A 500 FW would not be effective against triazine tolerant weeds and would be lost if triazine herbicides were to be withdrawn. Gardoprim A 500 FW at 5 litres/ha applies 2.5 kg/ha triazine, a substantially higher rate than is recommended for atrazine or simazine formulations approved for roses. For this reason, although no crop damage was recorded at Pershore, growers would be unwise to treat large areas of roses with a herbicidal combination containing Gardoprim A at 5 litres/ha until its crop safety has been fully evaluated.

The straw mulch was very successful for weed suppression and did not visibly affect crop growth. Like the chemical herbicides it did not limit perennial weed growth and where *Cirsium arvensis* (perennial thistle) was present as vegetative material the straw

*Part of Ministry of Agriculture, Agricultural Development and Advisory Service, now closed

Table 1. Weed count per two sq metres, 20 July

Weed Species	1 Atrazine	2 Ronstar + Javelin at 2 l/ha	3 Ronstar + Javelin at 1 l/ha	4 Ronstar + Simazine	5 Untreated Control	6 Untreated Control	7 Simazine + Butisan S	8 Stomp + Butisan S	9 Kerb 50W + Butisan S	10 Gardoprim A + Butisan S	11 Butisan S + Flexidor + Kerb 50W	12 Straw Covered
Calystegia sepium	9				4	1		16			2	
Capsella bursa-pastoris					19	7			1			
Cerastium holosteoides						1						
Chamomilla suaveolens					19	19						
Chenopodium album	25	22		34	484	555	10	22	22	2	12	
Chenopodium polyspermum						236			1			
Coronopus didymus	2		4		9	11			4			
Epilobium montanum									1			
Euphorbia helioscopica								2				
Fumaria officinalis					7	3			3			
Galinsoga quadriradiata			9		3							
Galium aparine								5			1	
Lactuca serriola											1	
Lamium purpureum			1									
Matricaria perforata					124	135		2	1			
Plantago major					1	30			1			
Poa annua			1									
Polygonum aviculare	8		4		31	26	1		10		2	
Polygonum persicaria			2		5	746			1	1		
Raphanus raphanistrum					3							
Rumex obtusifolius						1						
Senecio vulgaris			1		1	1			1			
Solanum nigrum	5	12	9		11	14	3	1	6		5	1
Sonchus arvensis	5		1		31	20			2		2	
Trifolium repens					1	4			1			
Urtica urens	1					22			5		5	1
Veronica chamaedrys	1		2		6	16						
Vicia tetrasperma						4		1				

presented no barrier. The forthcoming end to the practice of straw burning could, in some areas, increase the availability and reduce the price of straw. The straw used in the trial hampered the budding process, this being mainly due to the problem of hoeing out the earthed-up crop. Successful commercial application of a straw mulch for weed suppression on roses will probably depend on the following five factors:

i) Wide availability at a farm gate price of less than £2.50/T.

ii) Acceptable mechanised straw laying methods.

iii) A better understanding of the likelyhood of nitrogen starvation from straw breakdown affecting the crop. Economically and environmentally acceptable methods of countering progressive nitrogen starvation.

iv) Elimination of volunteer cereals in straw mulches.

v) Effective small rodent control in straw.

With the exception of the straw, the most effective triazine-free herbicidal combinations were oxadiazon (Ronstar liquid) and isoproturon plus diflufenican (Javelin). The reduction of the rate of Javelin from 2 litres/ha to 1 litre/ha adversely affected the combination's performance. This was disappointing because the chlorotic leaf blotching on the crop was also much less severe at the lower rate. The metazachlor, isoxaben and propyzamide (Butisan S, Flexidor and Kerb 50W) gave good results although earlier work at Luddington EHS had indicated that reduced rates of Butisan S could give a shortened period of protection. For this reason such a combination may require summer "topping up", even in a non-earthed up crop. Napropamide (Devrinol) was not included in this trial because earlier work had indicated it to be a far better herbicide for winter (post heading back) application than for late spring use without subsequent irrigation (2).

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MECHANIZATION OF ROSE TREE PRODUCTION

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In looking at this topic it must be understood that methods in areas covered will vary. I am in no way suggesting that the points raised here are the only means that rose tree production may be mechanised.

Soil Structure. Before starting to produce a crop of roses the first thing to note is the possible soil structure that a field can offer. I like to take a sample of soil from an uncultivated area, which can usually be found in a corner of a field, and compare it with that found well out into the field. Usually there is a noticeable difference. For instance, on many clay-based soils the particles are much more compacted in the middle of the field compared with the edge. Soil structure is a very important factor and can influence the cultivation, as well as the quality of crop.

Cultivation. The primary operation has to be sub-soiling followed by ploughing. As an alternative a digging machine can be used. These machines are non-rotary in action. Their digging action completely distributes any material on the surface throughout the whole of the working depth. Another advantage of this method is the variance of tilth as fine as that produced by a rotary cultivator.

The digging machine does, however, retain a soil structure where rotary cultivation tends to destroy it. Ploughs or any machine with a rotary action can, especially on clay based soils, create a pan or smear, which should be avoided. The digging machines cannot do this purely because of the downward thrusting action of the spades. This gives a further advantage as there is a reflection of this action below the working depth which aids drainage.

The time of year that we transplant stocks is when the weather is often variable and if we only disturb the soil when we are ready to plant, the resultant conditions are probably the best achievable.

The use of a reciprocating harrow directly onto the ploughing is a more conventional way of obtaining a planting surface. These machines will give a grading effect, and should be followed with a spring-tined cultivator to give the final tilth. With this method, care must be taken, especially on clay-based soils. Once again, these can smear and pan if the moisture level is high. Rotary cultivators are the last resort.

Planning the System. When adopting a system for rose growing we must consider all the operations necessary, from transplanting, through crop maintenance, to harvesting.

The most common width of bed used is 1.30m; with this we can operate a system of 1.70m. This allows a row width of 0.76m. Growers in the UK use anything from 0.71m up to 0.92m. However, the most common rule is the dimension of the tractor wheel centres used, divided by two to give the row width. It is, therefore, at the planning stage that we must consider the following points: 1) Are the fields flat; 2) if there are gradients, do they vary; 3) is the soil light or heavy?

We are dealing with a very high value crop which will take two years to produce, so we must have sufficient room for the tractor to move without causing damage. Always consider giving extra land to the wheeling, possibly 5 to 7 cm per row.

Transplanting. The final cultivation before transplanting must not leave the soil too loose and light, although a good surface tilth is desirable. The base of the neck of the root-stock has to be set at finished ground level. To set up a transplanter, a sample of the stock to be handled is placed in the plant holder and the mechanism rotated to the point of release. Observing from the rear, it should be possible to see where ground level will be at a given planting depth and how the root system will be contained in the furrow. If the root system protrudes below the base of the share, reposition the stock in the holder, or root pruning, will have to be done. The root system must never protrude below the base of the share otherwise "hockey stick" roots will be formed. Fine adjustments can be made in the field. Plant spacings generally adopted are 125 to 150mm.

We have to decide if we are going to earth-up now or make it a separate operation. Other operations need to be considered before earthing-up. It is easier to observe the quality of planting if you don't earth-up. Also, "gapping" is easier. When we earth-up as a secondary operation the application of fertiliser along the row can be made. It is preferable to earth-up the stock to within 25 to 50mm, this will give very good protection, preventing frost damage and the root stock from drying out.

Weed Control and Crop Maintenance. It has been the practice over many years to apply a chemical herbicide overall after the earthing-up. There are three options: chemical; chemical with mechanical; and mechanical. A chemical/mechanical operation is possibly the best. If a herbicide is applied just as a band only over the rootstock, then the growing crop should remain weed-free and the centre and wheelings can be mechanically controlled. A full mechanical control can be effected by the used of inter-row cultivators plus a blowing machine to deal with weed growth between the stocks. This method does require the earthing-up operation to be undertaken after each pass of the blowing machine.

During this first growing year it is probable that irrigation will be used. We must ensure that full use of applied water is made and that it is available to the crop without wastage. Too often this water will run off. To overcome this, break up the topsoil so that run-off is prevented. This operation can be worked very satisfactorily where the chemical/mechanical method of weed control is adopted. The machine is known as a ''soil loosener''. The machine has a wide spring with a trailing beam onto which is attached a leg with a winged foot similar to a subsoiler, but smaller. The machine only works the top soil to a depth of 150mm. The effect is to burst up from below the surface giving fracturing of the soil thus making it retain water. An added bonus is that the soil is aerated.

Budding. Before the budding can proceed the soil used to earth-up the crop has to be removed. This can be done in three ways, by hand hoe, by brushing machine, or by blowing machine. The first method is self explanatory. The brushing machine is worth consideration where the soil is reasonably light. If the soil has capped, through the action of rain or irrigation the brush alone can have difficulty in moving the soil cleanly away. It is worthwhile placing tines or shares on either side of the row to break the soil. The blowing machine is the best piece of equipment to use as there is no mechanical contact with the stock, only an air blast to remove the soil.

Secondary Maintenance. Once budding is complete a further inter-row surface cultivation can be made with a spring-tined cultivator. Another excellent machine to use is the soil loosener, but this time fitted with surface cultivating units. Fit plant protection plates to any machine used so that no soil is thrown against the bud. After a short period a second application of herbicide may be applied and the grower must decide what further maintenance has to be done. This dictates whether or not to adopt a chemical or chemical/mechanical weed control for the rest of the growing period.

Heading-back. Heading back is the term used for the removal of the unwanted stock top. The cut is made at about 12mm above the bud. Because budding is a manual task the bud height is variable, which means heading-back must be a manual operation too, but the waste can then be collected mechanically. Firstly, it is necessary to windrow the material to create sufficient bulk. All movement of these tops must be from the back of the stock so as to minimise damage to the bud. For windrowing, an ordinary agricultural swathe turner, set in a high position, will roll the stock top quite easily. The ideal machine for their collection is a full-chop forage harvester. These machines will chop lengths of about 25 to 50mm, which is thrown in the air, falling back onto the field, this will then break down. The only pieces that can possibly be found will be the occasional crown.

Third Maintenance. Three operations have to be considered: feeding, cultivating, and a final application of herbicide. A band application of fertiliser, often high potash, can be applied and at the same time a tilth should be produced to enable an application of herbicide to be effective. The soil loosener again has a very important role to play in aeration. During the period up to harvest a further mechanical operation is to ''stop'' the crop, cutting back the top to encourage extra shoots to break from the bud. Invigorating the plants in this manner can create more first grade trees. The machine used is a band saw, mounted on the horizontal. This machine can be either P.T.O. or hydraulically driven.

Before harvesting the crop, defoliation may be considered. The spraying of a solution of sulphate of ammonia if the weather is dry and warm can cause abscission effectively. Another possibility is leather thongs mounted onto a horizontal cylinder driven via the tractor P.T.O.

The machine that was used to stop the crop earlier, can be used to reduce the overall length of the trees. This is necessary to give uniformity to the height of tree to prevent damage to the crop while lifting. The height of cut is usually 50cm or less, but some growers cut back to 25cm.

Harvesting. The harvesting of the crop can start in early September. At this time of year the ground can be dry, especially on the heavier soils. To ease the entry of the lifter into the ground, first break up the headland using a deep cultivation tool.

Vibrating subsoilers will give an excellent shattering effect. With just two tines following the tractor wheels this machine can be taken through the crop with care, but only go over ground that will be lifted in the short term, traction later in the season could be difficult. If the use of the soil loosener had been adopted it may not be necessary to go through the crop with the subsoiler.

Lifting machines fall into three major categories. Fixed share, powered shaker, and side digger. For single row lifting it is usual to use a share width of 50cm, this will also allow a working depth of 25 to 30cm. The form of this share is an inverted ''U'', or if fitted to a winch plough or side digger, a ''J''. The dimension for a two-row share can be up to 150cm in ''U'' form.

Powered machines adopt two principles, one where the front share is fixed with movement of a shaking mechanism behind, and the other is where the front share also moves.

Some machines with a fixed front share have a shaker unit attached to the rear edge of the base and are hinged at this point, while others have a swinging grate. The main advantage of the swing lifters is that there are no bearings, axles, or moving points below ground so they should have an extended life. The machines

with a movement to the front share can aid the passage of the machine through the soil but it does mean that a number of extra mechanical parts are required to create this movement.

Once the trees have passed through the lifter, and have been gathered into bundles they are then tied with a tractor-mounted machine.

The Future. What of the future? A lot will depend on market trends and developments in alternative production methods, such as micropropagation. One company is at last finalising the production of a single row harvester with a tying machine mounted within the harvesting length of the machine. Developments will take place, but in which areas I cannot say, other than it will depend largely upon growers to create demand.

PERPETUAL FLOWERING GROUND COVER ROSES: THE "COUNTY SERIES"

PAUL MASTERS

Notcutts Nurseries, Ltd.
Woodbridge, Suffolk

INTRODUCTION

The name "County Series" has been given to a group of repeat flowering cultivars of ground cover roses. As a result of their repeat flowering nature they are much less vigorous than existing cultivars, such as 'Max Graf' and 'Pheasant'. This makes the "County Series" roses much more suitable for small gardens and container growing for garden centre sales. Each British county has its own distinct character as does each of the "County Series" roses.

Flowering from June to October on their own roots, sucker-free, pest and disease resistant and hardy, "County Series" roses have characteristics and a colour range that were not available in existing ground cover cultivars.

Planting distances depend upon the cultivar, but range between 45 cm centres for *R.* 'Rutland' and 75 cm centres for *R.* 'Surrey'. Petals drop cleanly so dead heading is not necessary. A light trim during the autumn and winter can be carried out to keep the plants tidy.

There are many applications for "County Series" roses in the garden and landscape, from conventional ground cover, particularly on banks and other difficult situations, to use as a bedding rose for which *R.* 'Kent' is quite outstanding. Budded onto a *R. rugosa* stem they make delightful weeping standards, and planted in hanging baskets add a whole new dimension to rose gardening.

THE CULTIVARS

***Rosa* 'Suffolk'** (Kormixal) 1988. Bright crimson single flowers with prominent golden stamens in great profusion, followed by orange-red hips in autumn; a low spreading shrub, 45 cm by 90 cm.

***Rosa* 'Essex'** (Poulnoz) 1988. Rich pink flowers in large clusters, low dense growth with remarkably even spreading shoots 60 cm × 120 cm. Amply furnished with small glossy foliage. Awarded Certificate of Merit by Royal National Rose Society 1987. Gold Medal, Dublin 1987. Certificate of Recommendation in The Hague, Holland.

***Rosa* 'Kent'** (Poulcov) 1988. Pure white flowers in large trusses. Semi-double blooms in great abundance which stand up to cold

wet weather during the summer, unlike so many others of this colour. 45 cm × 60 cm. Trial Ground Certificate at Royal National Rose Society, St. Albans 1989. Certificate of Merit, Belfast trials. Gold Medal at Baden Baden, West Germany.

***Rosa* 'Surrey'** (Korlanum) 1988. A wide-spreading shrubby grower 60 cm to 90 cm in height and up to two metres across, bearing great swatches of double blooms of soft pink, with deep rose within the heart of the flower, throughout the season until the first frost. Awarded Gold Medal by Royal National Rose Society, 1987.

***Rosa* 'Rutland'** (Poulshine) 1988. A single rose in soft pink freely born throughout the season until the first frost. The delicate pink flowers are set off well against glossy dark green foliage 30 cm × 45 cm. Certificate of Merit 1988.

***Rosa* 'Hampshire'** (Korhamp) 1989. Single glowing scarlet flowers with golden stamens followed by orange-red hips in autumn. Dense bushy growth 30 cm × 60 cm.

***Rosa* 'Norfolk'** (Poulfolk) 1990. Bright yellow, fragrant double flowers in clusters. Neat bush habit 45 × 60 cm. The first yellow and a major colour break in ground cover roses.

***Rosa* 'Northamptonshire'** (Mattdor) 1990. Flesh pink and white blooms of perfect buttonhole shape resembling *R.* 'Cecile Brunner'. A dainty but dense grower 45 cm × 90 cm. Awarded Certificate of Merit by the Royal National Rose Society in 1989.

PROPAGATION—CONVENTIONAL CUTTINGS

Soft material cut from a variety of sources, rooted cuttings, liners, and 2-litre container stock. Cuttings may be taken throughout the growing season as long as the material is soft. These are prepared as leaf bud cuttings, 25 to 30mm. in length. Larger nodal cuttings could also be used. Treated with a 0.25% IBA quick-dip solution and stuck into conventional trays in a 40:60 peat/bark compost. Cuttings could also be direct rooted, three to a liner pot, or in the larger individual cell type trays. Completed trays are placed under open mist. Rooting time depends upon cultivar but starts after 2½ weeks and a high percentage can be expected.

PRODUCTION

Conventional cuttings are potted on during November into a 7 cm peat pot and grown on under glass. This is a slack period at the liner unit and makes good use of available resources.

Liner Compost: Irish moss peat, 4 parts; Vapo Peat, 1 part; 5% grit by volume; Osmocote 8 to 9 months, 2 kg/per cu.m.; Dolodust; and Fritted trace elements.

Routine pest and disease controls and a good standard of hygiene must be maintained. The main problems are: downy mildew, powdery mildew, black spot, and *Botrytis.*

Liners are potted on into a 2-litre final container during April and May and grown on outside. Just before potting, the liners are cut hard back to encourage good shoot and root development. Very little further trimming should be necessary before first sales from the crop can begin in late July.

Final potting compost:

Peat—medium grade, Irish moss;
10% grit by volume;
Osmocote, 15-8-11, 12-14 months, 3.5 kg/cu.m.
Ficote, 16-10-10, 12-14 months, 2 kg/cu.m.
*Ficote, 16-10-10-, 8-9 months, 1 kg/cu.m.
Single Superphosphate 0.75 kg/cu.m.

*Reduce the amount by 50% for late-potted small liners, especially from micropropagation, since during hot weather release can be very rapid and may cause root burning.

PRODUCTION FROM MICROPROPAGATED PLANTS

The explants are weaned and rooted into cell trays in a Sonicore fog unit. From the end of September, supplementary lighting is used to extend day length to 16 hours. This is necessary to enable the unit to utilise space and labour during an otherwise quiet period, to ensure that the customer can receive his plants at the beginning of April, and because we have found explants coming out of 16 hours daylength in the growing room become dormant and often die in the lower light conditions during the autumn and winter.

Lights used are 400 watt SON. PT high pressure sodium lamps made by Thermaforce. These are set at 2.2 m above the crop height, 12 to each fog unit, which has an area of 160 sq. m. This provides a light level of 2,500 to 3,000 lux. Running costs for 28 lamps from the end of September through to the end of April are £400.

Weaned and rooted trays are moved to cold glass until despatch to wholesale customers, or potting-on for our own production. Young plants are potted-on into 7 cm. peat pots during February/March under glass. The liners establish quickly and can be potted into a final 2-litre container during April/May for sales in late July onwards.

Similar pest and disease controls as used in conventional cutting/liner production.

Commercial micropropagation labs. producing "County Series" roses in the UK include:

Micropropagation Services (E.M.) Ltd. East Leake, Leicestershire.
Notcutts Nurseries, Ltd. Woodbridge, Suffolk.
Pro Culture, Evesham, Worcestershire.

OPEN GROUND PRODUCTION

"County Series" roses bud well in a traditional open ground production system. Although they do not have the advantage of plants on their own roots, some cultivars have more vigour and will produce a larger plant.

Radclive Nurseries, Ltd. Faringdon, Oxfordshire, have used field growing methods to produce a bare-root "County Series" rose on its own roots. Fully hardened plugs from micropropagation are lined out in a bed system during May. Soil preparation to a seed bed standard is very important, as is irrigation, to ensure success. Growth is rapid and a well-branched sturdy plant can be achieved for sale in the autumn of the same year. The excellent shoot to root ratio of these field-grown plants makes them ideal for landscape planting or for containerising for garden centre sales.

PROMOTION

Notcutts Nurseries has been actively promoting "County" roses to the wholesale and retail trade Point of sale material is available for garden centres in the form of a waterproof poster and 8 x 6 in. bed label. Exhibiting at the Flower Show, Chelsea, and constructing a garden at the National Garden Festival, Gateshead, has increased public awareness and created renewed interest in using roses in the garden, which do not have the cultural demands of more traditional cultivars.

THE FUTURE

More cultivars are currently being trialed with improvements and new colour breaks emerging from breeding programmes each year. We have three new "County Series" roses for introduction in 1991: a "handpainted" single type with a white centre and pink edge, a single vivid pink cultivar; and a peach-coloured cultivar with a slight scent and the habit of *R.* 'Kent'.

BREEDING ROSES IN HOLLAND

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The history of humanity goes hand in hand with the history of the rose. There is no period in time when the rose did not play a role. It has been painted a thousandfold; numerous poems and songs have been devoted to it and in literature it figures more than any other flower. Its image is reproduced on coins, postage stamps, vases, and on primitive wall paintings.

My interest in roses dates back to the beginning of the 1960s. It was by chance that I came in contact with the families, Dickson and McGredy. The work in rose breeding of these two families held a very particular fascination for me and, in all fairness, I must admit it was they who inspired me to take up rose breeding. They taught me a great deal during our many discussions and they quite often made it clear that the breeding of roses was not just a simple matter of putting pollen on stigmas, but rather, involved the building of a line toward a specific goal. In addition, I was assured that the breeding of roses would be an extremely expensive ''hobby''.

As the rose is a heterozygote there are many more possibilities for its manipulation than with shrubs.

It seemed to me a fascinating occupation to operate such a concern alongside our traditional nursery stock business—to introduce new roses, with other forms and characteristics, and then to find a market for them; in 1964 we began to set up a breeding program for roses.

A rose breeder must know the material of all roses; the good points and the bad points and must know the laws of genetics.

Most botanical roses are diploid; that is, that they contain genetic information in duplicate and have two copies of seven chromosomes. A method of manipulating this information is through crossing, the chromosome number is doubled and most of the roses on the market, such as floribundas, hybrid teas and greenhouse cultivars, contain genetic information which is tetraploid: four copies of the seven chromosomes. Some roses, for example, *Rosa canina*, which is quite often used as a rootstock, is pentaploid and has 35 chromosomes, five copies of the information.

For breeding it is sometimes necessary to breed roses with different numbers of chromosome copies. A diploid species can give a haploid gamete, and a tetraploid can give a diploid gamete. Crossing these two results in a triploid offspring. It is common that triploid plants are partly or totally sterile. If you find a triploid

which is not totally sterile it is possible to transfer genetic information from the diploid species to a tretraploid species. In this way new genetic information can be introduced in cultivated species, which are mostly tetraploid. There are two disadvantages in doing this: First, all genes are not necessarily alike. Constant crossing of a strain means current cultivars have an unknown mixture of genes, so one cannot predict what characteristics the descendants will have, often all descendants are different. Secondly, one cannot obtain a cultivar that can be propagated true through seeds. Genetic research of roses is still in its infancy. We do not know if a characteristic is dominant or regressive. For example, we know that non-perpetual flowering botanical roses are dominant over perpetual flowering ones. If one crosses a non-perpetual flowering sort with one that is, you will obtain only non-perpetual flowering sorts in the first generation; and by crossing them with a perpetual sort you will obtain 50% perpetual and 50% non-perpetual.

It takes a minimum of two generations or three years to select a perpetual flowering cultivar where one can be assured that not too many non-perpetual characteristics were inherited.

New cultivars are bred by cross-pollination, so the breeder must intervene before nature has her way. Thus we begin crossing quite early in the morning, especially for garden cultivars, as it is necessary to collect the pollen from a flower before it self-pollinates.

After all flowers have been pollinated we place the left-over pollen in small round containers in a desiccator (a large glass bowl-like container) containing silica-gel to absorb moisture. The desiccators are then placed in a refrigerated unit. This ensures the availability of pollen, should there be no fresh pollen on any particular day.

Crossing takes place in Holland from April until the end of June. Then over the summer months the rose hips grow and the seeds ripen. Around the second week of September we begin to collect the rose hips, open them, count the seeds and note the crossings.

From about 35,000 crossings we average 180,000 seeds, with a germination factor of approximately 40 to 50%, giving us about 90,000 seedlings to select. From these 90,000 we will have made about 1,000 garden selections and 1,000 greenhouse selections.

Following this, the greenhouse selections are potted-up and checked for: color and form of bud and flower; the number of flower petals; length and stability of stem, and other characteristics such as thorns, resistance to disease, persistence of color, production and, of course, vase life. For our "Spray cultivars" we also note the spray form and if all flowers on one stem open simultaneously.

This strict selection leaves maybe a couple of hundred seedlings which we then graft on a rootstock in December or January and plant in February. We again make selections based on performance. Those up to our standards are forwarded to our representative who once again will graft and plant these selections, making further tests similar to those which we have conducted. From there, with great anticipation, we await the reaction of the growers, hoping that they will choose our selections. Meaning that finally, after years of work and high costs we are fortunate enough to have a "new rose" worthy of placing on the market! For garden cultivars, after the first selection these are budded in a field. The following year a second selection is made according to the following criteria: color of the flower, is it a floribunda, HT, ground-cover patio or shrub; is the flower full or single; is it perpetual flowering or not; is it self-cleaning; is it resistant to diseases, and does it remain in good condition during wet weather? Approved selections from here are then forwarded to rose trials all over the world.

THE DARTHUIZER ROSE FAMILY HISTORY

Some years after World War II, when The Netherlands was still recovering from the war damage, the Dutch Government Parks and Garden Services began rebuilding. Every year many new houses had to be built in order to repair the ravages of war...and all this in a country which was not only flat, but to a large extent, bare of trees as well. Thus, the polyantha rose was used by landscape architects to add the necessary color effects. Millions of roses were planted in the ensuing years...roses such as 'Peace', 'Hollanderin', 'Queen Elizabeth', 'Fanal', 'Lili Marlene' and others. We could perhaps conclude that the use of such large numbers of roses was a form of fashion.

In the early 1960s there was a distinct change, people wanted something different. A new generation of architects emerged who were no longer content with just polyantha roses. Thus, the "shrub" rose made its entrance. Modern ecological insights also caused many landscape architects to completely change their views. The excessive use of the polyantha rose was becoming too costly due to the rising cost of maintenance. The shrub roses, while becoming more in demand, had a major disadvantage since they virtually all only flowered for a short time in the spring.

It was our decision then, to begin a breeding program to develop shrub roses that would flower throughout the season, and which would also have ground-cover characteristics in order to keep maintenance costs at a minimum. And of course, this all in as wide a range of colors as possible.

Many crossings were used to find a favorable blood line. We crossed 'Mozart', 'Ballerina' and 'Yesterday' with the polyantha 'Rimbanbella'. The resulting seedlings gave us a great many descendants that had many of the characteristics sought by us. These shrub types with ground cover characteristics were a result of the named crossings crossed with certain seedlings developed by us over the years.

In the early 1970s, we brought a few cultivars on to the market, such as 'Fair Play', 'Smarty', 'New Face', 'Rosy Cushion', Summerrose', 'Red Blanket'. It is interesting to note here that our 'Lavender Dream' came from this line (a crossing of 'Yesterday' × 'Nasterana'). 'Lavender Dream' is a rose with extraordinary qualities because it does very well in hot climates.

In the very near future we will be introducing a yellow shrub and a yellow ground cover cultivar, which was a high priority in our program.

These shrub roses clearly met a great need and were planted within and outside Holland in large quantities. Very few rose breeders can make a living from breeding only garden cultivars. What began as a hobby for me, some 25 years ago, grew into a professional rose breeding department under the name "Interplant" (International Plant and Trading Company). The costs of breeding became so great that we realized we had to make a decision for the future: a) to keep it as a hobby, where the chance of producing good roses is rather slim; or, b) to make it a professional endeavour taking on personnel who have graduated with a degree in genetics and to create a department capable of delivering a profit. We choose the latter. And, as a consequence of this decision, Interplant now employs a supervisor and a technician, both graduates from high level universities, and two graduates with college level horticultural education.

In order to make a profit, we realized we would have to breed greenhouse as well as garden cultivars. As you may know, Aalsmeer in Holland, is the largest rose greenhouse market in the world, where each year 10 million roses are sold.

The big question was, what must one breed for this market? After much consideration we decided to try to produce a "spray rose". After all, we have the spray carnation and the spray chrysanthemum—why not a spray rose?

Many crossing possibilities were attempted, and after many disappointments we finally managed, eight years ago, to introduce our first spray rose...'Porcelina' later followed by 'Joy' and 'Evelien'. In 1988, 'Nikita' and 'Princess' were introduced. At this time we are proud to announce that "Interplant" is the largest producer of spray roses in the world. This year we introduced

four new spray cultivars; 'Purple Prince', 'Swing', 'Sentyna' and 'Elegance'. High on our priority list now is to develop a yellow spray rose.

Next to the spray roses we introduced new cultivars of long-stemmed roses. Among these are 'Only Love' a beautiful red HT and 'Rosette' a very exceptional rose producing 350 flowers per sq m.

Our company has been successful but we have to realize that the success of today is not the success of tomorrow. The proposed new laws on Plant Breeders Rights and the proposed revision of UPOV means breeders will receive far better protection. Everything being equal, we will obtain protection of the end product and hope to have the right to choose patents and/or plant breeders rights. In the future, large companies using biotechnology to produce new roses will require the permission of the original owner to use any material in their ''breeding'' programs.

The cost of rose breeding is phenomenal. It is estimated that breeding on our scale costs about 1 million guilders per year! Then when you realize that it can take up to 10 years or more before you begin to market a new rose, you have a slight idea of one's output before you realize any profit.

We also try to keep in tune with future trends and needs. We are trying to do our part by recognizing the environmental problems and taking steps to prevent further pollution. Our goal is to develop roses that are absolutely resistant to mildew and black-spot for both inside and outdoor cultivars. Rose breeders should be atuned to this problem taking similar steps. This is perhaps where biotechnology can assist us.

THE ROLE OF THE BRITISH ASSOCIATION OF ROSE BREEDERS

TERRY KENWRIGHT[1]

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HISTORY AND ROLE

The British Association of Rose Breeders (B.A.R.B.) is a non-profit association whose aim is:

(a) To license growers to propagate protected rose cultivars for sale and administer and monitor the numbers being grown.

(b) To collect royalties on behalf of rose breeders and/or their agents.

(c) To represent members' interests in all matters appertaining to Plant Breeders' Rights.

(d) To promote "New Roses".

After Plant Breeders' Rights were introduced in 1964 individual rose breeders licensed certain rose growers to propagate their new roses but this was found to be inefficient and expensive for both breeders and growers alike. It also had the disadvantage of different systems being operated by different breeders and, more particularly, did not promote the growing of the newer roses.

In the winter of 1972 a number of breeders joined together. The group included those well known names, Jack Harkness, Pat Dickson, and the late Alec Cocker and, after a great deal of hard work, B.A.R.B. was born in May 1973. Jack Harkness became the first secretary and was the author of the Rules and the Licence terms.

The aim of this small band of rose breeders was to create an organisation that could be used to licence growers and collect royalties in an easy and efficient way and, what was more important, develop one system so that all growers could propagate new roses without a great deal of paperwork.

B.A.R.B. now has a membership of 24 UK breeders and breeders' agents and 14 overseas guest members and, in all, represents 50 different rose breeders, some of whom are amateurs.

The Plant Variety Rights Office requires an overseas holder of Plant Breeders' Rights to have a UK representative or agent and B.A.R.B.'s full membership is only open to U.K. based nurseries whose main business is in the U.K , so overseas breeders appoint

[1] B A R B President

a U.K. agent. B.A.R.B. will also represent an amateur rose breeder but here again that breeder must be represented by a U.K. nurseryman. No rose breeder is refused membership providing he has been granted or operates Plant Breeders' Rights for a rose cultivar in the U.K. and abides by the Association rules.

The Association is run by a full time professional secretary who works in close liaison with the elected officers and with two part-time field officers. We now license around 250 growers to grow all or any of the 450 or so rose cultivars that are protected by Plant Breeders' Rights in the U.K.

The Association is funded by subscriptions from its members and a levy which is a proportion of the breeders' royalty income.

In order to make itself more efficient and effective the Association has, during the last four years, invested in a computer system with custom written software which not only handles all royalty invoicing and disbursements, but also provides valuable market and cultivar information to its members.

THE SYSTEM

The system is quite simple, easily understood, and has been operating successfully for 17 years. A grower who wishes to propagate protected rose cultivars applies to B.A.R.B. for a licence and, providing he is known to be a responsible nurseryman, one is

There is no charge to growers for registration, though there is a "minimum charge"; where a licensee's annual royalty account before VAT is less than £30.00 it is made up to that amount to cover the cost of administering the account, issuing standard documentation, mailshots, and other such costs.

In May each year, B.A.R.B. sends to all licensed growers "The Offer" which contains a list, submitted by all the breeders (or breeders' agents) of all the protected roses available in the U.K "The Offer" highlights the new introductions for that year and gives descriptions and information about fragrance and other relevant information as well as the various royalty rates.

Budwood is supplied to the growers free of charge by the breeders, providing the nursery has not grown that cultivar before; even so, some breeders will supply budwood free if the nursery is increasing the quantity it is growing of a particular cultivar.

Royalty rates are a matter for the individual breeders, but all breeders give a 40% "discount" to allow for losses and bad takes; 40% was chosen as most nurseries have saleable crops, taken as an average, of better than 60% of the crop budded. Some breeders also offer a discount for growing larger quantities of their cultivars.

Each grower is required to make a return before the end of September in each year of the numbers of protected rose cultivars he has propagated. B.A.R.B. raises one account for the royalties covering all the breeders. This is payable by the end of March in the year following the year of propagation. The grower pays B.A.R.B. just one cheque to cover the royalties of the roses he propagates from any of the breeders. B.A.R.B. breaks down this cheque and disburses the relevant royalties back to the individual breeder members or breeders' agents.

MONITORING THE NUMBERS BEING GROWN

B.A.R.B.'s policy is that it is fair to every grower regardless of his size and how he operates—in fact, the "Standard Conditions" have been vetted by the Office of Fair Trading, and any alternatives to them have to be similarly vetted before issue. It, therefore, falls to us to check the returns from time to time; this is done by our two field officers. They do their checks by physically counting the cultivars on the nursery, by checking against catalogues and, with the help of our Secretary and the computer, using the information we hold.

Our checks are not only to protect our breeders but also to ensure that no grower gets a price advantage over another by not paying all the royalties due.

PLANT BREEDERS' RIGHTS

There is a flood of new legislation in the pipeline in connection with Plant Breeders' Rights as follows:

(a) Revision of the U.P.O.V. Convention.
(b) Proposed European Community Plant Breeders' Rights Scheme.
(c) Draft European Community Directive on the legal protection of biotechnological inventions, and (because of the above)
(d) The problems of interface between Patent Protection and Plant Breeders' Rights.

All these matters, together with the day to day Plant Breeders' Rights legislation, are handled by the B.A.R.B. Secretary, supported by the Association's Solicitor, who is well versed in these matters. Our Secretary is also helped in this field, but to a much lesser extent, by a small committee of breeder members who help with interpreting how the new legislation will affect rose breeders.

MARKETING "THE ROSE"

Promoting "new roses" is not as easy as it sounds, because we must be even handed to all our breeder members. Our marketing mix consists of:

The recent appointment of a Press Officer.

Breeder/grower co-operation in the joint promotion of "Rose of the Year".

B.A.R.B. keeps growers informed of all new and existing protected cultivars and distributes to all licensed growers "colour work" of new roses as supplied by breeder members.

The newsletter, *"B.A.R.B. News and Views"* which is edited by our Hon. Vice-President, Jack Harkness, and circulated all over the world.

Holding open days from time to time to enable breeders, growers, and the media to discuss matters of mutual interest.

Cooperation with the R.N.R.S., with a stand at the Chelsea Flower Shows, with the objective of showing the gardening public new award-winning cultivars.

Cooperation with Burrell + Floraprint in extending their range of colour work to include many more new roses.

The joint Rose Growers Association /B.A.R.B. Rose of the Year promotion has proved a real boost for rose sales. With the exception of one Rose of the Year, all the others between 1982 and 1989 are in the Top 20 B.A.R.B. cultivars stocked by growers.

To demonstrate our success, the number of protected roses produced has increased from 2.28 million in 1973 to 6.2 million in 1989.

Information about current total rose production is not very well documented but B.A.R.B. enquiries lead us to believe that protected roses now account for almost a quarter of the total rose market in the U.K.

PLANT HUNTING IN CHILE

MARTIN GARDNER

Crown Estate Office
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Historically the main source of good garden plants has been from Western China. However, British gardens have also benefited a great deal from introductions hailing from southern South America. Although numerically these plants cannot attempt to compete with the vast quantities introduced from Western China, temperate South America can boast some of the most stunning and unusual plants cultivated in British gardens today.

The only countries of the South American continent having a climate comparable with that of Britain and Ireland are Argentina and Chile. Garden-worthy plants from these two countries have found their way into British gardens through the implacable efforts of intrepid botanists and horticulturists, such as the Victorian plant collector, William Lobb, who pioneered the introduction of some of the most noteworthy plants from temperate South America. Latterly, Harold Comber, who made several extended visits during the 1930s, not only reintroduced many of William Lobb's trees and shrubs but also made some notable additions. Many of the plants from temperate South America that grow in Britain and Ireland today, originated from the seed that Comber collected.

Chile has, for its area, the greatest span of latitude of any country; a distance of 4,200 km, and yet it is only 180 km wide in places. Its length is dominated by the backbone of South America, the Andes mountains, which in the north adjacent to Santiago is a crenellated wall of rock reaching intimidating heights of over 7,000 metres. Travelling south through the Andes the mountains become more diminutive in comparison and are represented in the Lake District by volcanoes which are barely 3,000 metres high.

The Chilean lake district is where many of the more horticulturally noteworthy plants come from. This area lies between southern Chiloe in the south and Temuco in the north, covering an area of about half the size of New Zealand's South Island, with which it has profound botanical affinities.

Here the temperate flora of Chile reaches its greatest degree of diversity and consists of moist temperate rain forests. In places, particularly at higher altitudes, these forests are dominated by the southern beech, *Nothofagus*. However, at lower altitudes the forest comprises an array of evergreen trees many of which are familiar garden plants in the milder areas of Britain and Ireland.

Much of the Pacific coast is still clothed in luxuriant primeval rainforest, particularly the region south of Valdivia and parts of the Island of Chiloe. The rocky outcrops are home to a host of native plants, some of which are well established in the British Isles for their salt tolerance, such as *Escallonia rubra* var. *macrantha*, which in the wild seems to have much richer crimson-pink flowers than the clone grown in cultivation.

As well as many species of terrestrial orchids and ferns, there are well known plants, such as *Gunnera chilensis, Gaultheria mucronata*, and thickets of *Fuchsia magellanica. Francoa appendiculata* can also be seen here and it is particularly interesting to note that in the wild this plant always favours a shaded position. In contrast, cultivated plants are normally grown in full sun and one would assume that this relatively tender plant would be afforded more winter protection if it were grown in woodland conditions.

Another plant which seems to be entirely restricted to the coast is *Lobelia tupa*. This beautiful and imposing perennial, two metres tall and the same across, has an impressive coastal distribution, from Santiago in the north, to 800 km south, just below Valdivia in the Lake District.

As one ascends the coastal Cordillera, through magnificent evergreen forests where every branch is festooned in mosses and liverworts, there is an air of familiarity with some of the plants which grow in Britain. One finds well known garden plants such as *Eucryphia cordifolia*, which towers into a deep blue sky, its dark green foliage dripping with bumble bees on white dog-rose-like flowers. Draped from one tree to the next, high up in the canopy, are the intertwining stems of *Lapageria rosea,* the national flower of Chile, which has bell-shaped, rich crimson flowers held in a pendulous position to give the ever-energetic humming-bird easy access to rich reserves of nectar, thus ensuring pollination.

The long and tubular, reddish orange flowers of another climber, *Campsidium valdivianum*, are also visited by humming birds and successful pollination results in the production of long, pendulous inflated fruits.

Perhaps the showiest of all Chilean climbers is *Mutisia decurrens,* a member of the Compositae, which has vivid orange flowers that almost glow within the relative darkness of these forests.

At higher altitudes of the coastal Cordillera just south of Valdivia there are vast forests of one of the most important trees in temperate South America, the conifer *Fitzroya cupressoides.* The sheer magnitude of this tree, which has been known to live 4,000 years, is awe-inspiring. Some specimens stand at over 70 metres in height and with a trunk diameter of over four metres.

Unfortunately, the timber qualities of *Fitzroya* are such that man has found it invaluable and this is reflected in the fragile nature of existing populations. Vast areas of the coastal forests have been destroyed by fire and all that exists of much of it today are their ghostly stark white trunks.

Fortunately some areas are still preserved and with them a very interesting flora. Shrubby plants include thickets of *Desfontainea spinosa*, *Drimys winteri*, *Ovidia pillopillo*, *Gaultheria phillyreifolia* and the red-fruited *Gaultheria tenuifolia* the foliage of which smells strongly of winter-green. In the more open areas of forest there is an abundance of the trunk-forming fern, *Blechnum chilense*. Many species of *Berberis* abound, including *Berberis linearifolia*, *B. ilicifolia*, and the ubiquitous but nevertheless beautiful, *B. darwinii*.

One of the commonest trees of the lowland and montane forests is the evergreen southern beech, *Nothofagus dombeyi*. This handsome tree, which grows to be the largest broad-leaved tree in these forests, occasionally reaches heights of 50 metres. Here it is often associated with other evergreens, such as the much prized timber tree, *Laurelia philippiana* which has strongly aromatic leaves and *Caldcluvia paniculata*, which has creamish-yellow flowers. Amongst the many similar looking species of myrtles which are often seen draped with *Tropaeolum speciosum*, are more distinctive small trees such as *Rhaphithamnus spinosus*. This spine-clad member of the Verbena family has unusually deep green leaves and both flowers and fruits are purple.

The margins of the many streams create an ideal environment for plants which also need a little more light and a damp atmosphere. Such niches are brimming with gems such as *Crinodendron hookerianum*, *Azara lanceolata* and *Lomatia ferruginea*. Beneath, on moss sodden rocks, are the tight mats of *Calceolaria tenella*, its foliage studded with small yellow flowers on fragile stems, and *Gunnera magellanica* forming carpets of glossy leaves which conceal elongated clusters of fleshy, orange fruits.

With a rise in altitude, there is a gradual change in the type of vegetation which, although comprising fewer species is nevertheless very interesting. One of the most important trees, which becomes predominant at higher altitudes, is the conifer *Saxegothaea conspicua*. The vigorous climber, *Hydrangea serratifolia*, may well be seen high up amongst its canopy, clothed in creamy yellow flowers. Less invasive climbers are the gesneriads, *Asteranthera ovata* with scarlet flowers, and *Sarmienta repens* which is an endearing fleshy-leaved plant with orange-red flowers. Both of these are often seen clinging to the moss-covered trunks, whilst the third member of this family in Chile, *Mitraria coccinea*,

is less of a true climber and often forms spherical entanglements perched high up in the canopy.

As might be expected, the climate is very wet with all-year-round precipitation. The total annual rainfall at higher altitudes can be a staggering five metres, with some areas receiving a metre of rain in a single month. Although winter temperatures are not as severe as those experienced in some parts of the British Isles, it is particularly interesting to note that between an altitude of 250 and 1000 metres above sea level there can be up to 150 days of frosts in a year.

It is the southern beech, *Nothofagus*, which forms the tree line in Chile. Two species, *N. antarctica* and *N. pumilio* are deciduous, the third, *N. betuloides*, is evergreen. In the northern part of Chile's Lake District these species are accompanied by the monkey puzzle tree. In almost all other temperate parts of the world the tree line consists solely of coniferous trees. There is great excitement as the horticultural seed collector reaches the tree line, as seed collected here is more likely to be hardy for cultivation in the British Isles.

Away from the wind-pruned *Nothofagus*, which hug the volcanic escarpments there are sheltered gullies that have formed from progressive bouts of fast-flowing water following incessant rains. These are sanctuaries for small trees and shrubs many of which are familiar garden plants. The most spectacular is the Chilean fire bush, *Embothrium coccineum*, ever glowing red with flowers, and alive with humming-birds. *Escallonia alpina* forms impenetrable thickets along with the high altitude variety of winter's bark, *Drimys winteri* var. *andina*. Other isolated groups of plants that have managed to stabilise the precarious black volcanic ash slopes are the barberry, *Berberis empetrifolia*, parent to many important horticultural hybrids and the low suckering *Gaultheria poeppigii*, clothed in fleshy fruits that vary in colour from white through to scarlet.

Above the tree line the volcanic ash has been wind-drifted to form sculptured ridges, and clinker forged to form vast craggy outcrops. The alpine plants that grow in this hostile environment have become very highly adapted. They have armed themselves with far-reaching, thick, fleshy roots and are often mat-forming or have tight leaf rosettes.

Although some of the alpines occurring above the tree line, such as gentians and eyebrights are easily identified, many of the more bizarre plants, such as violas and members of the Compositae, bear little resemblance to their more familiar counterparts. For instance, vegetative growth of the rosulate violet, *Viola coronifera*, looks like rosette-forming saxifrage; it is not until they are seen in flower that their true identity is revealed. The typical violet-shaped

flowers are borne between the tight whorls of leaves and are pale mauve with a yellow centre. Composites have also become highly adapted to this environment, including *Nassauvias* which form well-branched perennials with congested stems of fleshy grey-green leaves and usually white flowers. *Chaetanthera villosa* is a suckering member of this family with yellowish orange flowers and all parts clothed with long villous hairs. *Lucilia chilensis* is a silvery leaved mat-forming plant which is closely related to the New Zealand native, *Raoulia.*

Although most of the more horticulturally desirable Chilean native plants have now been introduced in to cultivation, there is still a need for their regular reintroduction in order to maintain a broader genetic base from which to propagate and hybridise. Of these introductions the most valued will be plants from higher altitudes as they should prove to be more winter-hardy in the British Isles.

ROCKWOOL BLOCK PROPAGATION SYSTEMS FOR NURSERY STOCK

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The Grodan Single Block System (SBS) is a new cutting propagation procedure which incorporates rockwool blocks ready filled in a modular tray for immediate use on the nursery. Practical aspects of its use and commercial growers' experiences are discussed.

The Material. Rockwool is a uniform growing material made from melted volcanic rock spun into fibres. It is inert and free from pests and diseases. In the same way as peats vary in their water:air holding characteristics so do different rockwools. Only Grodan rockwool is discussed here. This material has been used as a medium for the production of cut roses and salad crops for over 15 years.

Grodan SBS offers the potential for improved rooting percentages, faster rooting, and easier potting along with easier management. Because Grodan SBS is propagation block and carrying tray in one, this cuts out the labour input, machinery costs, and management time involved in organising the mixing of media and filling of trays with loose fill materials.

Two block sizes, 25mm (SBS 25) and 36mm (SBS 36) square give a choice to suit cutting size. For uniform softwood cuttings the 6mm diameter, 15mm deep cylindrical holed blocks should be used. For variable thickness cuttings the tapered holed block (8mm diameter at the top and 20mm deep) is the best choice. Both block sizes are also available without holes which some growers prefer for semi-hard and hardwood cuttings. All blocks are 40mm deep.

Two cutting densities are possible with each size of block. This is achieved with full trays and half-filled ''chessboard'' trays. The SBS 25 provides 150 or 75 blocks per tray and the SBS 36, 77 or 39 blocks per tray. This gives densities of 920 and 460 blocks per sq. m. using the SBS 25 and 470 and 231 blocks per sq. m. with the SBS 36. The trays (525mm × 310mm × 29.5mm) can be split into single (SBS 36) or double strips (SBS 25) for wider spacings.

Use on the Nursery. Many growers who have tried SBS for the first time have been successful even though it has been treated in a way similar to their existing peat system. Their results, in open mist, fog, sun tunnels, and tented polythene systems may be improved upon as more experience is gained.

On a nursery which runs a very dry regime, a take of 52% of *Garrya elliptica* 'James Roof' and 43% *"Rhumus argenteo"* was achieved compared to a take of 40% and 28%, respectively, in its standard grit medium. On another nursery using fog, a 77% take of *Garrya elliptica* 'James Roof' was seen in six weeks compared to a 45% take in nine weeks using 50:50 peat:bark mixture from late autumn cuttings. Cuttings from the same subject in late April again showed faster root initiation—three weeks in rockwool and six weeks in the nursery mix.

Rockwool has also proved to be a useful material for weaning off micropropagated material. *Yucca filamentosa* 'Bright Edge' weaned in a fog house achieved 49% take in the first trial and, with more experience, 62% take was achieved. This is compared to just 40% take in the normal nursery peat mix.

Using just main's water (pH 5.7) on a nursery in the West Country, a take of 75% was recorded with *Camellia japonica* 'Debbie' compared with 60% take in the standard grit system. An azalea, *Rhododendron* 'Addy Wery', also gave a high take of 94% in SBS.

In another trial looking at disease risk, using the standard nursery peat, *Rhododendron* 'Ruby Hart' × *R. forrestii* var. *repens* suffered 22% loss compared with just 2% in SBS. *R.* 'Percy Wiseman' was not so dramatic with 18% loss in the peat and 10% loss in SBS. With *R.* 'Cheer' there was no loss in either medium.

With easy subjects rockwool blocks, SBS, offers quick throughput. In a speed trial, *Lonicera pileata* from 2 May cuttings were potted four weeks before the peat modules. *Euonymus fortunei* 'Emerald & Gold' cuttings taken at the same time could all be potted on 1 June—with the peat modules judged to be at least two weeks behind With *Caryopteris* 'Heavenly Blue' much more even rooting was seen in SBS compared with the nursery mix.

Getting Started. The rockwool blocks must be thoroughly saturated with water, pH adjusted in hard water areas for ericaceous subjects. If the water supply is below pH 6 no adjustment should be needed for this group of plants.

The quickest way to wet up the blocks is to submerge the tray in a tank. The blocks are held firmly in the tray and will not float away. Alternatively, they can be watered overhead using a fine rose or placing under mist. Using this method it is important to remove a few blocks to check that they are fully soaked to the base The whole block will look olive green and water will be released if it is gently squeezed

Cuttings should be given a normal hormone treatment, if required, and then be pushed home into the blocks Trays can be carried vertically which allows one worker to carry up to 300 struck cuttings at a time. It also acts as a quality control since cuttings which have not been struck properly will fall out.

Propagation Bench. As with all propagation media it is important that excess water can drain away to prevent waterlogging. Place SBS rockwool blocks directly onto free draining sand or gravel beds. If the beds dry out, water will be sucked out of the blocks. One cure is to cover the bed with perforated material, such as Mypex, which will act as a capillary break and so stop the sand or gravel affecting water movement in the blocks.

Feeding. Rockwool does not contain any nutrients. This means crop nutrition is under the total control of the grower. Generally, a low nutrient level is required. At this stage the normal nursery water is used. After initial rooting, feeding can be carried out on a weekly basis during active plant growth. This is more important with very small cuttings that have limited nutrient reserves. The liquid feed should contain a balanced N:P:K ratio with full trace elements.

Rooted cuttings can be held back, pushed on, or just maintained by adjusting the feed. This should allow growers to manipulate growth to fit in with potting schedules but this is an aspect which has yet to be fully exploited by growers.

Regular monitoring of nutrient levels during propagation, using a conductivity meter (measures salt levels in the water) is a very quick and easy way to gauge if salt levels are building up or if more feed will be beneficial. A trial in the summer of 1990 maintained fully rooted *Spiraea japonica* 'Gold Flame' cuttings in SBS 36/77 rockwool for over eight weeks (June and July) without loss of quality using just a weekly feed. An autumn trial, when plant growth is less active, held rooted cuttings for six months. The subjects included material from the genera *Prunus, Ilex, Cotoneaster, Viburnum, Mahonia, Cistus, Garrya, Ceanothus, Choisya, Escallonia,* and *Euonymus.*

Watering. Because there is constant evaporation from the surface of the rockwool, the blocks will require more frequent watering than a peat system. Under mist this has the advantage of being able to run the mist to the cuttings' requirements with less risk of waterlogging. This movement of water also helps to maintain a more humid microclimate around the cuttings. In an autumn trial *Ilex* × *altaclarensis* 'Golden King' cuttings, taken in October, retained all their leaves in SBS 36/77 trays but suffered severe leaf drop in the standard nursery peat propagation mix.

Within the rockwool blocks the water is only very loosely held. Peat tends to bind a proportion of water onto its surface Dry rockwool will also rewet more quickly than peat.

Air. It can be argued that air is the most important component in the propagation mix. During rooting and root development there is a high demand for oxygen for cell division and expansion. Because finely milled peats have to be used to be able to physically

fill small celled module trays the result is a medium with very small pore spaces. These can easily be filled with water and air levels can drop to 5%. Over time the compost will settle and the larger air pores will be reduced. The risk of over watering is high and water management critical.

SBS rockwool blocks only contain about 3% rockwool fibres and offer the grower a wider working range of air percentages compared with peat modules—from about 12% to 45%. The constant evaporation from the SBS blocks means fresh oxygen is also moved into the rooting zone between each watering. It is this increased air percentage in the rooting zone that allows quicker rooting and high percentage take in a range of subjects.

Freedom from Disease. Since rockwool is formed at high temperatures it is clean. In all trials with commercial growers the level of disease has been very low. If fungicidal drenches are used as routine these should be applied after initial soaking up of the rockwool blocks. Existing recommendations for agrochemicals take account of the fact that a proportion of the chemical will be adsorbed onto the peat or soil particles. This does not happen with rockwool blocks—what is applied is present in the solution around the cutting base or roots. This offers scope for reduced chemical rates, generally down to 20 to 30% of the standard rate.

Potting On. Cuttings in rockwool blocks should be weaned off in the normal way before potting on. Four or five roots should be clearly visible outside the blocks before they are ready to pot. It is important to soak the blocks just before potting and to water in well directly after potting. This is because peat will tend to suck water out of the blocks. The blocks should be potted deep, up to 25mm, below the compost surface. This is to avoid the blocks becoming visible as the compost settles and to keep them below the dry surface. Keep the pots well watered for the first week after potting for good establishment.

Because rockwool blocks are self supporting, rooted cuttings can be potted at an earlier stage than peat modules. This is because roots have to bind around peat before the young plant can easily be handled. There is also less root disturbance with rockwool blocks since only the block is handled, not the delicate roots when potting. This also allows for easy grading at potting. If some cuttings are weak they can simply be returned to the tray and the propagation house for a little longer without damage This reduces waste of plant material.

Environmental aspects. Rockwool blocks will be physically broken up as stems and roots thicken. In the soil the rock fibres will gradually break down into mineral particles by normal weathering. One cubic metre of rock yields about 28 cubic metres of rockwool. Any sub-standard rockwool is recycled

HEATHER PROPAGATION

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Successful heather production begins with the stock plants. The younger, cleaner, and more vigorous they are, the better the crop of cuttings will prove to be. Highland Heathers maintains approximately 80 stock plants of each cultivar it sells.

Each year 20 plants of each cultivar are taken out of the saleable stock and potted up into 2 litre pots. The other stock plants are then potted up a size, that is, 2 litre into 4 litre; 4 litre into 6 litre; 6 litre into 7.5 litre; 7.5 litre into 10 litre. This ensures a steady turnover of stockplants and generates good, young vigorous cuttings. These stockplants are housed in a ventilated polytunnel on a capillary bed. This keeps the foliage dry which prevents *Botrytis* infection and prevents watersplash and the transfer of *Rhizoctonia*.

The plants are sprayed fortnightly with fungicide; alternately with Rovral and Elvaron. Stockplants are regularly trimmed to prevent their producing too many flowers. Too much flowering tends to mean harder wood and flowers are often a source of fungi. With the stockplants being under cover, it is easy to force an early crop of cuttings.

Propagation is done between May and February but with the cuttings also being taken in July and August when school holidays allow a good supply of labor.

Nodal cuttings of the current season's growth are used. Cuttings are 2 in. long with the bottom ½ in. stripped,and the very soft tip pinched out. Cuttings taken early in the season should be rooted in 2½ weeks to one month, depending on the cultivar, or 10 to 12 weeks in the winter The cuttings do not receive any hormonal treatment and are inserted into 75% peat/25% perlite rooting compost

We use two sizes of plug trays—the "273" tray which has 273 cells of 12 cu.cm. capacity and the "150" tray which has 150 cells of 25 cu cm capacity Generally, cuttings which are to be held for a longer period before potting are inserted into the larger size tray. This allows a greater root run and more space for the cutting to develop The cuttings are then watered in.

The cell trays are then placed on sand in the propagation case. These cases are basically a "Dutch-Light" propagation case within a polytunnel and the case itself is covered with polythene. In the summer the polytunnel is generally shaded. The advantage to us of having the polythene clear of the cuttings, as opposed to resting

on top of them, is that the cuttings are less prone to scorch and *Botrytis*. From mid-September on, soil warming cables maintain a heat of 15° C beneath the trays. When the plants are rooted, the polythene is removed and "Agrofleece" is layed over them for a week. After this, the cuttings can receive liquid feed and a Rovral drench—this is the first fungicidal treatment for the cuttings since being removed from the stockplants.

One new treatment for the newly rooted cuttings that we have just developed is to hang high pressure sodium lights over the cuttings.

We try to maintain a light level of 5,000 lumens per sq. ft. for 16 hrs. a day. On the "White Meter" electricity tariff, this costs just 0.2p per plant for 8 weeks. We use this in the winter months when the natural light levels are very low and it makes cuttings break into shoots as well as producing roots. This was tried on unrooted cuttings to speed them up in the winter, but so far without much success.

The next stage in the process depends on whether the plants are for sale as 8cm or 1 litre plants For 8cm production, we aim to have plants available all year round, so we pot all year round. *Erica carnea, E. mediterranea* [syn *E. erigenas*], and *E.* × *darleyensis* are potted around Easter into straight peat, with 2.5 kg Osmocote 12-14 plus, a kg dolomitic limestone and 200 gms Fongarid per cubic metre No bark or sand is added Everything else is potted with peat plus 2 kg Osmocote 8-9, plus 1 kg dolomitic lime and 200 gms Fongarid per cubic metre. With *Calluna vulgaris, Erica cinerea,* and *Daboecia cantabrica* we work back from when we want to sell them. For example, *Calluna vulgaris* 'Anne Marie' required for sale in September is potted in May. With the foliage cultivars of *Calluna vulgaris*, we can have a saleable plant in as little as 12 weeks.

All these plants are potted on a Javo potting machine; three people can pot over 12,000 plants per day in an 8 hr day. For the production of 1 litre heathers, we do not pot-on an 8cm plant—it is inefficient and too expensive Instead, we insert a cutting from a "273" tray into a "54" tray which has 54 cells of 80 cu. cm. The "54" tray is filled with 75% peat/25% perlite, 2kg Osmocote mini-granules, 1kg dolomitic limestone, and 350 gms of frit per cubic metre These are then grown on for 4 to 5 months before being potted on into their final pot. These are again machine potted and 5 people can pot 1200 per hr The same compost mixes as before apply

All the plants for growing-on are put down on sand in polytunnels with net sides. The main reason for this is that with over 2000 mm of rain per year, we need to keep plants dry—yet the net sides ensure good air movement The plants are regularly sprayed with

Elvaron or Rovral as *Botrytis* could become a problem under polythene. Apart from that, we do not have a regular fungicide programme.

It is our belief, and this has been proven conclusively by the West of Scotland Agricultural College, that fungicides applied on a regular basis to healthy plants have a detrimental effect. We do not use broad spectrum fungicides, we use specific chemicals to control specific problems. The best method of avoiding disease is to prevent the plant from being put under stress.

Developments we can expect to see in the future include:

1) Putting sodium lights over "54" trays to encourage the plants to break dormancy earlier. This will enable us to "time" crops much better, resulting in shorter growing times which should lead to a similar system to the pot plant or bedding plant market where crops are timed to a week number.

2) The incorporation of Osmocote mini-granules into the rooting medium to encourage better growth. The problem here is having a rate high enough to ensure even distribution but low enough not to damage the emerging roots. It may be necessary to add bark or granulated clay to act as a buffer to the Osmocote.

Finally, a lot of *Calluna vulgaris* cultivars, including 'Tib', 'Kinlochruel', and 'County Wicklow' do not produce many cuttings. One way to overcome this is to shorten the daylength of the plants. This encourages vegetative growth but without flower buds.

It is our belief that by starting with clean, vigorous cutting material and following through with good husbandry and management, a large arsenal of fungicides is unnecessary This is a saving in time, money, and wastage for the grower.

IN VITRO REPRODUCTION OF *NYMPHAEA*

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INTRODUCTION

This presentation does not claim to solve the problems of *in vitro* reproduction of waterlilies (*Nymphaea* spp), but I hope that it will provide an insight into the need to develop such a technique and give some indication of progress so far. The work that I and my colleagues have undertaken only refers to the *Nymphaea* subgenus, *Chamaenymphaea*—the hardy waterlilies.

The production of aquatic plants is one of the fastest growing areas in decorative horticulture in Europe, Australasia, and North America. It is estimated that 1.5 million households in the UK have garden ponds (3) and that the UK market in waterlilies is approximately 500,000 plants each year. Home production accounts for about 50%, the remainder being imported from continental Europe and Japan Waterlilies require specialised production and are high value plants retailing between £4.25 and £60.00 each, the average selling price being about £12 00.

Crown rot disease has devastated many UK stocks in recent years. The current virulent strain of this disease is believed to have arrived on imported Japanese stock. UK growers have set up and subscribe to a Waterlily Research Fund which is supporting investigations by the Agricultural Development and Advisory Service into the isolation and control of the pathogen. It is believed that if *in vitro* propagation can be achieved, then a non-commercial benefit would be the rapid multiplication and reinstatement of wild populations in UK waterways of *Nymphaea alba*. Rivers and waterway recovery are high priorities in current environmental programmes.

RESEARCH AWARD AND MARY HELLIAR AWARD

It is against this background that in 1989 I applied to the Department of Trade and Industry for a SMART (Small Firms Merit Award for Research and Technology) Award. My project was selected and work commenced in January 1990, with the Science Department, Askham Bryan College of Agriculture and Horticulture serving as sub-contractor. Funding for the project

[1] G B & I Region, Mary Helliar Travel Scholarship recipient, 1989/90

could only be granted for one year as European Economic Community rules prohibit government departmental support of horticulture or ship building! With time against us, and the prospects of a rapid breakthrough fairly slim, I applied for a Mary Helliar Travel Award from the IPPS in order to visit colleagues in Czechoslovakia where, allegedly, the most advanced *in vitro* work was being undertaken. They had followed different routes and were encountering similar problems. However, their experiences precluded us from making some of the same mistakes. Their work is integrated into this presentation, although it was not as advanced as I was led to believe

THE PROJECT

The major problem with tissue culture of waterlilies was believed to be endogenous bacteria, although preliminary work by Burgess (1) was inconclusive about this. Since then little work has been done with waterlilies other than excised embryos and, until very recently, only with the closely related *Nelumbo* (2). Young plants have been produced in culture, but as the embryos are clean to start with, this does little to point the way forward. Seed-raised waterlilies are few and only the species—which have little commercial appeal—can be increased this way. The problem being addressed is with hybrid or mutant cultivars which all have endogenous bacteria present

Work was started to produce mother plants that were as clean as possible, raising them under glass in controlled conditions. The cultivar used throughout has been *Nymphaea* × *marliacea* 'Carnea'. This is well known in commerce and is an early hybrid—possibly a union between *N. alba* and *N. odorata* var. *rubra.* Given that species can be tissue-cultured from excised embryos this hybrid is also likely to respond in the same way once clean stock has been produced.

Two further areas of investigation have been followed in order to overcome contamination problems The use of sterilant, antibiotic, or antifungal treatments, alone or in combination, as well as the investigation of systems which do not require the addition of sugar in order to achieve proliferating cultures.

To date, two systems have been evaluated for growing plants as cleanly as possible. A flushing tank system with plants continually washed in a current of tap water, and a spray tank system in which plants are suspended on netting in a clear closed container and intermittently sprayed with sterilized and filtered distilled water containing soluble plant feed

Small pieces of plant tissue have been removed from each of the cleansing systems and treated with sodium hypochlorite bleach and

mercuric chloride as surface disinfectants, followed by washes in sterile distilled water. They have also been treated with each of five antibiotics and with Captan fungicide incorporated into the growth medium, and with a combination of these treatments.

The plant material used in these trials has been either strong white/green anchor roots which grow very rapidly from mother plants suspended in water or air, leaf blade and leaf stalk, and eventually bud and rhizome material. It is anticipated that this latter material will be most useful for obtaining proliferating cultures.

Preliminary investigations indicate that clean cultures are possible. Clean growing root culture and leaf sections are currently in a sugar containing growth medium. Surface contaminants can be removed easily by clean growing methods and the use of chemical sterilants. However, many cultures start clean, but progressively become contaminated by apparent seepages of micro-organisms from the interior of the tissue. It is apparent that the predominant contaminants are fungal and not bacterial as first thought. This may be the result of the cleansing conditions. A possibility being investigated is that the effect of growing stock plants in the air has selected against those microorganisms that grow best in low oxygen concentrations present at the bottom of ponds. Varying oxygen concentrations are being used to investigate this.

Since there is still evidence of internal contamination causing the death of cultures, a further series of experiments is underway to assess the effect of feeding systemically-acting fungicides to plant tissue prior to sterilization. A technique—using a root growing in air which extends into a Benlate suspension for 2 days while being warmed by the direct radiation from an infrared lamp to ensure rapid growth has, following surface sterilization, started to grow in culture. This approach seems promising and is being pursued with other plant sections and a variety of treatments.

CONCLUSIONS

With refinements it is hoped that enough material can be produced to investigate the ideal media requirements necessary to achieve proliferation. As indicated earlier, successful experiments using excised embryos of *Nelumbo* and recent work with *Nymphaea* embryos suggests that this will not be unduly difficult to achieve in a commercially exploitable way.

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SOME DEVELOPMENTS IN MAGNOLIAS FOR THE GARDEN

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There are some 80 species of *Magnolia* with a natural distribution confined to two main areas: East and Southeast Asia and the Himalayas, and North and Central America.

The genus is divided into two subgenera: *Magnolia,* comprising mainly American species and the later-flowering species from Japan and China, and *Yulania*, comprising all the precocious flowering species that make such a brilliant contribution to spring gardens in Britain. All the species of the *Yulania* subgenus are worthwhile from a horticultural viewpoint and will provide the main focus for this paper.

The *Yulania* subgenus is divided into sections as follows:

Yulania Subgenus

Tulipastrum	*Yulania*	*Buergeria*
M. acuminata	*M. denudata*	*M. kobus*
var. *cordata*	*M. dawsoniana*	*M. stellata*
M. liliiflora	*M. campbellii*	*M. biondii*
	ssp. *mollicomata*	*M. cylindrica*
	M. sprengeri	*M. salicifolia*
	var. *robusta*	*M. zenii*
	M. amoena	

Most of the species have yielded variant seedlings named as individual cultivars mainly because of their distinctive flower colour, and almost all have been used in hybridisation programmes particularly over the last 35 years or so. Most of this hybridisation activity has been in the USA and more recently in New Zealand. Many of the earlier hybrids are now generally available with further selections being introduced progressively by breeders and evaluators.

There is a danger, as in other genera, of over-naming, and care will be needed to ensure that duplication does not become a problem. The new introductions will also need to be evaluated under UK conditions. There is empirical evidence that a warmer

environment with more prolonged sunlight can enhance the vividness and depth of flower colour so that some cultivars imported from the USA or from Southern Europe can be disappointing in the relatively dull maritime climate of the UK.

In the *Yulania* subgenus, the *Tulipastrum* section comprises two of the most important species—*M. acuminata* and *M. liliiflora.* Both have unique flower colour and both open their flowers simultaneously with the leaves, rather than precociously. This is a distinctive characteristic of this section.

Good yellow seedling selections have been named from *M. acuminata* and its subspecies *cordata*, both in Japan and in the USA. It is also sometimes known as the 'Blue Magnolia' due to the metallic blue colour of its flower buds in some clones.

'Kobandori' ('Green Yellow Bird') and 'Seiju' ('Blue Eternity') are typical Japanese selections, as are 'Miss Honeybee' and 'Golden Glow' from the USA. Possibly more exciting are the hybrids made in search of a yellow of improved form. Crossed with *M. liliiflora* at the Brooklyn Botanic Garden Research Centre, *M. acuminata* has produced *M.* × *brooklynensis* grex of which 'Eva Maria' is the type clone with flowers a curious mixture of rose magenta and yellow shaded with purple and green Back crosses have yielded stronger yellows like 'Yellow Bird', a smaller, true canary yellow flower, on a hardy vigorous upright tree. A cross with *M. denudata* yielded the well known clone *M.* 'Elizabeth', more cream than yellow at maturity, but precocious, hardy, and easy to propagate. Other breeders are introducing yellow clones both from this parentage and with pollen from *M.* × *soulangiana* forms.

M. liliiflora is the most widely used parent species—for its deep purple flowers. In addition to the Brooklyn hybrids with *M. acuminata,* it has produced the *M. soulangiana* grex with *M. denudata;* with *M. stellata*, the de Vos and Kosar hybrids, and with most other species some excellent individual hybrids. Its pollen has even been tried with *M. grandiflora,* with white flowers resulting.

M. × *soulangiana* is too well known to dwell on and many older cultivars have probably now been surpassed for quality of flower. However 'Brozzonii' still holds its own; 'San Jose' is excellent in the creamy pink end of the range, the ill-named 'Burgundy' has different lavender tones and is quite weather-proof, and 'Lennei' is still worth its place anywhere in spite of its untidy sprawl.

The *M.* × *soulangiana* Picture seedlings, raised by Amos Pickard of Canterbury are generally an improvement on *M.* × *soulangiana,* with greater vigour and flowers of greater size and substance. About a dozen clones have been named and a selection is a matter of taste and experience. We like 'Crystal', a white with a flatter goblet form, 'Opal' is another first class white with a purple base,

'Garnet' is a good dark purple, but reluctant to grow. 'Sundew' has no such inhibitions and is an excellent creamy white with a pink flush.

The so-called "Little Girls" hybrids by Kosar, the *M. liliiflora* × *M. stellata* hybrids from the U.S. National Arboretum at Washington, D.C. are so mixed up in the trade that 'Ann', 'Betty' and 'Jane' *et al.* could turn up under any pseudonym. Their colour as general garden decoration is good, though the individual form is wanting. Savill Gardens at Windsor, U.K. has them all and is the place to sort out your own preference. My own three are 'Ann' and 'Susan', reddish purple and upright, and 'Pinkie', a pale pink on a more spreading bush.

M. liliiflora continues to be widely used as a parent; with *M. sprengeri* 'Diva' its pollen has produced two neat trees, vigorous and very easily propagated from cuttings. 'Galaxy' and 'Spectrum' have blooms of good shape and a half-way colour of purplish rose. A cutting of 'Galaxy' taken in 1984 produced flowers in 1989 and this year carried 15 blooms on a tree that has exceeded three metres even after two successive years of drought.

The majestic *M. campbellii* as seed parent crossed with *M. liliiflora* has produced 'Star Wars'. Not the most appealing name, but arguably one of the very best modern hybrids with a 25 to 30 cm flower shading pale pink to a deep purplish red at the base on a vigorous tree. It is also easy from cuttings and extremely hardy. This will be featured in many gardens over the next 10 years as it becomes known and visible.

Apart from the *M.* × *soulangiana* grex, *M. denudata* has produced *M.* 'Wada's Snow White' with *M. salicifolia* as the other parent. This has a small *M. denudata* style of flower on a vigorous bush that flowers when very small.

M. salicifolia crossed with *M. stellata* has produced the *M.* × *proctoriana* grex. This is the first to flower in our Kent garden—a neat, densely branching small tree, exceptionally free-flowering.

M. stellata itself has may forms selected over the years. One of the best is 'Waterlily'. According to Treseder there are three clones under this name in the USA. That available in the UK appears different again and is a pure white of good form. 'Royal Star' is another good clone, very hardy and free with a distinctive flower, and the form from Trewithen in Cornwall I particularly like—a slow growing, rather spreading bush with a big, nicely scented flower. There is also a double white with some 50 tepals.

The pink forms can be disappointing in Kent. They all tend to have the same characteristic of quickly fading to white. 'King Rosea' and 'Rosea Massey' are more or less indistinguishable. The best pink form is probably that known as 'Rosea 32 petals' which has a good

rose bud and keeps the pink colour on the petal reverse. The general effect is pink. 'Dawn' is paler and 'Chrysanthemumiflora', a double that fades.

M. kobus × *M. stellata* has produced, in my experience, one of the best grexes for general garden decoration—hardy, reliable, very free flowering, easy to grow, and generally easy to propagate.

M. × *loebneri* 'Ballerina' and 'Spring Snow' are both outstanding, with the latter too rarely seen as it is slow growing and more difficult to propagate by cuttings. The ubiquitous 'Merrill' deserves all its popularity, as does the only coloured clone, 'Leonard Messel', with its strap-shaped tepals purple outside and white within. 'Starbright' is like an arborescent *M. stellata*. Plants from this grex ought perhaps to replace some of the common crab apple and cherry cultivars in parks and public places, as accommodatingly easy small trees.

M. sprengeri 'Diva' is potentially the finest genuine tree with vivid flowers for general use. There are several excellent colour selections. 'Wakehurst' and 'Copeland Court' are good pinks. 'Eric Savill' is a large tousled flower of really bright deep red/purple, and 'Burncoose' an excellent rather stronger purple on a big upright tree.

Apart from its *M. liliiflora* progeny, a hybrid of *M. sprengeri* 'Diva' with *M. sargentiana* var. *robusta* is 'Caerhays Belle'. A most beautiful clear pink with rather salmon tones.

M. sargentiana var. *robusta* is itself an excellent tree and does well in Kent with more exposure than it might be expected to tolerate from its size of flower and leaf. Its influence is being seen in some of the newer hybrids.

M. campbellii is providing the genes for large flowers of pure colour and I suspect it will not be too long before big pink flowers of genuine *M. campbellii* colour purity will appear on a tree of *M.* × *soulangiana* toughness, flowering late enough to avoid frost. With its subspecies *mollicomata* providing size and the 'Lanarth' form, lending vivid colour, the prospects are exciting. Already clones like 'Star Wars', 'Iolanthe', and 'Mark Jury' are available and more cultivars with *M. campbellii* ''blood'' are being bred in New Zealand and emerging from the later Gresham seedings.

Another species likely to be more used because of its form and freedom of flower is *M. cylindrica*, a magnificent small flowering tree in its own right. It usually sets some seed cones in Kent and is probably the most free flowering of all magnolias, which is no mean claim. A putative chance hybrid with *M.* × *veitchii* has produced 'Albatross', a small tree of exceptional quality to be seen at Lanhydrock in Cornwall.

The Gresham hybrids in the USA are providing some of the finest magnolias available for general planting. The first crosses were made in the mid-fifties and a steady stream of new introductions is providing a continuous supply of new forms and colours.

The original crosses were with *M.* × *veitchii* as seed parent with pollen from *M. liliiflora* and *M.* × *soulangiana* 'Lennei Alba', respectively. Many hybrids from these crosses are now available: 'Manchu Fan' and 'Sayonara' are excellent whites, the latter receiving the Award of Merit from the Royal Horticultural Society this year; 'Royal Crown', 'Heaven Scent', 'Raspberry Ice' are well known clones with shades of purplish pink.

Todd Gresham in California used a very wide range of species and cultivars in subsequent crosses. On his death in 1969 some 10,000 seedlings were sent to the Tom Dodd Nursery in Alabama and 1,600 larger plants to the Gloster Arboretum in Mississippi. Many are flowering now for the first time with *M. campbellii* ''blood'' and have inherited its size and quality of flower. The most worthwhile of these are progressively being selected and introduced as they flower.

The future will see more Gresham hybrids with flowers of greater size, substance, and more vivid colour on plants that are vigorous and hardy. Flowers of the quality of *M. campbellii* are likely to be produced on smaller trees that are later flowering. The attempts to produce a brighter yellow with the classical form and character of the *Yulania* section and the hardiness of *M. acuminata* will continue. Further crosses of *M. acuminata* with *M. sprengeri* 'Diva' and other pink species are, I understand, already producing apricot and orange shades that could extend the colour range of magnolias by a quantum leap.

WITCH HAZELS OF NOTE

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When I first began to study *Hamamelis*, or witch hazels as they are commonly known, in the early 1960s, there were far fewer species and cultivars available than there are today. Apart from the well known *Hamamelis mollis* and some of its cultivars, such as 'Pallida' and 'Brevipetala', as well as cultivars of *H. japonica* such as 'Arborea', 'Sulphurea', 'Flavopurpurescens', and 'Zuccariniana', and *H.* × *intermedia* 'Ruby Glow', there was virtually nothing else to be obtained from nurseries of the day. Since then about 20 new cultivars have been named and introduced.

Nearly all these are cultivars of *H.* × *intermedia*, the hybrid between *H. mollis* (Chinese witch hazel) and *H. japonica* (Japanese witch hazel). Several have originated in the Kalmthout Arboretum in Belgium, but others have been raised in England, Germany, Denmark, USA, and Japan.

A number of selections of the North American species, *H. vernalis*, (Ozark witch hazel) have also appeared during recent years. With, perhaps, one or two exceptions, I feel that they do not compare in terms of garden value with the larger flowered species and hybrids referred to above, and so I do not propose to deal with them in this paper.

It is not suprising that with so many new introductions there is often some confusion between growers and customers as to which are the best. There are few places in England where one can go to study and make comparisons among all the different witch hazels now available but there is a fine collection in the Hillier Arboretum, Hampshire, and another in the Valley Gardens, Windsor Great Park, Berkshire.

The National Council for the Conservation of Plants and Gardens National collection holder of *Hamamelis* is Mrs. P. Edwards, Bonningale Nurseries, Albrighton, Wolverhampton, Staffordshire. Comprehensive written accounts are also hard to come by. None are completely up to date, but the best ones known to me are:

1. Roy Lancaster—series of articles published in the *Gardeners' Chronicle,* 1970.

2. Herman J. Grootendorst—*Dendroflora* No. 17 1980. This annual publication is a useful source of information on new cultivars raised in Europe.

For sources of supply in the U.K. a useful publication is *The Plant Finder*, published annually by the Hardy Plant Society.

The following is my personal appraisal of the cultivars of *H.* × *intermedia* introduced to date:

Hamamelis × *intermedia* 'Advent' (Hillier & Sons, Winchester, 1980)

Habit	Medium to large upright shrub
Flowering period	Very early (mid-December to January)
Petal colour	Bright, clear yellow
Petal size	16 to 18mm long, 1 5 to 2mm wide
Calyx colour	Maroon-red
Scent	Faint
Autumn Colour	Yellow

Comments I have only seen the original plant in the Hillier Arboretum, which flowers very freely each year The earliest cultivar to flower, sometimes fully out by mid-December However, the petals do not open out completely flat and straight but remain slightly curved with crimpled edges Together with their medium size, this factor may prevent 'Advent' from being regarded as anything more than just another cultivar

Hamamelis × *intermedia* 'Allgold' (Hillier & Sons, Winchester Before 1970)

Habit	Medium sized to large shrub with ascending branches
Flowering Period	Mid-season (January-February)
Petal Colour	Deep buttercup yellow
Petal Size	15 to 16mm long, 1 to 1 5mm wide
Calyx colour	Purple-red
Scent	Sweet but faint
Autumn colour	Yellow

Comments Petals are long and narrow and crimpled as in *Hamamelis japonica* 'Arborea' Unlikely to ever become well-known

Hamamelis × *intermedia* 'Angelly' (J H M Van Heijningen, Breda, Holland 1985)

Habit	Vigorous, upright-spreading shrub
Flowering period	Very late (late February-March)
Petal colour	Clear, light yellow
Petal size	20 to 22mm long, 2 to 2 5mm wide
Calyx colour	Light green
Scent	Faint
Autumn Colour	Yellow

Comments Exhibited for the first time at the Flora Nova Show, Boskoop, Holland in 1987 where it received a gold medal Plants have only recently reached England so it is too early to reach a considered verdict on its merits However, it could be interesting for its large flowers and late flowering habit

Hamamelis × *intermedia* 'Arnold Promise' (Arnold Arboretum, USA 1963)

Habit	Medium sized to large shrub with ascending branches becoming vase-shaped with age
Flowering period	Late (February-early March)
Petal Colour	Light yellow
Petal size	16 to 18mm long, 1 5 to 2mm wide
Calyx colour	Brownish-green
Scent	Sweet and fairly strong
Autumn colour	Shades of orange and yellow

Comments: A valuable plant for its late flowering habit and good autumn colour Also for its upright habit at least in early years Makes an excellent container plant and always blooms very freely

Hamamelis × *intermedia* 'Barmstedt Gold' (J Hachmann, Germany 1975)

Habit	Vigorous shrub with narrowly ascending branches
Flowering period	Mid-season (late January-February)
Petal colour	Rich golden-yellow, stained red at base
Petal size	23 to 25mm long, 1 5 to 2mm wide.
Calyx colour	Deep claret, slightly glossy
Scent	Light-medium, sweet
Autumn colour	Yellow

Comments A first class witch hazel, likely to become very popular when better known

Hamamelis × *intermedia* 'Carmine red' (Hillier & Sons, Winchester Before 1960)

Habit	Medium-large shrub with spreading branches.
Flowering period	Mid-season (January-early February)
Petal colour	Red at base becoming coppery bronze at tips
Petal size	18 to 20mm long, 1 to 1 5mm wide
Calyx colour	Deep claret red
Scent	Sweet but faint
Autumn colour	Rich yellow

Comments: Superseded by newer cultivars such as 'Diane' and 'Jelena'

Hamamelis × *intermedia* 'Diane' (R de Belder, Kalmthout, Belgium 1969)

Habit	Medium to large shrub with wide spreading branches
Flowering period	Mid-season (late January-February)
Petal Colour	Bronze-red to deep coppery red
Petal size	16 to 18mm long, 1 5 to 2mm wide
Calyx colour	purple-red, glossy
Scent	Very faint
Autumn colour	Scarlet, orange and yellow

Comments The best red-flowered cultivar so far, and one of the best for autumn colour Supersedes the cultivars 'Ruby Glow' and Feuerzauber' in most respects

Hamamelis × *intermedia* 'Feuerzauber' (H A Hesse, Germany 1958) (syn *Hamamelis* × *intermedia* 'Magic Fire')

Habit	Medium sized to large shrub with ascending branches
Flowering period	Mid-season (late January-February)
Petal colour	Coppery-orange suffused red
Petal size	15 to 16mm long, 1 52mm wide
Calyx colour	purplish-red
Scent	Sweet but faint
Autumn colour	Orange-yellow

Comments Inferior to the newer cultivar 'Diane' in most respects No longer widely grown

Hamamelis × *intermedia* 'Gimborn's Perfume' (Von Gimborn Arboretum, Holland cf 1985)

Habit	Shrub of medium vigour and rather upright branches
Flowering period	Mid-season (late January-February)
Petal colour	Bright, clear yellow
Petal size	16 to 18mm long, 1 5 to 2mm wide
Calyx colour	Bright red, slightly glossy
Scent	Sweet and strong.
Autumn colour	Yellow

Comments I have only recently received plants of this new selection, so it is too soon to give a considered judgement on its merits

Hamamelis × *intermedia* 'Hiltingbury' (Hillier & Sons, Winchester Before 1945)

Habit	Large shrub with widely ascending branches
Flowering period	Mid-season (mid-January-mid February)
Petal colour	Pale copper suffused red
Petal size	16 to 18mm long, 1 15mm wide
Calyx colour	Purple-red
Scent	Sweet but faint
Autumn colour	Lovely shades of orange and red

Comments Perhaps worth growing for its autumn colour but inferior in flower to newer cultivars

Hamamelis × *intermedia* 'Jelena' (R deBelder, Kalmthout, Belgium 1955) (syn *Hamamelis* × *intermedia* 'Copper Beauty')

Habit	Vigorous shrub with ascending branches becoming vase shaped with age
Flowering period	Early (late December-January)
Petal colour	Reddish, basal third becoming ochre-yellow towards tip Overall effect is coppery-orange
Petal size	20 to22mm long, 1.5 to 2mm wide
Calyx colour	Claret-red, slightly glossy
Scent	Sweet but faint
Autumn colour	Scarlet, orange and yellow

Comments Deservedly popular for its large flowers and rich flowering characteristics

Hamamelis × *intermedia* 'Moonlight' (Hillier & Sons, Winchester 1970)

Habit	Medium to large shrub with ascending branches
Flowering period	Mid-season (early January-early February)
Petal colour	Pale, sulphur yellow, tinged red at base
Petal size	16 to 18mm long, 1 to 1.5mm wide
Calyx colour	Deep claret red
Scent	Sweet and strong
Autumn colour	Yellow

Comments Flowers paler and less densely clustered than *Hamamelis mollis* 'Pallida'. Not widely grown

Hamamelis × *intermedia* 'Orange Beauty' (Bruns, Germany 1955) (syn *Hamamelis* × *intermedia* 'Orange')

Habit	Shrub of medium vigour with an upright to spreading habit
Flowering period	Mid-late season (late January-February)
Petal colour	Orange-yellow, stained red at base.
Petal size	15 to 16mm long, 1.5mm wide
Calyx colour	Claret-red, glossy
Scent	Faint
Autumn colour	Yellow

Comments. Rather distinct and attractive in flower, but perhaps overall not in the first division of witch hazels Another cultivar I have seen called 'Aurora' is very similar

Hamamelis × *intermedia* 'Primavera' (R de Belder, Kalmthout, Belgium 1969)

Habit	Wide-spreading shrub of medium vigour
Flowering period	Mid-season (late January-February)
Petal colour	Clear bright yellow, stained purple-red at base
Petal size	16 to 18mm long, 1 5 to 2mm wide.
Calyx colour	Claret red, slightly glossy
Scent	Faint
Autumn colour	Yellow

Comments· A rich flowering cultivar which is still not well known If it has a fault it is that the petals do not open straight but remain curved and claw-shaped Also they face downwards after the fashion of the *H japonica* parent

Hamamelis × *intermedia* 'Ruby Glow' (Kalmthout Arboretum, Belgium 1946) (syn *H.* × *intermedia* 'Adonis')

Habit	Bushy, upright shrub with many thin, twiggy branches
Flowering period	Mid-late season (end January-February)
Petal colour	Brownish-red with lighter red to ochre margin and tip
Petal size	10 to 15mm long, only 1mm wide
Calyx colour	Dark purple
Scent	Very faint
Autumn colour	Orange, bronze and scarlet

Comments. Although not without merit this cultivar has now been largely superseded by newer ones such as 'Jelena' and 'Diane'

Hamamelis × *intermedia* 'Sunburst' (D. Veerman Jr , Boskoop, Holland cf 1965)

Habit	Vigorous shrub with vase-shaped habit
Flowering period	Early mid-season (January)
Petal colour	Bright, clear yellow, slightly darker than *H mollis* 'Pallida'
Petal size	22 to 26mm long 2 to 2.5mm wide
Calyx colour	Light claret red
Scent	None.
Autumn colour	Yellow

Comments: Outstanding for its large flowers Young plants tend to retain some dead leaves but this habit disappears with age Superior in flower to the well known *H m* 'Pallida' but alas, no scent Not as widely grown as it should be.

Hamamelis × *intermedia* 'Westerstede' (H Helmers, Germany 1977)

Habit	Vigorous, upright shrub
Flowering period	late (February-March)
Petal colour	Light yellow
Petal size	14 to 16mm long, 1 5 to 1 8mm wide
Calyx colour	Greenish-brown
Scent	Faint
Autumn colour	Yellow

Comments. Probably selected for its late flowering characteristics, which would be of more importance in Germany with their hard winters, although free flowering, it does not compare well with the more brightly coloured cultivars Likely to be superseded by the new cultivar 'Angelly'

Hamamelis × *intermedia* 'Winter Beauty' (K. Wada, Japan 1962)

Habit	Medium vigour, small broadly upright habit.
Flowering period	Early (late December-January)
Petal colour	Dark yellow, stained to brownish-red in basal third.
Petal size	20 to 22mm long, 1 to 1.5mm wide
Calyx colour	Dark red
Scent	None
Autumn colour	Yellow

Comments. An attractive cultivar, but not easy to grow Subject to damage or death in hard winters Hardly grown any more in nurseries

Hamamelis × *intermedia* 'Vezna' (R de Belder, Kalmthout, Belgium. 1970)

Habit	Fairly upright shrub of medium vigour
Flowering period	Mid-season (January-February)
Petal colour	Orange-yellow, slight red staining at base
Petal size	20 to 24mm long, 1 to 1 5mm wide
Calyx colour	Deep claret red, slightly glossy.
Scent	Quite strong and sweet
Autumn colour	Yellow

Comments A distinct selection but the very long petals are twisted and crimpled which detracts from its appearance a little Deserves to be more widely grown, however

G.B.& I. REGION SEMINAR SERIES

Three concurrent discussion groups considered the topics of: (1) *Betula* Propagation, (2) *Magnolia* Production, and (3) Plant Breeders' Rights. These seminars aimed to pool current knowledge on the topic. For the sessions on plant production the aim was to evaluate the various methods used by members. The aim of the session, Plant Breeders' Rights, was to brief members on the current situation and to assess the likely impact of forthcoming European legislation on Plant Breeders' Rights. Various methods of protecting cultivars would be discussed.

The significant conclusions developed by these groups are given in the papers that follow.

BETULA PROPAGATION

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SEED PROPAGATION

Collection. For the indigenous species, *Betula pendula* and *B. pubescens*, it was noted that collection from sources with a similar latitude to the final planting site was best because their growth pattern depends closely on the day length of their provenance. Seed collection allows for the introduction of Asiatic and North American species from known provenances in the wild permitting botanic gardens to build up a better picture of their variability and distribution. It is important not to collection seed from the various exotic species growing in parks, arboreta, etc. As a wind-pollinated genus, hybridization between species regularly occurs.

Seed treatments. Birch seed does not store well and rapidly loses viability, but as collection is easily accomplished each year, this is not a problem.

Germination percentages are much improved with a two or three week cold, moist stratification at 0 to 1° C. Naked stratification leads to problems with aeration, so it is recommended to mix the seed with a medium of 25% vermiculite or sand and 75% sieved peat—one part seed to three parts medium. Pregerminated seed must be sown very carefully.

Sowing. Difficulty can be experienced in achieving even distribution as seeds can clump together. Mix the seed and medium with dry sand and rub together between the hands. This will give a much more even sowing in the seed beds.

The seed must be covered with a light layer of grit and the seed surface kept regularly damped down in dry weather, otherwise germinating seedlings will perish. Shading seed beds in hot weather was thought to be of benefit as well.

CUTTING PROPAGATION

Propagation by cuttings is desirable for many birches because it obviates the possibility of an unsightly graft union, and for selected clones, along with other vegetative methods, is essential.

Birches known to have been successfully propagated by softwood cuttings include: *Betula nigra*, *B. pendula* cvs. *B. albo sinensis*, and *B. jacquemontii*, *B. nana* is always produced from cuttings.

Well-established hard-pruned stock plants are essential to provide juvenile cutting material. The earlier one can take cuttings

in the season the better—ideally before the end of May in Britain. Use heal or nodal-tip cuttings 15 cm or so long with the base starting to ripen, remove lower leaves and lightly wound. A hormone treatment of 0.8% IBA is beneficial.

Cuttings can be rooted in sun tunnels or in trays or cells under conventional mist or polythene. It is most important to establish a well-rooted cutting with subsequent shoot growth before autumn. Do not move the cuttings into pots until the following spring.

GRAFTING

For clonal selections and named cultivars grafting produces a saleable plant in a relatively short time.

The conventional method of side-grafting onto pot-grown rootstocks of *Betula pendula* in January/February is well documented so will not be discussed further here.

An interesting method used at Kinsealey Research Station in Ireland is as follows.

> Use 1+1 transplants of *B. pendula*, 5 to 8 mm diameter with a good root system. A bare-root wedge graft is carried out in January/February as low down on the rootstock as possible Well-grown scion material should be used which is about half the thickness of the rootstock. The cambium layers are matched on one side, much in the same manner as a wedge graft. The two are tied together with rubber strips and the whole union immersed in molten paraffin wax.
>
> Aftercare consists of plunging the root system in moist peat in a cold glasshouse or polytunnel. When white roots begin to grow in the spring, the plants are potted off into three litre containers and grown on under glass or polythene.

BUDDING

It was noted that both "T" budding and chip budding had been used on field-grown rootstocks of *Betula pendula*. While it is possible to achieve good results, they are often variable, probably due to lack of really good ripe buds of sufficient size each year; the prevailing weather and timing play a great part in success or failure. As with all budding of field-grown crops, consistent results are required for economy in production

GROWING ON

It was noted how important it is to pot-on bench-grafted birches in good time; if growth ceases because of lack of root space and nutrients it is very difficult to get them into growth again. Therefore, it is paramount to pot-on from the bench-grafting container while the graft is in active growth.

SUMMARY

For the indigenous species, large scale field production has been refined to a great degree in recent years. This is producing first quality transplants both for understocks as well as for amenity uses. Smaller lots of wild-collected seed, particularly from Asia, can easily be germinated in trays under glass. Bench grafting of the various clones and cultivars is still the norm in the industry, although there is an increasing interest in production from softwood cuttings. In reply to a plea from landscape architects for multi-stemmed birches, the nursery stock industry would grow them if the market was strong.

MAGNOLIA PRODUCTION

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SEED PROPAGATION

Seed propagation is used for wild-collected seed, for the production of understocks, for some species where the likelihood of cross pollination is not great, and for intended hybridization programmes.

Gathering seed is a problem with large plants so long arm pruners, or even shotguns are used. The time of ripening needs to be known so that seed can be collected before it has dispersed.

Seed must be extracted from the fruiting cones and the fleshy outer covering must also be removed. This is easily done by fermentation in a plastic bag and then extracted by maceration and flotation. Once extracted, the seed must be prevented from drying out by mixing with a moist medium.

The seed needs a cold period of two to three months at 0 to 1° C to overcome dormancy conditions so that germination can be obtained.

Because of their value, the seeds are best sown after pretreatment either into trays and pricked out later, or directly into liner-sized containers.

CUTTING PROPAGATION

This is the most satisfactory methods for magnolias. It is probable that over 80% of all magnolias are produced this way.

The source of cutting material is from protected stock plants or young container stock. This will enable cuttings to be collected and prepared in late May or early June. Either leaf-bud cuttings or nodal tip cuttings can be prepared, the leaf blade usually being trimmed to reduce transpiration.

Cuttings are lightly wounded and treated with 0.3% IBA in talc or 1000 ppm IBA quick-dip.

Conventional mist propagation has proved to be the optimum facility, with a basal rooting temperature of about 18° C. Rooting takes place in 6 to 8 weeks.

Composts for rooting can range from 100% peat to 50.50 peat/bark or perlite mixtures. The compost must not be allowed to become too wet.

Rooted cuttings should be overwintered in trays and not potted off until the following spring.

LAYERING

This is not practiced to any extent nowadays, although some of the more difficult-to-root sorts are layered in Holland.

GRAFTING

Grafting is only practiced where propagation by cuttings is extremely difficult or uneconomic. There are two periods of the year when grafting can be successfully done—late summer and late winter.

Rootstocks used are pot-grown seedlings of *M. kobus, M. sinensis, M.* × *soulangiana,* and *M. campbellii*. Scionwood must be hardened (2 year old base)—not soft and pithy.

A side-graft is used, tied with rubber strips, and the grafts placed in a polythene tent. Maintain a temperature of 18 to 21 °C and do not allow the union to get too wet. Gradual weaning takes place after 3 to 4 weeks and, once scion growth is strong, head back the rootstock to the union.

CHIP BUDDING

Chip budding can be successfully done on pot-grown rootstocks at the same time of year as for grafting. The advantage is in economy of scion material.

MICROPROPAGATION

Work is being carried out at the Efford Experimental Horticulture Station, Hampshire, UK. The technique is useful for difficult-to-root cultivars, to rejuvenate mother stock, and to bulk up new cultivars. It is at the experimental and developmental stage at present.

GROWING ON

It takes two to three years to produce a saleable container-grown crop. Adequate spacing and trimming of plants to achieve a good shape are essential.

Provide protection under glass or polythene in the early stages and under shade structures or wind-protected outdoor beds in the final season.

MARKETING

M. stellata will usually have flower buds at two to three years, as will some of the newer *M.* × *soulangiana* types and the Gresham hybrids. It is possible to cold store plants so that they flower in May at the retail outlet instead of in April. Careful transportation is needed to prevent flower buds from being knocked off. Color picture labels help. The public is still, perhaps, overawed by magnolias; more information is required and the "exotic" myth needs to be dispelled.

SUMMARY

Growers intending to produce magnolias must get to know the species and cultivars and the optimum methods of propagating them.

Give protection to young stock; growing conditions must not be too wet or too dry. Careful management is required in watering and in trimming to produce shapely plants, hopefully with flower buds

Under protection, red spider mites, whitefly, and capsid bugs are troublesome. The main disease problem is botrytis. Keep a constant watch for insects and diseases when plants are grown under protection.

PLANT BREEDERS' RIGHTS

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Plant Breeders' Rights are different from Plant Patents. During the period the Rights are in force, they give the holder—the breeder or creator of a new variety—the exclusive right to:

a) Sell, offer or expose for sale, reproductive material of the protected variety.

b) Produce reproductive material of the protected variety for sale.

c) Exercise any further rights specified in the scheme.

At present, Plant Breeders' Rights are only exercised in individual countries. Protection must be taken out separately in each country where it is needed. International rights are controlled by a Convention that meets in Geneva. There are proposals that, by 1992, all countries in the European Community will operate to a common law. This will greatly simplify registration and increase property protection for breeders.

THE CONDITIONS FOR GRANTING OF RIGHTS ARE:

Previous Commercialization. Plant material of the variety must not have been offered or exposed for sale before rights are granted.

Distinctiveness. The variety must be clearly distinguishable from other varieties by at least one characteristic capable of precise description.

Stability. The variety must be stable in its essential characteristics.

Uniformity. The variety must be uniform with regard to reproduction and propagation.

Duration. Rights normally last between 20 and 30 years.

Naming and Objections. Objections to registering a name can be raised for the following reasons:

1) It is the same as, or resembles, the name of another plant in the same class

2) It is likely to deceive or cause confusion about the plant's characteristics

3) It does not conform with international usage regarding nomenclature of cultivated plants

4) It is the same as, or easily confused with, a trade mark or name

5) It is liable to give offense

Participants agreed with the concept of Plant Breeders' Rights but felt there were a number of drawbacks to the way the system oeprates in Great Britain.

Cost. The rights are very expensive to take out yet the polıcing is left to growers to enforce and pay for.

There is no promotion from the Plant Variety Rights Office.

Information. Growers have great difficulty establishing which varieties are protected. In many cases plants are purchased in good faith but later turn out to be covered by P.B.R. This is compounded by the fact that the Plant Variety Rights Office prohibits by copyright the publication in trade magazines of lists of new varieties that have been granted protection. Growers are expected to subscribe to the official *Plant Varieties and Seeds Gazette,* which is mainly concerned with arable crops rather than ornamentals. There is no other way of finding out which varieties have protection in the UK.

Breeders need to be more aware of the problems and intricacies of the system and of the potential of world markets. It was agreed that, ideally, Plant Breeders' Rights need to be obtained, and agents appointed in all countries where the new plant is to be sold before launching the plant in any country. Unfortunately this is not always practical.

There was general agreement that as the complexities of the scheme are more fully understood, breeders' introduction procedures will tend to become standardised. At present, one must first apply to have a genus or group of plants registered for the scheme if no previous application has been made for that plant. There are many groups of plants in the hardy nursery stock trade that have not been included in the scheme simply because the value of inclusion has not been appreciated before.

LICENCES

There is much confusion on this point but the following conclusions were agreed:

1) The raiser or breeder of a new variety can propagate, introduce, and promote the plant himself, or can grant a licence to a grower or tissue-culture laboratory to do so. A licence can be granted to grow but not sell, where a second company could be licenced to sell.

Difficulties have arisen in the past because of sub-licences granted to other companies by the head licencee. Fair trading regulations demand that sub-licences are issued unless there is a very good reason not to. But there must be very good communication between breeders and licence holders. The lack of a clearing house for arrangements being proposed and initiated is the main reason for the confusion caused by cross-licencing and contradicting agreements have been made.

Identification. DNA fingerprinting of plants is one sure way to ensure that plants are not produced and sold under a different name. At present, protected plants can be pirated in one country, taken to another, propagated, and then sold back to the original country under a different name.

Policing. The British Association of Rose Breeders has a method of policing the rose budding of protected rose varieties.

What to Register. Any plant that is a new variety, including sports of existing protected varieties, can be registered as long as it fills the relevant criteria (see above). Some members of this seminar group felt that while breeders should be rewarded for their skill, new varieties that arose as sports were lucky chances that were less deserving. However the identification and recognition of the potential of a sport depends to a great extent on the skilled observation of an experienced plantsman.

CONCLUSIONS

The biggest difficulty facing growers is lack of communication and information. There is total lack of awareness of the plants protected, exacerbated by copyright restrictions. Plant Breeders' Rights need to be more clearly publicised. The lack of uniformity across Europe will be addressed by E.C. legislation. Growers are becoming more aware of the need to register plants of particular merit and, as it becomes more costly to breed and market new plants, the need for protection is increased.

ROOTING OF *CLERODENDRUM THOMSONIAE* CUTTINGS AS AFFECTED BY PACLOBUTRAZOL AND ROOTING HORMONES

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Abstract. The positive effect of a five min immersion in an IBA-containing solution on the number of roots formed on *Clerodendrum thomsoniae* Balf cuttings was greatly enhanced by paclobutrazol (PP333). Little was gained from the addition of IAA to an immersion solution containing both PP333 and IBA PP333 alone did not significantly promote root formation, but caused a decrease in mean root length and an increase in root diameter

REVIEW OF LITERATURE

Paclobutrazol (PP333, active ingredient ([2RS, 3RS] -1- [4-chlorophenyl] -4- 4-dimethyl-2-1, 4-triazol-yl-pentan-3-ol]) is an anti-gibberellin-like growth retardant which has been used successfully for height control on a wide range of ornamentals (5,9). It can be applied either as a foliar spray or as a soil drench. Substrate drenches with growth retardants are often preferred to foliar sprays since the former are more precise and their effectiveness is less influenced by environmental factors (13). Lack of uniform coverage, phytotoxicity, and the need for multiple applications are generally regarded as the major shortcomings of foliar sprays. Nevertheless, foliar applications are still widely used commercially because of their relative ease of application and the reduced labour required (12,13).

Attempts have been made to achieve sufficient growth inhibition by pre-plant treatments with growth retardants other than PP333 (8,10). Large numbers of rooted or unrooted cuttings could be quickly and conveniently treated prior to planting by immersing or soaking them in a solution of growth retardant, thereby eliminating the need for post-plant sprays or drenches. Preliminary experiments (unpublished) demonstrated the potential of pre-plant treatment of *C. thomsoniae* with PP333 as an alternative to conventional application methods. The results of these experiments also indicated a positive effect of the growth retardant on subsequent rooting.

These results are similar to those obtained by other workers. In hypocotyl cuttings of *Phaseolus vulgaris*, PP333 greatly increased the number of roots formed (14). This growth retardant also promoted root formation on cuttings of *Coleus blumei*, *Plectranthus australis*, *Prunus laurocerasus*, *Salix discolor*, and *Vitis labrusca* (3,4). In these experiments relatively low concen-

trations of growth retardant were used compared to those required to induce residual effects on subsequent vegetative and generative development. Rooting may be further improved by higher concentrations of growth retardent alone or in combination with rooting hormones.

The use of auxins in vegetative propagation is well established. Van Bragt, *et al.* (15) obtained a higher percentage of rooted cuttings of several ornamental species after immersion of the cuttings in an auxin-containing solution than after dipping the basal part of the cuttings in a powder mixture containing auxin.

Since positive effects on rooting would be an important added value of pre-plant treatments of ornamentals with growth retardants, it is necessary to quantify the effects of PP333 on root formation of cuttings and to test the hypothesis that further improvement of rooting can be obtained by applying the growth retardant in combination with one or more rooting hormones.

In previous experiments (unpublished) *C. thomsoniae* has been shown to respond greatly to post-plant treatments with PP333. Because of these clear responses, involving both height reduction and an increase in flowering, *C. thomsoniae* was used as a test plant in the present study.

MATERIALS AND METHODS

On December 20, 1989, internodal cuttings, each consisting of one leaf pair, attached to a stem piece (approximately 7cm) were harvested from *C. thomsoniae* stock plants. Upon harvest the cuttings were immersed in one of 26 solutions, containing 0 or 1.2 mmol/l PP333; 0, 0.4, 1.0, 2.0 or 4.0 mmol/l IBA; and 0, 0.4, 1.0, 2.0, or 4.0 mmol/l IAA. Only equimolar combinations of IBA and IAA were included. Both auxins were applied in the form of their water soluble ammonium salts. Application of PP333 was as an aqueous suspension of Cultar (7). The control treatment consisted of an immersion in distilled water Tween 20 (1.5 ml/l) was added to all solutions.

The experiment was set up according to a randomised complete block design, with eighteen cuttings per treatment and three blocks. Six cuttings at a time were immersed for 5 min. in 500ml of the appropriate treatment solution. After immersion the cuttings were left to dry on tissue paper before planting them into individual pots using a pumice. peat mix (2:1 v/v) and placing them under a closed misting system.

After three weeks the number of roots, their length, and root dry weight were recorded for each cutting. Mean root lengths were calculated by dividing the total root length by the number of roots. Means were separated using the least significant difference test with $p = 0.05$ after analysis of variance.

RESULTS

Rooting was significantly improved by prior treatment of unrooted cuttings with a solution containing 1.0, 2.0, or 4.0 mmol/l IBA (Table 1). Further increase in the number of roots was obtained with the addition of 1.2 mmol/l PP333 to an IBA-containing solution. The growth retardant alone did not significantly promote root initiation.

Table 1. Effects of PP333 and IBA on rooting of *C. thomsoniae* cuttings. Different letters within columns are comparable across all three tables and designate significant differences. Data are means with standard deviations in brackets

Immersion solution mmol/l		Number of roots per cutting	Root length (mm)	Root dry weight (mg/mm)
PP333	IBA			
0	0	6.0 k (2.5)	42.1 bc (13.8)	7.4 fghi (1.3)
1.2	0	10.3 jk (8.3)	30.6 fghi (5.6)	8.8 j (2.4)
0	0.4	11.9 ijk (4.5)	52.0 a (9.9)	7.1 cdefgh (0.7)
1.2	0.4	30.5 cd (10.8)	28.4 ghi (8.8)	7.5 fghi (1.2)
0	1.0	17.4 gh (5.5)	46.3 ab (10.3)	8.0 ghij (0.9)
1.2	1.0	34.4 bc (12.1)	34.3 defg (8.3)	6.0 abcde (0.9)
0	2.0	20.3 fgh (7.7)	51.1 a (9.3)	7.2 defgh (1.0)
1.2	2.0	40.4 b (15.3)	28.2 hi (6.0)	5.1 a (1.0)
0	4.0	34.1 bc (15.6)	51.7 a (9.7)	5.9 abc (1.1)
1.2	4.0	47.0 a (21.8)	24.7 i (5.2)	5.8 abc (0.6)

Immersion in a solution containing 0.4, 2.0, or 4.0 mmol/l IBA caused a significant increase in the average root length. PP333 alone, or in combination with IBA, reduced the average root length.

Root dry weight/mm was relatively unaffected by IBA. PP333 by itself increased root dry weight/mm, reflecting a larger root diameter. Application of both IBA and PP333 generally resulted in decreased root dry weights/mm compared to the control.

Immersion of *C. thomsoniae* cuttings in a solution of IAA prior to planting had little effect on rooting (Table 2). When applied in combination with PP333 a higher number of roots per cutting than for the controls was obtained only with 4.0 mmol/l IAA. The effect of PP333 on the average length per root was not altered by the addition of IAA. The increase in root dry weight/mm caused by PP333 was counteracted by simultaneous treatment with IAA.

Table 2. Effects of PP333 and IAA on rooting of *C thomsoniae* cuttings Different letters within columns are comparable across all three tables and designate significant differences Data are means with standard deviations in brackets

Immersion solution mmol l		Number of roots per cutting	Root length (mm)	Root dry weight (mg/mm)
PP333	IAA			
0	0	6 0 k (2 5)	42 1 bc (13 8)	7 4 fghi (1 3)
1 2	0	10 3 jk (8 3)	30 6 fghi (5 6)	8 8 j (2 4)
0	0 4	8 4 jk (2 7)	42 7 bc (9 7)	7 4 fghi (1 1)
1 2	0 4	9 6 jk (7 4)	30 7 fghi (8 8)	8 5 ij (1 6)
0	1 0	5 6 k (3 2)	38 0 cde (15 0)	7 4 fghi (1 6)
1 2	1 0	9 5 jk (6 1)	25 7 i (6 1)	7 2 efgh (4 4)
0	2 0	7 9 jk (3 7)	47 6 ab (15 6)	7 3 fghi (1 1)
1 2	2 0	11 4 ijk (13 3)	29 0 fghi (8 3)	8 3 hij (6 4)
0	4 0	13 7 ij (8 2)	45 0 b (13 6)	7.7 ghij (1 0)
1 2	4 0	21 9 fg (13 6)	30 4 fghi (6 8)	6 2 abcdefi (1 2)

The positive effect of PP333 in combination with IBA on the number of roots was enhanced with 1.0 or 2.0 mmol/l IAA (Table 1 and 3)

Table 3. Effects of PP333, IAA, and IBA on rooting of *C thomsoniae* cuttings Different letters within columns are comparable across all three tables and designate significant differences Data are means with standard deviations in brackets

Immersion solution mmol/l			Number of roots per cutting	Root length (mm)	Root dry weight (mg/mm)
PP333	IBA	IAA			
0	0	0	6 0 k (2 5)	42 1 bc (13 8)	7 4 fghi (1 3)
1 2	0	0	10 3 jk (8 3)	30 6 fghi (5 6)	8 8 j (2 4)
0	0 4	0 4	13 9 hij (5 5)	51 4 a (11 2)	8 0 ghij (1 2)
1 2	0 4	0 4	36 2 bc (11 7)	38 5 cd (7 4)	5 9 abcd (1 0)
0	1 0	1 0	22 3 fg (12 0)	51 3 a (7 7)	7 5 ghij (1 4)
1 2	1 0	1 0	47 2 a (13 9)	34 7 def (8 0)	6 2 abcdef (1 4)
0	2 0	2 0	23 7 ef (9 1)	51 1 a (9 9)	7 1 cdefgh (1 5)
1 2	2 0	2 0	48 0 a (17 1)	32 4 efgh (11 5)	5 4 a (1 2)
0	4 0	4 0	29 5 de (13 7)	47 9 ab (8 9)	6 8 bcdefg (1 5)
1 2	4 0	4 0	50 7 a (17 6)	26 2 i (7 9)	5 6 ab (1 4)

Few significant differences were found between cuttings which had been immersed in a solution containing IBA and PP333 and those which had been treated with both auxins as well as PP333. An immersion solution containing both IBA and IAA had no significant effect on root dry weight per mm, but addition of PP333 caused a reduction of root dry weight/mm compared to the control.

DISCUSSION

The growth retardant PP333 and IBA synergistically increased the number of roots formed on *C. thomsoniae* cuttings. Further increase was obtained with the addition of IAA, but only when applied in a concentration of 1.0 or 2.0 mmol/l.

PP333 by itself did not significantly promote rooting. Davis, *et al.* (3,4) demonstrated a positive effect of PP333 on rooting depending upon the species. They suggested that the lack of response of cuttings from some species may be due to insufficient uptake. In the case of *C. thomsoniae* this is not likely since PP333 did significantly affect other rooting parameters.

The roots on PP333-treated cuttings were shorter and thicker than those on controls. Similar effects were reported for other species (1,3,4,11). The advantage a sturdier root system may have in facilitating transplanting of rooted cuttings was lost when cuttings were treated with IBA as well as PP333.

The mode by which PP333 influences root initiation and development is not known, but may be related to its anti-gibberellin activity (3,4,14). The application of gibberellins to cuttings generally inhibits rooting (2,6) In the present study PP333 may have altered the root system by reducing the endogenous gibberellin levels, which were apparently low enough not to inhibit adventitious root initiation.

Further research will be necessary to investigate the interaction between PP333 and IBA. Results of the present study show similarities with those resulting from work done by Kefford (6), who obtained a higher number of roots after treatment with both auxin and the gibberellin antagonist, EL 531, than after treatment with only EL 531 or auxin by itself.

The obvious potential of PP333 in combination with IBA in enhancing root initiation holds promise not only with respect to pre-plant treatment of plants which require height control but also for species which are difficult to propagate vegetatively.

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BRACHYGLOTTIS COMPACTA: A NEW ZEALAND ENDEMIC SHRUB

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Brachyglottis compacta is one of a large number of endemic, New Zealand plant species. An endemic species is one that is native to and restricted to a particular localised geographical area. Endemism in New Zealand is estimated to be about 81% (4).

The plant was first recorded by Kirk in 1880 (2), and was then known as *Senecio compactus*. It is a member of the Asteraceae, the daisy family, one of the largest plant families in the world, with about 25,000 species. There are about 260 species of Asteraceae found in New Zealand (1). Many are woody or semi-woody species. This is unusual as most members of the Asteraceae, elsewhere, are herbaceous. *Brachyglottis compacta* is a shrub with a soft corky bark less than 2m high, semi-spherical in growth, with grey leaves, which are very hairy underneath. The inflorescences have yellow ray and disc florets.

THE ROLE OF CONSERVATION

Conservation of *Brachyglottis compacta* is important because the plant is confined to the limestone outcrops at Castlepoint, along the Wairarapa coastline (on the east coast of the North Island, New Zealand). An understanding of the ecology of the plant species is necessary to promote its long-term survival. Preliminary studies are under way to determine how the plant population is coping with conditions of the present day. These studies include work reviewing plant population characteristics, plant community relationships between *B. compacta* and other native plant species, as well as seedling site suitability.

One population at Castlepoint has been studied in detail. Situated by the Lighthouse, it is important because of the high human impact in the area. It consists of 111 plants, although there are several hundred plants on Castle Rock. Each individual plant within the population was tagged and measured. Measurements were taken of the diameter of the main stem at ground height. This was used as an estimator of age, because, of course, it is hard to tell how old shrubs are when it is not possible to cut them down and count the growth rings in the wood.

It is interesting to note that 60% of all plants on Castlepoint have a butt diameter of less than 5cm (Figure 1). There is a tail to the distribution showing there are only a few very large plants. Other data obtained indicate that flowering commences when the plant has a butt diameter of greater than 3cm; so only 40% of the plants flower and contribute seed towards the regeneration of the population. Further measurements taken over time will determine whether the seedlings and smaller plants will survive to reproduce themselves.

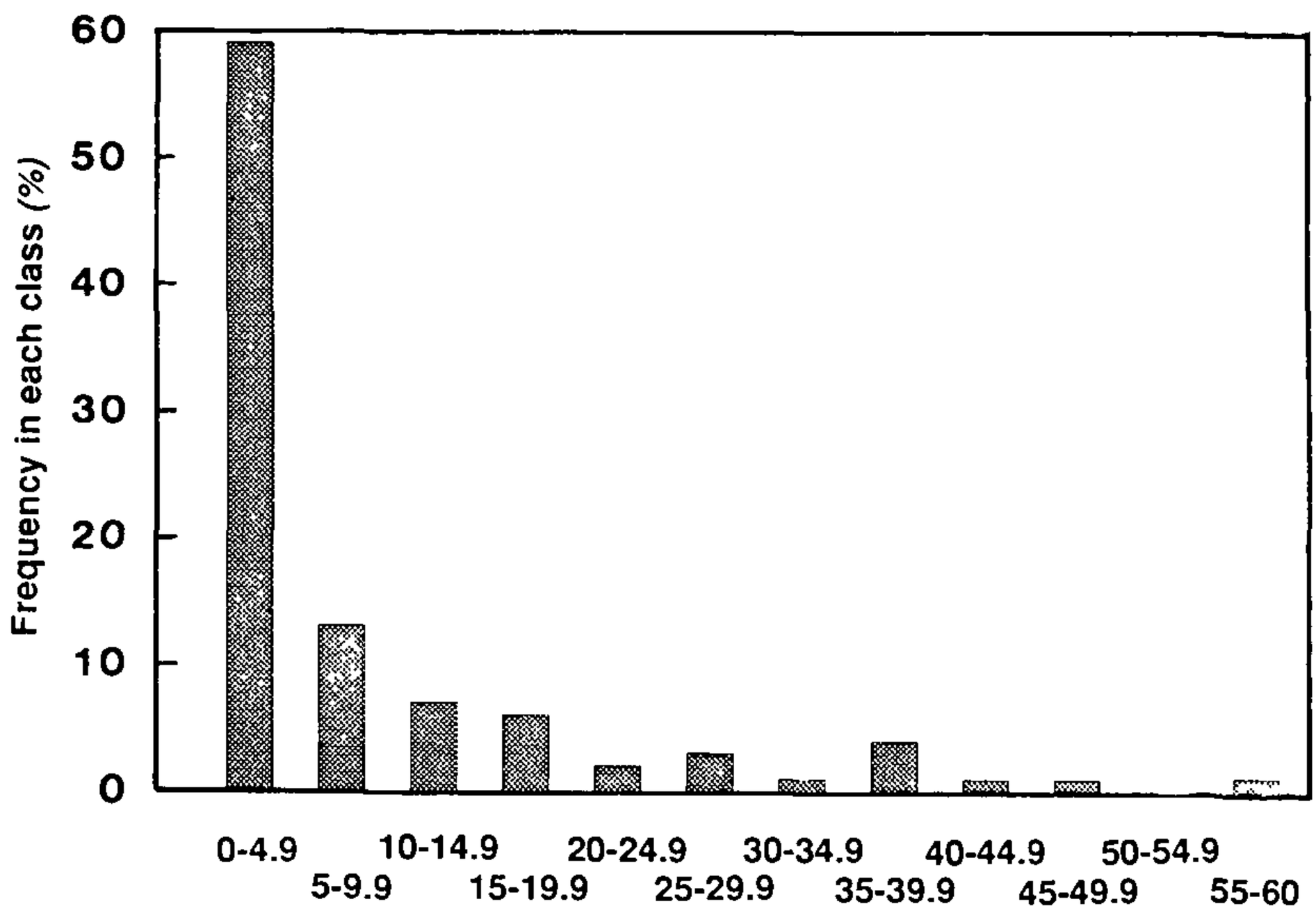

Figure 1. Frequency distribution of butt diameters for *Brachyglottis compacta* at Castlepoint Lighthouse in January, 1990 N = 111.

The survival of these plants has been enhanced by the implementation in 1978 of reserve status in the area. Castlepoint is now the responsibility of the Department of Conservation, which ensures that further browsing, mainly by sheep, does not occur. It is this browsing which, in the past, is probably responsible for the paucity of older, flowering individuals, especially on Castle Rock.

THE ROLE OF HORTICULTURE

Unknowingly, horticulturists have already played a role in conserving part of the gene pool of this particular rare species.

Brachyglottis compacta is one of a number of closely related species of tree daisies placed in the genera *Senecio, Brachyglottis,* and *Olearia. Brachyglottis greyi* for example, is a species found only at Cape Palliser. But to confuse matters, the parentage of a related garden plant has recently been questioned. Jeffrey (5) says:

> "The origin of the garden plant, previously known as *Senecio greyi*, is obscure. The oldest herbarium specimens known date from 1910-1913 and are from plants in the Dunedin Botanic Garden, Otago, New Zealand. Drury in 1974 (3) discusses the evidence for the parentage of the hybrids and concludes that it involves, on the one hand, plants of the *S. laxifolius—S. greyi* complex, on the other, a third New Zealand species, *S. compactus*".

What we have called *Senecio greyi* is not *Senecio greyi* (from Cape Palliser) but, instead, a hybrid containing some of the genes of *B. compacta,* thus preserving them. The garden plant formerly called *Senecio greyi* is now designated as *Senecio* 'Sunshine', which should currently be called *Brachyglottis* 'Sunshine'.

Copper and Keith Hay (Forevergreen Nursery, Tauranga) have grown *Brachyglottis* species for a number of years. They propagate them from cuttings. If seed is used it must be sown almost immediately as viability decreases rapidly after harvesting. The plants are grown under 30% shade cloth. *Brachyglottis* plants are hand-watered as it is best to avoid the use of overhead watering and capillary watering. Fongarid is used as a protectant spray against *Phytophthora.* All *Brachyglottis* species are susceptible to *Phytophthora*, especially in warm, humid weather.

Brachyglottis compacta plants are even more difficult to grow than plants in the rest of the genus. Muriel Fisher (Birkenhead, Auckland) has grown a specimen for the last 20 years or so. She was given the plant by the late Norman Potts from Opotiki. This plant was grown from cutting material collected from the wild. It now grows in a clay soil and is provided with a cool root run. The plant canopy grows in full sun. When planting *Brachyglottis* species she recommends the use of a mixture of 70% crushed scoria and 30% bark chip. This should be incorporated with the soil around the plant. It is also essential not to overwater the plants. Because of the difficulty in growing this plant it may well be best to grow *Brachyglottis* 'Sunshine' or new hybrids.

The potential for hybridisation work with *Brachyglottis* species is vast. Hybridisation between different *Brachyglottis* species is prevalent with both natural hybridisation occurring and spontaneous garden hybrids found where conditions permit. This was how *Brachyglottis* 'Sunshine' originated. It would be beneficial

to combine all the best characteristics of the different species into a series of garden hybrids. It would also be a useful way to overcome some of the problems associated with the propagation and growing of *Brachyglottis compacta*.

The most crucial factor, though, is the continued preservation of the parent species in its natural habitat, both for its own intrinsic interest and conservation value, and as a potential source of genes for horticultural plant breeding.

Acknowledgements. Thanks to Muriel Fisher (Birkenhead, Auckland) and Keith Hay (Forevergreen Nursery, Tauranga) for providing information regarding the propagation and growing of *Brachyglottis* species. Bruce MacKay assisted with the computing, and John Clemens commented on a draft of the text Thanks to Cathy, Jonathon, Joanne, Barbara and Kathryn for field assistance The Department of Conservation kindly permitted research on its estate

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PROPAGATION AND PRODUCTION OF SELECTED PLANTS FOR AMENITY HORTICULTURE

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For discussion purposes herbaceous plants will be separated from woody plants, with herbaceous plant material treated first. These plants are used for planting on traffic islands, median strips, road verges, etc. and are produced in large quantities. The propagation and production methods have been developed over a period of years with the objective of producing a large quantity of plants in the shortest possible time at minimum costs.

Seed of *Agapanthus praecox* ssp. *orientalis* [syn. *A. orientalis*] is collected in April (autumn) as soon as the pods start opening. After some drying the seed is roughly cleaned by rubbing and sieving, then sown as soon as possible into trays in a normal seed raising medium. The sown trays are stacked on top of each other, about 15 trays high, with an empty tray on top, on the floor of a house heated to 20° ± 2°C. After 15 days the stack is reversed and any moisture loss corrected. The stack is inspected every second day thereafter with germination occurring usually 19 to 21 days from sowing. When germination is obvious the stack is opened out onto a bench or floor in the same house and the seedlings grown on until they are 50 to 60mm high. The first production runs are potted into 6cm square peat pots which will be bagged on into PB5's before Christmas, while the later runs will be potted into 8 cm square peat pots for direct planting into the field the following winter. A normal potting medium is used and any weed control necessary is achieved by using Roundup® at half normal spray strength. The selected clone is usually 100% blue with the shade always constant but up to 5% can be white-flowered. The percentage of white-flowered plants appears to vary from year to year without reason.

Agapanthus 'Peter Pan' is a small growing, sterile cultivar that has proved to be very useful because of the lack of unsightly seed heads and its dwarf habit. Because of the plant's sterility large quantities of stock plants have to be available when it is to be produced in bulk. It has been found that single plants grown in PB3's can be divided three times a year, more than doubling stock numbers at each division. They will usually flower within three months regardless of the time of year. The quickest method of division, particularly with bags containing large clumps of plant material, is to lay the plant on its side on the bench, cut off the lower half of the root system and discard it. The remaining medium can

easily be shaken off and the plantlets separated by hand. This method automatically prunes the root system ready for rebagging.

Hedera canariensis has some major advantages over most other plant material used for these types of plantings. When planted at nine plants to the square metre, after 12 months it suppresses all weed growth, does not harbour paper litter, deters dogs, and, if desired, can be pruned by traffic. The cheapest production method to date is to direct stick 15 to 20cm long stem cuttings of current season's growth into 6cm square peat pots prefilled with a moist, free-draining fertilised medium loaded into trays. The cuttings are made with a basal cut 10 to 15mm below a node with the bottom leaf removed. These are dibbled into the peat pots and firmed in without enough pressure to fracture the peat pots. They are then watered in and placed on a bench or floor of a fog house which is heated to 21° ± 1° C.

Because of the transpiration of the large leaf area, the fog is on all daylight hours at the rate of 4 min. "on", 3 min. "off". Depending on the time of the year, the rooting medium will need checking for moisture level every two or three days. The cuttings will be rooted in 18 to 24 days and then they are transferred to a drier atmosphere and cooler house for 5 to 7 days. From there they go to a shade house where they are held until required for planting. Liquid feed is applied as required. With the exception of the first 2 or 3 weeks of spring, when the growth is very soft, a crop can be produced easily every month. However, with cutting selection and fine tuning this time can be reduced to every three weeks. A rooting hormone or bottom heat are not required.

Arctotis acaulis, *Eriophyllum lanatum*, *Gazania* 'Tesco' and, to a lesser degree, *Thymus* species and cultivars comprise a group of plants that are all propagated and produced by the same method. Tip cuttings are taken 8 to 10cm long (4 to 6cm for *Thymus* spp.) approximately 6 weeks before they are required for planting. Any foliage that will be buried in the rooting medium is removed and the basal cut made with sharp scissors at the appropriate length. The resultant cuttings are processed in the same way as for *Hedera* but are placed on a bench in a Novaroof house that has a token amount of heating in cold weather. (The house gets quite cold, down to 7° C in winter; and quite hot, up to 28° C in summer). The trays of cuttings are given two waterings, one to compensate for the absorption of the peat pots and then covered with a light weight clear polythene sheet. The sheet is laid directly on top of the foliage and hangs approximately 20cm over the edge of the outside trays. After 5 days the sheet is removed for one hour each morning and moisture levels checked before being replaced. After 15 days the sheet is removed and after a further 7 days the trays are moved

to a hardening-off facility with a high light factor. Fourteen days later they should be exposed to the vagaries of the weather, ready to be planted out in one week's time.

The deciduous trees that are used for Parks and Reserves plantings that will be discussed fit into three groups for propagation and production methods. The first group consists of *Acer*, *Aesculus*, *Fraxinus*, *Ginkgo*, and *Quercus* species. Seed of these trees is harvested as soon as it is mature but not dry, then sown immediately. Individual seeds are sown into 5 or 7cm Rootrainer tubes and placed in a house heated to 24° ± 2° C. Germination is usually immediate from those seeds that are going to germinate without other treatment. Seedlings continue to grow through the winter and, in spring when the danger of frost is reduced, they are between 20 and 30 cm high. They are then hardened off and lined out into open ground. Any distorted roots are removed at planting, taking care not to bare root the plant. With adequate fertilisation and irrigation, rods or feathered rods up to 2m high can be obtained by winter.

The second group consists of *Metasequoia*, *Platanus*, *Populus*, *Prunus*, *Salix*, and *Taxodium*. These trees are grown from hardwood cuttings taken late in autumn and before total leaf drop. The cuttings are approximately 1cm thick and 25cm long of current season's growth with any remaining foliage removed. A clean square cut is made 5mm below a node and a sloping cut 5mm above the node nearest to the 25cm length.

The nursery soil is a free-draining, sandy loam that is fertilised and cultivated earlier in the autumn, then lightly compacted and raked smooth. Thin black polythene 1m wide is laid with sides and ends buried to a depth of 10cm and heeled to keep the sheet smooth and tight. Further sheets are laid parallel with a 40cm wide path between them. Holes are punched through the sheet 15cm in from each side of the sheet and, as the cuttings are made, they are inserted into the holes and firmed in. It is essential that as the first leaves appear they are kept watered, as stress at this time is fatal. A side dressing of fertiliser is applied mid-summer on the paths and watered in. No rooting hormone is used. Good plantable grades can be expected of most of the species by winter with care and attention.

The third group consists of *Almus*, *Betula*, and *Carpinus* species. Seed is again harvested as soon as it is mature and sown immediately. It is sown on the top of a normal medium in a very free draining tray (hygiene plastic trays), not covered, and placed on a bottom-heated (22° ± 1° C) intermittent mist bench running at 20 sec. "on", 20 min. "off" day and night. Seed germination takes place 12 to 15 days from sowing. Seven to ten days after germination the seed trays are removed from the mist bench and

grown on in a house heated to 24° ± 2° C for two to four weeks. During this time liquid fertiliser is applied each week. The required number of seedlings are then tubed into 5cm Rootrainer tubes and grown on through the winter in the same house. When the risk of frost has diminished they are hardened-off and lined-out in open ground 25cm apart with the rows at 40 cm spacing. Treatment from then on is the same as for the second group of trees (above) and the same grades can be expected. Normally these trees are transplanted during the winter for another season to improve the grades and to produce a more fibrous root system that will transplant better.

The evergreen trees used for these plantings, i.e. *Cryptomeria, Casuarina, Acacia* species, plus various endemic species are produced, at this stage, by the usual conventional methods.

AN ISLAND FOREST—NEW BEGINNINGS

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During the late 1970s I became involved with the New Zealand Wildlife Service as a volunteer on Little Barrier Island in the cat eradication campaign. After the cats were finally exterminated from the island there was a period of rare native bird liberation on this and other safe islands around New Zealand's shores. Being involved in these expeditions over many years I had the chance to study the flora and fauna of a number of our northern islands. One of the areas, the Mercury Island group, was of special interest to me. I was part of a study of the saddleback, (a native bird), along with doing seed identification in faeces. All the Mercury island group have been extensively modified by human occupation and the introduction of feral (wild or untamed) animals. The plant life of these ''cultivated'' places is highly modified due to species being destroyed by fire, or unable to regenerate owing to the predation of seeds and seedlings by rabbits and rats. Often there will be only one or very few individual trees of great age perhaps fruiting in vast quantities and no resulting young plants. We have found fruits of rewarewa (*Knightia excelsa*) eaten on the tree by *Rattus rattus* (ship rat) to a height of 15m. Such rats will also eat all the buds from *Meryta sinclairii* (puka) and kill them.

With this background of interest in the islands I was recommended as a consultant to the owners of an island in the Mercury group who had a problem of erosion along one side of an airstrip and had been unable to establish any tree cover for the area. This island has had a long history and was possibly one of the first areas in New Zealand to feel the effect of human occupation. It has a very mild climate suitable for the cultivation of plants such as the kumara. Extensive walled gardens are still visible there today. There have been vast fires and most of the original bush has disappeared leaving a few pockets of trees among very large areas of grazed farming land.

Aspects of this island which had to be taken into account so that we could succeed in growing trees were varied. Firstly, the climate, while mild is very dry, being in the rain shadow of a large range of hills on the mainland. It often does not rain all summer (September-May) or, if it does rain, it is very little and soon evaporates. Secondly, there is a problem of gorse (*Ulex europaeus*). Until a few years ago the island was farmed with matches: the gorse and *Leptospermum* were burned and the resulting regrowth grazed. Soil disturbance results in thickets of gorse seedlings overnight;

2,4,5-T sprays are used to control these, although injuring and killing many of the large *Metrosideros* plants. Thirdly, it is very hard to tell cattle and sheep not to eat the trees, so that costly fences and cages must be erected. These fortifications are not always successful and many a young tree has ended up as a steak or as wool. Goats (now eradicated) must have eaten out many a rare plant growing on the steep cliffs.

Other factors to be taken into account are the preservation of archaeological sites and keeping the plantings in tune with the island flora, e.g. avoidance of exotics that will become weeds spread by seed. A plant that comes to mind is the fan palm (*Chamaerops* sp.) which was planted on Little Barrier Island many years ago. A few of these palms planted earlier on the island were pulled out as they could have eventually spread to other islands of the group with the aid of pigeons or parrots.

For the main planting, which was in very sticky subsoil taken from the airstrip, I had to plant small growing trees and shrubs (under 4m tall for air regulations). The area was fenced off but the first difficulty I ran into was the lack of suitable material. Most nurseries had large size plants but would not part with the larger tube lines that I knew to be suitable for the job. However, I did manage to collect enough *Pittosporum, Coprosma,* and a few flax, in addition to some large *Metrosideros* for the harbour area. These plants were packed and sent to Whitianga and duly sailed for the island. We followed by plane with a box of food, fertiliser, and spades. The planting was executed in foul weather, hurricane force winds, freezing rain, and gluelike clay. The main lesson was that the small plants chosen were the correct solution to the drought problem as the grass grew over them and protected them for the first season. Though I received considerable flack for the "untidy appearance" of the area, and still do, the long growth helps suppress gorse seed germination.

Over the intervening years the original project has grown and we are now planting up other desirable sites, the majority of plant material coming from the area. Seed and cuttings are collected and grown in Root-Trainers in the case of trees and shrubs. Flax (*Phormium tenax*) is contract-grown in the open ground. Problems which do not exist on the mainland have had to be overcome, e.g. transporting the plants to the island to coincide with farming operations and as near to planting time as possible as the cartons quickly rot and soggy boxes are hard to cope with on cliff side tracks. Organising food for 10 days or so for the team of 6 who are often away working on other island projects is also a big problem.

While this ongoing planting has been a challenge for our small nursery it is very gratifying to see the earlier plantings well on their way. Trees are now reaching 2 to 3m tall and starting to spread from

the coastal bush area. Possibly these will be living seed banks for the day when rats and cats are eradicated and rare birds can be reintroduced. My commitment to the conservation of our unique and beautiful land will have been in its small way fulfilled.

SEED PROPAGATING TIPS ON SELECTED SPECIES

Propagation of plants in our project has been mainly by seed. Some of the species we used are:

Planchonella novo-zelandica (tawapou) A medium-sized tree with dark shining leaves and colourful fruits The fruit is usually eaten by native pigeons and parakeets, the hard seed strewn beneath the tree Collected in May (autumn), the seed is washed, sown on the surface in planter bags, 50 seeds per bag, and set in a dark area of the shade house until germination after about 3 months They are potted the following winter and grown on for a further 2 years

Nestegis apetala (coastal maire) A medium sized tree with very glossy leaves and small pale purple fruits These can be collected in mid-May from the tree and the pulp removed Seed is sown and just covered then kept at 20 °C until mid-spring Most seeds will have germinated and will be large enough to tube up and grown on for 2 years

Coprosma robusta and ***C. macrocarpa*** These are small trees or shrubs with red fruits Seed is collected from plants in April, or from bird droppings in roost boxes, cleaned of pulp and sown in trays Germination occurs in 2 to 6 weeks, and the seedlings potted in spring They are pruned twice in summer and planted the first year Some excellent forms were grown from the "bird seed" and will then be propagated from cuttings

Metrosideros excelsa (pohutukawa) A large tree with red flowers Seed is collected in April from selected trees and sown fresh on the surface Germination occurs in a few days The small seedlings are pricked out in spring and either planted the first year or kept for growing on in planter bags

Griselinia lucida A medium sized tree with large glossy leaves, fruits are collected in April—May and the green pulp removed Sown on the surface, seed germination occurs in 5 to 20 days Seedlings are pricked out in spring and grown on for 2 years

Pittosporum (3 species) Seed pods are collected in May, mashed up in a bucket with petrol until the gum has dissolved, then washed in washing-up liquid with the rubbish floated off Seed is then sown in trays just covered Germination occurs in 1 to 5 months The seedlings are usually large enough to plant out the first season

Beilschmiedia tarairi A large tree with dark blue drupes, seed is collected in April and June, mainly from mounds of droppings from native pigeons Many hundreds of the large seeds can be collected from one mound, the odour being highly "aromatic" to say the least The seeds exude masses of "jelly" which appears to keep the young germinating root and shoot moist until the seedling takes hold of the soil Year-old trees are large enough to be planted out or grown on for a further year

SELECTING AND USING MAGNOLIA CLONAL UNDERSTOCKS

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INTRODUCTION

In ornamental horticulture clonal understocks have been used more for convenience than for standardising growth of plants produced, but clonal understocks have long been an integral part of commercial orchard operations. Fruit yield and tree performance can be controlled by understock selection, i.e. apple cultivars can have dwarf, semi-dwarf, or vigorous understocks. It is often more convenient to grow understocks from seed than by vegetative methods. This report discusses the selection of clonal understocks for *Magnolia* spp., but the principles can be applied to other genera.

WHY GRAFT MAGNOLIAS?

Plants of *Magnolia* spp. and hybrids are usually grafted. Grafting is a more economic method of production than either taking cuttings, when there may be low takes, or the high cost method of layering. Practical experience with grafted magnolia plants has shown some degree of dwarfing as well as increased flowering. Treseder (1) considered that grafting tended to reduce the vigour of a magnolia, irrespective of the understock, this being borne out by the fact that seed-raised trees of *M. sargentiana* var. *robusta* at Caerhays grew more vigorously than their grafted parents. Grafted plants of *Magnolia campbellii* subsp. *mollicomata* 'Lanarth' usually grew with greatly reduced vigour and began to flower before becoming excessively tall. This reduced size of grafted plants means that they can often be sold in flower. Dwarfing of magnolias, especially *Magnolia campbellii* cultivars, also makes them more suited to smaller, modern suburban gardens.

GRAFTING AND BUDDING METHODS FOR MAGNOLIAS

Summer Budding. This is done using chip budding and can be used with field-grown understocks or understocks grown in containers. The key is using well-ripened budwood and, with container budding, avoiding wetting of the budded stems.

Winter or Bench Grafting. This is done by using conventional whip and tongue grafts, with understocks appropriate to the scion cultivar. Root grafts can also be used if sections of root of similar caliper to the scions are available that also have healthy fibrous feeding roots Root grafting can be of assistance with preliminary

evaluations of newly selected seedlings for clonal understock production, and has the added advantage that no suckers are produced.

REASONS FOR CLONAL UNDERSTOCKS

When using seedlings as understocks each plant produced is effectively a different genetic scion/stock combination. The easiest difference to detect is the relative rate of caliper increase and degree of bulging at the graft union. This is related to the parentage of the understock or to the scion cultivar being examined. Magnolias with the fastest caliper increase come from *M. campbellii* subsp. *mollicomata* and some of the slowest are found among seedlings of the *M.* × *soulangiana* grex.

Variable caliper growth rate in seedlings leading to unsightly scion/stock unions first prompted the investigation of clonal understocks. In addition, some scion/stock combinations tended to make the scion cultivar lose terminal dominance and produce vigorous water shoots from just above the graft union. Long term observation also showed that variation in seedling understocks meant variation in relative dwarfing effects, with occasional combinations actually leading to increased scion vigour, and varying susceptibility to root disease, especially among seedlings of *Magnolia kobus* and *Magnolia* 'Charles Raffill'.

SELECTING CLONAL UNDERSTOCKS

Clonal understocks must be readily produced from cuttings. Three cultivars commonly grown that have been evaluated as clonal understocks are *Magnolia* × *loebneri* 'Merrill', *Magnolia* × *soulangiana* [clonal form] and *Magnolia* × *soulangiana* 'San Jose'. Each has characteristics worthy of a clonal understock to fit a range of scion cultivars. These characteristics are as follows:

Magnolia × *loebneri* 'Merrill': A hybrid with *M.stellata* and *M.kobus* parentage so it is very hardy [to Zone 5, USDA Hardiness Rating] and a moderately vigorous form, with a caliper growth rate comparable to the hardy *M.* × *brooklynensis* types and similar hybrids with *M. acuminata* parentage. This cultivar also shows a resistance to root disease that affects a high percentage of *M.kobus* seedlings.

Magnolia × *soulangiana* [clonal]: A medium to strong grower that covers the range of caliper growth rates from *M.denudata* through various hybrids and species such as *M.cylindrica*, and even *M. sprengeri* 'Diva' forms. However, *M. soulangiana* [clonal] is not vigorous enough for most cultivars with any *M. campbellii* parentage.

Magnolia × *soulangiana* 'San Jose': This bears a striking resemblance to *M.* × *veitchii* and some of its hybrids. When used as an understock *M.* × *soulangiana* 'San Jose' displays vigour corresponding to that of *M.* × *veitchii* [Table 1], making it a good understock for heavily-wooded species such as *M. campbellii* and the hybrids *M.* 'Caerhays Belle' and *M.* 'Charles Raffill'.

When using the above clonal cultivars it became apparent that at least one more clonal selection needed to be made to approach the caliper requirements of *M. campbellii* subsp. *mollicomata* forms. To do this 10-year-old grafted plants of *M.* 'Mark Jury' were examined closely. Two selections were made by cutting the trees to the ground and allowing the understock to regenerate. One [U/S A] showed an even caliper between understock and scion and the other [U/S B] showed a fairly distinct taper from a thicker understock to a thinner scion. The understocks were first reproduced by budding to produce a large volume of material for softwood cuttings. Eight-month-old rooted cuttings were field-planted through polythene mulch and budded as stocks 2 years old from the cutting. Budding allows for quick caliper comparisons since the scion grows vigorously, accentuating any differences in caliper growth rates, which are then visible by the end of the first growing season. When the same combinations are produced by bench grafting it may take 3 years for similar differences to appear.

A sample of ''scion ratings'' from over 30 studied combinations is presented (Table 1). The figures in the columns represent the average scion caliper for the first 15cm above the graft union expressed as a percentage of the understock caliper, so that a ''scion rating'' of 110% would be equivalent to a tree caliper of 10cm below and 11cm above the graft union. The final figure in the right hand column is the average of the measurements taken for each combination.

It is apparent that some variation can still occur within a group of identical scion/stock combinations. This is most likely due to the nutritional status of each individual in the group. However, the advantage of using clonal understocks versus seedlings is demonstrated. It must be remembered that each scion/stock combination is different, so each scion cultivar must be tested on a range of stocks to find the one most suitable.

This report has shown the advantage of using clonal understocks to accommodate caliper differences This is only one of the advantages that can occur, and it is anticipated that further benefits, such as controlled dwarfing, will be achieved by using clonal understocks for grafting magnolias.

Table 1. Scion ratings for selected *Magnolia* understock/scion combinations

Understock and scion cultivar combination	Age and graft type	Scion ratings					Mean
***M. kobus* seedling U/S**							
M campbellii 'Lanarth'	4yr bud	155	162	139			152
M campbellii subsp *mollicomata*	4yr bud	105	106	100	112		105
Magnolia 'Mark Jury'	4yr bud	114	113	126	104		112
***Magnolia* × *loebneri* 'Merrill' U/S**							
Magnolia 'Galaxy'	2yr grafts	107	106	103	90	100	101
M × *brooklynensis* 'Woodsman'	1yr grafts	86	94	83	90	77	86
Michelia doltsopa	2yr grafts	125	146				135
***Magnolia* × *soulangiana* [clonal] U/S**							
M camp subsp *mollicomata*	3yr grafts	132	110	93	117	92	108
Magnolia denudata	1yr buds	104	109	103	105	106	105
Magnolia 'Galaxy'	3yr grafts	108	111	115	113	112	111
M × *brooklynensis* 'Woodsman'	3yr grafts	97	104	97	97	95	98
Michelia doltsopa	3yr grafts	121	118				119
Magnolia × understock 'B'	2yr grafts	107	141	124			124
***Magnolia* × *soulangiana* 'San Jose' U/S**							
M campbellii 'Lanarth'	7yr buds	109	116	117	100		110
Magnolia denudata	7yr buds	100	96	100			98
Magnolia × *veitchii*	7yr buds	100	103	100	100		100
***Magnolia* × understock 'A'**							
M campbellii 'Lanarth'	1yr buds	105	104	111	107	105	106
M campbellii subsp *mollicomata*	1yr buds	110	92	114	111	102	105
Magnolia 'Mark Jury'	1yr buds	91	88	93	97		92
Michelia doltsopa	1yr buds	107	113	95	99	109	104
***Magnolia* × understock 'B'**							
M campbellii subsp *mollicomata*	1yr buds	105	101				103

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RUNNING AN ORGANIC NURSERY

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INTRODUCTION

I recall my university days on the subject of ''Management'' and the process of ''Decision Making'': Observe, Analyse, Decide, Action. At that time it seemed rather abstract, but now that I am running my own business it is much more real. It made quite an impact on me at that impressionable age. Since then observation has always been an important part of my life. As a plant propagator and retailer, I keep a very large working diary.

The commitment to becoming organic arrived through this observation process about ten years ago when I was foreman on a large orchard. I started thinking about the massive amounts of poisonous sprays that went onto the fruits and into the environment, and the consequences of that. I concluded that we must work towards enhancing and sustaining our world, taking out only what is put back at a renewable pace. If we are not prepared to confront the environmental problems of today they will be visited upon our children.

COMPOST OR GROWING MIX

The key to my success in organic production is the growing medium, and for this the art and science of compost making has to be well understood. Too often the composition of a planting medium is determined by the availability of the bulkiest and cheapest products and, as a consequence, plant health, quality, and survival are at the bottom of the priority list. I have a proven organic compost recipe (Table 1) for the base of my potting mixes. The compost must reach 70 ° C (170 ° F) for three weeks to be sure that all pathogens and seeds are destroyed. It has to be turned for the correct amount of aeration every three to four days.

To make the mixes I add sand, peat, liquid fish, and pumice, the proportions depending on the plants I am potting. For the lower pH plants such as rhododendrons and azaleas I make a different compost; I replace fowl manure with leaf litter and use a larger bark size.

Table 1. Ingredients of an organic compost

Material	Cubic meter
medium grade bark	6
sheep manure (with some wool)	2
fowl manure	2
sawdust	1/2
pine needles	2
seaweed	1
fresh cut grass	6
house scraps	as available

PROPAGATION

The principle of organic propagation is that you replace interventionist methods of using fungicides and insecticides to ensure plant health with more observation, and a greater awareness of the plants' requirements. By doing this the plant becomes stronger and able to resist pests and diseases on its own. Most of my stem-propagated plants have some organic compost mix in the medium right from the beginning. Humidity is controlled by observation twice a day when the cuttings are either covered or uncovered. Bottom heat ranges from 19° to 20° C, which is turned off during the summer. I use flat trays for large volumes and Root-Trainers for lesser numbers of plants.

PEST AND DISEASE CONTROL

Once the air and ground temperature in the greenhouse is raised problems such as aphids and white fly become apparent. In this situation infection can be controlled by either removing plants outside or cooling the temperature inside. This I do by air flow and sun protection. Oil sprays are very effective in pest control. I use Thuricide (*Bacillus thuringiensis*) and derris to keep brassicas clean. It is important to understand that pest and disease control happens over a long period as predatory populations become established.

WEED CONTROL

General weed control is done using a gas burner. It runs on LPG and is very cost effective, provided burn-off is repeated and at an early weed growth stage. For inside nursery areas, weeding is done by hand.

CONCLUSIONS

Managing a nursery along organic lines is a great challenge. The methods are sometimes more difficult and the income not as great, but the results are much more satisfying. I may make decisions not necessarily based on economic analysis but I believe that becoming an organic plant propagator is a start towards environmental sanity.

WHAT IS SOMATIC EMBRYOGENESIS IN A CONIFER?

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INTRODUCTION

Somatic embryogenesis has been reported in many plant species, with the earliest in carrot cell cultures over 30 years ago (3). There has been significant progress and many reviews in recent years (5). Woody species often require more complex cultural manipulations than herbaceous species. Reported successes include conifers (e.g. 1,2,4). Somatic embryogenesis has considerable potential as a basic technique for propagation of conifers. The ability to regenerate large quantities of plantlets or even artificial seeds from somatic embryos from superior trees with desirable traits, such as faster growth, better quality wood, and disease resistance would improve existing reafforestation programmes, and be a major asset to the forest industry.

Somatic embryogenesis is the formation of embryos similar to zygotic (sexual) embryos formed in nature, but initiated from somatic cells rather than zygotic cells. Somatic cells are from the plant body, zygotic cells are from the recently fertilised egg. The more traditional tissue culture process, organogenesis, is the initiation *de-novo* of organs, usually shoots and roots, from cells or tissues. Organs may form on the surface of explants or upon an intervening callus phase. Both the organogenesis and embryogenesis techniques have merit. Organogenesis is often the easier technique for propagating a wide range of plant species and the resultant plants are usually true-to-type. Somatic embryogenesis is a more difficult procedure, with cultural requirements often more precise and the appearance of irregularities more frequent. But it also has several advantages that have great commercial appeal. The plants produced are always juvenile, shoot and root axes generally are formed at a similar time and potentially very high numbers of embryos can be formed. For example, in *Pinus radiata* there are at least 10,000 embryo initials per gram fresh weight of embryogenic tissue. The technique could substantially reduce the high labour input compared with that required for multiplication and transfers of shoots and plantlets produced via organogenesis.

Dr. Dale Smith and his research team at the Forest Research Institute (FRI) have been researching embryogenesis in *Pinus radiata* for the past 7 years. Since 1988 this work has been in collaboration with NZFP Forests Ltd. There is still refinement

of conditions required to improve maturation, encapsulation, and liquid culture procedures but results are very encouraging with plants having been established in the nursery. This paper describes some of the techniques and results from this research.

SOMATIC EMBRYOGENESIS IN *PINUS RADIATA*

Explant Source: Immature cones are collected late November through to December (early summer). Over this period of time natural embryos become multicellular and this is the optimum stage of development to initiate somatic embryogenic tissue *in vitro*. The timing is crucial and usually cones are destructively sampled over this period to identify the correct stage of development. This varies among families of trees as well as season.

Methods: Immature seeds are easily extracted from the cones, as the cone is still soft and non-lignified. Once seeds are extracted they are sterilized in a hydrogen peroxide solution with a surfactant, and then rinsed in sterile water. Using aseptic techniques the gametophyte (this is food reserve containing the embryo inside the seed coat, and it looks like a grain of rice) is extracted from the seed coat and placed on an embryogenesis medium containing activated charcoal and sucrose in petri dishes. The gametophytes are incubated in low light conditions at 24 ° C. After 2 to 6 weeks embryogenic tissue emerges from the nucellar (sharp) end of the gametophyte. The embryogenic tissue is a mass of elongated cells (suspensors) bearing small embryo initials. If the timing of initiation from the cone into culture is accurate up to 70% of all the gametophytes can produce embryogenic tissue.

Once embryonic tissue masses are 3mm or greater in diameter they are transferred to a maintenance medium. Growth is vigorous on this maintenance medium, with tissues often doubling in weight every 10 to 14 days, and tissues are transferred at two week intervals. The embryo initials remain small and rapidly dividing. When embryo maturation is required, tissue is suspended in liquid medium and put onto an embryo development medium. Tissue regenerates from the suspension over a 4 week period and forms small embryos visible under the stereo microscope. It is then transferred to a medium that contains abscisic acid (ABA). Here, the tissue forms large white embryos (Figure 1). These appear similar to normal zygotic embryos. At this stage the most mature embryos are picked off and placed on maturation medium where they mature further and germinate. They are taken from *in vitro* to *ex vitro* conditions and planted in potting mix. They quickly acclimatise to glasshouse conditions, with little obvious water stress or difficulty compared with many exflasked tissue culture plantlets raised via organogenesis.

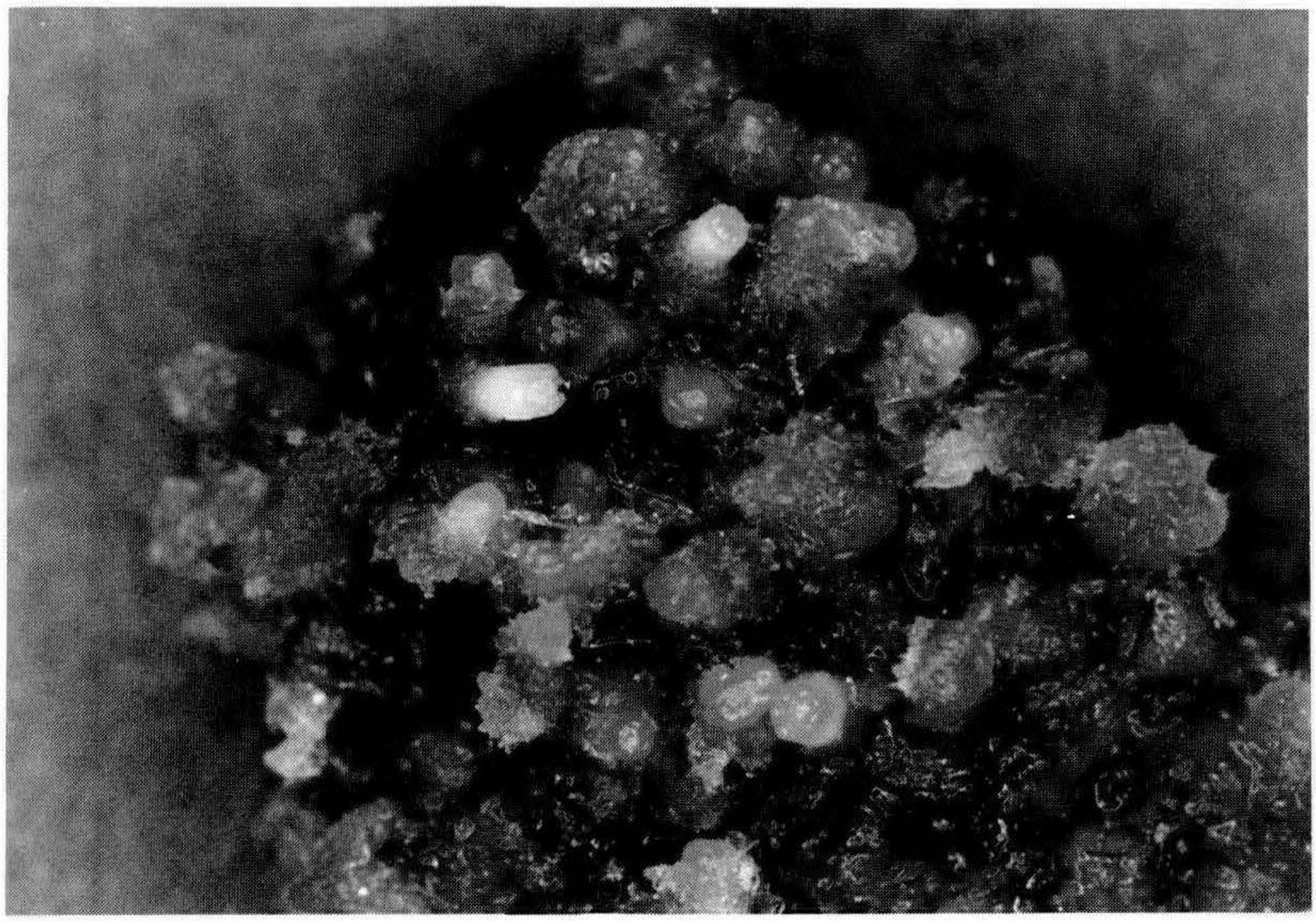

Figure 1. Somatic embryos of *Pinus radiata* forming on embryogenic tissue.

Future Prospects: In order to realise the potential of this technique further medium modifications (to satisfy physiological and biochemical requirements) are necessary to enable more of the thousands of small embryos present per gram of tissue to mature and form seedlings. Currently only a small fraction reach a plantable size, with many being lost as each developmental stage progresses. The Forest Research Institute is also investigating the use of bioreactors (automated vessels containing liquid media and embryogenic cell suspensions) for cultural phases after initiation of clones on solid medium. It is hoped that encapsulation of the somatic embryos from the bioreactor and sowing them directly into nursery beds will be possible. Early results are promising. Embryogenic suspensions have been multiplied in a bioreactor, and embryo development observed. Mature zygotic embryos have been used to test the concept of artificial seed coats, and the process is clearly feasible.

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CUTTING PROPAGATION OF *ROSA* 'MERMAID'

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The climbing rose, *Rosa* 'Mermaid', a hybrid with *R. bracteata* parentage, was raised by William Paul in 1917. It has fragrant primrose yellow single blooms and is perpetual flowering until the first frosts. Its habit is very vigorous with thorny branches that are evergreen in mild, and semi-deciduous in cooler climates.

EARLY METHODS

My first attempt at cutting propagation of the rose 'Mermaid' was in the early 1980s. Material was taken during January (mid-summer) from a healthy stock plant grown in a rose walkway within an open-sided glasshouse structure at the garden centre. Using a sharp pair of secateurs, cuttings approximately 150mm in length (10mm diameter) were collected from wood that had flowered with a cut straight across below a bud. Three-quarters of the foliage was removed along with the thorns. A 10 to 20mm wound was made at the base of the cuttings which were dipped into I.B.A. (8% in talc), bundled into tens, and wrapped in damp sphagnum moss with the foliage exposed. The bundles were wrapped in black polythene, bound with a rubber band then placed upright in a tray on a heated bench at 20° C with mist.

This technique was unsuccessful, the cuttings turning black with a 100% loss. My next attempt was with cuttings taken in February which were prepared in the same way. However, instead of bundling and wrapping in sphagnum moss the cuttings were set upright in polystyrene trays containing a peat and sand medium (1:2, v/v).

The cuttings were placed on a heated bench at 20° C with mist. After four weeks, roots appeared under the trays. The rooted cuttings were hardened off for a week, then potted on. The percentage with good roots was 80%. Considering this was the way to go I continued to take cuttings using this method but at varying times of the year. However, the results were only average.

PRESENT DAY TECHNIQUES

Cuttings were taken in February and March (late summer) from wood that had flowered and was of a good thickness (10mm). The cuttings (100 to 150mm) had three-quarters of the foliage and all thorns removed, then they were wounded, dipped in Liba 10,000 at one part to two parts water, for five sec. They were then direct

stuck into pots, half into a peat and sand mix only, and half into the same mix containing dolomite lime, Plantacote, and Ridomil fungicide. Again, pots were put into trays with bottom heat (20° C) and mist. After four weeks approximately 70% had developed a good root system with an indication that the additions to the mix may have been beneficial (Table 1).

Table 1. Effect of amendment[1] to a peat sand mix on rooting of cuttings of *Rosa* 'Mermaid'

Medium	Percent of cuttings rooted
Peat.sand only	50
Peat.sand amended	80

[1] See text for amendment details, 40 cuttings per treatment.

INTEGRATED PEST MANAGEMENT IN AN INDOOR PLANT NURSERY

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Integrated pest management (IPM) has been defined as... "the combining of biological controls and cultural manipulations to minimise dependency on pesticides."

Despite the widely publicized advantages of IPM, and the pressure to reduce the use of synthetic pesticides around the globe, many growers still have not accepted that IPM can work for them. Many lack confidence in IPM programmes and quite often they are satisfied with their present chemical control methods. My own experience with IPM has been in controlling two-spotted mite (*Tetranychus urticae*), or TSM for short.

In the winter of 1982 we leased a greenhouse that had several large specimen plants permanently planted in it. There were cultivars of *Ficus, Schefflera, Codiaeum,* and some palms. Within a few weeks we realised that we had inherited a healthy collection of assorted pests, namely, mealy bug, aphids, and TSM.

A routine spray programme soon had the situation under control through spring and early summer, or so I thought. As summer progressed I found that I was constantly battling TSM. The problem was the large stock plants, it was impossible to achieve good spray penetration because of the size and spread of foliage.

In the winter of 1983 I attended a field trip organised by the Department of Scientific and Industrial Research (DSIR), Mt. Albert, Auckland, where I learned that they were trialling the mite predator, *Phytoseiulus persimilis*. Though there were several greenhouse vegetable and cut flower growers taking part in the trial little work with ornamentals was in progress. I discussed my particular problem with them and soon we had a trial set up.

The predator was introduced when the population of TSM was high enough to support it, and then the nerve racking part began. It is hard for a grower to stand back and watch while mites crawl apparently unchecked around the greenhouse. I watched the population of TSM increase daily while *Phytoseiulus* seemed to be struggling to establish itself. Then on the advice of the DSIR I sprayed with Torque (fenbutatin oxide) which is effective against TSM but does not harm *Phytoseiulus.* After a while it became obvious that the TSM population was on the decrease and that the predator was winning. Mid-summer that year we were totally free of TSM. The predator even over-wintered and the following

summer we had no difficulty controlling TSM with an occasional application of Torque. *Phytoseiulus* had the situation under control.

Phytoseiulus is orange-red in colour and is pear-shaped, with front legs longer than TSM. It moves considerably faster than its prey and can be seen on the undersides of leaves where TSM is most abundant. Female predators' eggs are twice the size of TSM eggs, the young hatch out after a few days and prey upon the TSM eggs. *Phytoseiulus* does best at 18° to 35° C in 60 to 90% relative humidity. Since moving to our new premises we find that we have to reintroduce the predator every second year, usually around January or February when the hot dry conditions favour TSM. The important features of using biological control in our case have been:

1. A change in attitude to insects and other pests in the greenhouse, realising that there are acceptable levels of mite populations.
2. A change in the range of chemical used to control secondary pests and fungi.
3. Learning to correctly identify insects.

Biological control of TSM in our case has proved to be more efficient than chemical sprays and also cheaper. We have better pest control with less spraying, which is a step in the right direction both economically and environmentally.

THE USE OF PACLOBUTRAZOL IN THE ROOTING MEDIUM OF MICROPROPAGATED PLANTS

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Abstract. Paclobutrazol, a plant growth retardant, may be used in the rooting medium of micropropagated plants to prepare the plants for transfer to soil without acclimatisation The following plants have been subjected to varying strengths of paclobutrazol in the rooting medium, *Metrosideros* spp , *Eucalyptus ficifolia*, *Mandevilla* 'Alice du Pont', *Rhododendron* 'Anna Rose Whitney' and *Morus nigra*. The results show an individualistic response with respect to root growth but all plants that were transferred to soil without acclimatisation grew successfully

INTRODUCTION

Plantlets cultured *in vitro* on agar-based media in a humid atmosphere wilt rapidly when transferred to normal greenhouse conditions. Hence it is usual practice to acclimatise the plantlets in a humid environment for 2 to 4 weeks until new roots and shoots have grown.

The effects of paclobutrazol have been reported to include an improvement in stomatal physiology, an increase in the deposition of epicuticular wax, reduced wilting in response to water stress, and a strengthening of shoots and roots. The use of paclobutrazol in the rooting medium of micropropagated plants can eliminate the need for an acclimatisation period, and plantlets may be transferred to soil in a normal greenhouse or to field conditions (1).

MATERIALS AND METHODS

The product Cultar (23% w/w paclobutrazol; ICI) was diluted and added to the normal rooting medium of each plant at rates of 0, 0.5, 1.0 or 2.0 mg/l paclobutrazol. This was autoclaved at 121 °C for 20 min.

The following plants were treated: *Metrosideros collina* 'Springfire', *M.collina* 'Tahiti', *M.excelsa* 'Parnell', *M.excelsa* 'Scarlet Pimpernel', *Eucalyptus ficifolia*, *Mandevilla* 'Alice du Pont', *Morus nigra*, and *Rhododendron* 'Anna Rose Whitney'.

RESULTS

The rooting percentages of each plant in their normal rooting medium and with different levels of added paclobutrazol, are shown (Table 1).

Table 1. Effect of paclobutrazol concentration on rooting of plants.

Plants tested	Percent of plants rooted Paclobutrazol (mg/l) 0	0 5	1.0	2 0
M excelsa 'Scarlet Pimpernel'	100	90	95	90
M excelsa 'Parnell'	100	90	100	61
M.collina 'Springfire'	100	95	100	100
M collina 'Tahiti'	100	95	100	95
Eucalyptus ficifolia	100	13	4	2
Mandevilla 'Alice du Pont'	80	80	90	100
Morus nigra	70	0	10	0
Rhododendron 'Anna Rose Whitney'	0	0	0	0

Metrosideros excelsa 'Scarlet Pimpernel' and *M.excelsa* 'Parnell' showed similar reactions. On media with paclobutrazol added (in comparison with the control) the roots took longer to initiate and grow, the root length was variable and the stem internodes were shorter. The plants survived transfer to normal glasshouse conditions and after three months all plants were growing well.

For *M.collina* 'Springfire' and *M.collina* 'Tahiti' on media with paclobutrazol added the roots took longer to initiate and grow (in comparison with the normal rooting medium), but these were thicker and shorter. The stem internodes were also shorter. The plants survived transfer to normal glasshouse conditions and after three months there were a few losses but the remainder were growing well.

When paclobutrazol was added, the rooting percentages of *Eucalyptus ficifolia* and *Morus nigra* were so poor that the experiment was discontinued and no plants were deflasked.

For *Mandevilla* 'Alice du Pont' the greater the paclobutrazol concentration the longer and thicker the roots and the shorter the stem internodes. The plants survived well the transfer to normal glasshouse conditions. After three months the internodes remained short, the shoot tip buds were compacted and growth was limited. Since vigorous growth after deflasking is essential in a climbing plant, it was felt that the addition of paclobutrazol was unsuitable.

The use of paclobutrazol in the shoot elongation medium did not encourage root growth in the *Rhododendron* hybrid. Stem internodes were shortened and treated plants were half the height of the controls. Almost all plants survived the transfer to normal glasshouse conditions. After three months plants that received 0.5mg/l paclobutrazol were the strongest, i.e. taller with better leaf area.

DISCUSSION

By using paclobutrazol in the rooting medium of micropropagated plants, there is no need for acclimatisation in a humid environment at deflasking, and plants can be transferred to soil in normal glasshouse conditions. This may be a useful alternative where humid fog space is at a premium or where a customer does not have sophisticated deflasking areas.

However, the response to the addition of the paclobutrazol *in vitro* is individualistic, rooting percentages vary, and every kind of plant must be trialled and assessed for suitability to this technique.

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A FRESH LOOK AT PLANT NUTRITION

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It is often said that "money is the root of all evil". From my observations in growing plants and in horticulture, the person who first wrote that had not heard of fertiliser.

I am regularly asked to comment and advise on why people's plants are not growing well, and what we use in the nursery to get our plants to grow. We even sell our blend of fertiliser to the general public in an effort to assist. Modern high-quality, blended, slow-release fertilisers have taken much of the skill away from the art of plant nutrition. If a plant does not grow well with a handful of Osmocote, Nutricote, Magamp, or whatever, then it is declared impossible to grow, which is indeed unfortunate.

The correct use of fertiliser in plant nutrition is the difference between complete success and total crop failure. I am convinced the average nursery could double its output with correct plant nutrition. Nearly all fungal and bacterial diseases are a result of poor nutrition. The first sign that all is not well with plant nutrition is when the plants stop growing. When any visible signs of nutritional problems become evident, the plant is already chronically malnourished and prone to disease. Plant growth is regulated by the availability or not of the least available essential nutrient. Too much fertiliser is a far greater menace than too little. For example, we have proved conclusively when pricking out seedlings that if there is no fertiliser whatsoever in the mix there are never any losses. Pricking out losses increase with the increase in total dissolved salts.

The ideal for young seedlings would be to have no fertiliser in the mix and to liquid-feed them approximately two weeks after planting. I am also convinced when I see the high losses at pricking out of micropropagated explants that it is because the nutrition level is too high. Excessive total dissolved salts is evidenced by the burnt leaf tips and die-back, which can lead to the collapse and death of the plant.

To understand the nutritional needs of plants, *The Essential Elements of Life* must first be defined. These are:

Atomic No.	Chemical Symbol	Element
1	H	Hydrogen
5	B	Boron
6	C	Carbon
7	N	Nitrogen
8	O	Oxygen
9	F	Fluorine
11	Na	Sodium
12	Mg	Magnesium
14	Si	Silicon
15	P	Phosphorus
16	S	Sulphur
17	Cl	Chlorine
19	K	Potassium
20	Ca	Calcium
23	V	Vanadium
24	Cr	Chromium
25	Mn	Manganese
26	Fe	Iron
27	Co	Cobalt
28	Ni	Nickel
29	Cu	Copper
30	Zn	Zinc
34	Se	Selenium
42	Mo	Molybdenum
50	Sn	Tin
53	I	Iodine

Life is not possible without each of these inorganic elements being available in the correct proportions. Each of these elements is highly toxic, and all of them are lethal in excess. Other elements are found in plants in addition to those above. These can include:

13	Al	Aluminium
80	Hg	Mercury
82	Pb	Lead
48	Cd	Cadmium

These elements are considered to have no part in general plant metabolism, but may in fact benefit plants in other ways. For example, aluminium compounds are very good fungicides, and a high aluminium content in plants may confer resistance to fungal infections. The aluminium-rich clays in our area definitely give a growth response. However, this is no evidence that it is in itself a plant nutrient. I believe more work needs to be done on clarifying the place of aluminium in plant responses. Mercury is a lethal element with well known natural fungicidal properties. Many early fungicides were made out of this metal. High lead levels have been

recorded in plants, especially in gardens around old wooden houses that were painted with lead compound paints. These levels can reach toxic proportions in vegetables grown in lead contaminated soils.

Two of these elements, cobalt and selenium, are held to be not necessary for plant growth. However, cobalt is the central atom in the Vitamin B_{12} molecule, an animal protein. Cobalt is essential for bacterial health, particularly rhyzae-bacteria in legumes. Legumes cannot be grown without adequate cobalt. Selenium is not deemed to be plant food. However, it is an element required for neurological development in animals. I do not believe that there should be any differentiation between plant and animal nutrition when it comes to trace minerals, particularly in the production of horticultural crops, as these plants are required for animal food anyway. Selenium has been recorded in a number of plants at levels up to 3,000 parts per million. *Astragalus racemosus* is a selenium accumulator plant. The presence of selenium in this American plant is interesting, and leaves open the question of the place of selenium in plants' needs. I would like to point out that 5 parts per million in the dry matter of stock-food in considered lethally toxic. Therefore, 3,000 parts per million makes this plant extremely poisonous. However, it possibly could be considered as a very good organic source of selenium, to be used in selenium-deficient areas.

Hydrogen, carbon, and oxygen are the magic triad of elements of the photosynthesis carbohydrate miracle, and fortunately are adequately supplied naturally with good ventilation and proper watering. Extra carbon dioxide is sometimes provided with CO_2 enrichment of the glasshouse atmosphere. However, for the most part these three elements require no further concern.

This leaves 23 elements which need to be available at all times in the correct proportions to ensure optimum and balanced growth. It is a sad fact that if you mix all of these elements together nasty reactions take place. Nitrate reacts adversely with calcium; copper reacts badly with molybdenum; and a number of other adverse reactions can take place.

The principle of plant nutrition in modern nursery potting mixes must be totally divorced from the needs of plants grown in soil in the open ground. In soil every effort is made to have the nutrients readily available for the plant. The current practice of using silica sand in nursery potting mixes is a practice which defies logic. Sand has no nutritional value; it has no cation exchange capacity; it leaches badly; it is excessively heavy; and in sand it is almost impossible to stabilise a steady supply of plant nutrients. Furthermore, practically all the sand that is used in our local

nurseries is dredged out of rivers, which are the major source of the pathogenic water-borne fungi which create havoc in most nurseries.

The ideal potting mix requires that there be little or no nutrient available at potting up, and from then on be available in ever-increasing amounts as the plant grows in size, until it is ready for planting out, when maximum nutrient availability should be attained. In reality, the reverse is the case. Potting mixes normally have maximum availability at potting up, and nutrients become steadily less available as plants grow older, until such time as they are depleted and a side dressing is applied. This is, in fact, a highly unsatisfactory situation. Nature ensures that plants receive a steady supply of minerals from the natural weathering of rocks; from the accumulation of organic compounds in the soil; from acid rain which provides a steady stream of nitrates and sulphates; and from wind-evaporated sea spray which deposits countless tonnes of minerals over the land every day, further enriching the soil and contributing to plant growth. The long-term nutrient supply of potting mixes are best provided by the use of finely ground, non-activated mineral rocks. For example, calcium can be best provided by finely crushed oyster shell, limestone rock, and marble; iron would be best provided by crushed iron ore; and trace minerals of all kinds can be readily provided with crushed and finely ground mineral-rich rock, such as volcanic basalt and granite. Superphosphate is a menace in potting mixes, due to the "super" availability of phosphoric acid. Finely ground rock phosphate is excellent. The natural acids in the water and potting mix slowly release these minerals over a long time, allowing for a steady supply.

We have found that nutrients can be stabilised in sand by adding in clay, and we now advise our customers when planting in sand to mix friable clay in with their sand, so that the nutrients attach themselves to the clay instead of leaching out with the first shower of rain. Five percent friable clay added to an organic potting mix will not only supply a host of trace minerals, but will also provide cation exchange capacity. Free nutrients can attach themselves, giving stability to the minerals in the potting mix, and thereby preventing leaching.

A few years ago we tried growing some plants in charcoal, believing this would be an ideal sterile medium for the plant export trade. However, it was a total failure, because the plants would not grow at all. Recently, while judging at the finals of the School Science Fair in Auckland, I saw that a young girl had demonstrated that charcoal locked up nutrients and totally suppressed plant

growth. If wood charcoal is presaturated with trace minerals, a steady supply is then available to the plants throughout the life of the potting mix.

It can be readily demonstrated how important a steady supply of trace minerals is to a plant, by mixing up the total complement of minerals into a paste, using either petroleum jelly or lanolin (sheep wool oil) as a base. If a small patch of this paste is smeared on to tree trunks, it will be slowly absorbed through the bark into the tree, giving a dramatic improvement in plant growth and health. I have never seen mature trees respond so dramatically to any treatment as to this simple procedure.

In conclusion, long-term stable potting mixes containing all of the elements, can be achieved by going to every effort to ensure that the minerals are retained in the mix, but using the following techniques:

1. Use stable mineral sources, such as rock phosphate and finely ground natural mineral ores in place of silica sand.
2. Mix sulphates, etc. with fine acidic clay.
3. Use the unique properties of activated charcoal, which locks up compounds, making them less prone to leaching.

EFFECT OF CUTTING SIZE ON ROOT FORMATION OF *ABELIA, LEUCODENDRON, BORONIA,* AND *METROSIDEROS*

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Selection of propagating material is one factor that influences the success of subsequent propagating techniques. Theoretically, the larger the cutting the sooner the plant will reach a saleable size, provided that the basic character of the future plant is not lost. Ease of root initiation is quite possibly influenced by the size of the cutting. The objective of this trial was to investigate the potential for using larger than normal cutting material.

Four test plants were selected that varied in growth habit and ultimate use. *Boronia heterophylla* and *Leucodendron* were selected as cut flower crops and *Abelia grandiflora* and *Metrosideros excelsa* were used to represent hedging plants.

Tip cuttings were harvested in mid-autumn when the wood was mature. The cuttings were prepared, dipped in "Seradix" containing 0.1% indolebutyric acid (IBA), then placed in peat:pumice (1:1, v/v), on bottom heat at 21 °C under fog. Cuttings of five sizes were used (2,8,14,18 and 27 cm), representing a range from those that were smaller than those usually taken, to those that were far larger than normal. Table 1 gives an indication of the effect of cutting length on rooting.

Table 1. Effect of cutting size on rooting of cuttings[1]

Cutting size (cm)	Percent of cuttings rooted			
	Abelia	*Leuco-dendron*	*Boronia*	*Metro-sideros*
2	90	50	60	30
8	100	30	30	80
14	100	70	10	70
18	100	40	10	90
27	100	60	10	10

[1] 20 cuttings per treatment

RESULTS AND DISCUSSION

The species indicating the clearest treatment effect was *Boronia*, which gave the best rooting percentage at the smallest cutting size with rooting decreasing steadily at larger sizes (Table 1). This was reflected, too, in the number of roots per cutting which was approximately 2.5 in the two smallest sizes, dropping to approximately 1 in cuttings larger than 8 cm. The best rooting regardless of cutting size was found in *Abelia* (90 to 100%). There was an indication for this species that the largest number of roots (approximately 6 per cutting) were produced by the 14 and 18 cm cuttings.

The *Metrosideros* and *Leucodendron* produced approximately 3 to 4 roots per rooted cutting across all treatments and no clear indication of the most desirable size of cutting for the latter species was evident. Intermediate cutting sizes were indicated as being best for the *Metrosideros* (Table 1).

A study is being made at present of the subsequent growth of the rooted cuttings. It should be noted that cutting size had no effect on the number of cuttings available per stock plant because tip cuttings only were used. This would not apply when propagating species from stem cuttings.

IDENTIFYING TIMES OF HIGH POTENTIAL ROOTING FOR CUTTINGS OF FOUR COMMON NEW ZEALAND NATIVE ORNAMENTALS

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INTRODUCTION

There has been little work done on the influence of the time of year cuttings are taken on the rooting of cuttings of New Zealand native plants. Work of Butcher and Wood (1) on the rooting of cuttings of *Sophora microphylla* 'Earlygold', 'Goldie's Mantle', and 'Goldilocks' showed that certain times of the year were better for propagation purposes than others. After taking cuttings at three to four week intervals for a complete year they showed that approximately 100% rooting could be achieved with these three cultivars by taking semi-hardwood cuttings in June, July, or August (winter). This paper reports our studies on the effect of the time of year on the rooting of cuttings of four other common New Zealand native ornamental plants.

MATERIALS AND METHODS

Four species of native ornamental plants commonly grown in New Zealand were selected: *Cassinia albida, Corokia cotoneaster* 'Red Wonder', *Pittosporum tenuifolium* 'Sunburst', and *Pseudopanax lessonii* 'Goldsplash'.

Thirty tip cuttings of each of the four subjects were taken from plants growing in the Massey University grounds on March 21, 1989, and at two week intervals thereafter. Two separate stock plant areas were used alternately (except in the case of the *Corokia*) to ensure that a regular supply of cuttings was maintained. Cuttings were approximately 10cm (*Corokia* and *Pseudopanax*), 8cm (*Cassinia*), or 5cm (*Pittosporum*) in length and a basal cut was made just below a node.

Leaf area of the *Pseudopanax* cuttings was reduced to three leaves; the other three species had the lower third of their leaves removed. The purpose of this was to reduce water loss from the cuttings and to allow closer spacing in the propagation trays. The cuttings were then given a single basal wound, dipped in 0.8% IBA talc and direct stuck into a peat:pumice (1:1 v/v) medium in trays. The trays were placed under an enclosed mist tent with intermittent mist at five sec. every ten min. and 21 °C bottom heat

at the cutting base. The greenhouse temperature was maintained at a minimum of 22 ° C day and 15 ° C night.

Assessments were made when the majority of the cuttings were sufficiently rooted to be tubed up, as would occur under standard nursery practice. This was at six weeks from the time when the cuttings were taken for *Corokia* and 16 weeks for the other plants under study. The numbers of rooted cuttings were counted. The rooted cuttings were then graded by root ball size, this being determined by the distance between the tips of the longest roots.

RESULTS AND DISCUSSION

There is a period starting in October to November (depending on species) when rooting percentage drops to an unacceptably low level, this being maintained until the end of summer. Apart from *Corokia*, which showed very high rooting percentage throughout the March to September period, the species rooted best either in autumn (approximately April) or in winter (approximately July-August) with a depression in rooting in the May to June period (Table 1). The variation would have been due to complex interactions of seasonal growth and environmental factors.

The period of greatest root development coincided with that for best rooting percentage for *Pittosporum* and *Pseudopanax*. However, the best developed root systems were to be found on spring-rooted *Cassinia* and on autumn-rooted *Corokia*.

Table 1. Effect of time of year on rooting of cuttings of four New Zealand native plants[1]

Month	Percent of cuttings rooted			
	Corokia	*Cassinia*	*Pittosporum*	*Pseudopanax*
January (summer)	26	11	3	35
February (summer)	57	25	13	41
March (autumn)	86	39	10	61
April (autumn)	98	84	38	55
May (autumn)	96	85	26	40
June (winter)	98	63	72	26
July (winter)	98	93	57	55
August (winter)	93	88	41	46
September (spring)	85	98	10	11
October (spring)	80	71	2	15
November (spring)	32	53	0	10
December (summer)	13	19	0	7

[1] Monthly mean from 30 cuttings per treatment taken at two-week intervals

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NUTRITION OF CONTAINER-GROWN TUBEROUS BEGONIAS

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Abstract. *Begonia* × *tuberhybrida* was grown in a peat sand.sawdust (1 1 1,v/v) potting medium using a four factor central composite incomplete block design to measure the response to N,P,K fertilisation and liming, each at five levels This plant responded strongly to N and P. Nitrogen was singularly the most important nutrient element and its effects were enhanced by P fertilisation and liming

INTRODUCTION

There is little published work on the nutrition of tuberous begonias but they have been shown to respond to moderate N and comparatively high K fertilisation (7). It has also been shown that higher N than K in a liquid feed gives the largest container-grown plants (4). The P requirement in both cases was noted to be relatively low. Results from an earlier pot experiment at Lincoln (unpublished) found these plants to have a high N and a moderate P demand but were unresponsive to K and liming. The study reported here was initiated to determine the nutrient requirements of potted tuberous begonias.

MATERIALS AND METHODS

Experimental Design. A four-factor response surface programme of a central composite design with incomplete blocks was used for both experiments as for similar work (9). They involved N, P, K and lime additions with 30 treatments, each with ten replicates. The nutrient levels and lime rates used in both experiments are shown in Figures 1 and 2.

Fertiliser Rates and Potting Media. The medium used was equal parts Hauraki sphagnum peat, coarse sand, and untreated *Pinus radiata* sawdust. Nutrient levels were supplied from Osmocote (26%N), superphosphate (8%P) and potassium sulphate (39%K). Liming was based on a mixture of dolomite and agricultural lime (3:1 w/w) while trace elements were applied from "Sporumix A" (150g/m^3) and "Sequestrene iron chelate" (75g/m^3).

Plant Material and Environment. Seedlings for Experiment A (mixed colours) and of cultivar, 'Gold Plate' for Experiment B were pricked out individually into 1.8 litre planterbags on December 8. Final harvest for Experiments A and B occurred after 20 and 21 weeks, respectively. Plants were placed in a heated glasshouse with minimum temperatures of 8° C and fans set to operate when temperatures exceeded 22° C.

Data Collection. Visual ratings of foliage quality and vigour were carried out using a grading system based on plant appearance (0 = dead, to 5 = top grade and quality). Foliage colour was similarly assessed (0 = white, or very chlorotic, to 5 = green and healthy). Flower numbers per plant, foliar dry weights, and tuber measurements were also obtained. Nutrient levels and foliar dry weights were obtained by the methods previously reported (9). Data from the experiments were statistically analysed for analysis of variance and F test. Data presented in graphic form in this paper was computed from the equations of the response surfaces.

RESULTS

The results in the two experiments indicated similar responses (Table 1) although more interactions between nutrient additions and their growth responses occurred in Experiment B.

Foliage Growth and Flowering. Nitrogen strongly influenced the development of leaves and flowers (ratings at 8 weeks after potting) with optimum quality and highest responses at the 450 to 600g N/m^3 level (Table 1). It was further shown in Experiment B that foliage growth can be further enhanced by added P. The response surface (Figure 1) showed that highest foliar dry matter occurred when high N was combined with high P additions. Foliage growth and flowering were most benefited by a rate of 200g P/m^3 in Experiment A (Table 1).

The responses to potassium and lime were much less significant than to N and P (Table 1). There was no positive influence on foliage growth or flowering by K additions except when no lime was added in Experiment B (Figure 2) where the pH was 5.0. Additions of lime raised the pH to as high as 6.5 with the 12 kg/m^3 lime rate but there were few significant effects other than the very low foliar dry weight response shown in Figure 2 where K and lime were added at the highest rates.

Tuber Growth and Nutrient Analyses. Tuber growth in both experiments was influenced by all added nutrients and particularly N fertilisation (Table 1). Phosphorus strongly enhanced the effect of N on tuber fresh weights (Experiment B, Figure 3) so that the heaviest tubers were at the top rate of N and at least 200 g P/m^3. The combination of the highest N and lime additions also yielded

the heaviest tubers (Experiment B, Figure 3) while thickness and diameter were also maximised by high N (Table 1) and in the presence of high lime (Experiment B, data not shown). Potassium fertilisation showed no positive influence on tuber growth.

Table 1. Effects of nitrogen and phosphorus on foliage, tuber growth, and flowering of tuberous begonias (Experiment A) and significance levels for significant factors only in Experiments A and B
(***p<0 001, **p<0 01, *p<0 05; #=0.05 to 0 1)

Term	Foliage vigour rating	Foliage colour rating	Foliage dry weight (g)	Max tuber thickness (cm)	Max tuber diameter (cm)	Tuber fresh weight (g)	Flowers per plant
Experiment A							
N (g m^{-3})							
0	1.6***	1 8***	1 0***	1 5***	2 6***	9 2***	1 6***
150	2 7	2 4	1.9	2 1	3 8	18 0	3 7
300	3 4	2 8	3 0	2 5	4 7	27 4	5 2
450	3.5	2.9	4.3	2.7	5.2	37.3	6 2
600	3 2	2 8	5 7	2 7	5 5	47 7	6 7
P (g m^{-3})							
0	2 4***	2 9	1 2***	1 8***	3 1***	10 6***	1 8***
100	3 1	2 9	2 5	2 3	4 2	22 5	4 3
200	3 4	2 8	3 0	2 5	4 7	27.4	5 3
300	3 2	2 8	2 8	2 4	4 5	25 3	4.7
400	2 6	2 7	1 8	2 1	3 7	16.2	2 5
K	*	-	-	-	**	*	-
Lime	-	-	*	-	**	*	-
Inter-actions	-	-	-	-	-	-	-
CV%	32	21	60	25	23	58	65
Experiment B							
N	***		***	***	***	***	***
P	**		**	**	-	**	**
K	-		-	-	–	-	-
Lime	-		-	-	-	-	#
Inter-actions	-		NxP* KxLime*	NxLime*	NxLime*	NxP* NxLime*	-
CV%	20		48	16	16	37	48

The nutrient levels in the tubers for different elements were in the following ranges (observed values) N:0.98 to 2.37%, P:0.09 to 0.96%, K:1.23 to 1.47%, Ca:0.12 to 0.37%, Mg:0.14 to 0.37%. Computer analysis of tuber nutrient levels showed a strong negative influence of liming on tuber P levels while N additions had a positive effect. This resulted in tuber P being at a minimum level

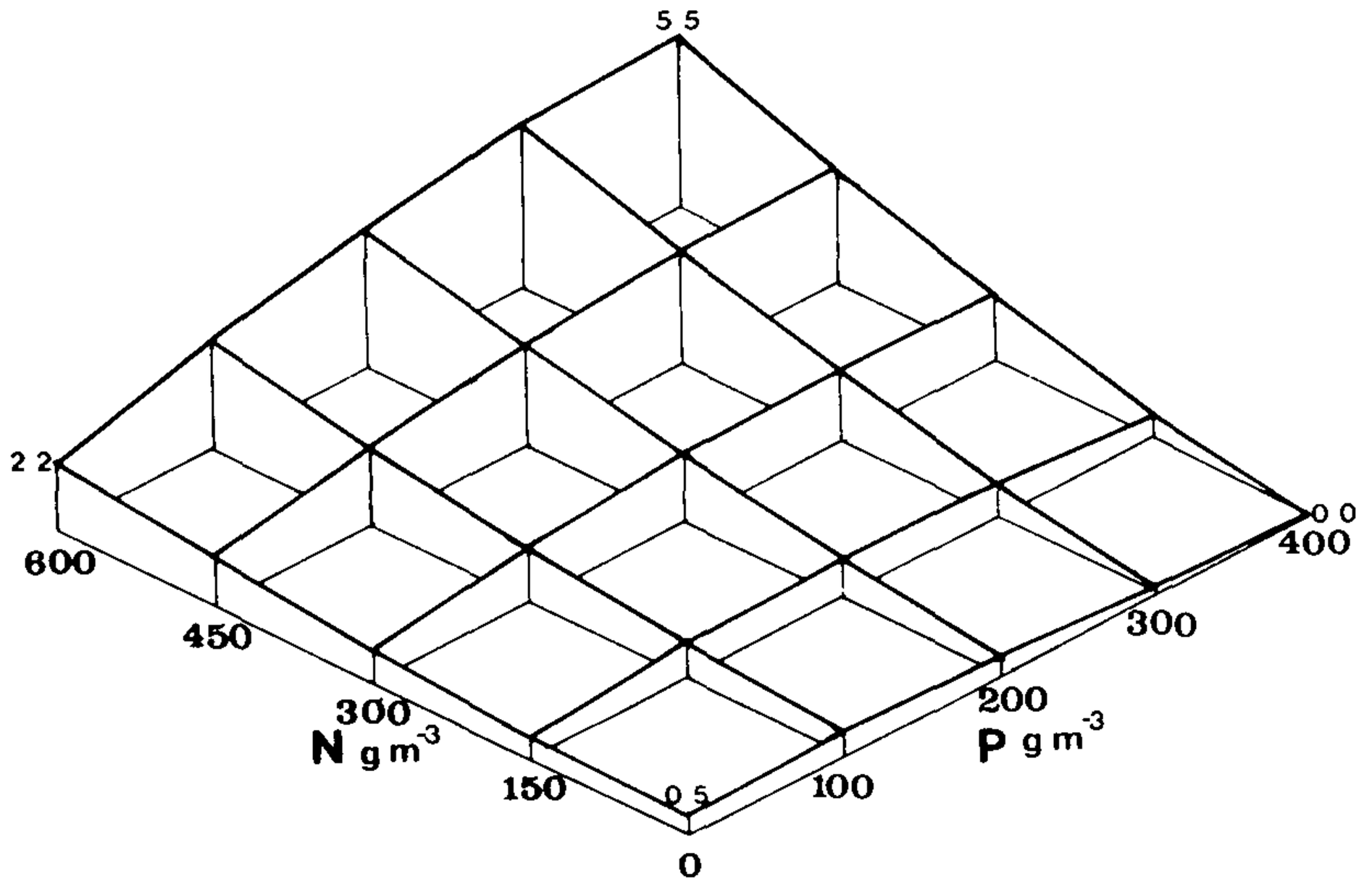

Figure 1. Interaction of N and P additions on plant foliage dry weight (g) Experiment B

of 0.1% when N and lime were highest, while in contrast the maximum predicted value for tuber P of 2.5% was at nil lime and the highest rate of N.

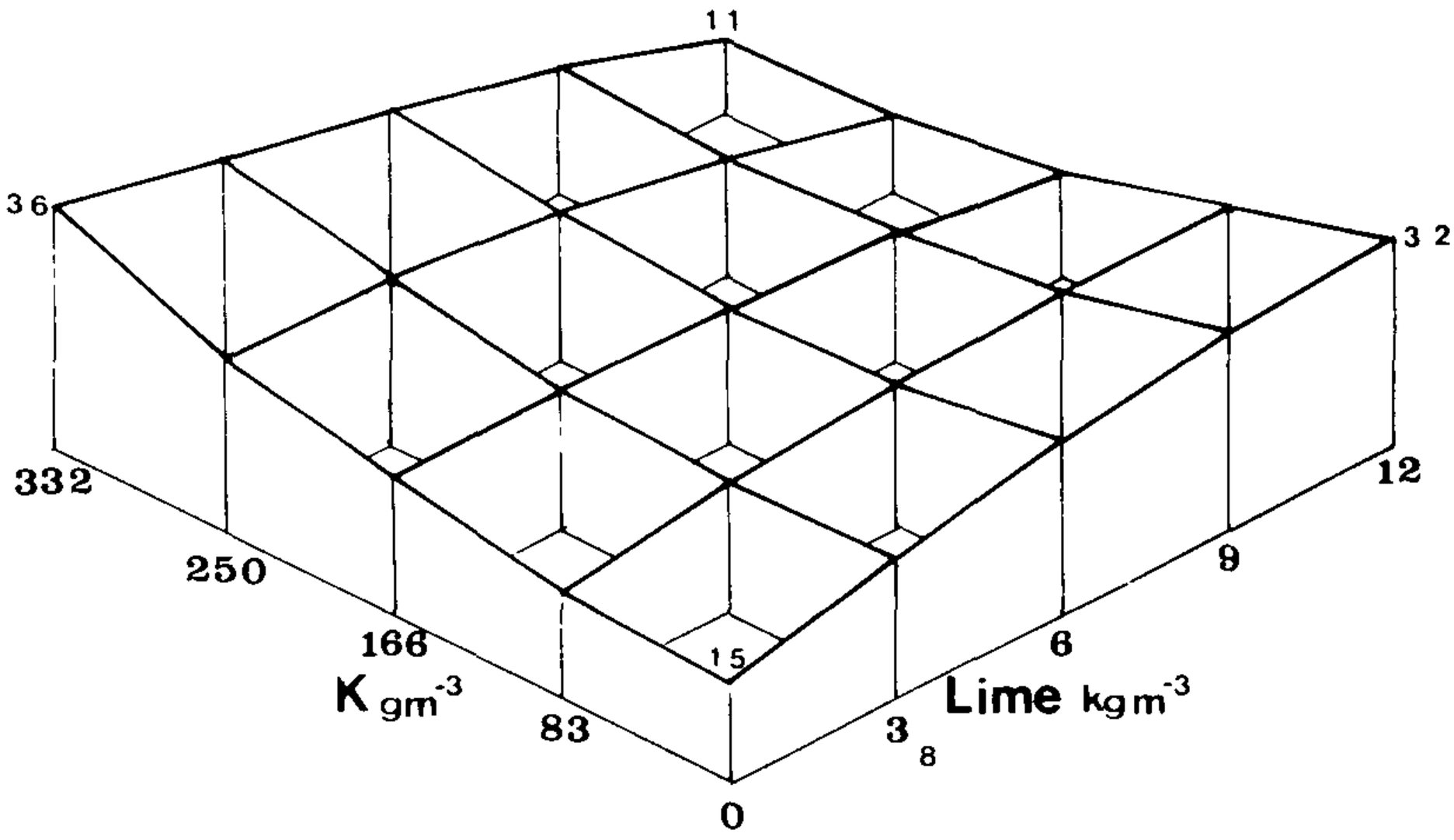

Figure 2. Interaction of K additions and liming on plant foliage dry weight (g) Experiment B

DISCUSSION

The strong influence of N fertilisation on foliage, flower and tuber production confirms the work of others (4,7). High K rates only promoted foliage growth at nil lime (Figure 2) and showed little other influence, which is in agreement with previous unpublished results with this plant at Lincoln. However, this contradicts the general response of begonia and other container-grown plants to K fertilisation (5,6) and where flowering of some pot plants was enhanced by high rates of K (1). Further work with a slow release form of potassium fertiliser would allow stronger conclusions on K requirements.

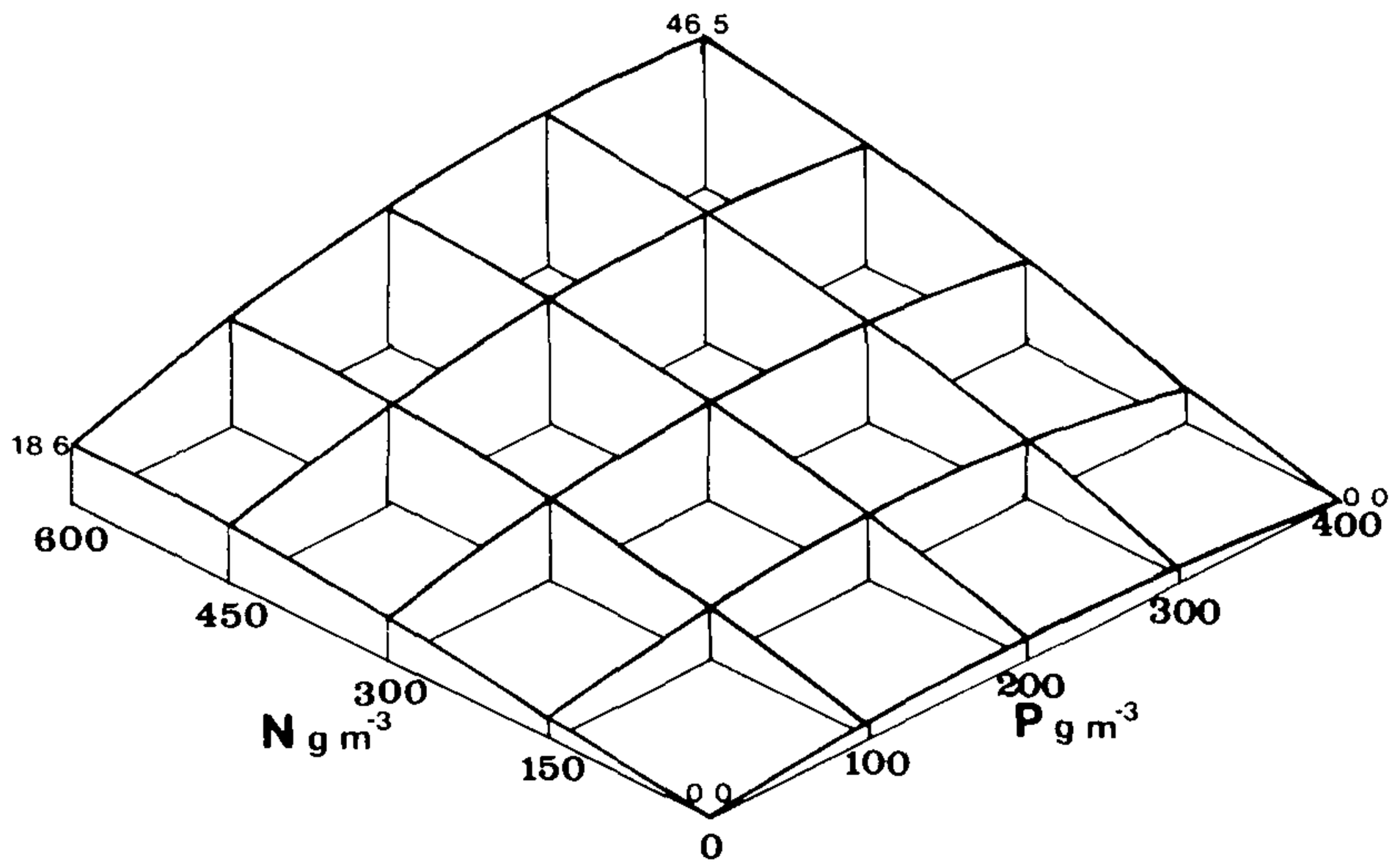

Figure 3. Interaction of N and P additions on tuber fresh weight (g) Experiment B

There was a strong positive interaction between N and P on both foliage and tuber growth which agrees with work on the flowering and corm production of potted freesias (8). The influence of lime on tuberous begonias was dependent on the level of applied N. Liming at high N rates enhanced tuber growth but at low N it was detrimental to growth. There appears to be a desirable balance between liming and P rates which, in turn, may influence the response to N. High liming can reduce P availability due to P combining with calcium and carbonate ions from insoluble salts (2,3). This was confirmed in the present work where liming strongly depressed tuber P levels particularly at high N rates. Tuber fresh weight was enhanced when high N was combined either with high

P or high lime (Figures 3 and 4). It, therefore, seems possible that all three additions at high levels of at least 600g N/m^3, 300g P/m^3 and liming at 6kg/m^3 (pH 6.4) should promote high tuber yields for this medium. Liming therefore appears to help to balance high N and possibly P rates, although further work is needed to confirm this.

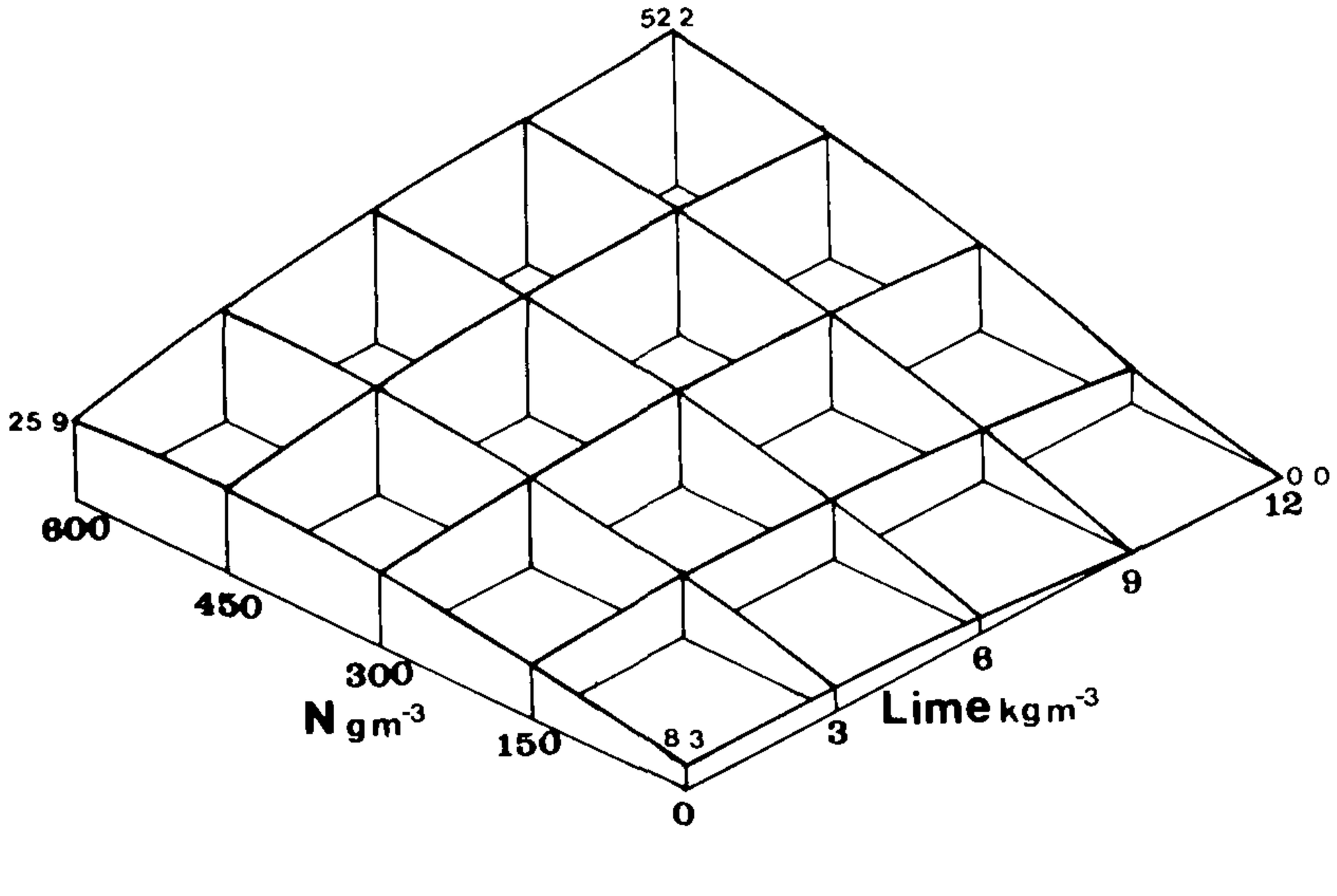

Figure 4. Interaction of N additions and liming on tuber fresh weight (g) Experiment B

Acknowledgements. We thank M Spurway for technical assistance, and Dalgety Limited for the supply of Osmocote fertiliser We are also grateful to A. Cox for providing begonia seedlings

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DEVELOPING A REGIONAL MARKET FOR NURSERY CROPS

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More often than not growers rate the virtue of a soil mix based on the low price of its components. Sometimes we use compounds reminiscent of toxic waste just because they are cheap. Soon it will be time to consider our soil mix for next season. Shouldn't we choose a soil mix because it's the only one that really works, it's the life of the system, it's the carrier of minerals and nutrients and oxygen, and represents everything that will make that little plant grow to be something exceptional? If we want to develop a regional market it is imperative that we "forget about the cheap and look for the leap." The point is, we should go for what launches us ahead and begin to enjoy the benefits of a great soil mix or anything else in those situations where we go for the best.

A REGIONAL MARKET

My idea of a regional market is anyplace within the confines of a one-way 6-hour drive. Under these circumstances your trucks can deliver, unload, and return to the nursery on a daily basis. Our company does 100% of its sales and expansion on this regional basis. Why go farther?

Many established nurseries, along with their competition, manage to saturate their regional market with existing goods and services. As a result they are forced to search farther and farther away to generate new sales. Little do they suspect gold lies in their own back yard. To find it they must redevelop their regional market. Let's do a little digging.

Many new nurseries never find their market niche. They wander around without a program or a creative thought, copy they guy down the road, and settle for whatever business falls their way. Most businesses, ourselves included, fall into this trap. But I want to tell you how by adopting a different perspective we eluded this cycle, built a company worth millions, and did it without any accumulation of debts. Sound interesting?

REGIONAL MARKETING IS A CHALLENGE

Before you get too excited, stop and ask yourself the question, "Am I willing to do what it takes to develop a regional market?" It's not easy! Do you want the headaches of retraining your labor force? Do you want to pay more attention to details? Do you

want the risk of failing, the job of explaining a higher price to customers, the guilt of making a profit, the stress of having to find and deal with different types of customers? Are you willing to increase your service?

For us the answer was easy because we wanted to see our employees build a winning team. We wanted the satisfaction of having the best by paying attention to details. We were willing to risk failure because it's more fun being leaders than followers. We wanted to survive long term so we had no choice but to make a good profit, for both a good living and as insurance for hard times. We wanted that undeveloped business so badly we had no alternative but to create and nurture new product lines, sometimes introducing them to non-traditional, unusual marketplaces.

We have to tackle some big challenges to generate some big benefits. If I invest "almost," then I can't expect "everything" in return. But I truly believe that if you put forth "everything," you can get "everything, and a whole lot more" in return.

MARKETING

Marketing is like a foreign language and most of us don't speak it, read it, or write it very well. We can become master merchandisers of our products and our companies if we learn that foreign language of marketing. Let's make it our native tongue.

We spend a disproportionate amount of time growing plants and declaring war on the business at hand. Certainly we must do these things, but if we want to develop a regional market we need to dedicate more time to looking for alternative "weapons" and homing in on our targets. Whereas the doctor on the battlefield has to feel the pulse before he knows what medication to administer, as a nurseryman I must develop the ability to recognize my consumer's lifestyle before I can respond to it effectively. For example, trade magazines provide an excellent source of ammunition, but let's not limit ourselves. Read and study all kinds of periodicals whether plant related or not. Pay particular attention to articles that exhibit trends in lifestyle. This kind of information proves invaluable in building and presenting our arsenal of plants and developing our personal creativity.

TREAT CUSTOMERS AS PARTNERS

A business relationship is like a marriage and it is what we make of it. If we want to develop a regional market we must treat our customers the same way we would treat our partners in a relationship.

1) Respond to their needs. We produce over 900 products, all developed from customer requests or spinoff ideas. Sound like a

mess? It is. But what sounds louder is my customer's satisfaction and my economic well being. When a customer gets excited about a plant or a concept, that's a sure sign I had better get excited, too. Learn as much as you can about your customer's business. Ask questions. You may be amazed by the feedback. Be an active, caring partner and you will gain the resources to respond to their needs!

2) Be considerate. Respect them and don't keep them waiting. My idea of, "I'll get it done right away", is not the latter part of next month. And how about that office and telephone etiquette? We have our secretaries trained with a barrage of armour designed to shield our customers from ourselves. Let's not build a wasteland of human barriers between our customers and ourselves. Be considerate!

3) Be loving. Tell them how much you love them. I'm a letter writer so it's love notes for me. But it can be done with a telephone call, a visit, or a holiday gift, but it has got to be personal. I heard it said once, "little things don't mean a lot: little things mean everything!" Pay attention to the details and be loving.

4) Communicate. Tell them the truth, and do it now. It might bring about some short-term disappointment; but if I let my customer learn the bad news by shipping them the bad news, then I get long-term disassociation. Once the customer opens the door of the truck, the truth is told anyway, except this time it carries visual impact. More efficiently than words, the optic image is photographed and faxed into the mind. It is also filed for future reference. We had better communicate!

5) For self preservation, understand human nature. Some people are never satisfied. If you're giving honest-to-goodness value, marry those customers who appreciate it and love them to death. And those that don't appreciate it should be immediately referred to your competition. For your own piece of mind, understand human nature!

6) Keep the marriage interesting. If my style hasn't been jazzed up within the past three years, the relationship is getting boring and she is going to lose interest. Always maintain two projects in continuous motion: one of change and one of growth. This will serve to keep the marriage interesting.

WATCH PRICES

Keep a rubber tree in your office. That's what I do. It reminds me to watch my prices so I've got bounce-back ability. Three uncontrollable factors reduce your bounce-back-ability: *Inflation, Judgment,* and *Nature.* If our prices remain unchanged for three years at a 4% inflation factor, we're making 15% less. Three years at 7% and we're down by 25%. Let's quit kidding ourselves. We

can't control the cost of inflation by using a cheaper soil mix, reducing our service, taking fewer precautions, or by finding lower-price people. Those "solutions" only give the costs different names: "disease problems," "irate customers," "hard luck," and "poor help." I don't have a solution for inflation. I just know that it's a wave, and you either ride it or get crashed on.

We make judgments of our own accord, but the criteria we base them on are unpredictable or outdated. We make an educated guess; but interest rates, market conditions, fuel prices, weather predictions, and what the competition has up its sleeve lie beyond our clairvoyant capabilities. As we speak, much of the industry finds itself in a fix. A clandestine set of circumstances has flip-flopped the marketplace. About the time we realize a trend is hot, it is nearly too late to gear up and take advantage of it. Why do we always try to steal a piece of someone else's stale pie, when baking a new pie is so much fresher and tastier? We had best give some thought to creating our own trends. Let us be the pace setters!

And finally there's good old Mother Nature. I've yet to see a year in this business when we haven't been ambushed by at least one weather-related catastrophe. Have I got you depressed, yet?

Well, cheer up, there's hope! By realigning the way we look at our market, each and every one of us can measurably improve our chances for success. First of all, the size of our nurseries is completely within our control. Numbers are impressive. You really feel like a big shot in a big operation. But each time you double your size, you double your risk: diseases, labor problems, potential pesticide accidents, public and governmental visibility. We don't need size to make more money. We need to keep a bigger chunk of what passes through our hands. One by one, analyze each product you grow. Establish a price where it really should be. How many can you sell without discounting? Grow that number, gradually creep the inventory up until you exceed that level, then back off a mite. Now take a look at the next product: repeat the same procedure.

We cannot afford to increase risk by choice. Most of us operate with a high-risk factor and a low-cushion factor. Any business is subject to the weather. Large numbers of plants, suspect soil mixes, and limited and non-niched product lines are all indicative of high risk. Low cushion is a problem with pricing strategies: ignorance of true costs, panic in the face of a soft market, and the silly belief that large numbers will replace small incomes. If I operate with a high risk factor and a low cushion factor, then I am positioned to be squashed. I want to be here to serve my customers next year and the year after that. That's a critical responsibility. Watch those prices!

CREATING SUCCESS THROUGH THE DEVELOPMENT OF A REGIONAL MARKET

Magic formulas or secret fertilizers won't work. Our answers do not lie in having a bigger volume and a lower price than the fellow down the road. Building a regional market is a philosophy that makes our decisions for us. It's expecting the best because we give our best. It's about making a long-term commitment to reinvigorating our outlook continuously. It's trying something different. It's looking positively at the future, but only after making sure we've learned everything we possibly can from the past. It's about listening, caring, and responding. Developing a regional market is about treating people the way we like to be treated and about finding enough guts to be fair to ourselves.

NEW PLANTS IN PRODUCTION AT FLOWERWOOD NURSERY

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1. *Abelia* × *grandiflora,* variegated prostrate form. This beautiful, creamy, variegated, ground-cover abelia is a sport of the cultivar, 'Sherwoodii'. White blooms in the summer and a prominence of pink-tinted foliage and stems in the winter means this plant is bound for greatness The new growth terminals are also pink Winter hardiness, drought tolerance, and old-time toughness are a few characteristics that are retained in this new cultivar of an old garden heritage This plant will be properly named and patented by Flowerwood Nursery

2 *Ilex crenata* 'Beehive'. This plant was developed by Rutgers University 'Beehive' is a small-leaved holly that can be pruned easily to a beehive or pyramidal shape The foliage color is gray-green. Winter was extremely cold last year and this proved to be the most tolerant *Ilex crenata* that we grow. It is a more attractive specimen than 'Highlander' and smaller in nature than 'Steeds' holly.

3. *Ilex crenata* 'Soft Touch'. 'Soft Touch' was found among an assortment of other small-leaved hollies by David Ellis and Dr. John Allan Smith of Magnolia Nursery. This beauty is mounding, compact, dark rich green, and very soft to the touch. 'Soft Touch' can be used like 'Wheeler's Dwarf' pittosporum, 'Helleri' holly, or dwarf yaupon, and has few problems

4 *Rhododendron chapmanii* × *R.* 'George L Taber'. We have called this hybrid "Jim's Hybrid" but now have named it *Rhododendron* 'JBH." It is the rarest plant I have ever found. *R. chapmanii* is the southernmost true rhododendron in North America, growing in five counties of north Florida. It is beautiful and endangered. I selected this individual from 1000 1-gal *R chapmanii* grown from seed It is a chance hybrid with a 'George L Taber' azalea It is a very vigorous grower that is infertile but easy to propagate vegetatively. This hybrid also exhibits some characteristics of both parents It possesses a rhododendron truss with florets that are indica-sized In addition, the bloom is light purple and fragrant. It is a heavy bloomer in spring and also shows blooms in the fall. 'JBH' is going to be a large-growing cultivar. The branching is twisting, spreading, and then upright. Winter foliage is tinted purple. The branches and bark surprise you in the winter with a plum tone. I think it is drought tolerant and probably hardier than you would expect.

5. *Rhododendron* 'Rebekah' 'Rebekah' azalea is a selection of Tom Dodd, Jr. It is a seedling of *R.* 'Pride of Mobile.' 'Rebekah' caught my eye in Green's Garden Center and Nursery in Fairhope, Alabama. I stopped to see if it was a true rhododendron, as I thought. 'Rebekah' is a very early, prolific bloomer with cluster-forming, light pink, hose-in-hose blooms. The bush looks and grows like 'Pink Ruffles' The pollen parent is unknown This variety can safely be planted in south, central, and coastal Georgia

6. *Rhododendron* 'Helen Curtis' A Shammerello hybrid, 'Helen Curtis' azalea has a white, semidouble, 2½ in. bloom with 10 frilled lobes The plant is semi-dwarf reaching 2 ft by 3 ft in 15 years It is very hardy and a prolific bloomer. A sister seedling to 'Elsie Lee'. Possibly a replacement for 'Snow.'

7 *Ilex* 'Wetumpka' These hollies of unknown parentage or origination are growing in a landscape at the McDonald's in Wetumpka, Alabama The owner thought they were American hollies. The landscape contractor planted them as 'Savannah ' Tom Dodd does not recognize it as any cultivar. The bush is broadly pyramidal with spiny, dark green foliage Some years it does not fruit It has fruited heavily after fall pruning It is the most beautiful holly I have every seen, and is definitely suited for central, coastal, and south Georgia

8 *Ilex* 'Mary Nell' This is a three-way hybrid evergreen, (*I. cornuta* × *I pernyi.* × *I latifolia*, hybridized by the late Dr Joe McDaniel of the University of Illinois, and selected and named by Tom Dodd This selection was named in honor of Dr McDaniel's wife, Mary Nell The mother plant is beautiful, standing 15 ft tall, and only 8 ft wide at its base Narrowly pyramidal, 'Mary Nell' has large, red berries set heavily with large, glossy, dark green, spiny leaves 'Mary Nell' has survived in the ground in north Alabama so she should do well over most, if not all, of Georgia

9 *Cornus florida* 'Stokes Pink' A selection made by Professor J A Foret of Louisiana, it makes a vigorous-growing, deciduous tree with ascending branches eventually making a graceful, round-headed tree 16 to 20 ft tall Flower bracts are a clear, rich pink and flowers are produced in profusion during spring. Autumn foliage is a blend of reds and purples. 'Stokes Pink' is the best and most reliable pink dogwood for the Deep South including coastal areas, and may do well in more northerly areas

10 *Cornus florida* 'Weaver's White' 'Weaver's White' is another proven winner for the coastal and lower South. This large-blooming dogwood is planted on the state capitol grounds of Florida in Tallahassee Gene Ellis of Tallahassee Gardens is particularly impressed with this cultivar's ability to bloom and grow well in full sun Large quantities of large white flowers are borne well before foliage appears 'Weaver's White' does well on its own roots Salable 5-gal plants are produced in only 17 months from a cutting

11 *Prunus caroliniana* 'Cherry Ruffle' I found this selection of cherry laurel along the roadside in North Carolina about February 1 a couple of years ago The mother tree stood 15 ft. tall and was a single-trunk specimen It was in full bloom. The blooms were prominent, about the size of your small fingernail Flowers, leaf petioles, and the fringe of the leaves were pink The leaves were slightly twisted and somewhat upright The waviness reminded me of *Ligustrum japonicum* var *recurvifolium* I have never seen a cherry laurel with noticeable blooms, color, and foliage like 'Cherry Ruffle '

12. *Dianthus* sp , mountain dianthus I am unsure as to the species of this beautiful fine-textured gray perennial As a ground cover, I think that it is far superior to santolina Being both heat and cold tolerant, it could be widely used all over the South I first admired it in a well-drained, full sun landscape close to Madison, Florida, the northeast part of the state I have not seen it bloom, but I understand that in springtime it gives a complete dianthus flower show I've noticed many growers around Knoxville, Tennessee, are producing and marketing mountain dianthus successfully

13. *Lagerstroemia indica* 'Centennial Spirit'. A development by Dr. Carl Whitcomb while he was with Oklahoma State University, this beautiful crape myrtle is semidwarf, 6 to 8 ft. tall The blooms are dark red and develop over an extended time The stems are strong with a few basal suckers. It can be trained as a small tree, but I like it as a bush. 'Centennial Spirit' is mildew resistant with red-orange fall foliage.

14. *Lagerstroemia indica* 'Prairie Lace' Another release by Dr. Carl Whitcomb and OSU. A bicolor, medium pink bordered pure white It, too, has an extended blooming season and is mildew resistant New leaves are wine red; fall foliage is red to orange-red. 'Prairie Lace' is superior to other bicolors on the market.

15 *Nandina domestica*, compact form.* This is a new strain of an old garden favorite I found this strain in a landscape in Texas Among 24 regular growing nandinas, one plants was very different. The plant is compact by nature, growing 3½ ft tall in full sun and 5 ft in heavy shade. It is stoloniferous, making it nice for constricted beds, planters, and mass plantings. Unlike the west coast *N. domestica* compact form that is sparse and light green to yellow, Flowerwood's strain is rich green in the summer and nicely touched with red to purple in the winter. Berry set is good

16. *Rubus idaeus* 'Bababerry' The words delicious, big, juicy, red, productive, and beautiful are appropriate when describing the 'Bababerry raspberry' It is exciting to have a new raspberry for southern gardens. It is adapted to a wide range of soils and climates. Being disease resistant and extremely vigorous, it does well all over the South The berries are large, sweet, and very good quality. They ripen in June and again in October. Prune when the June harvest is complete by mowing to a convenient height The plant is patented, and we are excited to be offering this great new cultivar

17 *Rubus* 'Navajo' Brand new blackberry from Dr J. N. Moore and the University of Arkansas, 'Navajo' is thornless, and that makes it great for home gardeners. The fruit size is medium compared to large thorny types, and ripens 2 weeks later than other cultivars The plants is erect growing. Again, this plant is patented, and we are licensed propagators and growers.

18 *Rhododendron* 'Variegated Dwarf' This is a very exciting azalea. It is a witch's broom of the patented plant 'Silver Sword' azalea, which is a sport of 'Girard Rose.' It has small leaves, compact and upright growth. I think the mature plant will be 3 ft high by 2 ft wide The bloom is rose red and of normal size Unlike most azalea witch's brooms, this sport shows great promise in small gardens and can be used where a small-size plant is appropriate.

19. *Rhododendron* 'Joseph Hill'. 'Joseph Hill' azalea is a North Tisbury hybrid, a product of Mrs. Julian (Polly) Hill's seed germination and introduction program with Dr Teuneshige Rokuyi of Tokyo, Japan Joseph Hill has a vivid red, 2¼ in , wavy bloom. The plant is a late, heavy bloomer and is the best ground-cover type that I know It will be only 1 ft tall and spread 42 in in 12 years.

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* Bot Ed Note· The cultivar name 'Compacta' is now often erroneously used for various compact clones and seedlings of *Nandina domestica* as well as the original named clone In order to avoid further confusion this new cultivar needs to be given a new cultivar name

SELECTION OF NEW PLANTS FOR PROPAGATION AND INTRODUCTION INTO THE NURSERY INDUSTRY

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Our American society has evolved into one that wants the latest styles. It is willing to try the latest diet plans, tennis shoes, trucks, and automobiles. It is subject to styles, crazes, and fads. I think that the plant-consuming public is infected with this same societal characteristic of demanding new styles accompanied by willingness to pay for them. For instance, Monrovia Nursery Company has been a very successful wholesale grower for many years. Monrovia offers a wide variety and is constantly introducing new plant types, usually at a premium price.

The landscaping sector of our industry is not greatly affected by new cultivars as it seems to be less imaginative, less likely to innovate and try different plants than are retail consumers. Throughout the South, cultivars that were used en masse 20, ten, and five years ago are basically the same cultivars that are used today. Kurume azaleas, variegated liriope, dwarf Burford holly, 'Helleri' Japanese holly, 'Compacta' Japanese holly, and junipers are examples of old standbys. These are available in large volume, are generally dependable, and perform well. Some plants fall out of favor such as variegated japanese pittosporum, waxleaf privet, and fraser photinia. Environmental conditions are the main reason for this. Chain discount nursery retailers many times continue to stock a few cultivars in large quantities year after year, ignoring the opportunity to sell new styles and new cultivars.

Besides meeting the demand to capitalize on the public's desire for new plants, there are other reasons wholesale growers should introduce new plants into their nursery. One reason is to offer the public a better plant—one that might have disease and insect resistance, superior foliage, bloom color, plant form, desirable bark characteristics, cold hardiness, or drought tolerance. Another reason is that a plant with these characteristics might be produced more economically.

For 10 years I have been primarily responsible for selection, introduction, and production of new plants for Flowerwood Nursery. We have 561 cultivars in production this year. Ten years ago we produced approximately half that many. Many introductions have been tried and have failed including *Berberis webberi, Kerria japonica, Ligustrum japonicum, Ilex crenata* 'Highlander,' and *Vitex.* Failure can occur due to several reasons

such as poor adaptability to container culture, lack of cold hardiness, or intolerance of the heat, humidity, and high rainfall that we experience on the Gulf Coast. Sometimes an introduction fails because it is just a sorry, ugly plant, or because of ineffective marketing by our sales staff.

HOW AND WHERE NEW SELECTIONS ARE MADE

Public parks, botanical gardens, arboretums, and university campuses are great resources for nurserymen looking for new cultivars. One particular treasure that I found, *Ilex* 'Martha E. Berry,' a beautiful, openly-pyramidal, female holly with light green foliage, was found at Auburn University.

North Carolina State University's arboretum is one of the best places to discover new cultivars. Dr. J. C. Raulston encourages nurserymen to observe and share with him the excitement of his work. He is generous and sharing, offering nurserymen cuttings of his selections. He routinely distributes worthy cultivars to nurserymen. *Cotoneaster dammeri* 'Skogholm', which he introduced to us, is one cultivar we produce because of its superior horticultural and cultural characteristics.

I have discovered pentas at Bellingrath Gardens, have seen *Cotoneaster horizontalis* 'Tom Thumb' at the Arnold Arboretum and have found many great azaleas growing at Callaway Gardens. These areas offer propagators great opportunities to expand their product lines.

Other nurseries. We don't always have to reinvent the wheel. If you are looking for good oleander cultivars, seek the advice of respected oleander growers. I found several good ones at Glen Saint Mary Nurseries. Lynn Taber, plantsman, propagator, and nurseryman was able to tell me his ideas about cold hardiness, blooming characteristics, and growth habits. I purchased a start of three cold-hardy oleanders to produce at Flowerwood.

I have also gone to Twisted Oak Nursery, Gilbert's Nursery, Duncan and Davies Nursery, Mitsch Gardens, Tom Dodd Nursery, Magnolia Nursery, Shadow Nursery, Appalachian Nursery, Monrovia Nursery, and others because they had attractive plant lists that included new and improved cultivars. I can take advantage of their experience and expertise by purchasing cultivars that they find superior.

Some cultivars I found at other nurseries include *Cornus florida* 'Weaver's White' and *C. florida* 'Stokes Pink,' variegated dwarf azaleas, 'Pink Cascade' azalea, *Hydrangea macrophylla* selections, selected viburnums, and seedlings of raphiolepis.

Wherever you go. Old neighborhoods, old towns, McDonald's restaurants, roadside parks, your neighbor's yard, your grand-

mother's yard, down on the river, or up on a mountain, down any road or trail, there might be a million-dollar plant waiting for you to discover it.

Country roads, private properties, and dirt roads all can yield very fine plants. I located a beautiful *Lonicera sempervirens* not three miles from my home on a country road. On Interstate 10 in Louisiana I found a dwarf southern wax myrtle, a 2½ ft. tall, dense female. On Interstate 20 in Texas I found one compact form of *Nandina domestica* that is rich green, compact, and stoloniferous. On Interstate 10 in Florida I found a witches' broom from the top of a wax myrtle that appears to be a ground cover when on its own roots. At Davis Grocery and Nursery on highway 98, Baldwin County, Alabama, I found a yellow-berried *Nandina domestica.*

Customers and Friends. Ask your customers for their ideas on new plants. Many times they can help you decide on what to grow that may be profitable for both of you. One example was Pete Pike's suggestion that we grow *Ilex crenata* '151' because it was his favorite. We did and are delighted with that decision. Many times my friends supply or tell me about great plants that they favor. The new thornless blackberry 'Navajo' (P.P. #6679) came from my friend Dr. J. N. Moore of the University of Arkansas.

Your own nursery. Look for particularly unique plants in your own nursery. Pick them out, set them aside. Grow, propagate, culture, observe, evaluate, and look for flaws. Propagate large numbers, show, talk about, name, trademark, patent, and license them. Then sell these new items and be pleased. Seedling populations offer the best chance to develop new, asexually-propagated clones of beauty.

Trade literature. Industry publications, university research and teaching professional books, trade magazines, retail mail-order catalogs, nursery catalogs, pricelists, trade shows, and industry associations, as well as industry gossip, are all good sources for new plants. 'Joseph Hill' azalea and 'Bababerry' raspberry (P. P. #4732) are just two examples of plants we learned about from such sources.

CONCLUSIONS

For the past ten years our company has advanced greatly by our willingness to seek out, evaluate, produce, and sell new and improved cultivars of hosta, hydrangea, Satsuki and hybrid azaleas, oleander, cotoneaster, holly hybrids, daylily, nandina, crape myrtle, rose hybrids, and more.

These items are of high economic value compared to basic plant groups. We have failed to develop some groups culturally including *Hedera helix, Pieris japonica,* and *Magnolia grandiflora.* Certainly better unusual plants with names and some packaging can be of greater value to the grower, retailer, and consuming public than regular or standard trade cultivars.

CONSERVATION OF WATER AND FERTILIZER USING PULSE IRRIGATION

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Pulse watering is a concept that was developed by Jan and Peter Groot who operate El Modeno Gardens in Orange County, California. The Groots developed this concept in response to environmental problems created by their excessive nitrate runoff. Water is applied for multiple short cycles that are spaced about an hour apart instead of in one long cycle. The hour pause between cycles gives the water time to soak into the medium before more water is added.

Irrigation at Lancaster Farms is totally automated, which made it very easy for us to try this new concept. We water early in the morning so that we can be finished before crews start their workday. In our old method of irrigation, a four-station program was designed to water each station for 60 min. beginning at 3:00 a.m. At 7:00 a.m. the irrigation was completed for the day. Now we program each of the four stations for 15 min. beginning at 3:30 a.m. They cycle is repeated at 4:45 a.m. and 6:00 a.m. Our daily watering is still completed by 7:00 a.m. All stations have an hour pause time between each 15-minute watering pulse, and our overall irrigation time is reduced by 30 min. We now apply 0.2 in. of water per day to everything.

This appears to be a lot of trouble; therefore, let us look at the advantages: As you can see from Figure 1, we used to apply 60 min. of water per day. Usually one afternoon a week we had to apply an additional 60 minutes of water. This resulted in each area receiving a total of 480 minutes of irrigation weekly. Now we apply water for 45 minutes per day, and no supplemental afternoon cycles are necessary. Plants are irrigated 315 minutes per week, which reduces our water usage by 33%.

We grow mostly 3-gal. hollies, azaleas, and junipers on a 2-year cycle. The first year we use only a liquid fertilizer program. During the second year, this is supplemented with 18-6-12 Osmocote to finish growing the material.

We are using the Virginia Tech. liquid fertilizer program developed by Dr. Robert Wright. We run pour-through samples weekly and adjust our liquid feed accordingly. Under our old irrigation methods the formulation (initially, 10-4-6) had to be changed as many as five times due to the leaching of the nitrogen from the media. For the last two years we have been able to keep

Figure 1. Comparison of timing using pulse watering vs regular watering

	PULSE WATERING				REGULAR WATERING			
Time	Area 1	Area 2	Area 3	Area 4	Area 1	Area 2	Area 3	Area 4
3:00					60 Min			
3:15								
3:30	15 Min							
3:45		15 Min						
4:00			15 Min			60 Min		
4:15				15 Min				
4:30	PAUSE TIME							
4:45	15 Min							
5:00		15 Min					60 Min	
5:15			15 Min					
5:30				15 Min				60 Min
5:45	PAUSE TIME							
6:00	15 Min							
6:30		15 Min						
6:45			15 Min					
7:00				15 Min				
Area Time	45 Min	45 Min	45 Min	45 Min	60 Min	60 Min	60 Min	60 Min
Total Water Time	<—— 3 Hours ——>				<—— 4 Hours ——>			

the 10-4-6 formulation throughout the growing season. Before pulse watering we were injecting the liquid fertilizer at a constant rate of 80 ppm nitrogen throughout the 60-min. watering cycle. We now inject the fertilizer at 60 ppm nitrogen only during the last two 15-min. pulses. We maintained the same plant growth and nutrient levels in the containers and cut our liquid fertilizer bill in half. We saved $50,000 on liquid fertilizer the first year and cut our Osmocote cost by 20%.

Because of our limited water supply, we collect and recycle approximately 80% of our runoff. By the end of the summer, some of our holding ponds have had Solubridge readings as high as 0.65. Since we have reduced the fertilizer in our runoff, the water quality is much better. The highest Solubridge reading since pulse irrigation has been 0.38.

Pulse irrigation also makes it much easier to quickly build up nutrient levels in a container. This is particularly important in the latter part of the growing season when slow-release fertilizers sometimes run out and it's otherwise necessary to top dress with more fertilizer. It is also important in rebuilding fertilizer levels after heavy rains.

In order to set up a pulse watering program, you must have an automated irrigation system. You also need an irrigation controller that is dual programmable with at least three independent starts on each program. There are many controllers that have these capabilities. At Lancaster Farms we use an IRRI-TROL DIAL AB.

Pulse watering does have a few disadvantages to be considered. Any weak points in your irrigation system will become apparent very quickly. We conducted a series of tests using rain gauges and found most of our irrigation system applied water uniformly with an efficiency of approximately 75%. However, in one area where different nozzles and spacings were used, water quantities were very uneven. We tried three different irrigation heads and orifice sizes before we found a combination that was suitable for that area. You cannot expect a uniform nursery crop without uniform watering patterns.

Pulse watering would also be almost impossible if you cannot water at night. Field crews could not work around the pulse irrigation system as easily as the longer watering periods. Pulse irrigation method also will probably reduce the life of pump motors since they will have many more start-ups on a daily basis.

At Lancaster Farms, we are convinced that the advantages of pulse watering far outweigh the disadvantages. Not only are we reducing the cost of our fertilizer but we are making our recycling more manageable by lowering fertilizer runoff and reducing water consumption. All nurseries will be facing stiff government regulations and mandatory monitoring in the future. By using an

integrated program of recycling, pulse irrigation, and chlorination, Lancaster Farms hopes to be able to meet all environmental regulations.

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NEW PROPAGATION TECHNIQUES

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At Flowerwood Nursery Inc., Loxley Division, we propagate all liners for Loxley's production. We also propagate all liners for three other Flowerwood divisions. Some of these are for liner sales. We produced a total of just under 5 million units in 1989.

PROPAGATION METHODS

We direct stick cuttings in Lerio 2¼-, 3¼-, and 4-in. cups. We root our cuttings under intermittent mist. Our main rooting structures are gutter-connected hoop houses, which we cover with two layers of plastic. This plastic is then inflated.

Our cutting crews consist of two 10-person crews. Each person cuts and sticks their own cuttings. The two crew leaders are responsible for dipping the cuttings in the rooting hormones. Since this is a very important step in the rooting process, we trust it only to our crew leaders.

Flowerwood Nursery has been very successful with this propagation system. We are never satisfied with slow-rooting or poor rooting percentages. As a result of trying to speed up rooting and increase rooting percentages, we have developed many new propagation techniques.

Testing procedures. We have set up a simple testing procedure for use for a cultivar that is slow to root. We also use this procedure on hard-to-root or new cultivars we have not rooted before. We fill a tray with thirty-six 3¼-in. Lerio cups. That gives us six treatments with six replications per treatment. One treatment will be the control with no rooting hormone used. Two treatments will be run with different strengths of the potassium salt of indolebutyric acid (IBA). Two strengths of IBA will be tried, and three different strengths of the combination of IBA plus naphthalenacetic acid, (NAA) will be tested.

Usually we can gain enough information from these tests to make an intelligent guess as to the best hormone to use. More trays can be added and different hormone combinations can be used to fine tune this testing system.

Using NAA. The results of many years of testing has shown that the addition of NAA to IBA helps speed the rooting process in come cultivars. Without the proper rooting hormone some cuttings only form a callus at the end of the cutting, with a single root often forming off that same callus. At this point, the cutting can become

lazy. It can take up water and some nutrients through the callus. We have found that the addition of NAA to the IBA solution speeds the cutting through the callusing stage, and then it produces more roots faster.

K-IBA—Potassium salt of IBA. IBA and NAA must be mixed with alcohol. Some cultivars we propagate are alcohol-sensitive. In those cases we use the rooting hormone, K-IBA, which is mixed with water. We root all azalea cultivars in K-IBA, ranging from 8000 ppm for indicas to 3000 ppm for kurumes. Barberries root well in 3000 K-IBA. *Ilex* × *attenuata* 'Fosteri' needs 10,000 K-IBA. As a rule for rooting junipers, we use IBA for dormant wood and K-IBA for actively growing wood.

As a result of using a wide range of rooting hormones at different strengths, we have learned to root many cultivars that are considered hard to root. The following are some examples of plants we have learned to propagate more effectively by upgrading our propagation techniques

Chionanthus virginicus Grancy gray-beard is very hard to root Our first attempt resulted in 4% rooting success out of 10,000 cuttings taken from seedling-grown plants We took cuttings from those 4% and had a better cutting percent the next year By following this procedure our rooting percentages have increased each year.

We take cuttings in early spring of hardened-off new growth We dip them in 1250 ppm IBA

Acer palmatum We take cuttings of dwarf japanese red maple in early spring as soon as the new growth has hardened The bigger the diameter of the stem the better it roots Dip the cuttings in IBA 6250 + NAA 2500 We overwinter the liners in a cool house, which never drops below 25° F The liners are planted the following spring

Cornus florida 'Stokes Pink' and 'Weaver's White' We dip these cuttings in 10,000 K-IBA using a slightly stiff, new-growth cutting taken in early spring We take a two-node cutting, sticking one node under the soil In the fall the best of these rooted liners are picked out and planted in 5-gal cans The rest are overwintered in a cool house and planted in 1-gal in spring They are then shifted to 7-, 10-, and 15-gal in late summer

Osmanthus fragrans. Sweet olive, or fragrant tea olive, is an example of a species that roots better when stuck at a particular time of year In our area, sweet olive rooting is spectacular when cuttings are stuck around the first of August We use a new-growth cutting that has hardened off The bigger the caliper of the cutting, the better it roots The dip is 15,000 ppm K-IBA

Mandevilla 'Alice duPont' This is a fairly new cultivar for us So far it has been an excellent seller We take a one-node cutting and trim off half of the leaf surface Dip the cuttings in IBA 2500 Mandevilla roots quickly and grows rapidly We stick the cuttings in July, plant out the liners in October, and sell the gallon plants in April

Hydrangea quercifolia Oakleaf hydrangea roots well in spring to early summer Take a one-node cutting and trim off ⅓ of the leaf surface Dip the cuttings in 3000 ppm K-IBA We have found the liners do not overwinter well in a warm house They must be kept cool during the winter

Vaccinium cvs We are currently growing five cultivars of blueberries A special soil mix is needed to root their cuttings successfully. Our usual propagation soil mix consists of 3 parts bark, 3 parts perlite, and 2 parts peat moss, but blueberries root well in a soil mix of 1/2 peat moss and 1/2 bark. Dip the cuttings in 8125 ppm IBA + 750 ppm NAA. Use a spring cutting of hardened-off new growth

Trachelospermum asiaticum. Asiatic jasmine cuttings are very easy to root. However, we always had trouble making a full liner. Now, when we cut Asiatic jasmine, we take a group of four to five cuttings and stick them in the center of a 3 1/4-in. cup The result is a fuller liner in about half the time.

Nandina domestica 'Compacta'* and 'Harbour Dwarf'. These two nandinas usually produce one plant stalk per one cutting stuck In an effort to grow a fuller, better-looking plant we came up with two methods to promote suckering Suckering fills the pot with new stalks, resulting in a salable plant much quicker.

The first method used to promote suckering is digging up suckers from stock beds Planting these in cans results in a plant that is likely to sucker.

The second method is to root a cutting with one node under the soil. When the liner is transplanted, bury it deep enough to cover the next node up the stem. The result is suckering from one or both of the nodes

CONCLUSIONS

The ability to use a wide range of rooting hormones and propagation techniques has contributed greatly to the success of propagation at Flowerwood Nursery. The system we use has evolved over the years and will continue to change in the future. Dedicated personnel is what keeps the changes moving in a positive direction.

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* Please see the editorial note on p 385

PROPAGATION OF *HEPTACODIUM MICONIOIDES*, SEVEN SON FLOWER, BY SOFTWOOD AND SEMI-HARDWOOD CUTTINGS

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Abstract. Softwood and semi-hardwood two node cuttings of *Heptacodium miconioides* from basal and middlestem sections rooted better than terminal sections. Basal and middle softwood cuttings exhibited greater rooting (65 and 55%, respectively), than terminal cuttings (42%). Basal softwood cuttings produced more roots (7 0) than terminal cuttings (3 8). Root length and rootball diameter were not different among the three cutting positions. Semi-hardwood basal cuttings produced an average of 53.5 roots while middle and terminal cuttings produced 25.8 and 19 7, respectively Cuttings treated with the potassium salt formulation of indolebutyric acid (K-IBA) exhibited increased rooting, greater root number and length, and greater rootball diameter in softwood cuttings. Semi-hardwood cuttings treated with K-IBA rooted in higher percentages and produced more roots than untreated cuttings

INTRODUCTION

Heptacodium miconioides (Syn. *H. jasminoides* H.K.A. Shaur; cf Hu, 1988) is a small deciduous flowering tree in the Caprifoliaceae family, native to Western Hupeh, China (1). It is considered a rare plant even in its native habitat and was only available to the western world following the 1980 Sino-American Botanical Expedition to China (2,3). *Heptacodium miconioides* has potential as a new nursery crop because of its exfoliating bark, vigorous growth, and fragrant white late-summer flowers. After flowering, the persistent calyces develop an attractive reddish color in the fall.

Preliminary studies in 1987 by the authors compared single-node softwood cuttings taken from the terminal, middle and basal sections of stems. The basal portion of each cutting was immersed in a 50% ethanol solution containing one of three IBA treatments: 0, 2500, or 10,000 ppm indolebutyric acid (IBA). Results indicated basal sections rooted better than middle or terminal sections. Rooting for terminal, middle and basal sections was 33, 48, and 76%, respectively. However, many of the severed portions of the cuttings were necrotic. This may have been caused by the alcohol solvent or use of softwood cuttings.

Therefore, two studies were initiated with the objective of evaluating the rooting response of softwood and semi-hardwood

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1 Former graduate student, presently Lecturer, Department of Agronomy and Horticulture, University of Agriculture, Malaysia; and Associate Professor, respectively

cuttings from terminal, middle, and basal sections treated with selected concentrations of the potassium salt (K-salt) formulation of IBA (K-IBA).

MATERIALS AND METHODS

Experiment 1. Softwood cuttings were prepared on May 20, 1988 from 2-year-old container-grown *Heptacodium* plants maintained under natural daylength greenhouse conditions. The excised shoots had leaves that were fully expanded and light green in color. The stems were light green, and firm, and the immature distal stems were quadrangular in shape. Each cutting consisted of 2 nodes and was 8 to 10 cm (3 1 to 4.0 in) in length. A light wound was administered to each cutting consisting of 2 equidistant vertical incisions on the basal stem to a depth reaching secondary xylem, each about 3.0 cm (1.2 in) long. The basal 3.0 cm were then dipped for 10 sec. into the following concentrations of K-IBA: 0, 2,500, 5,000, and 10,000 ppm. After preparation, the basal end of 3.5 cm was inserted into a medium of perlite: peat (3:1 v/v). Each cutting was inserted into one of 24 individual cells in a plastic tray measuring 30 x 50 x 10 cm (11.8 x 19.7 x 3.9 in).

The experiment was conducted in a glass-covered greenhouse maintained at day/night temperatures of 30 and 20° C (86 and 68° F). Intermittent mist operated 3 sec every 5 min from 8:00 am. to 6:00 pm. daily. The experimental design was a randomized complete block design consisting of 12 trays and 24 replications. Each tray contained two completely randomized replications.

Twelve weeks after the experiment was initiated, data were recorded. Data included percent rooting, number and length of roots, and root-ball diameter. Any cutting with one or more roots 1 mm (0.04 in.) long was classified as rooted. Standard analysis of variance procedures were utilized for node position data analysis and regression for quantitative hormone concentration treatment analysis.

Experiment 2. On August 12, 1988, semi-hardwood cuttings were taken from the same stock plants utilized in Experiment 1, and divided into terminal, middle, and basal sections. The leaves were larger and darker green than the softwood cuttings and the stems were rounded with a reddish-green color. The semi-hardwood cuttings snapped with a distinct sound when broken. Two-nodal cuttings from each of the 3 sections were taken. Each cutting was 8 to 10 cm (3.1 to 4.0 in.) long. All cuttings were wounded as described in Experiment 1 and treated by dipping the basal 3.5 cm (1.4 in.) for 10 sec in one of the following concentrations of K-IBA: 0, 2,500, 5,000, 7,500, and 10,000 ppm. After air drying for approximately 8 min., cuttings were inserted

to a depth of 3.5 cm (1.4 in.) into individual cells in a rooting tray measuring 30 x 50 x 10 cm (11.8 x 19.7 x 3.9 in.).

Intermittent mist operated 3 sec every 5 min from 8:00 am. to 6:00 pm. daily. The experimental design was a randomized complete block using 4 cuttings per treatment with 6 replications. Each replication consisted of 2.5 trays for a total of 360 cuttings. The cuttings were evaluated after 12 weeks. Data included percent rooted, number, length of roots, and rootball diameter.

RESULTS AND DISCUSSION

Node position influenced percent rooting and root number in both experiments. However, there was no interaction between node position and rooting hormone concentrations, therefore data presented are averaged across nodal positions.

Experiment 1. Softwood cuttings from the basal and mid-sections rooted better than terminal cuttings (Table 1). The rooting percentage obtained was 64.6, 55.2, and 41.7%, respectively. Basal softwood cuttings had more primary roots than terminal cuttings (7.0 to 3.8). Primary root length and root-ball diameter were not different among the three nodal positions.

Table 1. Node position effect on rooting of softwood and semi-hardwood cuttings of *Heptacodium miconioides*[2]

Type of cutting	Rooting (%)	Root no.	Root length (mm)	Root-ball diam (mm)
Experiment 1		Softwood		
Basal	64 6 a	7.0 a	65.3 a	47 2 a
Mid-section	55.2 a	5 6 ab	60 7 a	41.1 a
Terminal	41 7 b	3.8 b	61 0 a	45 9 a
Experiment 2		Semi-hardwood		
Basal	85 0 a	53.5 a	87.6 a	61.8 a
Mid-section	60.8 b	25.8 b	78 2 a	41 9 b
Terminal	37 5 c	19 7 b	84 2 a	51 6 ab

[2] Means of 24 cuttings. Mean separation within column by LSD, 5% level

K-IBA application significantly increased rooting percentage, primary root number, and root-ball diameter in softwood cuttings (Table 2). The highest primary root number was obtained by treating cuttings with 5,000 ppm K-IBA. Root length was reduced when treated with 10,000 ppm K-IBA.

Table 2. Effect of K-IBA concentrations on rooting of softwood and semi-hardwood cuttings of *Heptacodium miconioides*.

K-IBA concentration	Rooting (%)	Root no	Root length (mm)	Root-ball diam. (mm)
Experiment 1		Softwood		
Treatment				
Nontreated	30.6	0.6	61.7	21.1
2,500 ppm	58.3	5.2	69 8	50 2
5,000 ppm	68 1	8 7	67 1	49 1
10,000 ppm	58.3	7.3	50 6	46 7
Significance				
R^2	0.11	0.14	0 05	0 12
Linear	***	***	NS	***
Quadratic	***	**	*	***
Experiment 2		Semi-hardwood		
Treatment				
Nontreated	30.6	14 7	95 4	45.3
2,500 ppm	65 3	34 6	86.4	50 9
5,000 ppm	76 4	42.1	84 3	55 5
7,500 ppm	70.8	40 8	76 7	53 3
10,000 ppm	62 5	32 8	77.6	52 8
Significance				
R^2	0.26	0.27	0.03	0.01
Linear	***	*	NS	NS
Quadratic	***	NS	NS	NS

NS, *, **, ***· Nonsignificant or significant at the 5%, 1%, or 0 1% levels, respectively

Experiment 2. Basal cuttings from semi-hardwood cuttings yielded a higher percent rooting, root number, and root-ball diameter than mid-section and terminal cuttings (Table 1). Basal cuttings produced more than twice as many primary roots as terminal cuttings (53.5 and 19.7 resp.). Node position did not influence root length.

Rooting percentage and primary root number were significantly increased with application of K-IBA in semi-hardwood cuttings ($P^4 0.1$ and 0.05). A higher rooting percentage and a greater number of roots were produced with cuttings treated with K-IBA compared to nontreated cuttings of semi-hardwood materials. There were no K-IBA treatment effects on root length or root-ball diameter.

Data on growth after propagation is unavailable. *Heptacodium* in the North Carolina State Arboretum has reached a height of 3.6 m (12 ft.) and approximately half this width, but has been pruned extensively for propagation. Koller (2) reported that after five growing seasons seedling trees ranged from 1.8 to 3.0 m (6 to 10 ft.). Shoots from lateral cuttings appear to exhibit

plagiotrophic growth. However, they grow vigorously, and vertical shoots usually are initiated from the base of the plant.

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LINER PRODUCTION OF TEXAS NATIVE PLANTS

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We have been growing lining-out stock for eight years at Rennerwood Nursery. We grow about 60 cultivars and/or species of shade and ornamental trees in containers—no bareroot material. Less than half of these plants are Texas natives. Our liners range in size from a plug with a root mass 6 in. deep to 1- and 2-gal. containers. About 90% of our production is from seed and only 10% from cuttings.

PROPAGATION BY SEED

Seedling production varies from year to year by species and quantities. We gather about 25% of our seed, mostly the oaks. The rest we get from seed companies and other growers with whom we trade seeds for liners. We often lose specific kinds of seeds to the weather, notably spring seed crops.

We have a refrigerated room for seed storage and stratification. Seeds requiring no pretreatment are direct seeded after collection. We either direct seed into our containers or pre-germinate in seed flats. Those seeds that germinate poorly, such as those of *Metasequoia, Chionanthus,* and *Ginkgo* are all put in seed flats. We use 288, 200, and 120 flats (referring to the number of the individual holes in the tray). We use an Old Mill Seeder[1] for all small seeds. This seeder can handle seeds from the size of *Oxydendrum* (5 million to the pound), up to a *Magnolia* or *Koelreuteria.* It cannot handle winged seeds or those *Ulmus* seeds that seem to be made of Velcro. With a little talcum powder, however, some pass through the machine. We normally run the seeder at a rate of 10,000 an hour with 97% accuracy. We can also double- or triple-seed those items with poor germination. After the seedlings appear in the seed flats and are ready to pull, we transfer them to our containers.

Containers. We grow the seedlings in a variety of containers: plugs, rose pots, 4-in. pots, milk cartons, and the Rootmaker. We use more plugs than anything else, the hard-plastic tray, not Styrofoam. We have used 4-in. and rose pots for some seeds, such as those of *Quercus macrocarpa* and *Aesculus glabra* var. *arguta,* which are too large for a plug. But now that we are using the Rootmaker with superior results, we will not be using as many 4-in. or rose pots. We no longer use milk cartons. Although they

[1] Available from Old Mill Company, Savage, MD 20763.

produced very large lining-out stock, the root system never showed much root branching as all roots were directed downward; and a tray of one pint milk cartons filled with wet mulch was just too heavy to handle and impossible to ship.

Then came the Rootmaker. Thank you, Dr. Carl Whitcomb. It is a real pleasure to produce a liner for field growers that has the root mass, height, caliper, and branching that this pot gives. There is no root spiraling—there are hundreds of root tips in a Rootmaker—and the 4-in. spacing of the containers gives maximum air circulation for developing caliper and branching and cuts down on fungal growth. I can water these seedlings in half the time because the plugs are so dense the foliage sheds much of the water.

There are fewer culls with this pot, and I think it is primarily due to the spacing where the seedling can develop caliper more easily. In a plug tray I have 96 seedlings competing for light in a 14 x 24 in. area. There are about 32 Rootmakers in that same area. In one sense that is a problem: I can only get 24,500 Rootmakers in a 28 x 96 ft house; I get 75,000 plugs in the same house. However, the Rootmaker produces a far superior plant, which commands a higher price.

Shipping is another problem when using the Rootmaker. The size of the plants and the weight of the root mass add up to a greater freight bill. Where I can put 50 plugs to a bag and 250 in a box, I can only get 20 Rootmakers in a bag and 120 in a box.

Container mix. I do have some control over this shipping problem with the mix I use in the containers. We use two mixes: one for plugs and one for 4-in. pots, rose pots, and milk cartons. The plug mix is peat moss, vermiculite, and perlite. The pot mix is pine bark, peat moss, and sand. This bark mix is a lot cheaper to use but weighs a lot more.

For the Rootmakers I have tried both mixes. I prefer the peat moss mix. It is much lighter for handling and shipping, and I believe it is an easier medium for root development. It holds together better when you pull the liners and when you ship them. Often the bark mix falls away from the root mass on the top and edges.

We must separate these two mixes when we put them in a house. The peat mix will be on one side of the house and the bark mix on the other side. Each side is separately controlled for water. Contrary to most thinking, our peat moss requires more water. This is especially true for those houses with no shade cloth. Once that peat dries out, it shrinks from the sides of the containers. The density of the plugs also necessitates a longer watering period.

All of our containers are set on wire for air pruning of roots. We do not have benches, so we set the wire on 1- or 2-gal pots. The Rootmaker fits beautifully on 1 x 2 in. welded wire. Without benches it is much easier to clean the houses and move our stock around.

For the 1- and 2-gal. stock, we use the same pine bark mix but with a coarser grade of bark. All this stock comes from our own seedlings and is transplanted according to when the seedling is ready to pull and when the grower wants the plant. Most of our contracts call for fall delivery, so most of our transplanting takes place in April and May. Some species require more time to develop, such as ginkgos, magnolias, and Austrian pine (*Pinus nigra*). These we try to pull first. Others such as *Liquidambar*, *Betula nigra*, and *Taxodium*, require less time to grow off, so we try to delay their schedule.

Our one gallon containers are set in remesh wire, and T-post hooks are used to hook the wire over the edge of the pot. We never have to pick up a pot after a storm nor suffer wind damage to fallen trees. It also provides uniform spacing. In addition to our full-sun field, we utilize a natural shade area for understory trees like *Cornus* and certain *Acer* spp.

TEXAS NATIVE PLANTS

Acer grandidentatum, big-tooth maple, is one of several native Texas trees we grow. Many of the natives, such as *Quercus* and *Magnolia* species, are common to other areas. However, even when we geographically share a species, we probably treat the seed differently because of our weather. In Zone 8, *Cornus florida* seed requires a long stratification period for good germination—up to 120 days.

We grow several of the Texas natives that may not be familiar to persons in other areas. Following is a description of these plants and how we handle the seed:

Cercis texensis, Texas redbud, has a much shinier leaf than the eastern redbud but it is not as shiny or large as the Oklahoma redbud. We scarify seed in sulphuric acid for 30 to 60 min. followed by a 90-day moist, cold stratification.

Sophora secundiflora, Texas mountain laurel, is another Texas native that requires an acid treatment of seed. Soak one hour in sulphuric acid and plant immediately upon rinsing.

Pithecellobium flexicaule, Texas ebony seed also requires a one-hour acid treatment just before planting.

Ungnadia speciosa, Mexican buckeye, and *Aesculus glabra* var. *arguta*, Texas buckeye, seed are both planted as soon as they are collected, as are seed of *Chilopsis linearis*, desert willow, and *Diospyros texana*, Texas or Mexican persimmon. Cold storage of persimmon seed will induce dormancy and delay germination.

Of the oaks, *Quercus muehlenbergii*, or chinkapin oak, is really the only oak I delay planting until spring. *Q. virginiana*, *Q. phellos*, and *Q. shumardii* seed are all planted immediately after collection.

Q. macrocarpa is planted fresh or may be held in cold storage 30 days before planting.

One of the most popular Texas natives is *Prunus mexicana,* Mexican plum. This small tree is the first to bloom in Texas, before *Cercis, Cornus,* and *Sassafras.* It is often evergreen. Its flowers are white or pink. If you can beat the wildlife to the seeds, it requires an after-ripening period of 3 months in warm, moist stratification followed by a 2- to 3-month cold stratification period.

The big-tooth or lost maple, *Acer grandidentatum,* is a much-desired tree in Texas, but seeds are almost impossible to find. Since it thrives in alkaline soil, the demand for it is great, especially in large market areas such as Dallas. A 2-week water soak, followed by 4-months cold, moist stratification produces 20% seed germination. Our greatest problem with these beautiful and unusual Texas natives is the seed source. Some species are so isolated that collecting seed requires a 4-day safari with a guide.

PROPAGATION BY CUTTINGS

DeVos and Kosar hybrid magnolias make up the bulk of our propagation by cuttings. We also take cuttings of *Lagerstroemia,* and certain species for which we may not easily find seeds, including *Gordonia lasianthus* and *Chilopsis linearis.* The magnolias and gordonia have been easy for us to propagate by cuttings with no rooting hormone. *Chilopsis* is more difficult. Its aversion to water makes it difficult to coordinate under mist with such water lovers as *Lagerstroemia.* It cannot be kept moist in a cold room; therefore, we take only the number of cuttings we can stick right away. We direct stick all our cuttings in individual pots in the pine bark mix.

TRENDS

The magnolias appear to be gaining in popularity and use. Other trends we see from liner bookings are: more interest in the *Metasequoia glyptostroboides* (dawn redwood); less interest in the *Quercus shumardii* with a possible replacement of it by the *Quercus nuttallii.* There is increased use of Texas natives, especially the Mexican plum and Texas redbud. The bur oak (*Quercus macrocarpa*), is the most sought after tree in Texas, closely followed by the chinkapin oak.

Whatever the species, the overall trend in liner production has been to go to the field with larger containers. Field growers are finding that they cannot get the growth on their lining-out stock in the field that they can get from a container in a comparable period of time. It is less expensive to pay the difference between a plug and a 1-gal. at the outset than to grow off the plug to the same 1-gal. size in the field.

IMPORTANCE OF PESTICIDE REREGISTRATION IN PLANT PROPAGATION

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Before a pesticide can be labeled for use on an ornamental species, it must be registered by the Environmental Protection Agency (EPA). Normally, the manufacturer or registrant will develop necessary data to secure a new label. But, since the pesticide market for ornamentals is limited, many possible registrants estimate that potential profits do not justify costs and decide not to become involved in developing low-use labels.

The serious lack of pesticides registered for use on ornamentals was brought to light in several surveys carried out in 1976-1977 by the American Association of Nurserymen. The surveys disclosed that there were very few pesticide labels available for control of diseases, insects, and weeds in commercially grown ornamental crops, including floral and foliage plants grown in the greenhouse and out-of-doors; woody nursery stock, both container and field grown; shade and flowering trees; and turf and interior landscape plantings.

The National IR-4 Project is a USDA-funded cooperative effort established in 1963 for the registration of pesticides on minor-use food and feed crops. This group was approached for assistance in securing pesticide labels for ornamentals. With an appropriation of additional funds from Congress, IR-4 initiated its ornamentals program in 1977 and documented needs for more than 6,000 specific pesticide uses on ornamental species.

For over 12 years IR-4 maintained, updated, and enlarged its computerized records on pest control needs in the ornamental industry, and developed data required to include different ornamental species and cultivars on expanded pesticide labels. With the cooperation of research scientists at commercial nurseries, universities, and state and federal agencies, IR-4 has collected volumes of pesticide use information relating to disease, insect and weed control, and plant safety.

From 1977 until 1985 the IR-4 Ornamentals program was working in high gear. Starting from a base of over 5,000 pesticide label needs, several hundred new requests for pesticide labels were submitted to national IR-4 headquarters each year. The four regional IR-4

[1] IR-4 Southern Regional Coordinator

offices plus a special USDA Agricultural Research Service minor-use unit funded over 1,000 pesticide trials on ornamentals every year. Over 80 research scientists provided IR-4 with a continuous stream of field-performance reports. Data was collated and packaged into pesticide label petitions for study by potential registrants and EPA. IR-4 was successful in helping to secure an average of one new pesticide/ornamental use label for each working day during this eight-year period.

Since 1977, IR-4 data helped secure more than 2,800 pesticide label registrations on ornamentals. Numbers of ornamental species added to many product labels are listed in Tables 1, 2, and 3.

Table 1. Fungicide registrations supported with IR-4 data.

Brand name (Formulation)	Ornamental uses/ species labeled	Disease control
Aliette (80W)	45	*Phytophthora* and *Pythium* root rot
Banrot (40WP)	110	Damping off and root rot
Bayleton (25WP)	80	Powdery mildew
Chipco 26019 (WP)	157	*Alternaria* and *Botrytis* leaf spot
Daconil 2787 (F)	162	Foliar diseases
Dithane M-45 (80W)	69	Foliar diseases
Exotherm	13	Botrytis diseases
Funginex (50WP)	14	Powdery mildew
Kocide 101 (77WP)	43	Foliar diseases
Manzate 200 (80W)	69	Foliar diseases
Milban (EC)	11	Powdery mildew
Ornalin (50W)	143	*Botrytis* diseases
Streptomycin 17	4	Bacterial leaf spot
Subdue (2E, 5G)	49	*Phytophthora* and *Pythium* root rot
Terraclor	43	*Rhizoctonia* root rot
Terrazole (5G)	13	*Phytophthora* and *Pythium* root rot
Truban (25E, 30W, 5G)	154	*Phytophthora* and *Pythium* root rot

Southern states have submitted more than 12,000 pesticide clearance requests for ornamental use labels to IR-4 national headquarters. Field performance data has been developed from over 11,000 research trials. The Southern Region office of IR-4, located at the Pesticide Research Laboratory, IFAS, University of Florida, Gainesville, has supported research studies every year in Alabama, Arkansas, Florida, Georgia, North Carolina, South Carolina, Texas, and Virginia. Southern Region data is added to information from other regions. Any petition for a pesticide label amendment must include data from several trials in various locations that have different environmental and growing conditions.

Table 2. Insecticide and nematicide registrations supported with IR-4 data

Brand name (Formulation)	Ornamental uses/ species labeled	Pest controlled
Avid (0.15EC)	45	Leaf miner, spider mite
Dycarb (75WP)	27	Certain insects
Dipel (4L)	10	*Lepidopterous* larvae
Dimilin	2	Beet armyworm
Dursban (50W)	50	Foliar insects)
Knox out	28	Greenhouse insects
Lannate (L)	185	Various insects
Orthene (75W)	72	Various insects
Oxamyl (10G)	50	Nematodes
Pentac (50WP)	22	Mites
Pounce (EC)	32	Certain insects
Pydrin (2.4EC)	41	Foliar insects
Vydate (L)	106	Certain insects, mites, nematodes
SBP-1382	44	Greenhouse insects

During the past three to four years the IR-4 program on ornamentals has slowed to about half the rate of activity during its peak period. Fewer than 200 new pesticide clearance requests were submitted to IR-4 last year.

Now that the EPA is proceeding with a 9-year project to reregister all pesticides, many products may be cancelled and certain ornamental labels may be lost. The IR-4 ornamentals program in Florida and throughout the nation will continue to develop data for labels necessary to maintain effective pest control in ornamentals.

I would encourage you to submit clearance requests for labeling of biological and chemical agents to control pathogens, insects and weeds, as well as agents to regulate growth of container- and field-grown ornamentals maintained in the greenhouse, field, or inside buildings. If requests are not submitted, it will be assumed that the materials are not needed; and they will not be reregistered. Please submit requests to me, or contact me for information, Tel. 904/392-1978.

Table 3. Herbicide registrations supported with IR-4 data

Brand name (Formulation)	Ornamental uses/ species labeled	Weed control
Devrinol (50WP, 5G)	248	Preemergent annual weeds
Dual (8E, 25G)	69	Preemergent annual and perennial weeds
Dual + Princep	28	Preemergent annual and perennial weeds
Fusilade 2000 (E)	83	Postemergent grass weeds
Goal (2E)	8	Weeds in conifer seed beds
Lasso (EC)	16	Premergent weeds
Pennant (5G)	16	Preemergent weeds and yellow nutsedge
Poast (EC)	8	Postemergent grass weeds
Progrow (G)	103	Preemergent weeds
Ronstar (G)	103	Preemergent weeds
Rout (G)	21	Preemergent weeds
Roundup (EC)	132	Postemergent weeds
Surflan (75W)	121	Preemergent weeds

SOIL FUMIGATION USING BASAMID, A GRANULAR FUMIGANT

PAUL MILLER

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Timberline Nursery is a 75-acre, wholesale nursery specializing in providing bare-root juniper and arborvitae liners to nurseries throughout the United States. All of our propagation is done outside in topsoil beds. Each bed is 4 ft wide and 400 ft in length. The cuttings are taken from our nursery stock grown in containers.

For fumigation and sterilization of the topsoil beds we use Basamid—a safe, easy-to-use, granular soil fumigant. Basamid controls nematodes, weed seeds, and diseases such as root rot, *Phytophthora, Pythium,* and *Rhizoctonia.* The active ingredient in Basamid is dazomet.

Many appealing factors make Basamid our preferred fumigant. No special equipment is necessary such as soil injectors and plastic coverings. You can use equipment you presently have at your nursery. Basamid can be applied at your convenience since Basamid releases and forms a gas only after moisture is applied. This makes it a safe product to use at the time of application.

METHODS OF APPLICATION

Soil preparation. Before the soil is treated with Basamid, we subsoil and chisel plow the soil.

Application. We use a Paulk distributor, which is 5 ft wide with holes 2 in. apart. This gives an even distribution of the granular Basamid over our 4-ft beds. Another good applicator to use is the Gandy distributor. The rate we use is 350 lb per acre. The cost is approximately $3.00 per lb.

Tilling. Next, we till the Basamid in by using a rotary tiller behind a tractor driven in super-slow gear. The tiller reaches a soil depth of about 8 in. The tiller has weights on the back door so that the soil is slightly compacted to form a cap.

Irrigation. Water is added until the soil is saturated. This causes the Basamid to release and change to a gas. The cap formed during tilling seals the gas in the ground.

Soil aeration. Ten days to two weeks later the Basamid has fully released its gas and the soil is sterile. We aerate the soil using a smaller tiller so that we do not mix the treated soil with the untreated soil. Amendments such as fertilizers and lime are added at this time.

Ready to plant. After aerating the soil and adding the amendments, we are ready to plant. A bed 4 ft wide is formed with the tiller. We then lay down a guide string and begin striking cuttings in the bed.

DISCUSSION AND CONCLUSION

Basamid soil fumigant has proven to be effective in our nursery for sterilizing our topsoil beds prior to propagation. We find it to be safe and easy to use. Basamid requires no special equipment for the product to be applied. Basamid remains stable and does not change to a gas until water is applied.

For more information on Basamid Soil Fumigant contact Loveland Industries, Inc., P.O. Box 1289, Greeley, Colorado 80632, (303) 356-8920.

SMALL FRUITS FOR HOME GARDENING

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Recently there has been a nationwide resurgence of interest and activity in home production of fruits and vegetables. Several factors have contributed to this interest in home gardening, including wide publicity of the health-giving value of fruits and vegetables in the human diet and consumer concerns about the safety of purchased foods. This increasing interest in home gardening is providing new opportunities for nurserymen to expand propagation and marketing of nursery stock of fruit species.

Opportunities exist for the marketing of many fruit species, but I will limit my discussion here to only small fruits and grapes. This is appropriate since interest among home gardeners is especially high for this group of fruit crops.

Some of the characteristics of small fruits that appeal to home gardeners are: 1) high production in small amounts of space; 2) consistently productive perennials; 3) less pest problems on most than for tree fruits and vegetables; 4) difficult to purchase high quality fruits at retail, since quality is closely tied to freshness; 5) high vitamin content; 6) ideal for home processing; 7) easily incorporated into the home landscape; 8) no specialized or expensive equipment required for production; and 9) short juvenile period, resulting in quicker fruiting than for tree crops. I will elaborate on these factors in the following discussion of individual crops.

STRAWBERRIES

The strawberry, *Fragaria* × *ananassa,* is the most widely grown of all small fruits. It is grown in every state in the United States and in nearly every country of the world. However, strawberry cultivars are the most affected of all the fruits crops by the environment under which they are grown. Thus there are literally hundreds of strawberry cultivars, differing in regional adaptation. It is necessary, therefore, for growers, or nurseries supplying plants to growers, to ascertain the correct cultivar for each specific location.

Strawberries are among the most popular fruits for home gardens. Significant production can be obtained from small field space. For example, a 25-ft row of strawberries in a garden may produce 25 quarts of berries. Strawberries come into bearing quickly. The

period from planting to first harvest ranges from four to 14 months, depending on the cultural system used. They are long-lived perennials and will continue to produce for several years with proper care. Strawberry fruits are among the highest in vitamin content, are easy to process, and retain good quality as a processed product.

BLUEBERRIES

Until relatively recently, blueberries production was thought to be limited to only a few states in the U.S. Now, with newer cultivars and new cultural systems, commercial blueberry production has been extended into many states. As a home-garden fruit, blueberries are still being "discovered" in many parts of the U.S., especially in the South.

There are three types of blueberry available for home gardens: northern highbush, rabbiteye, and southern highbush (also referred to as "low-chill" highbush). Each of these has its specific climatic requirements, and is thus adapted to specific regions of the country.

The northern highbush, *Vaccinium corymbosum,* is the major blueberry of commerce, with Michigan and New Jersey being the leading producing states. However, it can be successfully grown in many parts of the U.S. Northern highbush cultivars have a winter chilling requirement of 800 to 1000 hours below 45° F, which limits their adaptation in the deep South. Some of the most popular cultivars are 'Bluecrop', 'Blueray', 'Coville', 'Collins', and 'Bluejay'.

The rabbiteye blueberry, *V. ashei,* is well adapted in much of the southern U.S. but is limited to regions where winter temperatures do not drop below 0° F. 'Tifblue' and 'Woodard' are popular cultivars. Recently, several new ones have been released. Among these, 'Premier' and 'Brightwell' appear especially promising.

The newest type of blueberry is the southern highbush, *V. corymbosum* [syn. *V. australe*], represented by such cultivars as 'Sharpblue', 'Avonblue', 'Georgia Gem', 'Cape Fear', and 'O'Neil'. These have been bred to combine the fruit characters of northern highbush with adaptation to low-chill southern climates.

The major requirements for successful blueberry culture are acid soils (pH 4.8 to 5.2) and plenty of water for irrigation. In many areas of the South, organic mulches have been beneficial for blueberry growth and production. Blueberries have few pest problems and are grown without pesticides in many areas. Plants begin bearing in one to two years after planting, but they do not reach full production (up to 15 pints per bush) for 5 to 7 years.

BLACKBERRIES

Blackberries (*Rubus*, subgenus *Eubatus*) are rapidly increasing in popularity as a home garden fruit. Since the fruit is the most perishable of all small fruits, fresh blackberries are rarely seen in retail outlets. Plants are productive, easy to grow, and nearly pest-free.

A major limitation to blackberry production is winter cold. Most cultivars may sustain cane and/or bud injury when temperatures fall below -5° F. In a garden situation, trailing types, such as 'Chester Thornless', 'Hull Thornless', and 'Black Satin' can be protected by covering canes during winter.

The most popular blackberries in Southeastern U.S. are the thorny, erect cultivars, 'Shawnee' and 'Cheyenne'. These are very productive with very large, high quality fruits. The new 'Navaho', an erect growing thornless cultivar with exceptionally fine flavored fruits, is being widely planted in home gardens.

RASPBERRIES

Raspberries, (red: *Rubus idaeus*, and black: *R. occidentalis*), are cool-season fruits and are best adapted to northern areas where summer temperatures are not extreme. 'Southland' and 'Dormanred' have shown good adaptation in parts of the South. The new 'Bababerry' is touted as a Southern-adapted red raspberry, but its potential has not yet been well defined. Some gardeners in the southern U.S. have had fair success with 'Heritage', particularly with its fall crop.

GRAPES

Recent releases of new table grapes, *Vitis labrusca* and hybrids, adapted to the Eastern U.S. have stimulated interest in both commercial and home-garden plantings. The seedless cultivars 'Venus', 'Reliance', 'Mars', and 'Saturn', from the Arkansas breeding program, are being widely planted in southern gardens. 'Orlando Seedless', from Florida, allows grape production in areas where Pierce's disease precludes the culture of most other cultivars.

Muscadine grapes, *Vitis rotundifolia,* are still popular garden fruits in the South. Many new cultivars with improved fruit qualities have been introduced in recent years. Muscadine grapes usually have fewer pest problems than do bunch grapes. Growers should be aware that some muscadine cultivars produce only female flowers and require a pollinator for fruit production.

SMALL FRUITS IN THE HOME LANDSCAPE

Small fruit and grape species can serve a dual purpose for the home owner: fruit production and enhancement of the home landscape. Shrub borders may be created with blueberries, blackberries, and raspberries. Single accent plants of blueberries in the landscape are attractive with their white, bell-shaped flowers in spring, clusters of blue fruit in summer, and red leaves in the fall. Strawberries and dwarf blueberries create attractive, fruit-producing ground covers, borders, or accent plants. Grapes can be trained into any desired configuration—from wall covers to overhead arbors to fence screens.

Many of the small fruits may be container-grown. Blueberries have a limited root system and may be grown in patio containers for several years. Strawberries may be successfully grown in almost any type of container, even window boxes for apartment fruit production. Two common methods of growing strawberries in small spaces for both fruit production and landscape beauty are the 'strawberry barrel'' and ''strawberry pyramid''. In these systems, the growing plants cascade down the barrel or pyramid giving a living, green, fountain effect.

IMPORTANCE OF THE CULTIVAR

The most important decision a small-fruit gardener makes is the choice of cultivar since the future success of the planting depends, in large measure, on the cultivars used. Most small fruits are greatly influenced by such climatic factors as summer and winter temperature extremes, daylength, humidity, length of the growing season, and rainfall. Since cultivars vary greatly in response to climatic and soil conditions, growers should always ascertain which are adapted to their region before purchasing plants. Nurseries, too, should be prepared to recommend the best adapted cultivars to their customers.

PROPAGATION

Small fruits and grapes are easy to propagate: most can be propagated in more than one way. Strawberries are normally propagated in the field by digging daughter plants from matted nursery rows. Highbush blueberries are usually propagated by hardwood cuttings, although softwood cuttings readily root also. Rabbiteye blueberries root less readily from hardwood cuttings, so softwood cuttings are usually used. Erect, thorny blackberries readily produce plants from root cuttings, while trailing types are propagated by softwood cuttings or tip layers. Most red raspberries

produce plants from root cuttings while black raspberries tip layer. Both can be propagated from stem cuttings. Bunch grapes can be propagated from either hardwood or softwood cane cuttings. Muscadine grapes do not propagate well from hardwood cuttings so softwood cuttings or trench layers are commonly used.

Tissue-culture propagation shows promise for rapid multiplication of most small fruits. Caution should be observed, however, since possibilities of somaclonal variation in tissue culture can produce off-type plants. This has been especially observed in some strawberry cultivars.

With proper cultivar selection and reasonable care, small fruits can be productive and enjoyable additions to home gardens.

P & P: A NEW FIELD-TYPE NURSERY OPERATION

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Growing high-quality container plants at a profit is the primary goal of Lancaster Farms. For many years we tried to grow large—10-gal and up—plant material utilizing our accepted production practices but with very little success. The market was asking for larger container plants, and we were unable to deliver a quality product profitably. Six years ago we started on a diversification plan to add a field-grow division to the nursery. In our first effort we used field-grow fabric containers and trickle irrigation. We experienced difficulties during planting, and the harvested product did not meet our expectations. Late in 1988 we decided a change was needed.

To meet our requirements for a profitable field division a new system must provide the following:

1) Trickle irrigation. Our concern for water runoff, groundwater pollution, and water conservation dictated that any expansion of the nursery utilize the advantages of trickle irrigation.

2) Wind blowover control. We detest performing any task that does not add value to our product. The system, therefore, must provide a means of growing the larger products wanted without the problem of knockdown in a moderate wind.

3) Winter protection. In southeastern Virginia overwintering structures are essential for the production of container-grown plant material. On the other hand, field-grown plants do not require special overwintering procedures. We wanted a system that provided both a growing and overwintering environment.

4) Mechanization. Any imaginative idea must have associated with it the ideas as to how the task can be mechanized.

5) Traditional marketing. Our nursery is in the business of selling plants, not new ideas. We spent more time selling the grow-bag concept than we did selling the product.

In the late fall of 1988 I spent a week touring nurseries with three Dutch nurserymen. In the course of our conversations concerning winter protection of container plants, we learned that some nurserymen in Germany plant their containers in the ground. This started me thinking. . .Why couldn't we plant container plants directly in the ground? The idea fulfilled most of the five initial criteria. But what about roots growing out of the container? And how do you mechanize the job? The concept was a good one but needed more thought.

During the 1988 IPPS Eastern Region meetings I had the opportunity to discuss the idea with friends, Pinney, Shadow, Machen, Stroombeck, Brush, and others. My living room was full of different size containers, and the ideas and suggestions on the system started to take form. We would plant a permanent container in the ground and then place inside this container another container growing the actual plant, a "Pot in a Pot" or "P & P."

THE PRODUCTION SYSTEM

Field preparation jobs of plowing, disking, and grading are completed as usual. Underground irrigation main lines are installed, and the field is laid out into the desired spacing. The entire area is treated with herbicides, and we are ready to set the permanent pots into the field.

A tractor-mounted auger is used to drill holes into which are placed permanent containers. A rigid, injected-molded pot makes an ideal durable in-ground container. We have used from 3- to 15-gal pots. This fixed pot is planted so 3 to 4 in. remain out of the ground. This allows for settling to take place and still keep the top lip of the pot above the ground surface. The area is then hand-raked, lateral surface irrigation lines are laid, and individual Roberts Spray Stakes are installed at each pot.

Plants are potted on our potting machine using a blow-molded container, transported to the field, placed into the permanent pot, and a spray stake is installed.

DISCUSSION

The system encompasses all of the original five requirements; however, we have had our share of problems. In some of first plantings we set the permanent pots too deep, and many of the pots filled up with field soil after a strong wind and rain storm. I might also add that any time a field pot does not have a plant growing in it we place an empty pot inside to catch leaves, soil, and debris. We want the permanent pot to stay as clean as possible.

When and how much to water is something that I cannot tell you. I can tell you that it is essential for plants with similar water requirements to be grouped together under one irrigation regime. Even though we are in a field-grow situation, the plants must be treated as container-grown. You cannot grow dogwood and river birch on the same irrigation line.

Roots growing into the surrounding soil is the major flaw in the P & P system. Even though we feel this is a primary concern we have had problems only on a few cultivars such as birch.

Criteria four for the system was misstated in our original requirements. Moderation of temperature would have been a

better requisite. Winter temperatures of 0° F resulted in no damage to sensitive foster holly. The advantages gained by keeping the root system cool during the growing season are impressive. I have never observed such outstanding root structure as the P & P system produces. This awesome root structure in turn creates a problem. Some form of protection must be given to the root system when harvesting in 100° F summer temperatures or else the plant is severely damaged. We have tried to protect the roots by painting the outside of the pot white or covering with microfoam.

SUMMARY

I am convinced that the benefits of the P & P System far outweigh the disadvantages. Large, high-quality container plants can be marketed any time of the year in an economical manner using the P & P System. I am certain P & P will grow in importance and become a standard procedure in future years.

REGULATORY UPDATE FOR NURSERY GROWERS

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As nurserymen, plant propagators, researchers, and horticulturists, I would like each of you to ponder a few questions. What would your business be like without rooting compounds such as indolebutyric acid (IBA)? Which plants would you have difficulty propagating? How would this affect your customers and, ultimately, the diversity of plants in our homes and landscapes?

What about the spread of destructive exotic pests, such as the imported fire ant, and the resulting quarantines on movement of nursery stock? Would the absence of safe, effective quarantine controls for the fire ant prevent you from shipping your products to many regional or national markets? Or would good-intentioned but poorly thought out safety or environmental protection measures render your business unprofitable?

Following is a summary of the current status of IBA registration and the imported fire ant quarantine, two major issues confronting southern nursery growers, and some suggestions on how we as an industry can adapt to increasing regulation affecting our ability to do business.

Since about June 1989, IBA and formulated IBA products have been making their way through the U.S. Environmental Protection Agency's registration and reregistration process. The basic purpose of pesticide registration, and now reregistration, as required by 1988 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act, is to ensure that EPA has adequate data to weight the health, safety, and environmental risks of chemicals.

Interestingly, the technical-grade IBA had never been registered through EPA. The concern over IBA's continued availability started about May 1989, when EPA placed a stop-sale on technical grade IBA pending its registration. Cost estimates for the required studies for registration and reregistration of IBA and IBA products were around $500,000. Though IBA is critically important to propagators, it is used in very small amounts, so we feared that the manufacturer of IBA might not have the economic incentive to register technical grade IBA and keep it available to the nursery industry.

Fortunately, in late 1989, EPA agreed to waive several studies in response to pressure from nursery associations, many concerned individuals, and the product manufacturer and formulators. For

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example, AAN staff communicated with EPA policy makers on IBA's importance and the way it is used. We also worked to encourage discussion among the companies that formulate IBA products.

As of now the news is good. On October 26, 1989, Debby Halliday of D. Halliday & Company, the U.S. representative of Syntex Co., manufacturers of technical-grade IBA, told me that D. Halliday & Co. had just received a conditional registration for IBA. As we spoke, IBA was already beginning to flow again to the product formulators. There should be no shortage of IBA, and you will still be able to get it from the same sources. The technical-grade IBA, however, will not be directly available to end-users, such as nurserymen. Cost of IBA formulations is not expected to change significantly.

A few additional points on IBA. First, if you would like a particular IBA formulation or product but cannot find it in your area, D. Halliday & Co. wants to know. They can be reached in California at (619) 728-2893.

Also, the IBA produced by Syntex is apparently 97 to 100 percent pure. If others begin producing IBA with a higher percentage of inert ingredients or contaminants, products could be cheaper, though not necessarily of the same quality. In other words, let the buyer beware. If someone offers you a deal that appears too good to be true, it probably is.

AAN will continue to be vigilant, and will continue to support the availability of IBA.

The imported fire ant, that pesky, destructive insect from South America, has also been in the news lately. Unfortunately, the ant continues to spread while we search for new ways to control it. Currently, the imported fire ant is found in much of the U.S. Southeast—from Florida, west through much of Texas, and north to extreme southeast Virginia. As its range increases, the ant seems to be adapting to drier, and perhaps colder, conditions. Clearly, it would survive in major agricultural states like California. Like many other pests, those of you who have it don't like it, but you learn to live with it. But those who don't have it don't want it, and often they favor the strictest possible measures to see that they don't get it. So, quarantines become controversial, emotionally-charges issues.

Since about 1979, chlordane has not been labeled for nursery uses. Granular chlorpyrifos, or Dursban®, incorporated into growing media, has since been the approved fire-ant treatment for container nursery stock.

During 1989 USDA's Animal and Plant Health Inspection Service, or APHIS, announced that their investigations showed the Dursban® treatment was not giving reliable control beyond as little

as 90 days, and would, therefore, be suspended as a treatment for nursery-stock certification. This would have left no treatment option for you who are located in the fire-ant zone and ship container plants outside the quarantine area. AAN and others fought this emergency measure hard, arguing successfully that suspending this treatment in the absence of others would seriously harm the Southeast's nursery industry. Instead, the fire ant technical work group, which includes researchers, regulatory personnel, and industry representatives, met to search for a better solution.

In July 1990, APHIS announced revisions to the fire-ant certification program for container plants. It retains the Dursban® treatment, with the addition of two treatments annually with Logic® or Amdro® bait, spot control of persisting mounds, and regular inspections. These revisions did not come smoothly, though. Some 11th-hour proposals would have required perimeter fencing of nurseries, burdensome requirements to notify those living nearby of pesticide applications, and *annual repotting* of container stock using freshly-treated media. Closely cooperating with the Southern Nurserymen's Association and several state nursery associations, AAN mounted a successful effort to have these unrealistic provisions deleted. In early July, our members received a regulatory alert announcing the quarantine changes. Many of our members learned of the quarantine changes even before the regulatory officials responsible for implementing them!

The IBA and imported fire-ant issues are two examples of regulatory threats to the survival and success of your business. I hope I have brought some good news for you on their status. There are two further conclusions I would like to draw. First, your national, regional, and state nursery associations, working cooperatively, can have a positive impact on laws and regulations affecting your business on the national and state level. There is strength in numbers; we need your support. Second, your individual input can make a difference. Many of you responded when asked to write letters supporting IBA. Those letters made a difference with EPA. Your support on these issues, when requested, is critical.

Supporting your Associations and taking personal action to support AAN efforts will be two effective strategies to help your business survive in the '90s.

EFFECT OF SCARIFICATION TREATMENTS ON GERMINATION OF *SOPHORA SECUNDIFLORA* SEEDS

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Abstract: Seeds of *Sophora secundiflora* (Ort) Lag ex DC. (mescal bean) were scarified with hot water and concentrated sulfuric acid to determine an optimal pretreatment for successful germination One-year-old seeds were successfully stored and germinated approximately two days before seed from the current year when both were given an acid pretreatment. Germination rate increased as acid pretreatment time increased from 30 to 120 min Soaking seeds in water at room temperature and in hot water (initially 93 °C) for 24 hr. had no effect on germination

The genus *Sophora* (Papilionaceae) consists of approximately 30 species with world-wide distribution (1). *Sophora secundiflora* is an evergreen shrub or small tree native to western Texas, New Mexico, and northern Mexico. Other species found in the United States are *S. affinis,* native to Texas and Arkansas, *S. arizonica* from Arizona, and *S. tomentosa,* which grows in southern Florida. *Sophora secundiflora* is an excellent native plant for landscaping purposes in Texas because of its tolerance to alkaline soil conditions and moderate drought. The foliage is a glossy dark green and the plant produces fragrant, showy flowers in terminal racemes during early spring. The plant is hardy in USDA zones 8 to 10 and can be used for screening, hedges, and as a specimen tree.

Sophora secundiflora is considered difficult to root and is propagated primarily by seed (5, 8). The seeds are reported to be short-lived, and shipment of seed as soon as ripe without drying is recommended (9). Successful germination of *S. microphylla* was dependent upon time of collection and the prevention of seed coat hardening due to drying (4). Old seed requires acid scarification for germination, whereas fresh, mature seed of *S. secundiflora* germinate readily (8). While seed germination appears to be the accepted method for propagating this species, few protocols were found regarding pre-treatment to break seed-coat dormancy. Therefore, the objectives of this study were to: 1) test the viability of one-year-old seed as compared to fresh seed, and 2) determine an optimal pretreatment protocol for successful scarification and germination of *S. secundiflora* seed.

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MATERIALS AND METHODS

Seeds were collected from wild stands of *S. secundiflora* in Medina County, Texas. Seeds produced in 1987 were collected in March, 1988, while seeds produced in 1988 were collected in December, 1988. Both crops were sealed in polyethylene bags and stored at room temperature (20 C) until used. In March, 1989, seeds were manually extracted from pods (approximately 3 to 4 seeds per pod) and inspected to insure that no damage occurred before use.

Treatments included:

1) control (distilled H_2O soak for 24 hr.),
2) hot water soak,
3) sulfuric acid (30 min),
4) sulfuric acid (60 min), and
5) sulfuric acid (120 min).

For the hot water soak, seeds were placed in distilled water at 93° C and allowed to cool for 24 hr. Concentrated sulfuric acid (18 N H_2SO_4) was used for treatment of seeds. Seeds placed in acid were gently agitated periodically then rinsed for 2 hr. in distilled water.

After treatment, 30 (1987) and 50 (1988) seeds per treatment were rolled in moist paper towels (10 seeds/replication) and placed in plastic bags for germination. Seeds were germinated in a germination chamber with a day/night temperature of 30/30 ° C and no lighting. Distilled water was added to moisten the paper towels as needed. On days 0, 1, 3, 5, 7 , 9 , 11, 13, 17, 20, and 27, seeds were removed, and fresh weight, seed width, and length were determined. A seed was considered germinated if the radicle was visibly protruding through the seed coat. The experiment was terminated after 27 days.

Seed coat samples taken after each treatment for scanning electron microscopy (SEM) observation were oven-dried at 70 ° C for 24 hr before gold sputter-coating. Electron micrographs were taken using a Hitachi S-450 scanning electron microscope. Data were analyzed as a general linear model.

RESULTS AND DISCUSSION

Germination of *S. secundiflora* seed was influenced by collection date and sulfuric acid treatment. All seeds treated with sulfuric acid germinated in 27 days, whereas only 1 control seed and only 4 hot-water-treated seeds germinated from the two seed lots. Seeds collected from the 1987 crop germinated an average of 2 days earlier (5.3 days) than seeds collected in 1988 (7.3 days). Mean number of days to germination decreased linearly (R^2 = 0.86) as acid treatment period increased from 30 to 120 min. Seed treated

with sulfuric acid for 120 min germinated in an average of 4.9 days compared to 6.2 days (60 min) and 8.3 days (30 min). After 27 days, remaining seeds from the control and hot water treatments were treated with sulfuric acid for 60 min. Over 90% of the seeds germinated within 5 days, indicating continued seed viability.

Initial seed size was not correlated with initial seed weight. Final seed length (1.97 cm) and seed width (1.37 cm) increased for the sulfuric acid treatments whereas the control and the hot water treatment showed no increase in size. Germination was not correlated ($r < 0.4$) with initial or final seed size or weight change due to imbibition.

Anatomical features of papilionaceous legume seed coats include three layers known as the cuticle, the epidermal, and the hypodermal layer (6, 7). The cuticle is made of cutin, a waxy, fatty hemicellulose, or pectinaceous outer layer of the seed coat. The epidermal layer consists of macrosclereid cells often known as the Malpighian cell layer. Malpighian cells are usually elongated, thick-walled, and approximately hexagonal when viewed in transection. The hypodermal layer consists of irregularly shaped osteosclereid cells, which are usually separated by intracellular spaces.

The cuticle was determined to be approximately 3μm in thickness. The epidermal and hypodermal layers were approximately 350μm and 230μm thick, respectively. The cuticular surface of legume seeds often appears smooth at low magnifications with textural patterns becoming visible in SEM micrographs above 50 $\times$ (6). At a magnification of 100 $\times$, the cuticle of *S. secundiflora* seeds soaked in water for 24 hr. appeared to be smooth with numerous nearly circular small patterns.

In some species of the legume family, the waxy seed cuticle may interfere with the uptake of water, thereby limiting germination due to a coat-imposed dormancy (2). Seeds treated with hot water showed some loss of cuticular material. Research with Penngift crownvetch seed showed that 1 min. in boiling water caused enough thermal expansion to rupture the seed coat and separate the Malpighian cells which allowed water to penetrate into the seed (3). No such rupturing of the epidermal layer was seen in this study due to the hot water soak.

Treatment of seeds for 30 min. with sulfuric acid resulted in removal of the cuticular layer and visibility of the Malphigian layer in a majority of the seed. Cracks in the outer portion of the epidermal layers were evident at high magnification (1800x). When seeds were treated with acid for 60 or 120 min., the cuticular layer was completely removed. The 60- and 120-min acid treatments resulted in localized deep etching of the epidermal layer. These same treatments dissolved the tops of the Malphigian cells and caused cracks in the epidermal layer.

Previous research suggested that impermeability of crownvetch seed was due to Malphigian cell layer caps (3). The cuticular and the epidermal layer have also been implicated in the interference of water uptake in leguminous seed (2). Scanning electron micrographs showed that partial removal of the cuticular layer in *S. secundiflora* seed was necessary before germination occurred. The hot-water soak resulted in poor germination because the treatment did not remove the cuticular layer. When seeds were treated with sulfuric acid, some or all of the cuticular layer was removed. Following the 30-min. sulfuric acid treatment cracks in the epidermal layer were evident, and 100% germination resulted. Therefore, it is evident that the cuticular layer in *S. secundiflora* can prevent germination by preventing inhibition of water. However, it could not be determined from this study whether scarification of the hypodermal layer was required for germination of *S. secundiflora* seed.

Seed stored for four months became sufficiently hard to prevent germination unless the seed was acid scarified. Germination rate increased as acid treatment time increased. Fastest germination occurred using one-year-old seed and acid scarification for 120 min. Soaking seed at 93 °C for longer periods of time may remove enough cuticular layer to enhance germination. While germination can be accomplished with fresh, mature seed that have not hardened (8), *S. secundiflora* seed can be successfully stored and germinated if treated with acid scarification.

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TRAINING MIDDLE-LEVEL MANAGEMENT PERSONNEL FOR NURSERY OPERATIONS

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The Bushnell, Florida division of Flowerwood Nurseries, Inc. was established in January, 1985. Bushnell is located 50 miles north of Tampa and 50 miles west of Orlando. This location is in zone 9a of the new USDA Plant Hardiness Zone Map. The nursery presently covers 65 acres with 40 acres in plant production, and it employs 35 to 40 people.

In the beginning, labor and management needs could be handled by relatively few people. However, as the nursery grew, the need for middle level managers and supervisors arose. Because of the quality of employees already on the nursery, we felt our need could be met through promotion and training from within rather than by hiring outside our employee pool. When considering possible choices, a candidate's job performance, honesty, and level of interest in the nursery in general are of primary importance. Basic plant and nursery skills can be taught later, while the desire to learn and willingness to perform cannot. The ability to complete assigned tasks without repeatedly having to question procedure is a good indicator of supervisory ability and signals confidence. This confidence in one's own decisions and ability is essential for a supervisor.

The ability to get along with co-workers is another important consideration while selecting a supervisor. A positive working relationship with other employees leads to cooperation and good job performance.

Finally, punctuality and attendance are important. Some employees that are hard-working when at the nursery seem to always have pressing matters that keep them away from the workplace, while others can be depended upon day after day. The supervisor needs to set the example for others to follow.

Once you have selected your supervisor trainee, the training begins. A good supervisor needs "hands-on" experience in all areas of the day-to-day nursery operation. Before instructing and directing others, a supervisor first must have performed the task. Explain methods, time required, and possible shortcuts while stressing the desired final results. Never make your new supervisor guess your thoughts. When the supervisor gains confidence in his/her own ability, it will be easier to instruct others. Give your new supervisor only a few jobs and people to work with at first.

Too many responsibilities at first makes it difficult to master any one particular task. Again, always stress the desired results. When the supervisor becomes comfortable, gradually increase responsibilities. As proficiency and confidence grow, give your supervisor freedom to make decisions. Watch progress closely and do not let little mistakes become large due to the supervisor's inexperience. Be available to answer questions, but allow the supervisor to learn from experience. Let your supervisor direct the performance of the nursery employees. It is a gradual process, but eventually they will look to the supervisor to answer their questions while at the same time respecting his/her position of authority.

Early morning meetings are a good opportunity to discuss the day's goals without the normal working hour interruptions. Use this time to point out privately weaknesses and concrete methods to correct them. Be sure to give praise when deserved. Stress the high-priority matters and discuss how they should be handled.

A weekly written plan outlining the desired accomplishments is helpful in giving the supervisor a long-term idea of your plans. Use some method to emphasize the high priority items on your plan, then permit the supervisor to carry out the plan. This will allow the day-to-day nursery operation to revolve around the new supervisor, freeing you to concentrate on other matters.

Finally, once the supervisor has learned your way of doing things, give freedom to add a personal touch to the nursery operation.

PROPAGATION AND PRODUCTION OF TENNESSEE PERENNIAL NATIVES

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Native perennials or wildflowers have become very popular with the gardening public in the past several years. Until recently, the source for wildflowers has been wild collection. The great increase in the demand for these plants, coupled with ever-increasing habitat destruction from development, has jeopardized the continued survival of many populations and species. Environmentally aware gardeners are rejecting wild-collected plants and are seeking a wide variety of high-quality, nursery-propagated wildflowers. Sunlight Gardens has been developing and refining wildflower propagation and production techniques for the past six years. In the following article, we will share some of our knowledge with you.

PROPAGATION TECHNIQUES

Basically, the propagation techniques for native perennials are the same as for traditional non-native perennials. Some species still present problems as their mysteries have not yet been unraveled. Following is a brief summary of basic techniques for propagating wildflowers.

Sexual propagation. Seed propagation is used when genetic variation is desirable or acceptable. Seeds are collected when the fruiting stems and heads are brownish and dry. This may be obvious and persist for a long time (Asteraceae), or the collection period may be very brief (*Geranium, Mertensia*). It is generally a good idea to collect the seeds before the capsule splits open (*Silene*), or the head shatters (*Echinacea*). In some species, the mature fruit is moist and not brown. *Trillium* and *Arisaema* have fleshy, red fruits. But generally, mature seeds are dark-brown or black. In any case, a general rule of thumb is that if the mature fruit is dry, the seed should be cleaned and stored dry. If the mature fruit is fleshy, then the seeds should be cleaned and stored moist, never being allowed to dry out, which may result in delayed and reduced germination, as in *Dicentra* and *Sanguinaria*.

Depending upon your production schedule and the species being grown, seeds may be sown during January and February in a heated greenhouse, or outdoors from June through August. For the summer sowings, sufficient time must be allowed for seedlings to

become established either in their flats or as transplants before cold weather. Seeds of some species need light to germinate and should not be covered with the medium (*Gentiana, Heuchera*). Others require a cold stratification period (*Silene, Sanguinaria*) or some alternating temperature/moisture regime (*Lilium*) before seeds will germinate.

Clean seeds are sown on a sterile, commercial medium designed for seeding. Flats are placed over heat to maintain a soil temperature of about 75° F. Seeds of species more difficult to germinate or slow to grow may be sown in prepared beds outdoors. To discourage damping-off, seed flats are drenched with Banrot after sowing. We begin fertilizing with a dilute liquid feed when 1 or 2 sets of true leaves are present on the seedlings and we begin transplanting when at least 2 sets are present. Some species will flower within a few months of sowing (*Dicentra, Coreopsis*); others must go through a winter first (*Aquilegia, Stokesia*). Still others take many years to flower (*Arisaema, Trillium, Mertensia*). This will largely determine your propagation schedule and method.

Asexual propagation. Cuttings, layering, and division are appropriate methods of increase when genetic variation is not wanted, or when seed propagation is difficult or slow. We take our softwood stem cuttings from supple stems while the plants are in active growth during the summer. It is best not to use stock that is flowering. Many species do not need a rooting hormone, but for those that do we have had success using up to 1000 ppm IBA or K-IBA. Cuttings are stuck in community flats of mixes such as peat:perlite, peat:sand, sand:perlite, or straight sand, depending on their propensity to root. Flats are drenched with Banrot and put under mist under 67% shade. Again, sufficient time must be allowed for rooted cuttings to be hardened off before cold weather.

Root cuttings are taken when plants are dormant in the winter. It is important to maintain polarity when the cut root portions are inserted into the rooting medium (sand). The following may be propagated by root cuttings: *Asclepias, Mertensia, Viola, Echinacea, Liatris, Claytonia.*

Division is used to obtain larger specimens quickly. We divide plants when they are not in active growth. Generally, spring bloomers are divided just after flowering or in early fall. Fall bloomers are divided in spring. Summer bloomers may be divided in spring or early fall. Anything with a spreading crown or with runners is a good candidate for division (*Aster, Monarda, Geranium, Polygonatum, Rudbeckia, Phlox*), while plants with tap roots would be poor choices (*Asclepias, Baptisia, Echinacea*).

PRODUCTION

Containers. At Sunlight Gardens, we produce plants primarily in 3 1/2 in. square pots for our mail-order business, and in 1-gal. containers for wholesale sales to landscapers and retailers. Our container medium is based on ProMix BX, to which we add perlite or composted bark depending on individual species requirements. Osmocote 14-14-14 or Sierra, with minors, is incorporated into the potting mix in varying amounts but usually not exceeding 250 ppm nitrogen. When visual inspection or soil tests indicate the need, we begin liquid feeding with Peters Peat-Lite Special. For most species it is unnecessary to add lime.

Ground. For the majority of the species we grow, container production works well. But there are others that are grown in ground beds. Slow growers like *Hepatica, Lilium,* and *Polygonatum* are grown in the ground and then potted the season before they are sold. Others that have a brief flowering period followed by a long dormancy, are kept in the ground as much as possible. These include *Mertensia, Dodecatheon, Arisaema,* and *Claytonia.*

We have ground beds both in the shade and in full sun. Our shade beds are frames constructed of treated 2 x 6 in. boards in varying lengths. For beds under natural high, open shade, tree roots growing under the beds pose a problem. So the frames are constructed over a layer of thick weed prevention fabric. The beds are filled with topsoil and compost. Sunny ground beds are tilled into existing top soil with no additives. All ground beds are fumigated with methyl bromide, which provides good weed control for an entire season. So far, we have resorted to mulching and hand weeding the following seasons.

WINTER PROTECTION

Winters can be very hard on containerized perennials in east Tennessee (USDA Zone 6) where an average winter day may range from 15 to 50 °F. The freeze/thaw routine must be moderated. We put all plants pot-to-pot either in walk-in cold frames 17 x 100 x 7 ft. or low hoops 6 x 100 ft x 18 in. All are covered with white poly that can be opened and ventilated easily. This year we will use an additional spun polyester blanket in the taller houses. We cover in mid-November and uncover in mid-to-late-April. Back-up electric heat is available to protect the flowers from the inevitable late April drop into the low 20s. Last, when all plants are in place, we give a Banrot drench and then try to keep plants on the dry side.

TEN EXAMPLES

The following are popular plants that are good sellers and fairly easy to grow. The production and propagation techniques discussed are those that we use at Sunlight Gardens.

Echinacea purpurea—Seed is collected when heads are dry in fall, cleaned, and stored dry After 6 weeks cold stratification, seed is sown in January on flats with germination occurring in 2 weeks. Seedlings are transplanted into 3½ in pots and will flower the first summer *Echinacea tennesseensis* and *E. pallida* are treated the same way except that seeds are sown in July, and young plants are over-wintered since flowering will not occur the same year seeds are sown Echinaceas hybridize freely so maintaining pure seed is essential. They also are harmed by winter dampness and will rot if precautions are not taken

Dicentra eximia—This species flowers from April to November, which makes it just about the longest flowering wildflower there is Seed is collected continually which helps keep the plants in bloom Attached to each seed is a white fleshy aril or elaisome which should never dry out If it does, germination may not occur Immediately upon collection, seeds are placed in a plastic bag of moist, milled sphagnum moss and put in the refrigerator Seeds are ready to be sown after 5 weeks of cold stratification Germination is rapid and flowering plants may be obtained just 4 months after sowing

Lobelia cardinalis—Seed is collected in the fall and requires 6 weeks of cold stratification for germination to occur. They should be sown thinly and covered sparsely since they are tiny *Lobelia cardinalis* will not flower the first year from seed, so seed should be sown in summer *Lobelia siphilitica* will flower the first year and so is sown in January Both are easy from division and from stem cuttings, which are good ways to increase the rare color forms.

Asclepias tuberosa, butterfly weed—Seed is collected in summer and fall just before the follicle splits and the seeds blow away Fresh seed, if sown immediately, will germinate readily with flowering occurring the following summer Seed stored dry needs 5 weeks of cold stratification. January sowing produces flowering plants that summer. Stem cuttings may be taken in early summer and stuck in 1 1 perlite sand, or root cuttings may be taken in winter. Cut roots into 3-in pieces, maintain polarity, and stick in sand. During all phases of its growth it should be grown in dry, well-drained soil, and in plenty of light Avoid winter dampness

Mertensia virginica—Seed which matures in June is very hard to collect since they drop off immediately Seeds require a 6 week cold stratification, but since it may take 3 years or longer to obtain a flowering plant from seed, we sow seeds in prepared nursery beds. A more efficient method of production is to grow stock plants in beds. Take root cuttings when plants go dormant in summer through early fall. These may be potted at that time for spring sales in pots.

Tiarella cordifolia var *cordifolia*—This variety of foamflower sends out leafy stolons which root at the nodes In rich loose soil, it is a good ground cover. Cuttings may be taken in late summer when root initials form spontaneously on the stolon nodes These stem cuttings do not root easily at other times Seed may be collected in early summer and sown for flowering plants the next spring. Seeds are tiny and need not be covered with medium The tiny seedlings are somewhat slow to get started. Plants can also be divided successfully in early fall. *Tiarella cordifolia* var *collina* is a clump-forming, non-stoloniferous variety so, therefore, cannot be propagated by stolon cuttings.

Iris cristata—In the wild, dwarf crested iris grows on shaded banks and produces fans every 2 to 6 in. on spreading runners For maximum production purposes, grow this iris in light shade (47%), in a well-drained mix, and be generous with the fertilizer. This results in very compact clumps that can be divided into many fans in late summer and early fall Fans produced on fattened rhizomes with multiple eyes will fill in a 3 1/2-in. pot and yield 10 to 20 divisions the following fall Fans with no eyes will either need another year or can be induced to produce additional eyes or breaks by piercing the growing tip (apical meristem area) of the fan with a sharp knife or razor blade Seed, which is sparsely produced and difficult to collect because the fruits are well-hidden among the leaves, should be sown immediately without drying into a prepared outdoor bed Flowering from seed takes 3 to 4 years

Phlox divaricata and *Phlox stolonifera*—These species and their cultivars are easily propagated by stem cuttings taken all summer and stuck directly into plugs or pots. They can also be divided during summer through fall Seed propagation is not recommended since the phloxes hybridize readily so cannot be used for propagating the named cultivars.

Conradina verticillata—Cumberland rosemary is a new plant in the trade and is grown much like lavender and rosemary. It is hardy at least through Zone 7. Softwood cuttings dipped in 500 ppm IBA and stuck in 2.1 perlite·peat are taken all summer Taking regular cuttings helps to prevent flowering, which normally occurs in mid-summer. *Conradina* needs good drainage and full sun. Plants need to be kept dry during winter

Lilium superbum—Turk's cap lily produces masses of seeds in early fall. The seeds show a double dormancy, but by following the procedure outlined here, you can gain one year Place seeds in moistened peat or sphagnum moss for 2 months. During this time, small white bulbs should form. Then give the bulbs 2 months of cold stratification Finally, after all danger of frost has passed, sow the small bulbs out in a nursery bed where a single leaf should emerge the first year. Expect to see flowers in about 5 years! A quicker, easier method of increasing numbers is by dividing the bulbs when plants have gone dormant in late summer and fall Small daughter bulbs produced on short shoots may be snapped off of the mother bulbs These may flower the following year Or remove the outer layer of scales from the mother bulbs. Replant the scales 2 in deep in nursery beds where they will develop bulbs and flower in 2 to 3 years. Turk's cap lily needs moist, fertile soil and at least 5 hours of sun each day

CONCLUSIONS

Wildflowers are very popular now and the demand is increasing for nursery-propagated plants. Although the trade is still a long way off in the efficient and cost effective production of native orchids and *Trillium*, for most species, production methods are easy and fast enough to provide a viable alternative to wild-collected plants.

PERENNIAL HERBS WITH LANDSCAPE POTENTIAL

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The business of herbs is becoming an important part of horticulture. Americans are becoming more health conscious and, in order to enjoy fresh seasonings, many people are growing herbs along with vegetables in their landscapes and gardens.

Herbs, loosely defined, include plants used in medicine, used for flavorings or seasonings, and for fragrances. Some also include plants used for dried flowers, dyes, or fibers. We feel if we were to look closely enough, most plants would have some type of herbal use. Herbs can be annual, perennial, woody, or herbaceous.

Following are descriptions of some perennial herbs that might be used in the landscape.

Santolina chamaecyparissus—lavender cotton A low-growing shrub that makes an attractive border—it may reach a height of 2 ft. Its silver color makes it a nice contrast plant It grows best in a dry, sunny location and does not do well in humid areas The branches of santolina can be hung in closets to repel moths There are also green-foliaged types

Verbascum thapsus—mullein. A medicinal gray-leaved accent herb that has a tall bloom spike arising out of the center of the plant. Although this plant is considered a biennial, the plants reseed and seedlings will be back every year

Rosmarinus officinalis—rosemary. Rosemary is a favorite in many herb gardens It is also an important cooking herb and may have medicinal properties. Rosemary has two growth forms, upright and prostrate Upright rosemary can have shrublike growth and reach a height of 3 to 5 ft Prostrate forms have more of a spreading habit and may reach heights of 2 to 3 ft. depending on cultivar. Rosemary may be marginally hardy in some areas, but some cultivars have shown hardiness to Washington, D.C.

Stachys byzantina—lamb's ears This soft-leaved plant may be used as an accent or border. When blooming, the plants may reach 18 in Lamb's ear leaves are medicinal, said to act as a styptic in stopping the blood flow of minor cuts and nicks.

Myrtus communis—myrtle Small-leaved shrub that can be used as a short hedge or border. It can also be trimmed into shapes or designs The leaves and flowers are used in potpourri

Tanacetum vulgare—tansy Attractive, spreading perennial that may reach 3 to 4 ft Tansy spreads by rhizomes but is not invasive Tansy was once thought to have insect-repelling properties. The flowers may be used to produce a yellow dye

Artemisia species. There are many ornamental artemusias that are grown for fragrances.

A. 'Powys Castle' is a good border or edging plant with nice lacy foliage and compact growth habit.

A. ludovıciana var. *albula*, silver king or ghost plant, grows to about 2 ft with a spreadıng habit. It ıs used in drıed bouquets and arrangements.

A. absınthium, wormwood, grows to 3 ft in poor soil. Plants are decoratıve in the back border of the garden. It may be used as a moth repellant.

Lavandula species—lavender. There are many lavender spp. and cultivars. Most do not do well in the humid areas, but are very popular throughout the rest of the country. The flowers are used for sachets and potpourrı. Lavender is also commercially dıstilled for its oil Heights range from 1 to 3 ft

Mentha speçıes—mınt Mınt is a good ground cover growing to about 1 ft tall. There are may flavors of mint, but the most popular ones are peppermint and spearmınt Trım mınts back often to keep them full

Salvia species—sage. Thıs ıs a very ımportant genus ıncludıng about 800 species. The most ımportant ıs *Salvia offıcınalis*, or what we call gray sage. Thıs speçıes ıs used as a seasoning There are some cultıvars of *S officinalis* that may have landscape potentıal. Purple sage, *S officinalis* 'Purpurascens', golden sage, *S. offıcınalıs* 'Aurea', and 'Trıcolor' sage may be slıghtly hardıer than *S. officinalis.* All have a good flavor and can be used as seasonings.

Other salvıas are primarily ornamental, but some may be used for potpourrıs. *Salvia farınacea*, or mealy blue sage, grows to 3 ft. Colors include blue and whıte.

Thymus speçıes—thyme. Thymes fall ınto three broad groups. upright sub-shrubs 12 to 18 ın. tall, creepıng herbs up to 6 ın. tall, and flat creepers that grow 1 to 2 ın. tall All of these can be used ın cookıng, but the creeping types are very tedıous to harvest

Varıegated lemon thyme has a lemony odor and flavor It makes a nıce 6-in ground cover There are many other thymes that are effectıve ın the landscape.

Vıola odorata—vıolet. Vıolets are good ground covers for shady or semisunny areas growing to about 12-in. mounds The oıl of violets is used ın perfume.

Poterium sanguisorba—burnet. This ıs an evergreen mounding herb that reaches 12 ın. in heıght. The new leaves from burnet add a cucumber flavor to salads.

Agastache foenıculum—anıse hyssop. Upright-growing plant that may reach 3 ft. Dried leaves are used for seasoning ın teas and are used in potpourri.

Helichrysum angustifolium—curry plant. Curry plant is hardy to about 10° F and has the fragrance of curry. It is not, however, what curry powder ıs made of. Curry ıs an upright grower and may be 2 to 3 ft. tall.

Hyssopsus officinalıs—hyssop Hyssop ıs an evergreen reachıng 2 ft when flowering. May be clipped to 8 or 12 ın. It can be used as a specımen or small hedge plant Hyssop leaves and flowers add a bitter taste to salads and meats.

Marrubıum vulgare—horehound. Horehound is an herb that reaches 3 ft. and has lovely gray-green foliage It is used ın traditional medıcıne and ın making candy.

Teucrium chamaedrys—germander. This is a dwarf, upright shrub with small, waxy leaves It grows easily and requires mınımal care It can be used as a small border or hedge. Germander was once thought to be a cure for gout but ıs now known to have no medicinal use

Leonotis leonurus—lion's ear. Lion's ear is an upright-growing, root-hardy perennial It has striking orange flowers and may reach 3 ft in height. Its flowers may be used dried in arrangements.

Asclepias tuberosa—pleurisy root. This is a root-hardy perennial that grows 1 to 2 ft. tall. It is mainly grown for its striking orange flowers. It is also known as butterfly weed because butterflies are attracted to it. Pleurisy root was once thought to be medicinal, but now it is known that it has no medicinal properties.

Mentha pulegium—pennyroyal. Pennyroyal is a low-creeping ground cover, rarely getting over one inch tall. It is used in teas and medicines.

Melissa officinalis—lemon balm. Lemon balm is a hardy perennial growing 18 in tall. It has an excellent lemon flavor that can be used in tea and salads.

Satureja montana—winter savory. Winter savory is a spreading, low-growing evergreen sub-shrub that may reach 12 in. tall. It is used as a vegetable seasoning.

Allium species—chives, and garlic chives. There are several onion relatives that can be used as borders or accent plants. *Allium schoenoprasum*, chives, may reach 12 to 18 in. in height. *Allium tuberosum*, garlic chives, grows a little larger and has flatter leaves than common chives. *Tulbaghia violacea*, society garlic, may reach 2 ft in height. It has attractive lavender flowers.

SEASONAL ROOTING OF BLUE CHINAFIR CUTTINGS

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Landscape architects and nurserymen are constantly looking for new plants that may serve as an accent or focal point of urban landscape design. Before these new plants can be produced by the nurseryman in a profitable manner, successful means for propagation and nursery production must be developed.

A specimen plant with good potential for the southeastern United States is the blue chinafir (*Cunninghamia lanceolata* 'Glauca'). This selection of chinafir has a lustrous, glaucous blue foliage and is an excellent accent plant. It has slightly pendulous branches bearing large flat needles that give it an exotic appearance. A tree growing on the University of Tennessee, Knoxville, grounds has survived all adverse weather conditions for the past 20 years, including temperatures as low as -24° F, and has had no insect or disease problems. The blue chinafir is probably a more suitable blue-foliage conifer for the Southeast than either blue spruce or concolor fir, even though it has a somewhat coarser foliage texture.

Little information is available on the propagation of this species. Dirr (1) recommended taking cuttings during November and using high concentrations of indolebutyric acid (IBA). Since no other published information on the rooting of blue chinafir could be found, it was not clear whether it would root fairly well like *Taxus*, or have a narrow window of rootability like *Sciadopytis*. Since the plant is somewhat rare in the nursery trade, it was suspected that problems might be encountered.

Differences in genetic characteristics, such as anatomy and physiology usually explain why certain plants do not root readily (5). Hartmann and Kester (3) stated that hardwood cuttings of certain narrow-leaved evergreens are slow to root, often taking several months to a year. They categorized rootability of various species as easy (*Thuja*, creeping juniper), fair (*Taxus*), difficult (*Picea, Tsuga*), and very difficult (*Abies, Pinus*). They recommended that narrow-leaved evergreen cuttings be taken between late fall and late winter. Lanphear and Meahl (4) showed that rooting peaked for Andorra juniper cuttings taken in December, January, and February with relatively poor rooting taking place from June to October. Propagation research conducted on *Sciadopitys verticillata* showed that the highest levels of rooting occurred in February and March and again in July and August (9).

Cuttings of Leyland cypress (× *Cupressocyparis leylandii*) are most successfully rooted from February to March (2).

Quite different seasonal rooting responses are evident in deciduous ornamental species (8). Cuttings of certain broad-leaved plants have very distinct "windows" of rootability. Succulent deciduous azaleas cuttings root quite readily if taken in early spring, but by late spring, rooting percentages decline rapidly (6). Chinese fringetree, (*Chionanthus retusus*), is notoriously difficult to root except during a month-long period beginning about 6 weeks after bloom (10). Pokorny and Dunavent (7) showed that cuttings of southern wax myrtle (*Myrica cerifera*) rooted satisfactorily only during the period between May and August.

Cuttings of *Cunninghamia lanceolata* 'Glauca' were taken at intervals throughout the year in order to develop a rooting curve to show peak periods of root formation. A second purpose was to determine effects of varying levels of IBA on root formation.

MATERIALS AND METHODS

Forty cuttings were taken at about two-week intervals from a superior mature blue chinafir located on the Agricultural Campus of the University of Tennessee at Knoxville. Terminal cuttings four to five inches long were removed from random lateral branches in the lower half of the tree. Wounding of each cutting consisted of removal of basal leaves for two inches. Propagation was carried out in 4-in. deep flats filled with a peat moss and perlite (1:1) medium. Flats were placed on a greenhouse bench equipped with mist irrigation and Biotherm bottom heat at 18° C. Mist intervals were 12 sec every 6 min, from 8 a.m. to 5 p.m. The bench was covered with a polyethylene tent to prevent air currents from disturbing the mist pattern.

Four levels of a commercial IBA hormone powder formulation, Hormex, were used to initiate rooting. Concentrations used were 8000, 16,000, 30,000, and 45,000 ppm. Ten cuttings were treated with each concentration per date.

Cuttings remained in the bench about 2½ months. Data were recorded on number of roots per cutting for each hormone level at each cutting date. The percentage of cuttings that rooted at each hormone level at each cutting date was calculated. The experiment was arranged in a randomized complete block design. Data were statistically analyzed using PC-SAS procedures.

RESULTS AND DISCUSSION

Seasonal variation and rooting. Nearly 100% rooting occurred in March and again in late June and late July. Figure 1 shows pooled data averaged for all hormone concentrations. Rooting exceeded

80% from June 20 to September 20 and then declined to a low of about 30% in January. Poorest rooting occurred in mid- to late May when the tree was making a growth flush. Cuttings taken on dates that gave the highest percentage of rooting also showed the largest number of roots per cutting. A small number of roots per cutting coincided with poor percent rooting (Table 1). This data suggests that *Cunninghamia lanceolata* 'Glauca' has a bimodal seasonal rooting curve with a narrow peak in late winter and a broad peak in mid- to late summer.

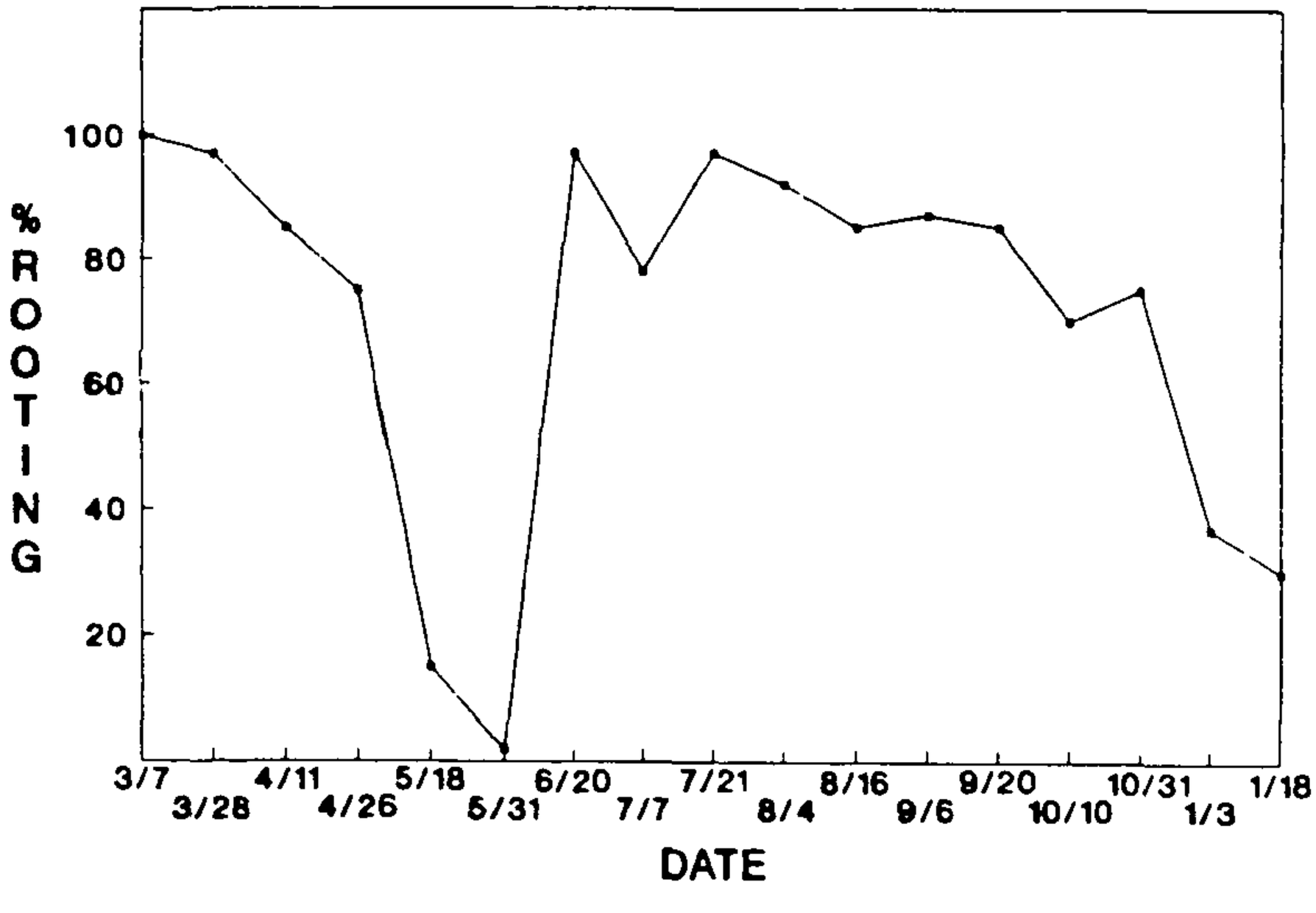

Figure 1. Effect of cutting date on percent rooting of blue chinafir

Hormone concentration and rooting. There was little effect of hormone concentration level on the rooting percentage of cuttings (Figure 2). Hormone concentrations of 8000 and 16,000 ppm were sufficient to induce an acceptable level of rooting. There were a few minor aberrations in the mean number of roots produced per cutting and in percent rooting. One occurred August 16 in which the mean number of roots was highest in the 45,000 ppm IBA treatment (Table 1). Another was the high rooting percentage in the 16,000 ppm IBA treatment on October 31 (Figure 2). These values are probably random effects due to the small sample size and should not be interpreted as being different from the general pattern.

Table 1. Number of roots formed per cutting of blue chinafir for each IBA level at each cutting date.

Date	IBA ppm				Overall Mean**
	8000	16,000	30,000	45,000	
3/7	5.7*	8.9*	9.8*	11.5*	9.0 bc
3/28	6 8	9.1	5.4	8.8	7 5 cd
4/11	6 8	5.0	5.1	6 9	6.0 de
4/26	3.3	3.5	4 6	6 7	4.5 efg
5/18	2.3	0.1	0.2	0	0.7 h
5/31	0	0	0	0 4	0 1 h
6/20	12 3	14 1	9 8	14.7	12 7 a
7/7	6.9	3.0	4.7	6 6	5.3 ef
7/21	9.7	8 4	7.5	8.1	8 4 bc
8/4	12.6	14 5	8.6	3.4	10 0 b
8/16	7.8	6 4	6 1	16.7	9.3 bc
9/6	8 0	5.3	6.2	4 8	6.1 de
9/20	7.8	6 9	5 2	3.2	5 8 e
10/10	4.6	5.5	2 8	2 0	3.7 fg
10/31	7.5	6 7	5 1	3.9	5.8 de
1/3	1.2	0 5	2.0	0.8	1 1 h
1/18	5.3	3.2	3 7	0	3.1 fg
Overall Mean	6.39a**	5 97 a	5 11 b	5.82 a	

** Means within a row or column followed by the same letter are not significantly different using Duncan's multiple range test at the 5% level
* Mean of ten cuttings.

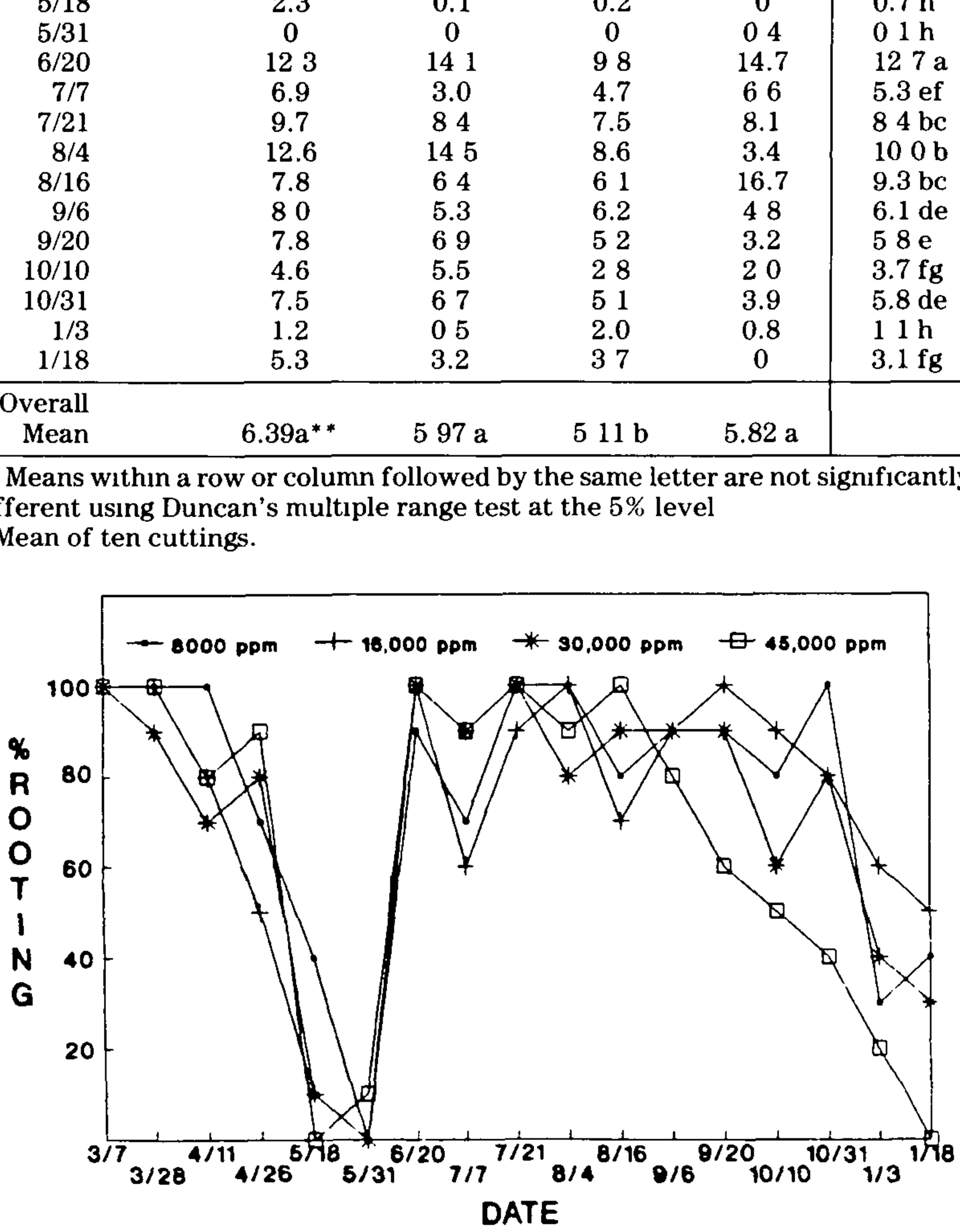

Figure 2. Effect of IBA level on percent rooting of blue chinafir at each cutting date

In summary, data collected on the rooting of *Cunninghamia lanceolata* 'Glauca' shows two periods when cuttings may be rooted successfully, one in late winter and one in late summer. Cuttings taken in late winter have only a narrow "window" in which they will root well while cuttings taken in late summer have a longer rooting "window". The 8000 and 16,000 ppm levels of hormone were adequate for satisfactory rooting and for root numbers per cutting.

A question yet to be answered is whether or not these rooted cuttings will grow into attractive normally-shaped small trees. We anticipate that topophysis may be a problem, with the lateral branching habit of growth persisting for a time. Therefore, further research is being conducted on methods to encourage development of the spiral or radial habit of growth of the central leader as opposed to the flattened 2-ranked planar habit of the lateral branches.

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SEXUAL AND ASEXUAL PROPAGATION OF NORTH AMERICAN RHODODENDRONS

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This paper will discuss the propagation of some of the native species of deciduous rhododendrons, more commonly known as native azaleas.

I believe the North American species of deciduous azaleas are some of the most beautiful of our native plants. Colors can range from white to yellow, orange, red, and pink, with almost any combination in between. Natural and deliberate hybridization have resulted in the availability of many superior forms in terms of bloom size, color, and adaptability.

Propagation is commonly by seed or cuttings. Seed propagation is simple, reliable, and economical, but the resulting offspring will usually be extremely variable. While this is an advantage for the hybridizer looking for new cultivars, it is a disadvantage to a commercial nursery trying to produce a predictable representative of a species.

Seed capsules are collected in the fall as they change from green to brown. They can be dried at room temperature by placing in a paper bag or an open container.

When dry, the capsules are broken open to release the seed. They can be rubbed through a screen or crushed by hand—we use an old coffee grinder. Separation of the debris of the capsule from the seed is not necessary.

The seed flats are prepared by first pressing a layer of peatmoss approximately 2 in. deep in a well-drained flat. Then, a thin layer of milled sphagnum moss is added to a depth of ¼ to ½ in. and thoroughly wet.

Seeds are then broadcast on top of this and watered in with a fine mist nozzle. The flats are kept wet until germination occurs, usually by 2 to 4 weeks. Disease problems are minimal during germination when sphagnum moss is used, so fungicide applications are not usually necessary until the seedlings start to crowd each other.

The seedlings can be pushed with liquid feed and transplanted in the spring, or can be held without fertilization until the next fall and then transplanted. Although this is much slower, they are easier to handle and require much less intensive care than with spring transplanting.

Propagation by cuttings can at times be difficult, and there is much variation among species in ability to root and survive. Very often, the problem is not getting roots but getting the rooted cutting to survive through the winter and continue to grow the next spring. Generally, from my experience, the easiest species to produce from cuttings are *Rhododendron viscosum*, *R. austrinum*, *R. canescens*, *R. flammeum*, *R. periclymenoides*, *R. prunifolium*, *R. oblongifolium*, and *R. arborescens*. The more difficult ones are *R. alabamense*, *R. bakeri*, *R. serrulatum*, and *R. calendulaceum*. Again, the problem is not usually rootability, but survivability.

The following recipe has proven to be the most consistently reliable so far for me. Cuttings 4 to 6 in. long are taken as early as possible from vigorous, preferably container-grown, stock plants. Cuttings are not stripped or wounded. They are dipped in 6000 ppm K-IBA and stuck in pots filled with straight pine bark then placed under mist.

After sticking, foliar feeding is begun at weekly intervals using 200 ppm N. Rooting usually occurs within 4 to 6 weeks. Liquid feed is continued after rooting to force the plants into growth, which will normally ensure survival through the winter and subsequent growth in the spring. The cuttings are over-wintered in a cool greenhouse kept above freezing and potted the next spring when growth begins.

The key factor in this method, especially with the more difficult species, is the liquid fertilization. The cuttings are maintained in a vigorous, healthy condition and, when rooting begins, are primed to begin vegetative growth. Hormone concentrations can be juggled to find the optimum range for root initiation; but unless the cuttings resume growth after rooting, success is not assured.

RECYCLING IRRIGATION WATER

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Water is the largest single ingredient involved in plant growth, yet it has generally been taken for granted, used inefficiently, and discharged uncaringly. After all, it's only. . . water! But times are changing; the population is growing; environmental concerns are increasing; and the quantity of available, good quality water is decreasing.

Water recycling is a relatively new factor that can have major implications on plant growth. At a few nurseries this has been a voluntary action (5), at others it has been mandated. Governmental agencies have essentially taken the position that whatever a nursery does to the water they use, they must live with in the future, via collection and recycling.

Four major changes in water occur as a result of collection and recycling. Pathogen populations build up, water chemistry changes, herbicides and weed seeds accumulate.

Pathogens. The pathogens are mostly the water molds *Phytophthora, Pythium, Rhizoctonia,* and others. Because earth is an excellent filter, most wells are pathogen-free. However, once the water flows across plant surfaces, leaches through containers, and bathes dead leaves, clippings, and other debris on the container-bed surface, it is a different story. Decaying organic matter carried along with or suspended in the water creates a haven for water-mold pathogens (6). These are the so-called root rots.

The worst of the lot is *Phytophthora* (6). When water is collected and recycled, the population of disease organisms generally increases dramatically. This increases the diseases pressure on the plant. For example, if there are 500 spores of *Phytophthora* per gallon of irrigation water, all plants may grow well with few, if any, noticeable complications. Plant roots are generally white at the tips and back some distance, depending on the species. If the spore population increases to 5000, those plants growing in areas where drainage around the container is poor are likely to show reduced growth, and inspection of the roots shows white root tips only. If the spore population reaches 50,000, many of the plants will grow poorly or die because of the severity of root damage. The slower the plants grow, the greater the stress level that may predispose them to some weaker pathogen that is not normally a problem. A prolonged rainy period may be the thing that tips the environmental

scale in favor of the pathogen, changing what looked like a fair crop into a disaster.

There are two practical treatments to reduce the pathogen load: chlorination and bromination. Water can be chlorinated by either granular calcium chloride on a small scale or gaseous chlorine on a larger scale. The key is having enough free chlorine (about 0.5 ppm) in the water for sufficient time (roughly one minute) to kill the pathogens. Various techniques have been used to increase exposure time such as double-loop intake lines or injection of the chlorine in the surface water where it enters the suction line. The pump's impeller further aids mixing.

Daughtry (3, 4) provides good information on the experiences of using gaseous chlorine at Lancaster Farms, Suffolk, Virginia. It is important to remember that chlorine gas is very hazardous and must be handled with adequate safeguards.

The newest technique for control of water-mold pathogens is the use of Agribrom. The concentration required is higher than for chlorine (5 to 10 ppm of free residual bromine vs. 0.5 ppm chlorine) but it is safer to handle and is reported to be equal to, or better than, chlorine in pathogen control in irrigation water. Exposure time is about the same as with chlorine (about one minute) (2).

Water chemistry. Recycled water will, in nearly every case, have a mineral composition different from the original water source. In a case where the container nursery operates with black poly over the soil surface, the mineral composition of the water may be lower in the collection reservoir. This is because the growth medium in the containers absorbs some of the minerals such as calcium, magnesium, sodium, potassium, and some of the micronutrients. Further, if any soil contacted by the water during its flow back to the reservoir is highly leached and acidic, some additional bases may be removed. On the other hand, if the container beds are lime rock or some other material containing a soluble element, that element is likely to be found in the reservoir.

It has been my experience that surface-water sources tend to have a much lower mineral composition than well water. Water in wells percolates through the soil, ultimately accumulating in a sand or rock strata beneath the surface. In many areas, the key material through which the water must percolate is limestone. Even though the solubility of limestone is quite low, it does dissolve sufficiently to change the chemistry of the water. In areas where the rainfall is acid or increases in acidity after moving through highly acid soils, the limestone below is dissolved more rapidly, thus hastening the rise in dissolved minerals. This change does not occur in water that accumulates after running across the surface of the soil.

Two cases are worth noting here. In one case, the nursery takes its water from a stream that originates in a soil area of nearly pure

sand that is very acid. The pH of the water is about 5, but there are few minerals in the water. When this water percolates through containers, it very quickly dissolves the dolomite used as a calcium and magnesium source. The result is severe magnesium deficiency, mild calcium deficiency, and very unattractive plants. The solution is to switch to a much less soluble source of magnesium, magnesium oxide, (7, 8, 9) and to coarse granules of calcium carbonate to reduce particle surface area. Increasing the size of the particle of a material with moderate water solubility extends the time required for it to be dissolved.

In the other case, a nursery has a good supply of irrigation water, but the water is high in bicarbonates. Sulfuric acid is injected to reduce the bicarbonates to a level that will not cause foliar damage. The pH of the water is lowered from about 7.8 to 6.2. This is a desirable practice, and the lower pH of the water creates no complication or injury to the crop directly. However, the nursery was designed with limestone-covered beds and roadways. When the acid water runs over and percolates through the lime rock, the calcium level in the water rises from the base level of about 70 ppm to over 200 ppm.

In this case the calcium increased dramatically, but the magnesium increased very little due to the composition of the limestone. The problem was two-fold. The level of magnesium must be increased to narrow the Ca:Mg ratio to about 2:1, and the level of micronutrients in the growth medium must be increased to minimize the negative effects of the high calcium. Since there is no practical treatment for the removal of calcium dissolved in water, the effective approach is to minimize its negative effects. In most cases water from the original water source can be blended with the recycled water to provide a mineral composition suitable for plant growth (5). However, in nearly every case, some adjustments in the additives to the base mix are required because of changes in water chemistry.

A few other suggestions. DO NOT inject any micronutrients into irrigation water. Minimize the use of liquid fertilizers to reduce algae and weed problems. Good slow-release systems are available that contribute very few nutrients to the runoff water and in turn, make recycling less complicated.

Herbicides. Recycled water will reflect the practices used in the nursery. If a water-soluble herbicide is used anywhere in the system, it will be in the accumulated water. Do not treat the soil/gravel surface beneath containers with Princep (simazine). With a water solubility of 3.5 ppm and at the rates used for soil sterilization, Princep will be in the recycled water returned to the crop. It will accumulate in containers over time and will damage most species other than conifers.

While visiting a container nursery several years ago, I was asked if I would look at some problems they were having with yaupon holly. After looking at tops and roots of several holly, I asked to see their barberry. I was told they had all died. Then I asked to see althea, rose-of-sharon. Same reply! Then how about crapemyrtle? Same reply! I then asked if the gravel-covered container beds had ever been treated with simazine. Yes, just last spring because another nursery was doing it and said it worked well. The difference was that the other nursery did not recycle their water.

My advice is never use an herbicide with a water solubility greater than 1 ppm in a container nursery. The preemergent herbicides (and their water solubility in ppm) that fall in the *desirable* category are Goal, 0.1; Ronstar, 0.7; Treflan, 0.3; and Prowl (pendimethalin), 0.5; and probably Galaxy, 1.0 (1).

The undesirables are Surflan, 2.5; simazine, 3.5; Devrinol, 75; Lasso, 242; Pennant or Dual, 530; and Karmex, 42. Every recycle catch pond should have a silt collector. This can be a shallow pond above, a grass vegetation area to slow the water, or some other technique. Even with very low water solubility herbicides, some can accumulate in the recycle pond. However, the desirable products will be attached to soil and organic particles and will be dissolved in the water only in extremely low levels. Thus, if the silt and organic matter are allowed to settle out before reaching the main reservoir, the problem can be minimized.

Weeds. Seeds of some weed species are very small. It has been my experience that nurseries that recycle their water have a much greater problem with prostrate spurge than those that do not. The seed is very small and will pass through most screens and orifices.

I have irrigated from a surface water supply for many years, and the clues began to mount. In years when the reservoir was low, and by July the exposed soil around the water line was covered with prostrate spurge, our problems in the containers were much greater. In the next year the reservoir was high all season; our problems with spurge were minimal. It took a layer of a very finely woven fabric suspended in an empty 10-gal. container and several waterings to find the seed. Interestingly these seeds were very viable. In later studies with spurge seed collected in the fall, the seeds would not germinate. It is as if they have a built-in sensor and know not to germinate unless in a container!

The practical solution appears to be a fine sand filter, in combination with the vegetation trap and one or more silt ponds above the major collection reservoir.

Sanitation. Since the water that returns to the recycle reservoir has bathed nearly everything in the nursery, it can be either a real cesspool or a pristine pool, depending on the management of the

nursery. My advice is to rogue out diseased or problem plants consistently, control water mold pathogens with chlorine or bromine, monitor and adjust nutrients in the mix as indicated by the chemistry of the water, control weeds everywhere including roadways, ditches, and banks of the reservoirs, and monitor plant growth and health closely. Concentrate on preventing problems rather than treating for, or trying to cure, problems later. Water frequently, but lightly, so as to minimize runoff. My recent studies suggest that this not only minimizes runoff but enhances plant growth and quality as well.

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EFFECT OF ETHYLENE AND JUVENILITY ON ADVENTITIOUS ROOT INITIATION

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Ethylene was shown to induce root initiation by 1933 (13), yet its use remains controversial and has not been accepted commercially (9). Juvenile cuttings root easily but the reason is not well understood. The purpose of this report is to propose a relationship between ethylene and juvenility to explain easy rooting of juvenile cuttings.

Juvenile physiological development. Juvenile growth of plants is physiologically controlled by two principal growth regulator systems. Gibberellins and cytokinins promote cell division and cell elongation while auxins and cytokinins further control growth through apical dominance (8). Other growth-regulating systems exist, but these two should be given prime consideration when explaining root initiation.

Ethylene is known to be an ever-present growth regulator with multiple functions (8). It has an important role in healing, where it is known as wound ethylene (1). In my research, ethylene was released from poinsettia, *Euphorbia pulcherrima* Willd., cuttings and improved root initiation was obtained from applying ethylene as ethephon (Figure 1). Mudge (9) reported that ethylene stimulated rooting in 68% of 52 plant species. Variability of research reports leaves some uncertainty concerning its application to all plants. However, for poinsettia, improper research procedures (2, 11) were the cause of negative results.

Poinsettia cuttings treated heavily with ethephon develop yellow leaves that abscise, indicating movement of metabolites from the leaf. Recent research supports the idea that such mobilization is caused by ethylene (12). Kinetin prevents mobilization (8) and senescence of leaves, but kinetin-treated poinsettia cuttings remained green and failed to root.

Endogenous cytokinins are produced in all meristems of plants, but movement from root meristems is considerable (8). The cutting is deprived of this source of cytokinin since it has no roots. This deprivation combined with the mobilizing effect of ethylene would be expected to mobilize metabolites for rooting. The interaction of ethylene and cytokinins was tested by applying ethephon at rates sufficiently high that abscission should occur and following the

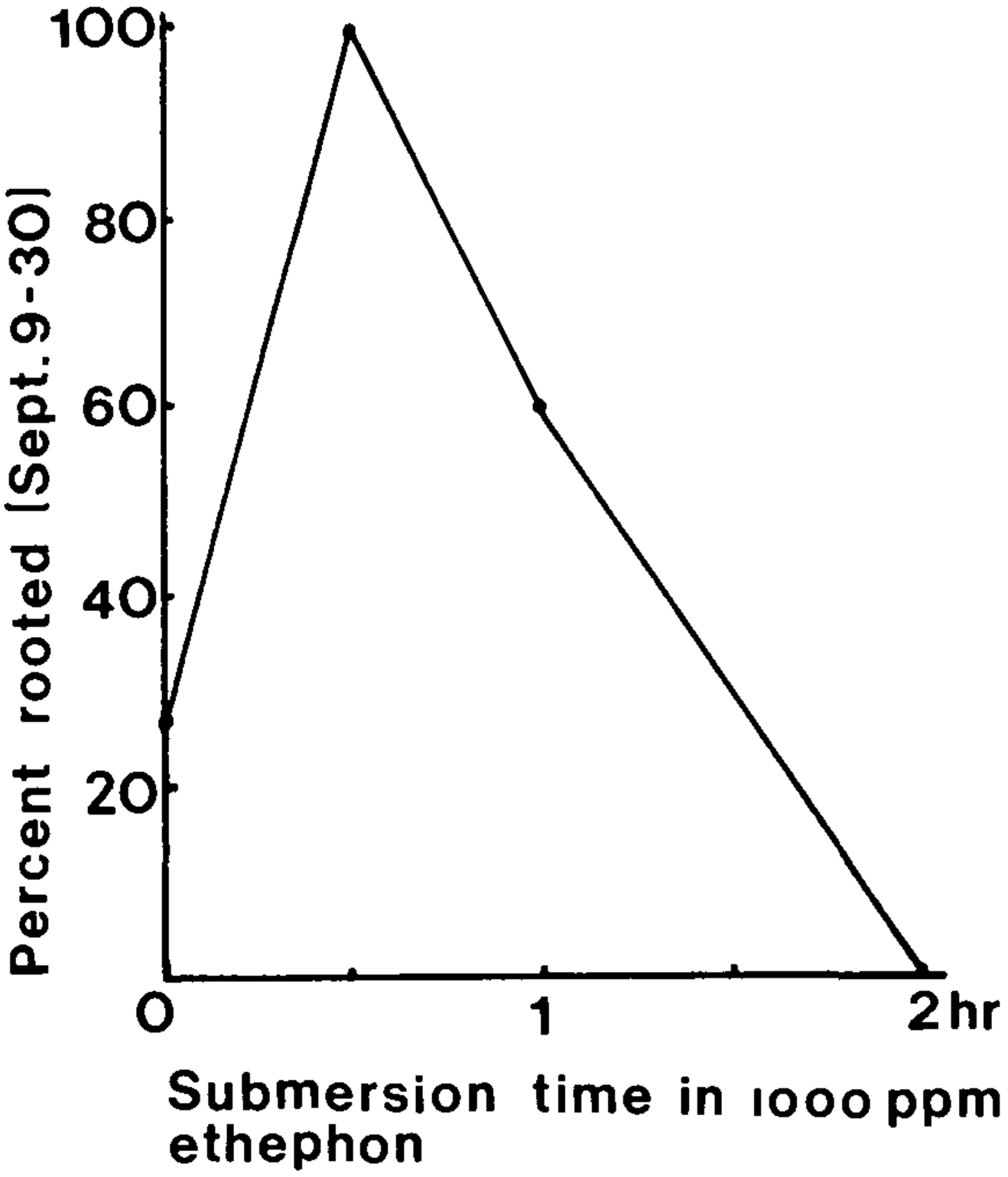

Figure 1. Percent rooting of poinsettia cuttings after submersion in 1000 ppm ethephon (Ethrel) for 4 durations Average deviation from the mean = 9%

ethephon with kinetin treatments. Vigorous rooting was accomplished without leaf abscission, but application rates were very difficult to manage. These results indicated that an ethylene-cytokinin balance is important for the rooting of cuttings and is in accord with the results of Fabijan, *et al* (4).

Ethylene is also released in response to auxin (1,5,8,9). Auxins move from the top of the cutting downward and accumulate at the base of the cutting. Auxin-mediated release of ethylene is consistent with stress-induced release of ethylene if the reaction to concentrated auxin is considered traumatic. While

auxin-induced ethylene accounts for some of the rooting response, it does not account for all of it since low concentrations of auxin are required for root growth. The need for an ethylene-cytokinin balance and an ethylene-auxin activity indicates that cuttings from juvenile mother plants root easily if trauma-induced ethylene is balanced with existing growth regulator systems.

Mature physiological development. Mature woody plants are characterized by the onset of flowering. The large number of shoots (twigs) on mature plants reduces the amount of water and nutrients available per shoot. The long shoots typical of juvenile plants become the short and often spur-like twigs of mature woody plants. Short shoot growth indicates that growth of mature plants is suppressed more than on juvenile plants. The dominant growth-suppressing hormone is abscisic acid though many others are known (8).

Cuttings from mature mother plants may contain larger quantities or different types of growth suppressors (3,10). They appear to interfere with root initiation by preventing new shoot growth. New shoot growth promotes the initiation of vascular tissue from which new roots can develop. Growth-inhibitor suppressed mature cuttings are generally released from dormancy and resume new shoot growth before rooting. Deciduous cuttings of crape myrtle, *Lagerstroemia indica*, and kiwifruit, *Actinidia deliciosa*, regularly grow shoots with mature leaves before roots emerge. Cuttings of some species are too weak to root after growing leaves and die (7).

Root initiation of cuttings often follows callus formation. Callus and vascular growth result from relatively differentiated cells, generally parenchyma cells. Cell division from this type of cell apparently is initiated by ethylene since ethylene initiates adventitious roots (13). Ethylene-induced cell division must not be suppressed by abscisic acid or other growth regulators since callus formation occurs on almost any cutting whether dormant or not. Callus tissue results from a proliferation of cell divisions to form a mass of undifferentiated cells. Differentiation of roots can occur from callus (6). Conditions in the cutting must be favorable for root initiation since shoots have also been observed to be initiated from callus. The more common occurrence is a change in color from white to brown or red. Root initiation is generally very slow on cuttings with colored callus.

Results of my research indicate that ethylene has an active role in root initiation. The interaction of ethylene with other growth regulators is proposed to be part of the healing process that began when the cutting was removed from the mother plant.

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AFTER THE FIRST FORTY, WHAT IS NEXT?

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It is a tremendous pleasure to be back in Cleveland, and to see many friends, including several charter members. What I'd like to do this morning is to take us back through the first 40 years and trace some of the major developments that took place in the area of plant propagation and then finish up with a glimpse of the future.

The big challenge for propagators—in particular, propagation by cuttings—is to control moisture loss from the cuttings during the period of rooting. One of the early approaches to controlling water loss from cuttings was the bell jar. Although it works very well, you have conflicting demands of trying to keep the moisture contained, but at the same time not trapping too much heat from sunlight. As a result, you have to work with shading to keep the temperature under control, but the reduction of light reaching the cuttings reduces photosynthesis, which is essential for the production of carbohydrates and other substances used in root initiation and growth. This is a "Catch 22" situation if there ever was one. The bell jar technology was scaled up to the commercial level in the form of the Wardian case. Although more efficient in terms of handling large numbers of cuttings, the same problems were there. That is, the need to retain moisture and the liberal use of shade to prevent overheating. This combination of requirements restricted the range of plant materials that could be propagated by cuttings. During the evolution of the Plant Propagators Society, plastic films were introduced facilitating cutting propagation. Although plastic film gave us some new conveniences, we were still battling the basic problem of reducing moisture loss and maintaining reasonable temperatures through the use of shade.

There were some novel approaches that people used to try to address this challenge. Guy Neering in New Jersey developed the "Neering Frame." Neering built a frame which was exposed to the north with a large reflector on the south side. By this design, the cuttings received reflected light which provided reasonable light intensity without the heat. An even more novel approach was Leslie Hancock's operation in Canada, called the "burlap cloud" method of propagation. After the cuttings were stuck in outdoor frames, burlap was stretched over the cuttings. The burlap was frequently sprayed with water during the day. The evaporating moisture from the burlap kept the humidity high which reduced moisture loss from the cuttings, the process of evaporation

provided cooling which also reduced moisture loss from the cuttings, and burlap also provided shade. At the end of the day, Hancock removed the burlap and the cuttings were allowed to "breathe."

During this period, extensive use of root promoting substances such as indolebutyric acid (IBA) and naphthaleneacetic acid (NAA) emerged. I remember one preparation called "Chloromone" that created a lot of interest. The manufacturer said he used the "two by four" method of extracting the preparation from young alfalfa shoots. Our tests indicated that it contained a high concentration of a substance that looked very much like NAA. However, the combination of NAA with a plant extract may have had a synergistic effect.

But even with root promoting substances, propagators were continuing to seek better ways to root cuttings and to extend the range of materials propagated. A number of researchers found that by adding humidity to the air, such as by the Binks humidifying system, the space around the cuttings could be larger and higher light intensities could be used. The space in the bell jar or Wardian case was kept small because it was desirable to have a small air volume which took less moisture to build high levels of humidity. This was important because the source of the humidity was moisture evaporating from the cuttings and the medium until an equilibrium was reached inside and outside the cutting. The disadvantage was that the small space would also heat up quickly when exposed to direct sunlight. By adding moisture from an external source, such as the Binks system, less moisture was lost from the cuttings and they remained turgid, and the space around the cuttings did not have to be confined. Cuttings could also be taken earlier (softer) after the new growth in the spring. Cell division is more active in the soft or less mature cuttings, and they are easier to root.

Investigators then discovered that even better results could be obtained if the cuttings were sprayed with a fine mist. When a film of water was maintained directly on the leaves of the cutting, there was no longer a need to confine the air surrounding the cuttings. Cuttings could be propagated in full light intensity and even out of doors. Originally, oil burner nozzles were used to provide the mist. But they frequently clogged and self-cleaning nozzles were introduced, followed by impact nozzles. The latter design, in which a fine stream of water is directed against a flat surface, became the industry standard.

Refinements on the mist system of plant propagation continued to be made. We were able to show that an intermittent form of mist was better than constant mist. The advantages were that when leaf temperatures were not lowered below optimum, there was less leaching of nutrients from the cuttings, and the medium was better

aerated and less likely to be water logged. Other advantages were that less water was used and drainage problems were reduced. A variety of control systems that provided intermittent mist during daylight hours evolved, including timers, and "electronic leaves" and similar devices based on the principle of evaporation. As the film of water from the "leaf" evaporated, the circuit was broken and a relay turned the mist on to reestablish the water film. Once the film was reestablished, the mist was shut off. Other systems used the weight of the water film to "trip" an on/off switch. The advantage of the latter systems of controlling the mist applications was that they were "weather conscious" and applied more mist during bright sunny weather and less on cloudy days.

Mist propagation represents one of the major breakthroughs that occurred in the formative years of the Society. We asked the question, why was it that we could get such high levels of rooting under mist compared to the conventional approaches to rooting softwood cuttings? In our work we measured the temperature, the rate of photosynthesis, the rate of respiration, and the carbohydrate content of cuttings under mist and compared them to cuttings in the standard Wardian or grafting case. As you would expect, the leaf temperature under mist was much lower, an average of 75° F, as compared to 86° F in the Wardian case. Full light intensity could be used with cuttings under mist. In the greenhouse at Ithaca, New York, light intensity averaged 7000 ft-c in the summertime. In the Wardian case, with the necessary shade, the light intensity was 240 ft-c. The combination of higher light intensity and lower leaf temperature (and a corresponding lower respiration rate), resulted in net accumulation of carbohydrates in the cuttings under mist of 138 mg per cuttings. There was little or no increase of carbohydrates in the cuttings in the Wardian case. Dogwood cuttings (*Cornus florida* 'Rubra') were used in our experiment. The rooting percentage under mist was 96% compared to 22% in the Wardian case. Because the environmental conditions under mist provided a net gain in carbohydrate production, it was possible to use very immature or soft cuttings. Even though soft cuttings may have a very low level of carbohydrate reserves at the time of taking the cuttings, the mist conditions provided the environment in which the carbohydrates and other substances essential for rooting could be synthesized and used in root initiation and growth.

In addition to the internal factors which appear to help explain the success experienced with mist propagation, there was much less disease experienced under mist conditions. One explanation was the fact that the cuttings were turgid and able to manufacture carbohydrates, and the cells were less susceptible to invasion by pathogens. Another factor is the fact that the intermittent

application of mist may have washed fungal spores or bacteria from the leaf surfaces. Also, the presence of a film of water and cool temperatures may have inhibited the germination of some spores. In contrast, the environment of the Wardian case with high humidity and high temperatures was almost ideal for the development of molds.

Propagators continued to experiment. One of the leaders of innovation was Harvey Templeton. Harvey developed the phytotector method of plant propagation. He combined some of the advantages of mist and some of the older techniques of using a polyethylene tent with some shade. The cuttings were rooted directly in the soil. The combination of mist and a plastic tent resulted in the cutting tissue being kept turgid by the application of the mist, with reasonably high temperatures that stimulated root initiation.

Another innovator is Bruce Briggs from the State of Washington and a frequent attender of the Eastern Region meetings. Bruce decided he would do away with the rooting medium and used styrofoam sheets to support the cuttings with the base in the dark, but in the air rather than in a rooting medium. The concept of rooting and growing plants with the rooting in the air continues to be explored, including developing systems of growing plants in space stations. The examples I have just given are an indication of the tremendous amount of creative activity that was shared at these early meetings. Everyone left with a whole new set of ideas to try in their own operations. We went from a group of professionals who guarded our practices and actually padlocked our propagation units, to an open sharing of ideas. The result was that almost everyone gained new ideas and tremendous progress was made in the field of plant propagation.

Although mist propagation was a major advance in the field, there were still many challenging questions to be answered. For example, why were there a lot of plants which just could not be propagated by cuttings, even when mist propagation was used? We began asking questions about what was going on inside of cuttings that made some easy to root and others difficult. We used *Hedera helix* as our experimental material. You are most familiar with it in its juvenile form as a very easy to root ground cover. The mature form, which is found on the tops of walls or trees, is very difficult to root. When you do get a cutting of the mature form to root, it will grow into an upright shrub. Juvenile cuttings form roots very well without any root promoting substance, but they also show a significant increase in the number of roots when NAA is applied. In contrast, cuttings of the mature forms root poorly and also show little response to the NAA treatment. This is one of the common observations in propagation—the more difficult to root a cutting

is, the less its response will be to auxin-type root promoting substances, such as IBA and NAA. So the question is, why? What is going on or not going on within the cutting to make the big difference in rooting ability? One important observation to make here, and I will refer to it later in my presentation, is that the juvenile and mature forms of *Hedera* are found on the same plant. Therefore, we are working with the same genetic material, even though there is a tremendous difference in the rooting ability of the two forms. Something within the ivy plant is turning some genes on to express juvenility—horizontal growth, lobed leaves, anthocyanin production and easy rooting—or to express maturity—upright growth, entire leaves, a lack of anthocyanin, the ability to flower and being difficult to root. This makes *Hedera* a particularly valuable plant in which to study root initiation. There are great physiological differences between the two growth forms, including rooting ability, but the genetic makeup is the same.

Other investigators studying difficult to root grape cuttings found that if hardwood grape cuttings were soaked in water for a period of 24 hours, the cuttings became easier to root. They suggested that an inhibitor had been leached out of the cuttings. To support their hypothesis, the researchers applied the leachate to easy to root grape cuttings and they became more difficult to root. Another approach is to look for evidence of root promoting substances. For example, we grafted scions of juvenile ivy on cuttings of mature ivy and found that the presence of the juvenile tissue enhanced the rooting response of the mature cutting. So now we have evidence of the presence of both root inhibiting and root promoting substances.

In the 1940's and 1950's, procedures had been developed to extract and biologically assay growth promoting and inhibiting substances in plants. So we applied these techniques to juvenile and mature *Hedera* tissue. The tissue was lyophilized (freeze dried) and extracted with ethanol. The extract was concentrated and spotted on a paper chromatogram—a strip of filter paper. The paper was dipped into a solvent which, as it ascended, separated the mixture of substances into individual components. The paper was dried and cut into sections for biological assay to determine if growth promoting or growth inhibiting substances were present. The biological assay was cylinders of tissue from oat coleoptiles whose growth in length was proportional to the amount of growth promoting substances present. Since there was some elongation of the coleoptile sections even without growth promoting substances, it was possible to also measure the presence of inhibitors. We used the biological assays on dormant and growing *Hedera* tissue.

We found that the *Hedera* tissue extracts contained both growth promoting and growth inhibiting substances. Growing tissue

contained more growth promoting and less growth inhibiting substances, as would be expected. However, although there were slightly higher levels of growth promoting substances in the juvenile tissue, the differential from the mature tissue did not seem substantial enough to account for the great difference in rooting ability. Also, there was not enough difference in the amount of inhibitors present to account for the difference in rooting. In fact, in growing *Hedera* tissue, the inhibitor content of the juvenile tissue was slightly higher than that of the mature tissue.

We then decided on another approach. We developed a new biological assay which was based on root initiation rather than cell elongation. In retrospect, this makes sense since we are interested in substances which regulate root initiation. Our bioassay was based on the rooting of cuttings made from mung bean seedlings. The mung bean germinates quickly, and the cuttings were small enough that you could place ten cuttings in a shell vial with the chromatogram section much in the way we had done with the oat coleoptile test. The cuttings rooted in about six days. The number of roots on each cutting was counted, and an average for the ten cuttings in each vial was determined. The results were expressed in the number of roots per chromatogram section. Len Stoltz, Charlie Heuser, and Dale Herman, all here today as members of the Eastern Region, and who worked on the root initiation studies as graduate students, had a lot of experience in counting roots on mung bean cuttings.

Using the mung bean bioassay, we did find differences between the extracts from juvenile and mature *Hedera* tissues. There were four major peaks of activity in the juvenile tissue with a couple of smaller peaks in the mature tissue. Since the substances appear to react synergistically with indoleacetic acid (IAA), we called these peaks of activity "rooting cofactors." Using the data from the *Hedera* experiments, we developed a working hypothesis about the rooting ability of cuttings. If a cutting was easy to root, then all four rooting cofactors would be present, along with an adequate supply of IAA, carbohydrate, and nitrogenous substances. If a cutting was difficult to root, it may lack enough IAA and this could be supplied with a synthetic root promoter such as IBA or NAA. But as I have pointed out, the more difficult to root cuttings do not respond to IBA or NAA. In this case, one or more of the cofactors may be missing and the degree of difficulty would be an expression of how many of the cofactors were not present in adequate levels.

One of the rooting cofactors seems to be a phenolic compound. Phenolic compounds are active in the mung bean bioassay and work synergistically with IAA. We also found that the structure of the phenolic compounds determined their ability to stimulate root initiation. Root initiation was stimulated only when the hydroxyl

groups on the benzene ring were next to each other in what is known as the ortho position.

While studies on the physiology of rooting were going on, there were also a lot of accomplishments being made in the field of plant tissue culture, which is another major breakthrough that benefitted the field of plant propagation. Initially, propagators cultured the growing points of plants to produce virus free plants. In using this technique for orchids, propagators observed that the growing points proliferated and produced what they called protocorms, each of which produced an individual plant. Plant scientists then found that it was possible to generate plants from callus tissue. Subsequently, other investigators found that the callus could be separated into single cells, each of which could produce a whole plant. When Sid Waxman and I were graduate students at Cornell in the early 1950s, the famous English plant physiologist, F.C. Steward, introduced the term "totipotency" to describe the fact that each cell in a plant contained all the genetic information that was required to form another whole plant. We now know that the information is included in the DNA located primarily in the nucleus. Another variation of this theme was discovered by J.P. Nitsch, a member of the Society and the major professor of Sid Waxman and myself. Not only could you develop a plant from a cell, you could also do it with a pollen grain. But here there was a difference. Since the pollen grain is a product of meiosis, it contains only one set of chromosomes rather than two sets. Therefore, the plants generated from pollen grains were haploid. But they could be treated with colchicine which would double the chromosomes and return the plant to the diploid status. The resulting plant would be homozygous, an advantage for plant breeders looking for the expression of recessive traits.

While horticulturists were doing all this good work with tissue cultures, scientists in medical schools were looking at the chemical structure of the chromosomes and the genes located on them. They discovered deoxyribonucleic acid (DNA) and that they were able to snip out pieces of DNA from the chromosome and in this way isolate a single gene. They found that it was also possible to reinsert that gene into a plasmid, a circular piece of DNA. The plasmid, with the new gene, could be put into a cell and, using the horticultural techniques of tissue culture, regenerated back into a whole plant. So we have seen during the past forty years the whole concept of genetic engineering and molecular biology evolve. It is now possible to take a single gene from one organism and put it into another.

A couple of examples will give you an idea of what we can expect in the not too distant future from this new technology. Scientists were looking for resistance to the broad spectrum herbicide, Roundup. They found resistance by growing bacteria in a solution

of Roundup. A few survived, and the survivors differed from the non-survivors by a single gene. The gene was isolated from the resistant bacteria and, using a plasmid, it was inserted into a plant. The plant now had resistance to Roundup and that resistance was passed on to future generations of the plant. This showed that the new information was incorporated into the genetic information in the plant.

A similar approach was used to develop insect resistance. The tomato hornworm can defoliate a tomato plant overnight. As you may know, you can use biological control for tomato hornworm. The product is called Dipel, and it is a culture of bacteria that produces a highly specific protein that is toxic only to the tomato hornworm. The disadvantage to using Dipel is that you have to reapply it frequently because the active material is destroyed by sunlight. It turns out that the toxic protein is produced by a single gene in the bacteria. That gene has been removed from the bacteria and inserted into tomato plants. The tomato plants can now produce their own protein which is specifically toxic for the tomato hornworm and is safe over humans and even other insects. Given the public concern for impact of agricultural chemicals on the environment, this approach to speed the development of genetic resistance to insect pests has great economic and environmental potential.

In addition to adding resistance to herbicides and insects, it is also possible to regulate growth and development processes such as ripening. The genes regulating the process of fruit ripening are being identified. In one case the gene has been removed, turned around, and reinserted into the plant. The result is that the gene produces less of the substance involved in ripening and the ripening process is slowed. The research is being conducted with tomatoes. Conceivably, it will be possible to pick a tomato when it is "vine ripened" and by slowing the balance of the ripening process, it can be shipped to the consumer firm rather than in the form of a puree.

Now, what does the future hold? It turns out that there are many hundreds of thousands of genes in every plant and scientists are beginning to map them. Some genes are called housekeeping genes. That is, they are in every part of the plant and they are turned on all the time. They are being expressed. There are genes in other parts of the plant that only get turned on at certain times; so there are genes that are turned on when flower initiation takes place, or turned on for pollen formation. In fact, one of the latest accomplishments is the identification of the gene that regulates pollen formation. By regulating this gene, it has been possible to turn that gene off and make male sterile plants. This is a great advantage when producing hybrids where you want to avoid self pollination.

Well, what has all this to do with plant propagation? Let us return to our story of juvenility in *Hedera*. As I mentioned earlier, we have an example in *Hedera* in which the same genetic material behaves very differently at different stages of growth, including the ability to root. What is happening is that different genes are being turned on or off to produce the juvenile and mature stages of growth. For the future then, our challenge is to identify those genes that are turned on to provide the juvenile stage, and more specifically the genes that are turned on to give easy rooting. By knowing the genes, it will be possible to also identify the specific substances that are involved in the process of root initiation and growth.

We have been through a tremendously exciting 40 years with the Society. We have seen the discovery and use of plant growth substances and their application in root promotion, substances like IBA, NAA and others; we have seen mist propagation expand the range of plant material propagated from cuttings as well as increasing the efficiency of propagation; we have gotten a better understanding of the complex nature of root initiation; we have watched the development of plant tissue culture and the growth of plants from single cells; and finally, we have entered the world of molecular biology or genetic engineering in which we can move genetic information, one gene at a time, among totally unrelated organisms. It has been an extraordinary 40 years, but we are really just at the beginning of the biological revolution. We now have the tools to ask questions and get answers in a way we have never been able to do before. Even the question "What makes a cutting difficult to root?" should be finally answered in the next forty years!

PETER ORUM: It is my pleasure to next introduce our program chairman for this meeting. He is a hardworking plant propagator, and a very good friend, Clayton Fuller.

CLAYTON FULLER: Thank you, Peter. I am very pleased to be here with you and I would like to thank all the speakers and moderators for their willingness to seek and share. Our moderator for this morning session is Robert E. Schutzki.

ORNAMENTAL ASIAN CLIMBING VINES FOR THE PACIFIC NORTHWEST

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One of the major components of the University of British Columbia Botanical Garden is the David C. Lam Asian Garden which is set in native coastal forest. This fortunate setting has enabled us to grow a number of choice and unusual climbing plants into and up many of the native trees, which include *Abies grandis*, *Tsuga heterophylla*, and *Thuja plicata*. The natural effect of growing vines in this way has stimulated others to use them in a similar fashion in the Vancouver landscape. This paper briefly describes a number of these choice vines, their culture and propagation.

An outstanding member of the Hydrangeaceae family is *Schizophragma hydrangeoides*. It climbs to 12 m (40 ft) on the bark of trees and bears a mass of creamy-white flowers in July. The reddish new shoots are particularly attractive. Provenances from Japan have shown some interesting variations in foliage color, particularly in the more glaucous-blue colorations. It is effectively propagated from seed following a 10 to 12 week cold stratification period at 1 to 3 ° C (34 to 38 ° F). Alternatively, it can be propagated in June using nodal tip cuttings or single nodal cuttings with two opposite buds. An effective hormone treatment is 0.5% IBA in talc. The most easily rooted cuttings are those obtained from non-flowering shoots near the base of the plant. These shoots often have pre-formed root initials. A particularly desirable form of *S. hydrangeoides* is 'Roseum' which has bracts that are flushed pink.

Another self-clinging species of the Hydrangeaceae family is *Pileostegia viburnoides*, one of the few evergreen climbers in our collection. It is significantly slower growing than *Schizophragma*, and produces panicles of creamy-yellow flowers during the late summer. Minimal seed propagation has been tried at the Botanical Garden, but it does root effectively during July-September using 0.5 to 0.8% IBA in talc.

A rare *Actinidia* species that we have obtained recently is *A. hemsleyana*. This vigorous, narrow-leaved species grows to over 10 m (35 ft) and is unique because of the bright red soft bristles on the new growth. It may be propagated from single nodal cuttings during June-July using 0.8% IBA in talc.

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[1] Director

An under-rated, vigorous, evergreen climber in the Lardizabalaceae family is *Stauntonia hexaphylla*. Our experience has shown that this species is considerably more hardy than originally thought. The monoecious flowers are white tinged with mauve and appear in April. Successful fertilization will produce fleshy purple fruits in the fall. The species is easily propagated in 4 to 6 weeks using single nodal cuttings in July-September and 0.5% IBA in talc.

An outstanding honeysuckle from China is *Lonicera tragophylla*, which has particularly attractive new growth followed by large golden-yellow flowers in June-July and red berries in the fall. It is equally effective in the landscape on pillars and arbors or grown naturally in evergreen and deciduous trees. This species is best propagated from nodal tip or single nodal cuttings in May-July, using 0.3% IBA in talc. Alternatively, it may be propagated under glass as winter hardwood cuttings in January, using 0.8% IBA in talc. It can be slower rooting than other *Lonicera* species.

A rare species of *Aristolochia* that deserves to be more widely cultivated in gardens is *A. heterophylla*. This Chinese species has interesting small, purplish-brown and yellow flowers in the form of a miniature "Dutchman's pipe". It can be propagated by softwood single nodal cuttings during May-June, using 0.5% IBA in talc.

Sinofranchetia chinensis is a little used, hardy, deciduous climber belonging to the Lardizabalaceae family. The young shoot growth is covered with a purplish bloom, and rather insignificant white flowers are produced in May. Clusters of lavender-purple fruits should arise in the fall providing that male and female plants have been grown together. Propagation is by single nodal cuttings in June-early July, using 0.3% IBA in talc.

A vine that excels in the Pacific Northwest is *Vitis coignetiae*. This vigorous species has large heart-shaped leaves that turn orange-scarlet in the fall, and is excellent for training up large coniferous trees. I have not yet seen this species listed in any catalogue in this region, but we are currently in the final process of having it virus-tested with the cooperation of the Plant Quarantine division of Agriculture Canada, Sidney, BC. Propagation is best carried out using single nodal cuttings in May-July, with 0.5% IBA in talc. Winter propagation is effective in January-February, using vine eyes or nodal cuttings 20 cm (8 in.) long.

A climber in the Asteraceae (Compositae) family that is not widely known is *Senecio scandens* from eastern Asia. The yellow daisy-like flowers appear in July and continue to bloom into October. The species grows up to 5 m (16 ft) tall, and is particularly useful for sheltered walls or scrambling over tree stumps or shrubs. It is not

hardy but can be treated as a herbaceous perennial in colder climates. The species is best propagated from seed following a 6 to 8 week cold stratification period at 1 to 3° C (34 to 38° F).

Finally, mention should be made of a little-known herbaceous climber that belongs to the Campanulaceae family and is native to western China and the Himalayas. *Codonopsis* species are normally tuberous although some do produce multiple stems. We have had considerable success with *C. convolvulacea* by allowing it to grow through rhododendrons. The lavender-blue, star-shaped flowers are particularly effective in mid-summer against the dark green foliage of the rhododendrons. *Codonopsis* species are best propagated from seed.

Only a few of the many climbing plants growing in the David C. Lam Asian Garden have been described in this paper. Most genera and species are readily propagated, but considerable care and time is needed in their production and marketing. However, it is in the landscape that climbers are really under-utilized, and we still have many imaginative ways in which they can be used.

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PROPAGATION AND PRODUCTION OF TEXAS FIELD-GROWN ROSE BUSHES

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Abstract. Texas is the second largest U.S. producer of field rose bushes, having a 20 million dollar industry New techniques are needed to reduce the 2-year production cycle and increase the yield of Texas field rose bushes There are advantages in simultaneously bench chip budding and rooting. Chip budding was successful using both manual techniques and a Liliput grafting tool, while parafilm strips were the most effective graft wrapping material. To establish the optimum time for rose propagation, leafless hardwood cuttings were harvested from field-grown stock plants and propagated in raised field soil beds at intervals of 2 to 4 weeks from November to February Cutting position had no effect on percent rooting, however basal cuttings had the lowest root number. Starch content was positively correlated and nitrogen negatively correlated to rooting. Maximum rooting of cuttings for field propagation was from 15 November to 15 December, which also corresponded to a low N and higher starch content in propagules harvested from stock plants.

Under present practices, often less than 65% of hardwood cuttings initially planted are harvested as marketable No. 1 rose bushes. New techniques are needed to more effectively produce field roses that are individually handled 20 to 25 times during their 2-year production cycle (Table 1). Objectives of these outlined studies were: (1) to investigate simultaneous bench chip budding and rooting as a more efficient system for producing field roses, and (2) to analyze basal, medial, and apical cuttings for seasonal rooting, and to correlate seasonal rooting changes with carbohydrate-nitrogen ratios.

Table 1. Two year field rose production cycle, East Texas, USA Grading, storage and packaging processes have been omitted

Nov., 1990-Jan., 1991	*R. multiflora* hardwood cuttings placed in field for rooting
March-July, 1991	T-budding of *R multiflora* understock with budwood collected and stored from late fall, 1990
Oct -Dec , 1991	Breaks from *R multiflora* understock used as hardwood cuttings
Jan -Feb , 1992	Scion budwood, which was forced during previous season, is cut back to prevent scion damage before *R multiflora* understock is cut back by machine
Feb -March, 1992	Budded *R. multiflora* understock cut back by machine to encourage scion bud break
Oct -Dec , 1992	Rose bushes pruned for budwood and later dug and processed for storage and shipping

RESULTS AND DISCUSSION

Chip Budding and Rooting. There are advantages of simultaneously bench chip budding and rooting which would eliminate production steps since cutting switches, de-eying cuttings (removing lower axillary buds to prevent suckering), and budding can be done at the same time indoors during the "downtime" of winter, reducing time and discomfort to the worker who would bud on a bench vs. conventional T-budding in the field. Other advantages of bench chip budding are budding onto dormant understock vs. field seasonal rainfall dependence on T-budding to maintain active understock cambium; with chip budding the production cycle may be reduced since a 3 to 6 month advantage may be gained in the development of the scion.

Successful bud unions occurred with both the Liliput budding tool and manual budding techniques (Table 2). Poorer responses occurred with manual chip budding of 'Blaze' budwood on the indexed understock which may have been attributable to smaller bud pieces used; it has been our observation that 2 to 3 cm bud pieces are more effective in chip budding of dormant rose understock. Parafilm was more effective than traditional budding rubbers used by growers, by acting as a protective barrier and possibly reducing desiccation.

Table 2. Effect of bench chip budding by manual technique and by Liliput budding tool using Parafilm strips and budding rubbers when budding 'Blaze' and 'Climbing White American Beauty' to the rootstocks *Rosa multiflora* 'Brooks 56' and a disease-indexed *R. multiflora* free of spring dwarf and mosaic virus. (2)

Treatment		Bud union (%)			
		'Blaze' scion		'Climbing White American' 'Beauty' scion	
		Rootstock		Rootstock	
Budding method	Wrapping material	'Brooks 56'	*R. multiflora*	'Brooks 56'	*R. multiflora*
Manual	Parafilm	87a[1]	53b[1]	93a[1]	80a[1]
	Budding rubber	67b	27c	67b	73a
Tool	Parafilm	93a	93a	87a	87a
	Budding rubber	80a	87a	67b	80a

[1] Values followed by the same letter are not significant at the 5% level.

Simultaneously bench chip budding and field rooting has the potential for improving production efficiency of field rose bushes in Texas. There are obvious labor advantages in utilizing a Liliput tool for chip budding with nonskilled laborers. Parafilm wrapped 2 to 3 times around the graft is more effective than conventional budding rubbers since some girdling and tissue necrosis occurred

with budding rubbers; grafts were buried under the soil and budding rubbers were not subjected to ultraviolet light breakdown, which normally happens in the above ground T-budding process.

Seasonal Rooting Response. There was a significant relationship between percent rooting, root number, and propagation date. The highest percent rooting and root number occurred from 15 November to 15 December (Table 3). Cuttings taken during cooler periods (30 December to 15 January) had decreased rooting (42%), while low rooting in February (37%) was attributed to the competing sink of axillary bud growth which had begun on stock plants by this time (axillary bud growth was observed, but not quantified). Root number was highest on cuttings propagated from 15 November to 15 December, which may also be attributable to a more moderate temperature and sufficient precipitation levels for non-irrigated field propagation.

Cutting Position. There was no difference in cutting position for percent rooting of field-propagated *R. multiflora;* however, basal cuttings had the lowest root number (Table 3). This agrees with unpublished rooting studies with *Rosa indica* (M. Raviv, personal communication, 1989).

Table 3. Seasonal rooting and starch.N ratio and total carbohydrate·N ratio of field-propagated *R multiflora* 'Brooks 56' hardwood cuttings.

	Percent rooting	No. of roots per cutting	Starch·N ratio	Total C:N ratio
Propagation date				
Nov 15	72.5	7.9	11.1	13 1
Nov. 30	85 8	7 1	11·1	15.1
Dec. 15	80.8	5 6	8·1	12.1
Dec 30	39.2	1 8	5 1	8.1
Jan. 15	44.2	2 3	6 1	8:1
Feb. 15	37.5	2 2	5.1	7.1
Cutting position				
Apical	58 3a	4.5ab	—	—
Medical	65 8a	5 4a	—	—
Basal	55 8a	3.5b	—	—
Significance				
Month (date)	**	**	—	—
Position	NS	**	—	—
Month x position	NS	NS	—	—

Chemical Composition, C/N Levels and Rooting. Starch levels decreased and N levels increased in propagules harvested from stock plants toward the end of the propagation season, which corresponded with poorer rooting capacity (Table 3). In addition,

high starch content was positively correlated and high N negatively correlated with rooting. Brandon (1), using nonquantitative KI histological staining techniques, was unable to find a correlation between the starch content and ease of adventitious root formation of selected *Rosa* species. This contrasts with the positive correlation of high starch accumulation and rooting of our research, and may explain why KI histological observation has not been a widely used test for the commercial determination of cutting fitness to root. Stored forms of carbohydrates, such as starch, are needed for the rooting of hardwood cuttings that are leafless and unable to photosynthesize (3). During highest field rooting (15 November to 15 December), all three cuttings types average 0.85% N, and during low rooting (30 December to 15 February) N increased to a combined average of 1.03%. Optimum and supraoptimum levels of N have been reported to play a role in the rooting of *Vitis* (5).

CONCLUSIONS AND RECOMMENDATIONS

Mid-November through mid-December is the optimum period for propagating *R. multiflora* 'Brooks 56' hardwood cuttings. This roughly corresponds to the time of planting presently used by many Texas rose producers, even though growers will plant as early as 30 October and as late as 15 February to use available labor. Successful early propagation dates will most likely depend on the prevailing climatic conditions, with adequate rainfall and cool temperatures being advantageous. Planting after 30 December in Texas would not be advisable based upon these data and another seasonal study (4). Collection of cuttings and field planting is advisable at temperatures $\geq 5°$ C, as cuttings in this and another study (unpublished data) planted under colder conditions failed to give satisfactory results. The apical and medial sections of the *R. multiflora* canes were generally the best position to take cuttings for propagation.

C/N ratios appear to be important for optimum periods to harvest propagules from stock plants. An 11-8:1 starch:N, and 15-12:1 total carbohydrates:N, were desirable levels for optimum rooting, and as C/N decreased below these levels, so did rooting. N levels also appeared to be an important predictor of rooting potential. When all three cutting types averaged 0 to 0.85% N, high rooting occurred vs. 1.03% N when rooting was low. The importance of N in rooting underscores the potential for stock plant manipulation through fertilization practices, since low to moderate N fertility will help increase starch levels, C/N ratios, and rooting success. Currently, rootstock plants of *R. multiflora* are not fertilized during the first year of commercial production, after which cuttings are taken for the next crop rotation. Future research implementing simplified

screening tests for starch and N in determining C/N ratios could improve industry propagation efficiency for field rose production.

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URBAN HORTICULTURE—BASIC HORTICULTURE FOR THE NEXT DECADE

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Simultaneous establishment of many formal urban horticulture programs has occurred within the last decade. One of the first to be established was the Center for Urban Horticulture at the University of Washington (7). Now in its tenth year, the Center has established the following program priorities: to build a national center for scientific research; to train leaders in research and professional practice; to build an interdisciplinary program; to build a system for distributing information; and to develop advocacy for trees in cities.

The following summary emphasizes several areas of research and public outreach currently in the Center's programs.

ENVIRONMENTAL STRESS

Researchers have shown that when one part of a plant is stressed, often another part of the plant responds in some way in order to increase the plant's chances of survival. In the laboratory directed by Dr. Barbara A. Smit (2), they are studying the means by which long distance signaling occurs within plants.

In one system being used, specific leaves on plants of a hybrid poplar *Populus* × *generosa* (*Populus trichocarpa* × *P. deltoides*), were wounded (as often occurs with insect feeding). This wounding elicits the production of substances in other leaves which are thought to be defense proteins. This can tentatively be thought of as a "plant immune response."

Specifically, a leaf (labeled as number 9 position) was wounded. After a specific period of time, all of the leaves from positions number 9 upwards to number 3 were assayed for chemical responses. In this instance, both the number 9 and number 4 leaves showed the same response. We already know that these two leaves have direct connections by which the leaf at position number 9 feeds sugars to the growing leaf at position number 4. Now researchers are trying to determine the nature of the other materials.

Understanding this type of defense mechanism may enable us to genetically manipulate plants to enhance their resistance to insect and disease problems. It certainly could have implications for plant production in the future.

PLANT INTRODUCTION THROUGH CLIMATE ANALYSIS

The ease of travel has opened new international vistas for the exchange of plant materials. However, this further emphasizes the need for better determination of genetic background, which ultimately determines how well a plant will grow in a new area. Plant introduction studies of Dr. Clement Hamilton are using a type of diagram developed during the years 1960 to 67 by Heinrich Walter and Helmut Lieth (5). This uses a series of diagrams of temperature and rainfall which takes into account the duration of cold seasons, rainfall total, and seasonal patterns of temperature and precipitation.

As an example, Figure 1 depicts the climatic information for Seattle, Washington. The horizontal axis (Figure 1a) represents January to December in the Northern Hemisphere (July to June in the Southern Hemisphere). The vertical axis has divisions for each 10°C (temperature) and 20 mm (precipitation). In Seattle, the temperature curve (Figure 1a) illustrates that the average daily temperature is highest in the summer and lowest in the winter. The precipitation curve (added in Figure 1b) shows higher winter rainfall. If you superimpose the two curves, the relatively humid season (shown as vertical shading Figure 1c) and relative drought (dotted pattern) appear. When the precipitation exceed 100 mm per month, the area under the curve is colored black.

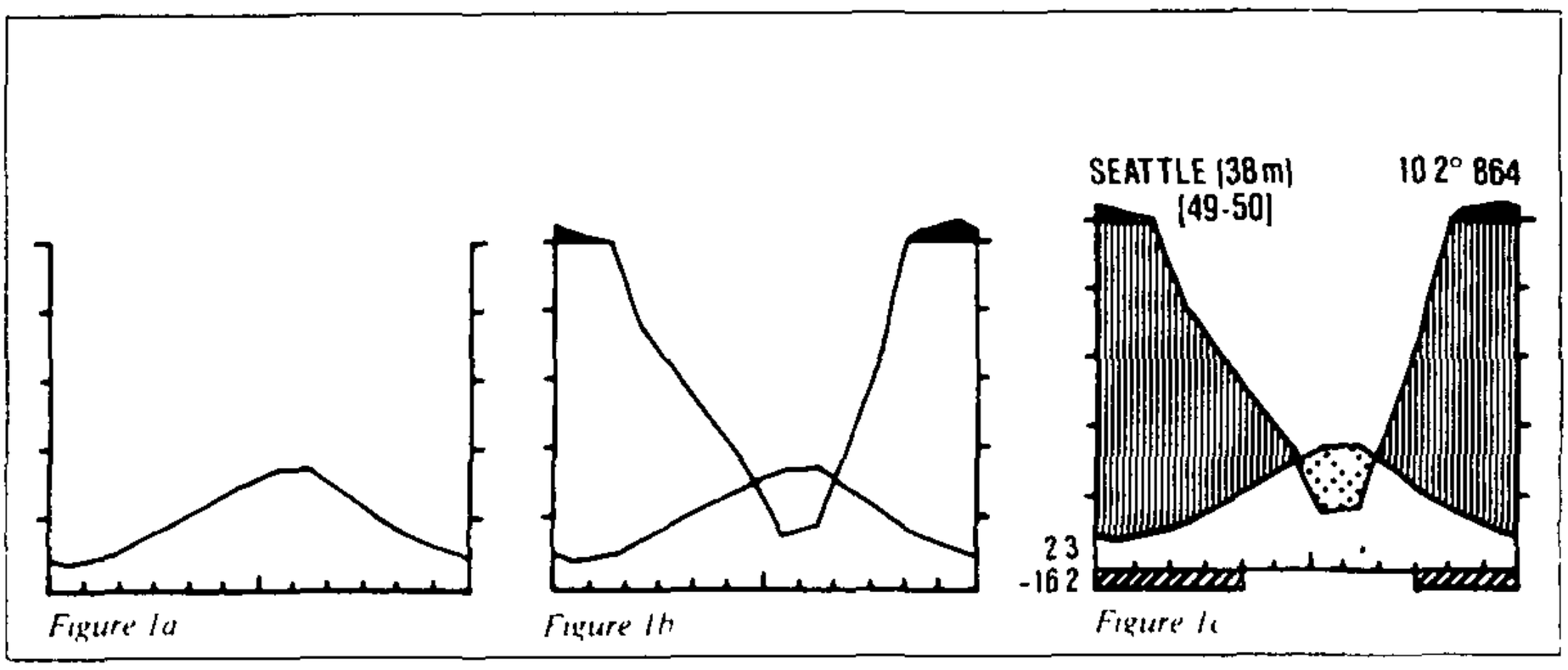

Figure 1. Development of the Seattle, Washington, U S A diagram, number 360 on the North America map of the Klimadiagramm-Weltatlas, redrawn by Karen Krager. (Reprinted by permission of the The Public Garden)

The horizontal bars across the bottom of the diagram (Figure 1c) indicate what months the temperature usually drops below 0° C at least once (diagonal shading). The top number, 2.3 is the mean daily minimum of the coldest month. The lower number (-16.2° C) is the coldest temperature on record.

The number in parenthesis to the right of the station's name indicates that Seattle's elevation is 38 m above sea level. The numbers below show that the graph is based on 49 years of data for temperature and 50 years for precipitation. The numbers in the upper right corner represent annual means, i.e. the average temperature in Seattle is 10.2°C and the average annual precipitation is 864 mm.

Dr. Hamilton and Ms. Reichard have used the above information to select an area for a collection trip to Southern Chile in 1988, an area with a similar climate to Seattle. From this trip, several plants, including *Orites* and *Embothrium* are now being tested (6). In addition, the natural forests of *Araucaria* were evaluated. Similar studies are needed in order to evaluate the potential of future plant introductions.

SELECTION AND EVALUATION OF URBAN TREES

The massive nursery production industry has grown highly sophisticated through the agricultural-type of research conducted by multitudes of Land-Grant institutions. In an effort to produce a large number of similar plants in as short of period of time and at the most efficient cost, ease of propagation and transplantation are among the criteria for efficient nursery production (Table 1).

Table 1. Criteria for nursery production of trees (from J R Clark)

Market potential of the crop
Ease of propagation
Ease of transplantation
Responsive to intensive culture

The qualities of an "ideal" street tree are listed in Table 2. Urban forestry professionals such as Dr. James R. Clark (1) are now actively involved in trying to develop vigorous testing and evaluative techniques for plants in the urban environment. This includes studies on selection, growth habits, durability, longevity, and stress resistance.

Table 2. Qualities of an "ideal" street tree (from J R Clark)

Moderate size	Hardy
Regular upright form	Minimal litter
Deep-rooted but not invasive	Durable and fast-growing
Stress tolerant	Solar-friendly
Pest resistant	Easy to transplant
Excellent ornamental features	Strong wood compartmentalization
Not responsive to artificial lighting	

It is apparent that the nursery production environment with its intensive cultural techniques is totally dissimilar to the urban environment in which the nursery plants are then planted (Table 3). Nurseries most often occur in rural areas, with moderate climates, usually have agricultural soils, and use intense fertilization, irrigation, pruning, and pest management. In urban planting areas, temperature extremes are common, soils are highly disturbed, and management intensity is moderate or minimal. Moreover, urban areas possess an abundance of people.

Table 3. Comparison of nursery production to street tree program (from J R Clark)

	Shade tree nursery	Street tree program
Primary goal	Production	Management
Product	Tree	?
Rotation length (yr)	2 to 4	50 to 100
Intensity of culture		
—irrigation	High	Low
—nutrition	High	Low
—pruning	Annual	3 to 10 year cycle
—pest management	High	Minimal

The Center has also been instrumental in bringing together professionals in many diverse areas of urban forestry, all of whom have some type of management responsibility in urban street trees. In January 1990, municipal foresters, community planners, community activists, politicians, landscape architects, public utility officials, arborists, urban forestry professionals, and educators attended an informational forum entitled "Your Community Trees—Asset, Not Liability". During the program, the new *Urban Forestry Notebook* (4) designed for use by public agency employees who have responsibility for urban trees, was unveiled. This 90-page 3-ring hardbound notebook was a cooperative project between the Washington State Department of Natural Resources, Puget Power Company, and the Center for Urban Horticulture.

NATURAL WETLANDS

Natural wetlands are coming under increasing pressure from urbanization. Because of expected or observed degradation, regulatory agencies are requiring management, restoration, and creation of wetland systems. These activities often require the incorporation of new planting material (3).

The major causes of failure of new plantings in wetlands include: a) choosing the wrong species, b) incorrect timing of planting, c) failure to match environmental conditions with plant requirements (which may include nutrient levels, organic material, periods of

both soil saturation and lack of aeration). The research of Dr. Kern Ewing will look at the specific requirements of three indicator species (*Carex spp.*) and three trees with potential utility for restoration (*Alnus oregona* [syn. *A. rubra*], *Populus trichocarpa, Fraxinus latifolia*). He is also conducting studies on plant responses to increases in heavy metal concentrations and to hydrologic perturbations.

PUBLIC OUTREACH

Continuing education and public outreach continue to be a top priority in the Center's programs. Programs are currently conducted for kindergarten through college-age students, general and enlightened public, professionals in horticulture, urban foresters, landscape architects, and multitudes of plant enthusiasts. In addition, professional graduate programs are now producing graduates for employment in urban horticulture/forestry fields.

The program directed by Dr. John A. Wott currently has the highest number of annual contacts of any continuing education unit on the University of Washington campus (Table 4). Classes, lectures, demonstrations, and guided tours are held on both the Union Bay headquarters site and in the 200-acre Washington Park Arboretum. In 1989, over 8000 participants attended 94 seminars as part of the second annual Northwest Flower and Garden Show in the Washington State Convention Center.

Table 4. Total Number of Contacts in Continuing Education and Public Outreach, Center for Urban Horticulture, 1989

Type of activity	Number of programs	Attendance
Public lectures	54	1,085
ProHort seminars	21	704
Special activities	31	1,236
N W Flower Show seminars	90	8,000
Arboretum tours	142	1,995
Miller Hort Library tours	31	545
Community lectures	55	3,255
Other arboretum activities	84	2,000
Miller Hort Library contacts		3,019
Graham Visitors Center contacts		38,688
Master Gardener contacts		1,975
Horticulture organizational meetings	95	2,457
Hort Shows/plant sales	8	4,650
Total	611	69,609

Continuing education and public outreach are the last step in bringing the latest scientific research in urban horticulture to audiences ranging from school children to professionals. It is

important that proper public understanding is developed and also that professionals implement new procedures.

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THE NEW ZEALAND CALLA

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The calla lily (*Zantedeschia*) is not new to floriculture. Members of the genus have been cultivated in greenhouses or outdoors in Mediterranean climates for many years. The New Zealand hybrid calla with its diversity in colour and form is the focal point of a current revival in popularity amongst florists.

Papers on the topic of callas appear in recent volumes of the IPPS Proceedings. One of the most significant was a paper presented by Cohen in 1981 (2) detailing his work on micropropagation of callas. This work opened the doorway for commercialisation of a crop that was previously slow to clonally propagate in large numbers.

In 1983 Hatch (4) outlined procedures involved with breeding and selecting hybrid callas. This was followed in 1986 by a paper I authored entitled "A system for the evaluation of *Zantedeschia* (calla lily)" (7). In 1988 I joined with Plummer to co-author a paper entitled, "Preliminary evaluation of dwarf white calla lily as a potted plant" (10).

This paper will describe the evolution of the calla into a commercial crop for New Zealand and it will discuss the problems and opportunities encountered.

THE GENUS

The term calla lily misrepresents the true classification. The genus *Zantedeschia* correctly belongs to the family Araceae. It is more closely related to the caladium and does not have the same habit and cultural requirements as found in true lilies. There are six known species in the genus *Zantedeschia* (5):

Z. jucunda	deciduous, yellow (not used horticulturally)
Z. aethiopica	evergreen, white flowers
Z. rehmannii	deciduous, small pink flowers
Z. albomaculata	deciduous, cream flowers
Z. elliottiana	deciduous, yellow-gold flowers
Z. angustiloba [syn. *Z. pentlandii*]	deciduous, yellow/gold

Over 50 years of crossing and selecting the last four species has produced the present range of cultivars available in New Zealand. *Z. rehmannii* has enabled breeders to produce a smaller growing species, with lanceolate leaves more suitable for pot plant

production. *Z. elliottiana* has given greater size to spathe, leaves, and flower stems for cut flower production.

The deciduous types form an underground tuber which is dormant over winter. Growth and flowering is not greatly affected by daylength; however, plants must undergo a rest period (6 to 8 weeks) before growth will resume. The growing cycle ranges from 16 to 24 weeks and the rest period can be induced by cold or dry periods. Form and habit vary among the named hybrids. Leaf shape is lanceolate, hastate, or sagittate (lance, spear or arrow). Leaves can be heavily spotted with white markings through to plain green. Plants are either monopodial or sympodial in branching habit depending on the cultivar. Established plants range in natural height from 30 to 150 cm tall.

The "flower" is composed of a central spadix which bears the true male and female flowers, a coloured spathe and a scape (flower stem). The top of the flower spathe is round or pointed in shape and the front can be open or semi-open. Flower quantity is dependent on cultivar, tuber size, storage treatments, and growth regulator applications. One to three flowers can be expected from a 4 to 5 cm diameter tuber. The flowers are green at macrobud stage and gain full colour upon opening. After pollination flowers often deepen in colour, begin to re-green, and then close. Re-greening occurs from four days to 21 days after opening depending on the cultivar (7).

PROPAGATION

The true species are propagated by seed. Many of the small flowered pink, yellow and cream cultivars available to growers are produced by seed with the majority of seed-grown tubers originating from a California nursery. Breeders in New Zealand are currently working in the direction of making more cultivars available true-to-type from seed, however the range is still very limited.

The early hybridizers in New Zealand used natural division of tuber offsets as a means of propagation from the early 1900s to the 1980s. Bulking up of plant material in this way is slow and conducive to carry over of bacterial and viral diseases. While natural division is an acceptable method for cut flower growers to increase stock, it is not a realistic approach for commercial tuber production.

The technique for micropropagation developed at the Division of Scientific and Industrial Research (DSIR), Palmerston North, was a milestone for the commercial development of callas. Initiation in culture is simple and multiplication rates are high (2). The tissue culture of callas has enabled propagators to rapidly bulk up a wide

range of selected clones which would not come true from seed. Callas are one of the ariods which suffer from the aphid vectored virus. Provided material is indexed as clean when initiated, tissue culture is the only means of ensuring clean propagules (11).

TUBER PRODUCTION FROM TISSUE CULTURE

Once plantlets are removed from the flask they require two growing cycles before they reach a natural flowering size of 4 to 5 cm in diameter (8). With each growth cycle, consisting of 4 to 5 months growing and a 6 to 8 week rest, natural flowering-sized tubers can be achieved in just over 15 months if greenhouses are used for out-of-season forcing. Tuber production can be cycled for year-round production, particularly when shipped from one hemisphere to another.

FLOWER FORCING

Forcing for cut flower production can occur at any time of year provided soil temperatures can be maintained at 13° C minimum. To obtain high quality flowers with strong stems and vibrant colours, light levels must be high, but temperatures in excess of 25 °C must be avoided. New Zealand growers use open field production techniques for flowering the crop over summer under natural flowering conditions. Tubers are planted early and late in the season under protected environmental structures to extend the harvesting period to cover 6 months.

Flowering productivity is greatly enhanced by the use of gibberellic acid GA_3 (3). Yield increases range from 200 to 400%. Treatments at 25 to 500 ppm have been reported as being successful (9). The use of GA_3 treatments are also important for pot plant production, not only to increase flower number but also to ensure that 100% of the tubers flower. This is particularly important when smaller planting material is used.

Potted plant production of callas has met with only limited success. The hybrid coloured callas do make attractive flowering plants when treated with GA_3 to increase flowering, and with Bonzi® (paclobutrazol) as a soil drench to reduce plant height (6). Post harvest keeping qualities are not good with the coloured callas when they are kept under low light. The dwarf white calla has adequate keeping qualities under low light conditions making it a suitable choice for production as an indoor potted plant (10). The hybrid coloured callas make excellent patio pot plants as they require high light to produce flowers true to colour.

BREEDING OF NEW ZEALAND HYBRIDS

Calla lilies have probably been grown at Kew and other European botanic gardens since the discovery of South Africa's flora. At the turn of the century, Luther Burbank, a noted early plant breeder in California, was making many crosses within *Zantedeschia* using some or all of the deciduous species mentioned above. His work yielded several horticultural cultivars (1).

There is no record of when the first zantedeschias were introduced into New Zealand. A 1912 Yates Bulb Catalogue does list three species and cultivar selections bearing names used by Burbank. One can only surmise that early introductions were brought in directly from Africa or from horticultural collections in California and Europe. There appears to have been an abundance of amateur breeders making crosses in the early 1900's. However, most of the cultivars available in New Zealand appear to be the result of three hybridisers, each working independently. Brljevich of Maungaturoto, began breeding in 1932, Matthews of Waikanae, started collecting and breeding in 1946, as well as Harrison who was active in the 1960s.

Today's commercial hybrids have been selected from gene pools created by the above mentioned plant breeders. Hybridising is continuing amongst some calla growers with the intention of improving characteristics important for commercial production. Their objectives include improvement of: stem strength, plant habit, flower forms, colour purity and diversity, productivity, and disease tolerance.

New Zealand has inherited a world leadership role in the development of new calla cultivars and their commercialisation. To maintain this world leadership will be a challenge for the New Zealand floriculture industry.

As quantities of calla tubers began to build up in the mid-80s a two-pronged export industry in callas began to emerge. Calla tubers for export to pot plant forcers and calla cut flowers for shipment to overseas flower markets were both achieving near equal returns. Exports of both products have remained near equal from 1986-90; however exports of tubers have suffered from difficulties. As a result, two of the three major tuber exporting companies have withdrawn from the calla industry. The majority of tuber exports from New Zealand now originate from cut flower growers selling surplus stock.

TUBER EXPORT DIFFICULTIES

Too much disease in exported tubers has been a common complaint. Bacterial soft rots (*Erwinia*) are often the cause of losses when forcing callas in artificial environments, i.e. soilless potting

mix and warm humid greenhouses. The pathogen is always present in calla crops to a certain degree and over the years calla growers have learned to manage the disease with better cultural practices. These include: good aeration in the medium around the tuber, avoiding excessive overhead irrigation, and starting with plant material that is not more than two growing cycles from tissue culture as opposed to field divisions.

Virus can also be another disease problem in callas. The main virus which infects callas is Dasheen Mosiac Virus (DMV). It is spread by aphids and is systemic in the plant once infection occurs. New Zealand propagators are now beginning to have mother stock virus indexed prior to initiation into culture. Again, for health reasons tubers for flower forcing should be two cycles from tissue culture.

Marketing difficulties have also slowed the growth of tubers for export to the Northern Hemisphere.

Tuber growers have, in the past, been guilty of producing tubers only when it suited natural growing conditions. Grades and standards have not been rigourously set and adhered to, resulting in customers often receiving undersized material. The price structure has been based on cost of production and producer/broker profit margins, resulting in a low return product for potplant producers facing market set pricing for the end product.

Product performance of tubers destined for pot culture do not always meet up to customer expectations. Uniformity of forcing time is complicated by lack of information on individual cultivars and pre-planting storage history. Coloured calla flowers fade under low light conditions after 5 to 10 days, reducing the shelf-life dramatically as an indoor pot plant. Lack of knowledge of growth regulator requirements has also lead to poor flowering and leggy plants.

CALLA INDUSTRY OPPORTUNITIES:

1. *Production of calla tubers for export from virus indexed tissue cultured material under protected environments.* This will greatly minimize disease occurrence and provide tubers ready for forcing at the time of greatest demand for pot forcers (winter and spring).

2. *Promotion of pot callas as an outdoor patio plant.* Callas will perform for 6 to 8 weeks in flower true-to-type if kept outdoors under full light or partial shade. The foliage will continue after flowering for a further 6 to 8 weeks.

3. *Propagation of small tubers (2 cm diameter) for growing on in the Northern Hemisphere or tropical areas.* This will allow for year round supply of calla tubers ready for forcing.

4. *Expansion of cutflower production.* A recent study by the New Zealand Trade Development Board showed that both demand and production levels will continue to increase (11). The cut flower section of the calla industry has a good reputation for quality and consistent grading standards. The product is available at a time of year when demand is high, October to April. Producers are now gaining adequate experience to control harvesting dates through staggered planting and losses from diseases are under control. Calla flowers are exported to Japan, Europe, North America, and Hong Kong. They command a high price and are used by "up market" florists in these countries. The potential for market development and further expansion of the cut calla industry is promising.

5. *World leadership in callas.* New Zealand is currently the leader in coloured calla production and marketing. This leadership position, however, has largely been acquired by chance. To continue to lead, the industry is starting to develop and implement a strategic plan. This plan will incorporate efficiency in: production technology, new product development leadership, a market development programme, strong industry organisation and co-operation, and accurate information systems on industry performance.

CONCLUSIONS

In conclusion, the calla industry in New Zealand has gone through the growing pains of developing a new crop for international floricultural consumption. The future growth in export of ornamental horticultural crops from New Zealand is likely to occur from new crops. Most will have a similar development pattern as was experienced with callas. The lessons learned from the calla industry will greatly assist development of future new crops for the world to enjoy.

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THE IMPORTANCE OF GARDEN FESTIVALS TO THE NURSERY TRADE

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Garden festivals as a concept originated in Germany after World War II. They were conceived as a vehicle to attract attention to the urban renewal programme that was necessary as a consequence of war dereliction. It was considered that gardens and greenery were the best means to entice residents and investment to an area that had been devastated by the war. The colour and spectacle of a Garden Festival was seen as the ideal means to create a new image for an area.

The first garden festival was held in Dusseldorf in 1952. Since then, Germany has hosted many other garden festivals.

German festival sites are planned and planted over a 10 year period, so that all plants are very well established by the time the gates open to the public. After the Festival, these sites become new important high grade open spaces or parks for the host city.

The Garden Festival movement is controlled by the Bureau Internationale Exhibitions (BIE) in Paris. Various countries, around the world submit bids to host Garden Festivals and from these bids certain sites are selected. The process is somewhat similar to selecting an Olympic site and I believe the lobbying and politics can be just as intensive.

The approval by the BIE gives the event status and prestige. Adjudication of competition is by panels of judges approved by the BIE and the Association of International Professional Horticulturists (AIPH). International entries will not and do not participate in non-approved events. A grade 1 garden festival corresponds to a world festival. Seville, Spain hosts the grade 1

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in 1992. A grade 2 approximates to a Continental event and this status has been granted to Columbus, Ohio. The connection between Seville, Spain, Christopher Columbus, and Columbus, Ohio is a powerful link that will generate enormous worldwide media coverage.

In this paper, I will set out the reasons why nursery people should participate in garden festivals based on our involvement in three festivals to date. We supplied grasses for a Grass Garden at the Liverpool Festival in 1984. In the Glasglow Garden Festival we created a grass garden. This attracted a lot of media coverage, was nominated the most innovative and imaginative garden in the Festival, was awarded a gold medal and was declared the overall winner of its particular section. In 1990 we designed and built the Irish garden at Expo '90 in Osaka, Japan. This garden was also awarded a gold medal and was adjudicated in two competitions as the best garden in the festival, beating entries from 81 other countries and 53 international organisations.

The publicity generated for Ireland as well as our own business is immeasurable. The cost of purchasing such publicity as advertisements would be the equivalent of $20,000,000.

Why should nurseries be involved in a garden festival? Why should they take time out from their busy production schedules to familiarise themselves with the rules of entry, the construction and exhibition regulations, and the standards required by a Garden Festival? More particularly, why should a wholesale nursery with no contact with the public involve itself in something from which it can have no direct feedback or benefit. Is it not more natural and sensible that it leave such activities to the garden plant retailers and landscape contractors who can measure the direct dividends of their involvement in such a promotion?

Unfortunately, nurseries elsewhere have not confronted these questions. They have asked, but then arrived at the convenient conclusion that they should not get involved. By Irish standards we are a large nursery, by British standards we are a small nursery, and by US standards we are only a cabbage patch operation. However, with a small home market, we are committed to exporting, with over 70% of our produce sold through the top garden centres in Britain. We are committed to delivering a quality product and to innovative marketing. We are recognised as a source of new and original plant material.

To capitalise on this preception is what spurred us in October, 1985 to make what was for us, then, an outrageous commercial decision, that is to participate in the 1988 Glasgow Garden Festival. We had gathered together a fine collection of grasses and wanted to publicise their attractiveness and usage. There was little demand for these plants and we wanted to create a market for them. We took the decision to create a grass garden. Grasses have hovered

on the fringe of horticulture for a long time but have never really made an impact. They are continuously overshadowed by more flamboyant flowering plants.

Why promote a difficult group of plants? That was a challenge we felt worth confronting. It imposed on us the difficult design exercise of creating a garden of grasses or plants with grasslike foliage. Without other plants, it was a challenging design discipline to present grasses in an attractive way which would appeal to the general public and not just to the more aesthetic of landscape designers who already use them freely anyway.

The Garden was a resounding success. The Garden was not an advocation of "grass only gardens" but was the most powerful means to draw attention to a group of plants that were not considered garden-worthy on their own. These plants, if intermixed with other plants in a more typical arrangement, would attract little attention and most certainly they would have neither created impact or attracted the attention they did.

The benefits of participating are still accruing to us and are doing so at an increasing pace. Grasses are now in demand, are very much a fashionable plant, and the Glasgow Garden is widely acknowledged as the inspiration for this increased demand.

It is my firm belief that plant producers must publicise the uses and benefits of their plants. In the automobile industry, the publicity is created by the major manufacturers, not by the dealers. The same principle must hold true in our industry and nurserymen must budget part of their resources to meet this need. From our experience of three Garden Festivals we know that such publicity generates demand for our plants.

This feedback to our nursery becomes our tractor to expanding production and selling more plants. Worldwide, there is no doubt that the sale of plants can be expanded enormously. The AmeriFlora '92 gives the American nursery industry a magnificent publicity vehicle onto which they should jump. We are all in the leisure business and the dollar that we fail to attract as a plant sale will, you can rest assured, be wrestled from us by the sleek professional operators in other areas of the leisure and tourist field.

Nurserymen should be warned, however, that a Garden Festival is not a Trade Show Booth, a mere presence to wave the flag is not sufficient. Garden festivals are about publicity and that goes to those who create gardens that are original, innovative, imaginative, that stimulate the public interest and capture their imagination. Too many garden entries at the British garden festivals have been historic, nostalgic and a reworking of old themes, plant groupings, associations and ideas. These efforts, whilst safe and competent did not generate much excitement, and worst of all, generated little publicity.

Gardens, at Garden Festivals are something like restaurants, you remember the very good, those that are different, or those where you had an awful experience. The reasonably good or the competent middle of the road design is instantly forgettable. In a garden festival, you must aim to design the best garden, the one that's most different or, failing that, the worse one. So far, we have managed to stay in the best category. That is good for our business sales, our production crew, and now we have more people employed in our propagation department, thanks to Garden Festivals.

HYGIENE—THE FORGOTTEN TOOL

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When I was asked to prepare a paper for this conference I took no time at all to decide to speak on hygiene as an almost forgotten tool in many propagation houses one visits.

Chemical treatments have come in over the last few decades and in some ways have masked larger problems that lurk just behind this barrier. Dr. Ken Baker (1) in his book *The U. C. System for Producing Healthy Container Grown Plants* says, "*Emphasis in control is placed on clean soil, clean stock and sanitary procedures to keep them that way. Once the pathogen has penetrated into a plant it is not economically possible to eradicate it. Chemical treatments generally are ineffective. For this reason prevention is emphasised in plant disease control rather than cure as in medical procedures.*" Similarly, we can take an extract from James S. Wells book (2) *Plant Propagation Practices*—"*A good grower is not dirty and untidy especially in his greenhouse area. Is a trim appearance enough? No it is not! We need to go far beyond this if we are to ensure success.*"

What is hygiene? The principles of health which pervade our thinking in all we do in life. In propagation, hygiene must be taken to almost extreme lengths to achieve optimum results. I feel that many people are not too particular in their attitude to themselves and the way they live.

People with this attitude should not be employed in our nursery creches. Cuttings and seedlings are, by their very size, susceptible to infections and at this stage have very little resistance because of their tender, succulent tissues.

When one prepares a cutting, the wounded tissue immediately becomes an open channel into the tissues of the plant for disease to enter. When seedlings are disturbed, such as happens in pricking out and repotting, roots are damaged. This creates the same open door for pathogens to enter.

Up until the 1950s hygiene and specific nursery practices were the hallmark of a successful propagator. However, over the last 30 years we have become lax because of the development of chemical crutches. We are continually bombarded by chemical companies with all sorts of products that are, if one believes the publicity, the answer to all of our prayers. I am the first to acknowledge that many of these have become useful allies in our constant battle for higher strike rates, and better productivity. However, in the process,

many of our younger propagators have developed in an era when the first reaction taken to a problem is to drench it with an appropriate "witch's brew". In many cases this treatment can mask the cause. My purpose in putting together this paper is to encourage our propagators to open their minds to the needs of each plant and consider them as individuals, as one would different people.

The needs of plants are in many cases similar except for small and important differences. I am sure, with more investigation and research, many of these problem areas that surface ought to be solved by good nursery practice and intuitive investigation into such individual plant peculiarities.

I want to give a couple of examples to explain what I am getting at in these statements. These have occurred in our own nursery business in the propagation department, over the last 20 years. These examples, upon which I will soon expound, made the crops concerned uneconomic ones for us to grow and market, yet the demand was such that if we could unlock the keys to success, we knew they would become very profitable for us. In each and every case, nursery advisers told us to drench or spray with first one chemical or another to cover the particular problems we were encountering. In each and every case, we solved the problem through a change in nursery practice.

The first example I want to explain covers grevilleas, an Australian native plant, and, in particular the tropical species. In the early years through the work of amateur breeders, a number of grevillea hybrids began to appear on show benches and, on occasion, in public places. Great demand was evident, and as an industry, many growers and propagators began to try to produce these plants. At that time these plants were almost impossible to multiply.

Stock plants were grown in beds initially, but also in pots in nursery rows. All of these plants are fast growing in warmer weather, and it was hard to get mature or semi-mature wood to use that was clean of a sooty mould (*Cladochaete coronata*) which occurs on their stems in nature. At that time propagators were using wood for propagation that was maturing. This mature wood was almost always infected with this debilitating mould but often was not apparent to the eye on new cuttings.

A group of nurserymen, *W.O.N. PTY Ltd*, in which our company has a shareholding, put their efforts into this problem. The plant they worked with was *Grevillea* 'Robyn Gordon'—a very desirable cultivar. After many trials, it was discovered that very young tip cuttings in full growth with a bit of trimming to the leaves were giving some promise. However, they had to be held too long on cutting benches, and, again were going down with the sooty mould before they were callused and rooted enough to be taken off mist.

Part of this problem was that the cuttings drooped over before they rooted. Dropping the cuttings, as they were harvested, into a bowl of chlorinated water plus added refined sugar was trialled. We used sugar at the rate of 1/2 cup to 2 gal. of water. After soaking for one or two min the cuttings were removed and then wrapped in wet newspaper to hold them. These were taken to our propagation area, prepared, and then rewrapped before sticking later the same day. This provided the final link. Success rose straightaway to 60/65%. Over the years since, this percentage has improved until now virtually 100% rooting is achieved.

In this case, extreme care to keep cuttings turgid and clean, together with strict control of cleanliness of water for misting and watering is essential. Planting in a clean medium of perlite and peat and making sure the area surrounding the cuttings in the mist benches is clean at all times are necessary. Practices, not chemicals, or drenches or sprays, solved our problems.

Dieffenbachias are a crop that changed in presentation and growth characteristics about 1975 with the introduction of superior cultivars to the industry. However, these newer cultivars, because of their dense clumping growth habit, were tremendous disease spreaders. The most devastating of these diseases was an *Erwinia* species, a soft rot that found a good home in the tight foliage. All research papers we could find recommended spraying and drenching. I recall one treatment was with streptomycin. We decided not to go this way, but to try to eliminate the disease by changing the traditional way we grew the plants.

Our first move was to grow on elevated wire mesh benches, some 4 ft (120 cm) from the ground so that we could water the plants but have the media drain and the foliage dry as fast as possible. Wire mesh benches gave us good air movement around the plants. Even this move cut the incidence of disease. However, there were still many times when 100% of the cuttings in our propagation benches collapsed and had to be destroyed. Our next attack was time consuming and therefore costly.

We decided to sterilize our cutting knives after each and every cutting was severed by dipping the knives in a solution of household bleach in water. Cuttings were isolated so that each stock plant did not touch the leaves from any other. Our propagators washed down arms and hands, if by chance they cut into a diseased plant before seeing the disease as it often was hidden by the thickness of the plant. Almost overnight the problem disappeared. Today we never see it in our crop at all. The above method of cutting has now been dropped. We now cut and collect all cuttings needed and plant them under mist on bottom heat. The crop is good and highly profitable. Again practice of hygiene, not chemical crutches conquered it.

The last example I will give concerns *Mandevilla splendens* [syn. *Dipladenia sanderi*], a truly spectacular flower crop for containers. After introduction to us we had to find out how to grow it. Different types of cuttings were trialled, and all showed the same problems. Large patches of grey appeared on our propagation benches, and our lovely green cuttings disappeared. We were puzzled on how to tackle this, and for quite some time the only success we had was in using a drench of Ridomil at monthly intervals on our stock plants. We were growing these under 50 to 70% shade. We began to try many things and eventually discovered a solution. A small batch was put down in full sun on a well drained bed of stone, some 3 in. (75 mm) thick. They flourished and looked so good we decided to harvest cuttings and try them. Imagine our delight when the problem we had with us up to that time vanished.

Now our whole crop is grown outside on well drained beds. Our cuttings are harvested from these and planted in our usual mixes under mist on bottom heat. The only time we have problems now is after dull, cloudy or wet weather. Again, nursery practice is the solution. I could give other examples.

There is one other area in which we are doing special treatment of all plants whether stock plants, in propagation areas, or in our growing-on and selling areas. This is in chlorinating all water being used in irrigation on our properties. We use both well water and above ground water stored behind dams. The water from our reservoir is filtered through a sand filter and then chlorinated. Our well water is chlorinated but does not require filtering.

We use an injection method of treatment where liquid sodium hypochlorate (4% active chlorine) is injected into the water as it is pumped into storage. We aim for a residual of 3 to 4 parts per million of chlorine going onto the crop. (Easily monitored with a pool test kit.) This treatment eliminates *Phytophthora* and *Pythium* and suppresses most bacterial problems in the nursery. We would never irrigate unless water is treated. This treatment is common practice in Australia. Plants grow so much better that it is apparent to the eye in most cases. The foliage looks cleaner and greener and crops turn over quicker.

Whilst there are probably some crops that need drenching to root and survive, I am quite sure that most crops we handle have specific needs, and if we find these keys to growing, we cannot only achieve better quality, higher propagation results, and cheaper running costs, but we can also be more in tune with the environment in which we live. Our fragile planet can take all the help we can give it. I hope I have challenged you to open your minds to problems, to change and adapt to suit each problem you encounter.

As propagators we are challenged to continue supplying more and more plants to make our cities and surroundings pleasant places

to live. By careful monitoring and observation, we can do our work and, in many cases, not have to resort to the many chemical helpers that are given to us. After all is said and done, if we can achieve the results we need by understanding our work better, we are not only building our own success in the business of plant propagation and growing, but we are helping the very world on which we all depend.

LITERATURE CITED

1 Baker, K. F , ed 1957 *The U.C. System for Producing Healthy Container-Grown Plants.* Univ of Calif. Div of Agr. Sci Berkeley, California.

2. Wells, J S. 1985 *Plant Propagation Practices.* Amer. Nurs. Publ Co , Chicago, Illinois.

Tuesday Afternoon, December 11, 1990

The afternoon session was convened at 2:15 p.m. with David Beattie serving as Moderator.

The Luncheon honoring Charter Members was held in the Grand Ballroom with Peter Orum, President I.P.P.S.—Eastern Region presiding. International Board members present were introduced.

Roger G. Coggeshall, member since 1952, introduced the Charter Members in attendance: David Dugan, Richard Fenicchia, and James S. Wells. Each Charter Member made a short presentation. Charter Member L. C. Chadwick sent his greetings on a tape that was played at the luncheon.

Elton Smith, President I.P.P.S., presented the 1989 International Award of Honor to James Wells.

Ralph Shugert, Historian, I.P.P.S., made the following presentation.

FROM HERE TO HERE

RALPH SHUGERT

Zelenka Nursery, Inc.
Grand Haven, Michigan 49417

International President Smith, International Board members, Eastern Region President Orum, Eastern Region Board members, Society members and guests, and Charter members of the International Plant Propagators' Society.

It is a high honor to speak to you today celebrating our Society's 40th Anniversary. All of the words I will share with you today will not appear in the 40th Proceedings. Eastern Region Editor Heuser has a paper covering the salient points of my comments, but I plan to do a bit of digression during this discourse.

For the edification of those of you who do not know me, I have served as I.P.P.S. Historian since 1971, and have had the high honor of sitting on the International Board since 1970. I have proudly attended all Board Meetings since that date.

I attended my first meeting, in this great city, in 1954 as a guest of my mentor, Hugh Steavenson, and in 1955 with quaking knees presented my first paper. I appear on Secretary John Wott's records as an Eastern Region member since 1957. I have been extremely fortunate to attend every Eastern Regional Meeting since 1954.

I was asked, in 1985, by David Byers to write a history of our beloved Society. I decided to write this in four chapters, each covering a decade. Yesterday, I submitted Chapter IV, entitled "The Society Today" to the International Board, along with an epilogue. I wish to share with you the words in the preface of this discourse at this time.

PREFACE

In 1985, David Byers, Huntsville, Alabama, asked the author if he could put down on paper some personal remembrances of the Society. The author's hope was to have this partially achieved by October, 1987, for the International Board meeting, presided by President Byers.

While the author is indebted to his countless friends in the Society, the words, and indeed philosophy, are his own. My memory was refreshed by re-reading business meeting minutes from past Proceedings and reviewing past issues of *The Plant Propagator*.

The words are mine, with no collaboration from any Society member. They are presented to show the growth of the Society, which neatly fits into the age-old quest, "A search for knowledge". I also like to believe the words exemplify our motto—"To Seek and Share".

I would like to express my appreciation to my employers for the utilization of a professional secretarial staff who carefully deciphered my handwritten notes.

Every effort has been made to be fair in my personal evaluations and observations. Obviously, in certain instances, I had to make some assumptions as to individual ideology and I trust those assumptions were germane.

I fervently hope these words, in some small way, further strengthen the powerful bond of the International Plant Propagators' Society.

It is interesting to note that our G.B.&I. Region has published Chapter I (''In The Beginning. .'') and Chapter II (''A Truly International Society'') in a publication which they present to new members. Hopefully, by April, 1991, the entire history will appear in a format such as I am displaying to you. The Charter members with us today will vividly remember, as I do, the meetings from 1951 through 1958 held at the Wade Park Manor Hotel in Cleveland, Ohio. As I look back on those meetings it is interesting to recall that when one went down to the coffee shop for breakfast our academic friends were in one corner of the room and our commercial members, growers if you will, in another area of the room. Fortunately, that day is no longer with us. It is also with deep joy that I recall a few gentlemen sitting in the very front row of the meeting room attentively listening to each speaker's words and making the appropriate comments. If you will allow your memory to go back with me, I recall the faces of Hoogendoorn, Van Hof, Vermeulen, Nordine, etc.. As a young novice propagator, I wondered why some of the questions were being asked. After a few years it dawned on me that the person asking the question was merely trying to clear up a comment or point that the speaker made that the majority of us in the room just did not understand. This was a very, very pleasant memory.

The Society progressed in the Cleveland years and backing off just a bit, the Organizational Committee for what was then named The Plant Propagators' Society was held in July 1951 in Detroit in conjunction with the AAN Annual Convention.

The first Organizational meeting was held in Cleveland, and the officers elected for 1951 were our own Jim Wells—President, L. C. Chadwick—Vice-President and the late Ed Scanlon as Secretary-Treasurer. The first meeting held on November 5-8, 1951, had 75 people in attendance and they were duly noted as Charter members of this august Society.

In 1959 a very revolutionary step was taken and the meeting was moved from Cleveland to Philadelphia. I can vividly remember the comments from many people stating that no one will attend a meeting historically held in one city and moved around the country. As an up-shot of this, there were 227 people in attendance at that

Philadelphia meeting. This meeting was also historic in that the grand sum of $1,000 was allocated for four Eastern Region members to travel westward and see if there would be a possibility of the establishment of a Western Region. That Region as we know it today, had its birthday in 1960 at a Conference held in Asilomar, California, with Don Hartman serving as President.

At that meeting, spearheaded by Richard Fillmore, the philosophy of the Society was explained to the newly founded Region. It is interesting to note that the keynote address at this conference was presented by James Wells.

As we progress through history, the 1961 meeting of the Eastern Region was held in Cincinnati and at that meeting the name International Plant Propagators' Society was approved. I might say that this was not without debate and argument and it was marvelous to have the insight from people like Chadwick, Fillmore, Hill, Steavenson, Wells, explaining why the international view of our Society is so important. Unfortunately, a few members left the meeting hall and never returned. We moved into the early sixties with the first International Board Meeting held in California with one of the most dynamic, loyal, members this Society has ever had serving as Vice-President, and that person was Bill Snyder. Snyder attended every IPPS Board Meeting until his retirement in March of 1986.

The input that Bill Snyder and our respected International Editor, Hudson Hartmann gave to each consecutive Board over the years is beyond comparison. You see, good people, one of the problems that any international organization encounters is a different ideology of a Chairman and quite often Board members. Being from various areas throughout the world, they are concerned with a specific problem for their specific region. The guidance of Snyder over the years, and Hudson with his quiet, professional manner soothed many a "savage" breast.

As we moved on to Regional development, G.B.&I. (Great Britain and Ireland) was created in September of 1986 due to the marvelous visionary and missionary endeavors of Jim Wells. Again, Jim was there to offer his guidance and to offer opening remarks at their initial meeting. Some of you in the room fondly recall, as I do, the International Board Meeting with the G.B.&I. Region in 1973 aboard an airplane, which Jim Wells was able to have a rhododendron grower pilot for us. I am sure that is one of the reasons the plane was so smooth over the Atlantic and back home again!

Wells then went on to New Zealand, at that time a Chapter, which became a Region in September of 1972, and Australia in October of 1973. The final Region to join our Society was the Southern Region in December of 1976 and their keynote address was delivered by Bill Curtis, a marvelous gentleman who spearheaded

much Western Region activity, as well as Jim Wells. Their topic was "The IPPS—What is it". The Southern Region, as have all Regions, has produced many dynamic people, not the least the indubitable Charlie Parkerson who Chaired the IPPS Board Meeting in Scotland in 1983.

Over the years of Eastern Region involvement, as well as International involvement, what have I seen? Probably the single vivid point in my mind is the autonomy given today to Regions which was not existent a decade ago. This autonomy has strengthened the Society as a whole. The seeking and sharing of dreams of many people in this room have been realized and are with us today. Our Society is prestigious, and professional, due to Regional Editors working under the guidance of Dr. Hudson Hartmann, our International Editor.

Our "Black Bible" as many of my friends like to refer to our Proceedings, is in every horticultural library in the world. The overview for growth down the road, hopefully prior to the year 2,000, is overwhelming. With the recent European developments there is now an opening for Regions in areas here-to-fore thought impossible, such as: Bulgaria, Romania, Italy, Japan, Israel, etc. The rotation of the International Board visiting Regions is so valuable and so important. I believe that the representatives from the three Regions outside the North American continent would heartily agree with this. The G.B.&I. Region International Board Meeting with Mike Dunnett Chairing was outstanding, as was the meeting the year previous in New Zealand with Ruth Henderson as President and two years prior in Australia with our friends from that Region. We are stronger every year and the motto of Seeking and Sharing which was, incidentally, Peter Vermeulen's contribution to our Society, is a motto that is adhered to and not a group of words that are meaningless.

Marvelous, marvelous memories, and I'm sure our Charter members to whom this is dedicated can look back in their minds and see those faces who aren't with us today, but they certainly are in spirit. Remembering not only the people that presented papers at the various conferences, but the loyal Society members that were there, present when we needed them and offering advice in their manner, either at breakfast, coffee break or whatever. The Society's strength is in its members, and the members each year adding more and more to the art and science of plant propagation is indescribable.

It has been a delight to share these few words with you and, without question, the International Plant Propagators' Society is on a level by itself. Nothing in the field of horticulture can approach it, from a practical stand point at any rate, and it has reached that pinnacle due to people such as yourselves sitting in this room today at noon. Charter members, I salute you, God bless you all.

PRODUCTION OF HARDY ROSES BY SOFTWOOD CUTTINGS

ROBERT H. OSBORNE

Corn Hill Nursery Ltd.
RR #5, Route 890
Petitcodiac, New Brunswick E0A 2H0, Canada

INTRODUCTION

Our nursery is located in Hardiness Zone 4 in the province of New Brunswick, bordered on the south by the cool waters of the Bay of Fundy and by the relatively warmer waters of the Gulf of St. Lawrence to the east. To the north and west, in a straight line to Alaska, 4000 miles of arctic highs. Our site has an average minimum winter temperature of -30° C with a record low near us of -50° C.

Growing roses commercially in such a place may seem a daunting prospect to those of you familiar with the vagaries and uncertainties of rose growing. Certainly if we were attempting a crop of hybrid teas we might well be carted off to the jails we call mental institutions. But the roses we grow are quite special. I like to think of them as masters of supercooling, that amazing talent possessed by hardy plants which enables them to transfer all water outside the cell walls except a thin pliable film of water which protects the cell's vital components until spring.

Our interest in roses happily coincides with the recent release of many new roses, the results of efforts by breeders to introduce longer flowering period, disease resistance, and flower form into the hardier species of roses. These are roses that will soon transform northern rose gardens into visions only dreamed of by generations of frustrated growers. There is also a tremendous resurgence of interest in roses, such as the hybrids with *Rosa* × *alba* and *Rosa gallica* parentage that graced many gardens of the past. It is exciting to witness these roses, new and old, blossom into well deserved recognition.

With some exceptions, most roses today are propagated by budding. It is our contention that, aside from the usual disadvantages of rootstock suckering, and occasional graft incompatibility, budded roses are not as desirable in northern areas. The commercial rootstocks, such as *Rosa multiflora*, are not reliably hardy in Hardiness Zones 4 and colder. Hardy species that can be used for rootstocks, such as *Rosa rugosa*, can cause suckering nightmares. With this in mind, we have tried to devise a system of producing, by softwood cuttings, the many different roses we grow. Although each cultivar is a completely different case and may require variations in method, most rose cuttings need similar conditions to root in economically acceptable percentages.

PREPARATION OF CUTTINGS

As in all cases, healthy rooted cuttings come from healthy cutting material. We endeavor to grow our stock plants under the best of conditions for balanced, vigorous growth, for a cutting that is low in essential nutrients is much less likely to survive. We have recently begun to establish stock blocks of our key cultivars. These mother plants are kept under growing conditions as good as any plant receives in the nursery.

We never take cuttings which show signs of disease. Fungal diseases, such as blackspot, will find conditions ideal in the greenhouse and can wreak havoc. As well, insect pests do not belong on the cutting bed. We soak our cuttings for one minute in a 1 to 50 solution of insecticidal soap. The cuttings are then rinsed and readied for sticking. Great care is taken during this process to avoid bruising or injuring the leaf or stem tissues.

Our best results come from cuttings taken just prior to flowering. We begin gathering cuttings as soon as the first flower buds begin to form, which for us is not until early June. From then on cuttings are cut from stems about to flower. Hybrids with *Rosa rugosa* parentage in particular show a noticeable drop in rooting percentages when taken from stems which have finished flowering. We feel that timing is one of the more critical factors for successful rooting.

Generally, the larger the cutting, the more vigorous the rooting and subsequent aftergrowth. We are careful, however, particularly with hybrids derived from *Rosa rugosa*, to avoid using large caliper vigorous shoots which often emanate from the base of the plants. These are usually watery, with a proportionately lower level of carbohydrates available for rooting. We have found these less likely to root than lateral shoots.

Our cuttings are taken from both stock blocks and field plants until late July. Cuttings taken after this date generally are not ready to set into the field until after September 1. If we set out cuttings after this date we increase the risk of having them heaved by frost during the winter.

After being gathered and washed, the cuttings are cut into 2 to 4 node sections, depending upon the cultivar and the availability of wood. All flower buds are removed. Once prepared, the extreme base of the cutting is dipped into a #2 IBA talc preparation and any excess shaken off. The cuttings are placed in trays of 32 individual 1½ x 1½ x 2½ in. pots. The medium consists of coarse perlite and peat moss (5:1, v/v). Although a light mixture by most standards, we have found larger percentages of peat moss will keep the mix too moist and will cause the cutting bases to rot. Pure perlite will work, however the presence of some peat moss stimulates root hair

production, enabling the cutting to establish itself faster in the field.

We use a small amount of slow-release fertilizer in the mix. The last two years we have used a Nutricote 14-14-14, 70 day release formula. We use one litre per cubic yard of rooting mix. Directly after sticking there are few available nutrients to encourage the growth of fungi on the injured portions of the cutting. However, by the time that root initiation has begun there is a level sufficient to stimulate growth. When we first began using slow-release fertilizers in our rooting medium we noted a substantial increase in both the quality of the rooted cuttings and in the percentage of successful takes. Without the fertilizer many cuttings would form roots, but before any appreciable growth could take place the leaves would drop and the cutting would eventually die. Now our cuttings often put on several nodes of growth before they are removed from the beds.

ROOTING CHAMBER ENVIRONMENT

Our trays of cuttings are placed directly on the ground in the greenhouse. The more difficult-to-root subjects are placed on beds heated by hot water pipes. The temperature of these beds is kept at 25 °C (approximately 78 °F). At present we employ an Agritech fogger to provide humidity in the house. Earlier attempts to root roses with overhead misters were often unsuccessful because the medium tended to be too wet and the large amounts of water tended to leach nutrients from the leaves, causing them to drop prior to rooting. We are considering purchasing a high pressure fog system, as we feel the smaller droplet size will further minimize these problems and will create a better rooting environment.

As all of our cuttings are taken between June 1 and July 30, the temperatures within the greenhouse can become quite high. We provide just enough ventilation to keep the temperature at ground level from exceeding 32 °C (90 °F). We have, however, allowed the temperature to rise as high as 40 °C (104 °F) with no perceptible damage, but such high temperatures slow the rooting process.

We do not use fungicides in the greenhouse with the exception of wettable sulphur on cultivars which are particularly susceptible to blackspot infection. When fungal problems occur in the cuttings the cause can often be traced to either high or low humidity levels. If placed in wet areas such as near the actual humidification unit or under a drip, both cuttings and medium can become waterlogged and subject to fungal attack. If placed in a "shadow" area which receives too little humidity or in a draft, the cuttings will dry out. Once wet again, the dead leaf tissue becomes a perfect medium for many fungi. We have found that close attention to humidity levels and the placement of the cuttings prevents problems from

developing. Most cultivars we are dealing with are quite resistant to blackspot and mildew and this aids us considerably. When working with disease susceptible cultivars preventative measures do become necessary.

We humidify the house from approximately 9:00 a.m. to just before sunset. Our units can deliver from one to 40 gal per hour. This level is adjusted during the day according to both the time of day and the intensity of sunlight. During an average sunny day both units will be delivering 30 gal per hour during the middle of the day. On a cloudy day we may only use 10 gal per hour per unit. Our humidifiers are located at each end of a 20 x 100 ft coldframe. They are placed 6 to 7 ft above the floor and to one side. With both units operating, a circular air flow is created which distributes humidity evenly throughout the house.

Although some cultivars may show root initiation in as little as 10 days, most will show root initials by 14 days. Some may not root for 20 days or longer. Roots of most cultivars will reach the pot edges and emerge from the bottom of the pots within 30 days. When they have reached this point we remove the rooted cuttings from the humidity chamber and place them in a shaded greenhouse for a period of hardening off. Careful attention is paid to watering. The first three days are critical, and the rooted cuttings are watered lightly and frequently. As the leaf stomata strengthen and the cutting is better able to handle the drier air, the frequency of watering is decreased, while the amount each receives is increased so that the roots have plenty of water available to them.

TRANSPLANTING

After one week the rooted cuttings are transferred to an outside area to await transplanting or, depending upon their condition, are brought directly to field beds. These field beds are 4 ft wide. A device which is hauled directly behind the rototiller creates four-rows 3-in. deep. Cuttings are brought to planters who place them 12 in. apart in the rows. Although labor intensive, the careful attention given to each cutting assures that the soil is carefully compressed around the very fragile roots. Directly behind the planters a crew places shredded bark 2-in. deep around the cuttings. Once the beds are barked we irrigate them for four hours or until they are saturated. Unless we experience severe drought conditions, irrigation is not required again. If water is available, we try to water at least once again within the week to insure that plenty of moisture is available to the establishing roots. By freeze-up (in our location November 15) the cuttings have put on approximately two nodes of growth, with corresponding root growth, and are established enough to withstand the frost heaving

process. The roses are fed and watered according to need the following year and are ready to dig by early November. Cuttings that are not ready to set out by September 1 are transplanted into 4 in. pots and overwintered under thermal blankets in poly houses covered in opaque plastic. These are either potted directly into 2-gal. pots for sale the next spring or transplanted into field beds.

Roses grown from cuttings generally have a smaller and more fibrous root system than the older root systems of budded roses. Depending upon the vigor of the cultivar, the tops can be equally as large as a budded rose, but are usually smaller. Slow growing cultivars can be quite small by budded rose standards. It is important that your market understand that these size differences are related to the propagation process and do not have any bearing on the quality of the plant or its ability to grow in the future. Once established, an own-rooted rose will often be less trouble to maintain and will bring to its owner that which we all desire in a rose—rainbows of sun-washed petals and evenings filled with exquisite perfume.

HERBS: COMMERCIAL PRODUCTION IN CONTAINERS

J. JACOB JOST

Jost Greenhouses
12340-48 Eckelmannhane
Des Peres, Missouri 63131

Jost Greenhouses are located in a very-affluent, residential section of St. Louis County. Needless to say, the business is as welcome as a boil.

Our growing area consists of 22,000 sq ft of very old glass greenhouses plus about ¾ acre of cold frames. The basic business concerns itself with the wholesale production of perennials, herbs, and assorted ground covers.

The production of containerized herbs has been sort of like "Topsy"—it just grew year after year. Now, after seven years of production we are up to approximately 350,000 3-in. pots, plus some few hundred quarts and gallons.

Our herb houses are all benched with a bio-therm type heating system. Some of the houses are also equipped with rolling benches, thus making greater use of existing area.

All of the herbs, whether culinary or aromatic, are sold with tags that supply minimal cultural information. Some tags have pictures.

Stock pots are always tagged in that many of the rosemary's, as well as other plants, take on a different look when almost constantly cropped for cuttings. To avoid confusion, tagging is an absolute must.

Some plants such as the bay tree offer questionable profitability in anything other than small pot sizes. They just take too long to grow. French tarragon is possibly an exception to the previous statement in that we can never grow enough in any pot size.

Lavender and rosemary can be sold in almost any pot size from 3 in. up to 2 gal. patio plants with good return.

Our regular 3-in. pot fits a 3-in. Kord tray that holds 28 individual pots. We do not sell mixed flats. At one time, we did with a 20% mixing charge which proved to be a real pain.

Some of our cuttings like the tri-color sage are propagated in a 128 cavity tray using Redi-Earth as the rooting medium. Using 75° F soil temperature and manual misting about three times a day, we are able to root these soft tips in about ten days. They are then potted to 3-in. pots using a very open mix from Fisons and are ready for sale 25 to 28 days from cutting date. Some plants like lettuce leaf basil are even faster.

Thyme, and it really doesn't differ much with the species or cultivar, is slow. We stick multiple cuttings and cut back severely after rooting. It probably takes close to two months to produce a heavy 3-in. pot.

Decoration pots with plants such as the Puerto Rican oregano are placed around our home gardens so that our clients might have a better idea of what finished herbs look like and how to use them.

Scented geraniums, while not really herbs, are sold as aromatics. We only grow about ten selections but we always sell out, particularly of apple, nutmeg and old rose.

Our watering is all done by hand in that most herbs are extremely sensitive to "wet feet". Watering is always a judgement call—generally we say if it needs water today—wait until tomorrow.

We consider six major cultural considerations of extreme importance in growing containerized herbs and these are as follows:

1) They all, both culinary and aromatic, need to be pest and pesticide free. Insects and diseases are not tolerated by the trade. For a minor crop as herbs, no pesticide manufacturer will risk the litigation potential of labeling their products for these plants.
2) Most, not all, are very prone to root rots, induced physiologically by overwatering, or pathologically by overwatering, thereby setting up an environment that is favorable to the proliferation of the various root pathogens.
3) Herbs need warm soils to prosper and really grow—balancing a temperature and a moisture regime is tenuous.
4) Herbs require high light, most particularly those of Mediterranean origin, as are a lot of the culinary selections.
5) Seed viability. Good seed that offers high germination percentages, seedling vigor, and is really true to name is quite hard to find. Very few hybrids are available so most of the open-pollinated material is, at best, variable.
6) Low fertilizer requirements seem to be in order for most herbs that we grow. Peters 9-45-15 is about the best we have found to date. Thank goodness our product is not benched long enough to have real fertilizer needs. Stock plants are usually treated with a single application of Osmocote (R) 13-13-13.

High intensity sodium vapor lamps have proven to be a real help to us particularly where we are doing an accelerated tip cutting program. St. Louis has its dark winter days too, so from December 15th to almost April 1st, we supplement with 18 hours of light per day. The fixtures are expensive to buy and install but very inexpensive to operate. We figure that we have paid for them in two years just by enhancing our basil and tarragon production.

Some stock pots are carried over the benches as a means of saving bench area for production pots.

Inexpensive 20-in. box fans ($17.99 at Ace Hardware) have all but solved our *Botrytis* and foliar *Rhizoctonia* problems. In bad years, prior to the acquisition of the fans and instituting a program

of horizontal air flow, we on occasion dumped as many as 1200 to 1600 flats of basil and sweet marjoram.

We grow about 46 different species of herbs and probably too many cultivars but the 12 best selling ones for us in St. Louis are:

Basil—6 selections, lettuce leaf the best
Parsley—2 selections, Italian flat is the most flavorful
Marjoram
Oregano—2 selections, Greek and Mexican sell equally well
Thyme—4 selections, all are good but lemon probably best
Chives—2 selections, grass outsells garlic
Rosemary—3 selections, but we have 8, all are good
Tarragon, French—only one but we never have enough
Lovage—just one but it sells well
Coriander (cilantro) the yuppie herb—sells like mad
Dill—dill bouquet—the shorter one is best for us
Lavender—3 selections—English outsells the French

Questions always come up as to what is easy or hard to grow and we always have to say that our site, under our conditions, using the techniques that work well for us, we can say that:

Easy to grow herbs are.

Parsley	Culinary sage
Chives	Pineapple sage
Mints	Lemon verbena

More difficult subjects are:

Basil	Dittany
Lavender	Golden sage
Tarragon	Curry plant

Some differentiation need be made between propagating and growing-on. Sixty percent of production is from seed with the remaining 40% from cuttings. A good numbers of our herbs are produced from cuttings since it assures us reproducibility of a pretty exacting nature and, in the case of French tarragon, and some of the scented geraniums where no seed is set, it is the only way we can increase our number of plants. Generally we produce the following herbs from cuttings:

Basil (tips)	Tarragon (roots & tips)
Marjoram (tips)	Lavender (tips)
Oregano (tips)	Mints (roots & tips)
Thyme (tips)	Pineapple sage (tips)
Rosemary (tips)	Scented geraniums (stem)

In many ways, because of some unusual needs, herbs are a real pain. However, they offer a great deal of product flexibility and allow a grower to get in or out of a crop cycle in a very short expanse of time.

For the last five years, we have increased our thru-put at 15% per year. We now have no more dedicated square footage to use unless we decrease the amount of space allocated to ground cover plants.

Nothing on the place makes us as much money as herbs. So that is why we grow them. The average 3-in. pot in three rotations at our wholesale prices produces $46.24 per square foot of bench space.

PROPAGATION OF WETLAND SPECIES

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There is a growing interest today in nursery production of wetland plants. With some overlap in species, the trade in wetland plants is basically divided into two groups (for the purposes of this paper, true aquatics are not being included, although many of the same propagation techniques can be used):

1) Species used for ornamental horticulture, i.e. water gardens, bog gardens, and landscaped areas associated with wetlands. The emphasis in this group is on plants that have ornamental qualities, yet can survive under wet conditions. Almost all species in this category are herbaceous.
2) Species grown for restoration, wetland replication, or revegetation purposes. This group includes naturally occurring woody and herbaceous plants, and many species in this group would not be considered ornamental in the usual horticultural sense.

The relatively recent interest in revegetation has raised several issues that should be taken into account by nurseries growing plants for restoration. The first issue is genotype. Most plants used in revegetation at the present time come from nurseries or wild areas hundreds of miles away, usually from Wisconsin or the Lake States. There is, however, a growing interest in using plants grown from local genotypes (phenotypes) for revegetation. Several nurseries catering to trade in local species have recently sprung up, and several other established firms are beginning to add local genotypes to their offerings. With the exception of research papers on a handful of species, little is known about where a genotype for a particular species begins or ends or if, in fact, there is a difference in genotype from, say, the U.S. Midwest to the Eastern Seaboard. Nonetheless, increasingly, many ecological engineers and land planners are attempting to locate sources of material in approximately the same area when revegetation is necessary. This recent trend, which makes good sense from an ecological standpoint, has the potential to add a source of revenue to local nurseries throughout the country.

Another issue involved in propagation of wetland species for revegetation is the issue of soil saturation during cultivation. It has long been known that root systems of woody species develop differently under saturated conditions than if they are grown under normally-aerated conditions. In wetlands, there is often little if any oxygen available to the roots. Herbaceous species seem to be

able to pump oxygen to the roots of the plants when the soil is saturated, and although woody species apparently are not able to perform this function as well, they are able to develop different root systems (as well as make use of different strategies) to survive. However, a woody plant that is grown under aerated soil conditions will not develop this tolerance to saturated soil easily. Often a container-grown woody plant that is normally considered a wetland species will expire within one year of being placed in the saturated soil of a wetland. Figures of between 30 to 50% mortality in the first year of planting have been quoted by wetland experts in the Northeast. However, other wetland scientists say that the type of wetlands being planted is also a factor in the survival of woody species coming from normal nursery stock.

To increase the survival of wetland species, many nurseries are growing their woody plant in containers inside frames lined with plastic and filled with water, so that when the material is transplanted to the wet area, the root systems will already be adapted to the low oxygen, saturated situation. Other growers have stated that trees and shrubs grown in the usual fashion but with extra heavy irrigation will also survive. However, it is not clear if the same type of shallow root system prevalent in the "wet cultured" plants can be developed by simply heavy irrigation. More research is needed to determine if "wet-cultured" woody material has a better survival rate in the field, and also if increased irrigation alone can acclimate the plant successfully for survival.

PROPAGATION OF WETLAND SPECIES FOR ORNAMENTAL HORTICULTURE

Almost all species in this group are herbaceous and are propagated by division. Many can be divided year-round if kept in a greenhouse above freezing. Although many species can be started in the usual nursery in containers or seed flats, growing these plants underwater provides better growth according to some growers. All are considered emergents—that is, they can grow under water to varying depths depending on the species. Plants are often grown in dug-out, shallow ponds or frames lined with plastic. These ponds and frames are often drained in winter.

The following plants are all listed in the nursery trade and division is the main method of propagation. Other notes on propagation are also given for each species. All plants in this list are hardy in Zone 6 or better.

Acorus calamus, A calamus 'Variegatus'—also rhizome cuttings
Butomous umbellatus—sow seed as soon as ripe
Caltha palustris, C. palustris 'Alba', *C palustris* 'Monstruosa'—seed should be sown fresh, a warm/cold period is needed
Dulichium arundinaceum [syn. *Cyperus arundinaceus*]—dried seed germinates well

Eleocharis montevidensis
Equisetum hyemale, E. scirpoides
Eriophorum angustifolia [syn *Scirpus angustifolius*]—dried seed germinates well.
Glyceria maxima 'Variegata'—no pretreatment necessary.
Hibiscus moscheutos—softwood cuttings, seed does better after a hot water soak
Houttuynia cordata and cultivars
Iris fulva, I. sibirica, I. laevigata, I. pseudacorus, I. versicolor and cultivars of these species—most seeds need a moist/cold period for germination
Juncus effusus, J. effusus 'Spiralis', *J. effusus* var *glaucus*—no pretreatment of seed is required
Lobelia cardinalis, L. siphilitica—seed stored under dry refrigeration germinates well
Lysichiton americanum, L. camtschatcense—seed must be sown as soon as collected for best germination; very slow growth
Marsilea species
Mentha aquatica, M. × *piperita* var. *citrata*—softwood cuttings also
Menyanthes trifoliata—dried seed sown outside in fall will germinate in spring
Mimulus ringens—soft wood cuttings, dried seed germinates
Myosotis palustris—no pretreatment of seed is needed
Myriophyllum aquatica
Orontium aquaticum—seed germinates immediately if freshly sown.
Peltandra arundinaceum, P. virginica—mixed results from seed, seed kept moist germinated best after moist/cold.
Pontedaria cordata—freshly cleaned seed germinates best.
Sagittaria latifolia, S. sagittifolia 'Flore Pleno' [hort. syn *S japonica*]—moist/cold for best germ.
Saururus cernuus—moist/cold for best germination.
Scirpus albescens [syn. *S. inundatus*] *S. americanus, S. lacustris*—dried seed may be more difficult to germinate—moist/cold treatment.
Typha angustifolia, T. latifolia, and cultivars—no pretreatment necessary

PROPAGATION OF SPECIES FOR WETLAND RESTORATION

The following species are often used or are requested in wetland restoration. Most of the trees and shrubs are propagated by seed or cuttings, established in containers, and then grown on under saturated soil condition so that they are adapted to wetland soils. It should be noted that building up stock through collection of seed from a number of different local sites is the best way to insure as large a measure of genetic variation as possible.

Propagation notes will be made only for herbaceous species. Production is usually by division in the case of most herbaceous species, but seeds may be started in flats of moist soil or flats sitting in trays of water until germination. Seedlings are then moved to larger containers in wet beds or frames lined with plastic.

Trees

Acer rubrum, A. saccharinum
Chamaecyparis thyoides
Fraxinus nigra, F. pennsylvanica
Ilex opaca
Nyssa sylvatica
Pinus taeda
Quercus bicolor, Q. palustris
Salix bebbiana, S discolor, S lucida, S. nigra, S. sericea
Ulmus rubra, U americana

Shrubs
Alnus rugosa [syn *A. serrulata]*
Cephalanthus occidentalis
Clethra alnifolia
Cornus amomum, C racemosa, C sericea [syn *C stolonifera*]
Ilex verticillata, I laevigata
Leucothoe racemosa
Lindera benzoin
Lyonia ligustrina
Myrica pensylvanica, M gale
Rhododendron viscosum
Rosa palustris
Salix discolor
Sambucus canadensis
Spiraea tomentosa, S alba, S latifolia
Vaccinium corymbosum
Viburnum cassinoides, V. lentago, V recognitum

Herbaceous Perennials
Acorus calamus—rhizome cuttings
Alisma plantago-aquatica—dried seed germinates without pretreatment, blooms first year
Asclepias incarnata—no pretreatment necessary
Aster novae-angliae, A novi-belgii, A simplex—no pretreatment
Bidens frondosa—no pretreatment
Calla palustris—seed must be kept moist, a moist/cold treatment is necessary
Caltha palustris—sown seed as soon as collected, needs warm/cold treatment
Chelone glabra—softwood cuttings, no pretreatment for seed
Cicuta maculata—seed probably needs moist, cold
Eupatorium fistulosum, E maculatum, E perfoliatum, E purpureum—softwood cuttings, no pretreatment for seed
Hibiscus moscheutos—softwood cuttings, soak seed in warm water for best germination
Impatiens capensis, I pallida—sow seed fresh outside
Iris versicolor—moist, cold period for seed germination
Lilium superbum—seed need warm/cold period to germinate, pull scales from bulb after blooming
Lobelia cardinalis, L siphilitica—seed stored dry under refrigeration germinates well
Ludwigia alternifolia—no pretreatment necessary—blooms first year from seed
Lysimachia terrestris—no pretreatment necessary
Mentha arvensis, M × piperita, M spicata
Myosotis laxa, M. scorpioides—no pretreatment necessary
Peltandra virginica—germinates better after moist/cold
Phragmites australis [syn *P communis*]
Polygonum species—no pretreatment necessary
Pontederia cordata—fresh seed seems to germinate best
Rumex verticillatus
Sagittaria latifolia—seed needs moist/cold treatment
Saururus cernuus—germinates best after moist/cold treatment
Sparganium eurycarpum, S americanum—no pretreatment
Symplocarpus foetidus—seed probably needs to be sown fresh in fall to germinate in spring, rhizome pieces with a node can be successful
Typha angustifolia, T. latifolia—no pretreatment necessary

Veratrum viride—sow fresh seed, probably a warm period followed by a cold period is best, but definitely need cold
Verbena hastata—no pretreatment necessary—blooms first year from seed, also softwood cuttings
Vernonia noveboracensis—no pretreatment necessary—softwood cuttings also

Grass species. Most species germinate well if seed is stored dry under refrigeration for several months before sowing Some need no pretreatment, but light is beneficial for germination
Calamagrostis canadensis
Echinochloa muricata
Glyceria canadensis, G obtusa
Leersia oryzoides
Panicum virgatum
Phalaris arundinacea
Poa palustris
Spartina pectinata
Zizania aquatica

Sedges and Rushes
Carex lurida, C. rostrata, C stricta, C trisperma, etc —seeds of almost all species germinate well without pretreatment
Dulichium arundinaceum—no pretreatment necessary
Eleocharis sp
Scirpus americanus, S. atrovirens, S cyperinus, S. fluviatilis [syn *S maritimus*] *S lineatus, S validus, etc* —variable in germination, best to use moist-cold pretreatment, but many do not seem to require this
Juncus effusus, J. militaris, J nodosus, J. tenuis—no pretreatment necessary

Fern Species. Ferns are grown from spores but they are slow Most plants available in the trade come from the wild.
Onoclea sensibilis
Osmunda cinnamomea
Osmunda regalis
Thelypteris palustris

PROPAGATION BY SOFTWOOD CUTTINGS OF *GLEDITSIA, AMELANCHIER, BETULA,* AND OTHER TREES

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The apparent vigor, vitality, and increased growth rate of trees on their own roots when compared to trees produced by other methods, justifies looking further and harder at propagation procedures.

Our methods of trying to propagate trees by softwood cuttings utilizes double-layer, inflated polyhouses, 30 x 95 ft with a 2 ft hard sidewall insulated for cold protection. The overhead mist system we use has Eddie mist nozzles, water pressure of approximately 50 psi controlled by a variable timer. The procedure starts with 10 sec of water every four min, depending on the weather. We use well water, approximately 58° F, with a pH of 7.2.

The rooting containers used are 2 3/8 or 3 5/8 in. "Anderson" bottomless tree pots placed directly on plastic net floor covering, over well-drained sand. The rooting medium is a peat and perlite (1:1, v/v) mixture. The peat is steam-sterilized, then mixed with the perlite.

The floor and the pots are treated with Physan before the pots are lined out to receive the soil. The pots are filled in place in a manner to protect against soil compaction.

The rooting hormones are protected by refrigeration or dry stored as prescribed. The rates used in this crop were 2500 ppm Woods, 500 ppm Woods, and #3 hormone powder. The liquids are mixed as needed every few days.

The normal time for propagation in Indiana starts in June when stock is at the right rate of growth (tender new growth).

We use Physan 20 and disinfect all the working areas and tools daily. This includes cutters, tabletops, trays, and containers.

The plant material is cut and collected, preferably in the morning of the day to be used, then placed in plastic bags. The rough cuttings are put directly on the cutting table or refrigerated in the plastic bag until needed. Cutting material may be stored overnight with refrigeration, but we attempt to collect, cut and stick in the same working day.

The cutters try to get as many good two-node cuttings, in addition to the tip cutting, as possible. These are immediately placed into separate trays for tip cuttings or stem cuttings, then hand misted. The cuttings are collected and bunched with the cut ends even (hopefully with the top end up) and bundled with a rubber band.

At this point, all materials are handled with rubber gloves. The bundles are submerged into a solution of Physan 20 and water and allowed to drain for 3 to 5 min. The Physan-treated bundles are given a 5-sec dip into the hormone being used.

As soon as possible after dipping into the hormone, the cuttings are stuck into the prepared, pre-watered pots. The mist system is on and functioning at the 10 sec every 4-min cycle while the sticking procedure goes on. Care is given to prevent compaction or contamination during the entire preparation and sticking procedure. No cuttings are stored over a weekend, everything is stuck Friday before anyone goes home.

Misting of the cuttings is during daylight hours only. The timing sequence is adjusted according to the sunlight, humidity, temperature, and signs of rooting. The mist system timing is varied and "cutback" to prevent overwatering and to help the new growth.

Our propagation houses are shaded to 50% with latex paint. We use no heat during the rooting procedure. We do heat late in the season to allow the rooted plants to form good buds on the new growth.

Two taxa of amelanchier were cut on Monday, June 25, 1990. We stuck a native selection of *Amelanchier arborea* and a commercial selection of *A.* × *grandiflora* called 'Cole's Select'. These were stuck directly in 2 3/8 in. tree pots. We stuck 3,990 *A. arborea* with 1925 rooting for 48.25%, and 3,885 'Cole's Select' with 2535 rooting 65.25%. We used the 500 ppm IBA for both selections.

We stuck *Betula nigra* on Thursday, July 19, 1990, using two pot sizes and three hormone treatments. We used 3 5/8-in. pots with 3 cuttings each for clumps, and 2 3/8-in. pots for single plants. The pot size only affected the resulting growth after rooting—bigger pots, bigger plants—but did not affect the rate of rooting. We stuck 325 *B. nigra* using 500 ppm hormone with 97% rooting, 390 using 2500 ppm with 93% rooting, and 325 using #3 powder with 85% rooting.

We stuck *Gleditsia* in 2 3/8-in. tree pots on Tuesday, July 17, 1990, using three hormone choices: 325 using 500 ppm with 4% rooting, 715 using 2500 ppm with 20% rooting, and 195 using #3 powder with 25% rooting.

The rooting of trees by softwood cuttings does not guarantee that the rooted cutting will survive the first winter and break bud the following spring. The new growth after rooting is very important and must be encouraged to produce a good viable tree the following year. Trees from cuttings made in June of one year can be 6 to 7 ft tall by September of the following year (15 months).

CARBOHYDRATE METABOLISM IN CUTTINGS DURING ROOTING

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The interest for a possible role of carbohydrates in controlling rooting of cuttings originates from an observation, that tomato stem segments which had a high C/N ratio produced most adventitious roots (8). Although many experiments have been performed since then to test this hypothesis, its validity is still uncertain. One of the main obstacles is how to produce stock plants with different levels of carbohydrates.

Veierskov, et al. (9) found no apparent correlation between C/N ratio and root number in the cuttings, when using seedlings with different reserve nutrients and growing the plants under different light levels. However, altering the environment under which plants are grown, may also change important growth stimulants which makes it difficult to distinguish between the role of carbohydrates and the environmental impact. By use of pea plants with genetic lesions in their photosynthetic apparatus, it was possible to grow the plants under identical environment, and obtain plants with different levels of carbohydrates. When these cuttings were rooted, a correlation between the level of carbohydrates and root number was observed within any of the cultivars tested, but it was not possible to correlate a given level of extractable carbohydrates to a given root number, independent of cultivar (10). It is thus possible that the carbohydrate status might influence rooting of cuttings.

In order to have a horticultural significance, it has to be possible to alter the carbohydrate status of the stock plants in practice. It is not easy to try altering the photosynthetic capacity of plants directly. It has however, been observed that carbohydrates accumulate in nutrient deficient plants. Although nutrient deficiency causes diminished photosynthetic capacity, the plants accumulate large amounts of soluble carbohydrates (3). That the best rooting in cuttings was obtained when the stock plants were grown at a nutrient level below what was optimal for growth, has been observed in several nursery plants (7). The beneficial effect of growing stockplants at suboptimal nutrient supply may thus be an increase in the level of soluble carbohydrates, which in turn may facilitate root formation.

When nutrients are limiting, the photosynthetically fixed CO_2 will first go into the carbohydrate pool, then it can not be

metabolized further because most organic compounds contain nitrogen, phosphate or sulphur. In this case the plant transports the carbohydrates as sucrose to long term storage locations such as the stem. Because cuttings do not have an active root system, they are unable to take up minerals, and therefore, as soon as the initial free reserves are utilized, either growth must cease or the necessary minerals have to be mobilized from organic materials. If the latter situation occurs, we observe the changes similar to senescence, which is the initial steps to death.

Although the initial level of carbohydrate may influence the subsequent rooting, more interest is put into how the cuttings behave during the rooting period. How an intact plant responds to the environment with regard to photosynthesis and carbohydrate metabolism has during the years been thoroughly investigated. In cuttings, however, our knowledge is more limited. Inasmuch as a cutting may look as an intact plant without roots, major changes occur in its physiological behaviour. It is a well observed fact that elongation of the stem decreases during root initiation, whereas dry weight increases when compared to similar tissue not made into cuttings (4). Concurrent with the increase in dry weight is a large accumulation of carbohydrates observed in all parts of the cuttings (4, 9).

Though the initial carbohydrate level of the cuttings has been given some attention, most work has been concentrated on what is occurring in the cutting during the rooting period. When cuttings are compared to attached shoots, the first carbohydrates to accumulate are the soluble sugars, followed by starch (5, 9). The accumulation of carbohydrates happens immediately after excision in photosynthetic tissue, whereas a lag period, or even a decrease is observed in the basal part.

The total level of carbohydrates in pea cuttings increased from about 8% of the dry weight to 20% during the root initiation period. Since the increase in dry weight in the cuttings is larger than the one observed in seedlings (4), either an increased photosynthetic rate has occurred, or the respiratory rate has decreased. Net photosynthesis has been determined in pea cuttings, and shows a decrease of ⅔ in the period until the root emerges (2).

Although this author was unable to find major changes in respiration, other work has shown that dark respiration decreases to 25% of the initial level during the first 24 h after excision of the cutting (1). It was notable that the decrease in dark respiration was dependent on the irradiance at which the cuttings rooted. It was shown that, independent of how little light the cuttings received, the dark respiration decreased such that the cuttings could maintain a positive net photosynthesis. It seems to be of importance for the cuttings to ensure accumulation of carbohydrates during

the rooting period. A reason for this may be that many biosynthetic processes that are necessary for adventitious rooting are coupled to energy consumption.

Determinations of the energy level (ATP) during rooting has shown, that the amount of ATP doubles in the base of the cuttings, during the first days. If the cuttings had been treated with auxin which caused the root number to triple, a 5-fold increase in the ATP level was observed (6). These results, and experiments by others, indicated that one important role of auxin is to make carbohydrates available in the base of the cutting. Carbohydrate then ensures that a high ATP level can be maintained. Many biochemical reactions require a high energy level before they can occur. The increased ATP level in the base of the cuttings may thus be the reason for those alterations in metabolism that initiate the rooting process.

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COMPARISONS OF STOCK PLANT ETIOLATION WITH TRADITIONAL PROPAGATION METHODS

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INTRODUCTION

The development of any novel or improved technology would be incomplete without extensive comparisons to pre-existing technology. For novel methods of propagating ornamental plants this comparison typically starts in the research phase with comparisons of rooting, establishment, and survival percentages. Yet, ultimately, the comparison ends on the accountant's desk, where the costs incurred in each propagation method are balanced with the revenue returned from each plant sold.

At Cornell University we have worked for the last eight years on improving and testing methods for increasing the success of softwood cutting propagation. We have focused on improved stem banding methods and stock plant etiolation schedules which extend the production season in northern climates by moving stock plants indoors early in the year. We have applied stock plant etiolation and stem banding with success to nearly 60 ornamental tree species and cultivars (12). These methods consistently improve the rooting percentages, root numbers, and quality produced by species which are reputedly very difficult to root, and extend the window of propagation opportunity, allowing higher rooting responses up to 2 to 3 months after the rooting of untreated material has fallen-off. Admittedly, our interests have been research-based, and etiolation and banding have been useful tools for our investigations into the physiological and anatomical bases for adventitious root formation in stem cuttings.

Many of the treatment responses we have observed fall into the "commercially acceptable range". We recognize, however, that the value of a technological improvement is limited until it is adopted by the industrial world. To see if stock plant etiolation and banding methods can make this hurdle, we have turned our attention to an examination of the establishment, survival, post-propagation performance and quality of plants propagated from initially etiolated or banded shoots, as compared to plants produced by cuttage, graftage, seed, and micropropagation.

WHY USE CUTTINGS?

Vegetative propagation uses clonal material for its obvious advantages: preserving desired genetic and epigenetic traits for

their economic value, accelerating species selection and improvement by preserving genetic gains made through conventional breeding programs, and making efficient use of selected germplasms by avoiding problems of alternate bearing in seed production.

As compared to graftage or micropropagation, cutting propagation makes more efficient use of limited production space with less skilled labor and fewer costs. And while the producers of micropropagated plants have come a long way in reducing costs, largely by increasing production volumes, they may never compete with cuttage in terms of the species diversity, level of skill, or lower costs possible when propagating low-volumes of plant material.

The rooted cutting has been touted as the solution to problems of incompatibility, suckering, and rootstock variability encountered in budding and grafting. This has probably come true for the more easily rooted species, but budding and grafting still remain the methods of choice in the production of dwarfed fruit trees and those species which do not root readily from cuttings (including material from mature stock), and budded or grafted plants often overwinter and grow better the first year, due in large part to the vigorous and well-established understock (5, 8). However, cuttings, with their genetically uniform roots and shoots, can be expected to grow more uniformly than grafts.

The recent attention given to problems with somaclonal variation among micropropagated plants, which increases with the rate of adventitious shoot formation, suggests that cuttage will continue to be one of the most important means of vegetatively propagating ornamental trees and shrubs (10).

COMPARISONS OF ROOTED CUTTINGS AND PLANTS PROPAGATED BY OTHER MEANS

Numerous comparisons of propagation methods have been made over the years. The initial growth of plants raised from seedlings and cuttings appears to be about equal (e.g. lowbush blueberry (1); Douglas fir (5); Monterey pine (7); Nootka cypress (11); English oak (14); white pine (15), although later on the growth of cuttings may lag if ramet maturation comes into play, as mature material typically grows more slowly (7, 11, 15). The greatest problem with cutting-grown, as opposed to seedling or seedling-grafted material, may be that the adventitious root system is of lower quality.

The roots of cutting-grown plants are typically shallower, less well-branched, and less adept at nutrient (15) and water uptake (9). Flemer (8) recounted several disappointments with own-rooted plants which died unexpectedly, did not overwinter well, or were poorly anchored. It has been suggested that the number of major roots on plants propagated from cuttings is determined at the time

of propagation (15). If this number is low it might detract from subsequent plant growth or root system support.

Regarding comparisons of rooted cuttings with micropropagated plants, it must be remembered that virtually all of the micropropagules produced today are still just rooted cuttings, and there is no consistent evidence that tissue-cultured plants will outgrow rooted cuttings or grafted plants (4, 10). Observations that micropropagated plants branch or grow better could reflect the residual effects of growth hormones applied to the plants *in vitro*. One real benefit of tissue culture is the potential for year-around propagation, and the potential to maintain the active growth of the propagule, which is difficult to achieve using rooted cuttings. Each propagation method has obvious advantages for either propagation, growth, or establishment. The bottom line, however, remains economic, and any method stands to benefit from technological or labor-saving advancements.

HOW DO WE EXPECT STOCK PLANT ETIOLATION AND STEM BANDING TO STACK UP?

Certainly, the need for stock blocks or containerized stock and the cost of material and labor for shading and banding will add to the expense of producing plants from etiolated and/or banded shoots. An excellent cost accounting of the production of several flowering dogwood cultivars by stem cuttings yielded a final cost estimate of about $0.34 per cutting (2). We have estimated that etiolation and banding could be expected to add from $0.11 to $0.16 to this cost, for a total of $0.45 to $0.50 per cutting (3). These costs are perhaps five to ten times that expected in the production of a 1-0 seedling (16), one-half that estimated for a budded plant (3), and one-third to equal that of a micropropagated plant. The trade-off must come from the benefits we can attribute to propagating from etiolated or banded shoots: increasing the range of species available from cuttings, using a simple yet effective technology, extending the production schedule, and obtaining improvements in plant quality deriving from the increased root numbers and root system quality typical of initially etiolated or banded cuttings. Forcing containerized stock in the greenhouse allows us to propagate earlier in the season, which may allow for additional top-growth, shortening production times and reducing costs. A plea was voiced recently for increasing the use of stock blocks and hedges (6), both of which adapt wonderfully to the application of stock plant etiolation and shading.

USING ETIOLATION IN THE NURSERY INDUSTRY

In cooperation with Schichtel's Nursery of Orchard Park, New York, we obtained funds from the New York State Agricultural Research and Development Grants Program, in 1989, to evaluate the commercial potential of cutting propagation using etiolation and banding, and to compare this with conventional methods. We have completed the propagation phase of this project, and the materials we propagated are being grown-on and overwintered before we start a field comparison this next year. Our goal is to assess the effects of initial stock plant etiolation and stem banding on rooting, establishment, survival, plant quality and cost. Etiolation, which refers to initially growing cutting material in the dark, has been recognized for decades as a technique for improving the rooting of stem cuttings. Banding is a localized form of etiolation using hormone-laden black Velcro tape to cover the base of the shoot as it is developing on the stockplant. We are focusing on four ornamental tree species not produced in large volumes because of the cost or difficulty of current methodology. We will compare the field growth of cuttings produced from initially etiolated or banded stock with plants propagated by seed, budding, and micropropagation. A cost analysis of the etiolation and banding treatments applied on a commercial scale will complete the study.

The following species were chosen for this study (the comparison method of propagation is indicated in parentheses). *Carpinus betulus* 'Fastigiata', European hornbeam (cleft grafted seedling understock); *Corylus colurna*, Turkish hazelnut (seed); *Malus* 'Spring Snow', flowering crabapple (micropropagated or budded); and *Syringa reticulata* 'Ivory Silk', Japanese tree lilac (budded on seedling understock). Between 1,200 and 3,200 cuttings of each of these four species were taken from containerized stock forced in a greenhouse in February, and field-grown stock in June, 1990. The cuttings were rooted in peat:perlite (1:2, v/v) under mist for 60 days (Table 1—indoor propagation; Table 2—field propagation) and, though root number and length were also evaluated, only percentage rooting data are shown. All of the species except the Japanese tree lilac showed strong responses to the use of indole-3-butyric acid (IBA) as a 5-sec dip at sticking. The European hornbeam and Turkish hazelnut responded to the application of Hormodin 3 at the time of banding, while the 'Spring Snow' crabapple responded to both etiolation and banding, with no additional response to hormone on the band. The Japanese tree lilac also responded to hormone on the band, and showed a synergism between banding and prior etiolation. Greenhouse forcing also improved overall rooting percentages over that seen in field-grown cuttings, a common observation in cutting propagation.

Table 1. Effect of stock plant etiolation and stem banding on rooting percentages of four greenhouse-forced ornamental tree species[1]

Species	IBA conc (ppm)[2]	Light-grown			Etiolated		
		No band	Band 3[3]	Band +H3	No band	Band -H3	Band +H3
Carpinus betulus 'Fastigiata'	0	17	21	21	10	31	55
	2000	91	98	78	97	88	85
Corylus colurna	0	0	0	13	0	0	13
	2000	3	6	41	2	13	28
Malus 'Spring Snow'	0	7	15	7	11	35	38
	2000	18	17	20	33	69	41
Syringa reticulata 'Ivory Silk'	0	51	51	64	75	86	100
	2000	67	61	72	69	97	98

[1] Each mean represents 6 replications of 6-12 cuttings
[2] IBA applied as a 5-sec dip at sticking
[3] H3 The application of Hormodin #3 (0 8% in talc) with the Velcro™ band was investigated as an additional factor in the banding response of rooting

Cuttings which rooted were grown on in a greenhouse and treated to stimulate additional shoot growth using combinations of defoliation, night interruption, cold and growth regulator treatments (see article by Maynard, Sun, and Bassuk in this volume). In the spring of 1991, these plants will be lined-out in side-by-side comparisons with the corresponding budded, micro or seed propagated materials of equivalent production age.

The determination of costs associated with etiolation and banding are underway, and final growth and cost evaluations will be completed by October, 1991

CONCLUSIONS

The stock plant treatments of stem banding, etiolation, and even light shading are proven research tools, and can yield tremendous improvements in propagation response. However, as Mark Richey of Zelenka Nursery, Inc. (13) pointed out, the bottom line in plant propagation is not just the percentage rooting but also the labor given to the production of the crop. We hope that our story does not end here. Whether it is by increasing the range of materials which may be produced on their own roots, by extending the production season, or by increasing the success of propagation and establishment, we hope that methods which exclude or reduce light during shoot development will be recognized as valuable tools available to the commercial plant propagator.

Table 2. Effect of stock plant etiolation and stem banding on rooting percentages of four field-grown ornamental tree species[1]

Species	IBA conc (ppm)[2]	Light-grown			Etiolated		
		No band	Band -H3[3]	Band +H3	No band	Band -H3	Band +H3
Carpinus	0	4	8	54	13	25	31
betulus	1000	27	34	76	34	40	61
'Fastigiata'	4000	39	31	82	40	48	57
Corylus	0	0	0	6	—	—	—
colurna	2000	6	2	27	—	—	—
	4000	5	0	14	—	—	—
Malus	0	3	13	12	—	—	—
'Spring	2000	3	18	28	—	—	—
Snow'	4000	2	27	27	—	—	—
Syringa	0	38	35	69	—	—	—
reticulata	2000	3	18	28	—	—	—
'Ivory Silk'	4000	2	27	27	—	—	—

[1] Each mean represents 6 replications of 6 to 12 cuttings.
[2] IBA applied as a 5-sec dip at sticking.
[3] H3 The application of Hormodin #3 (0 8% in talc) with the Velcro™ band was investigated as an additional factor in the banding response of rooting
(—) = Treatments not applied.

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Thursday Morning, December 13, 1990

The morning session was convened at 8:00 a.m. with Anna J. Knuttel serving as moderator.

PROPAGATION TECHNIQUES OF *CORNUS KOUSA* AND *HAMAMELIS TAXA*—1940s VS. 1980s

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It has been said that with the advent of antibiotics the science of medicine emerged from the dark ages. It may also be said that plant propagation underwent similar advancement when root-inducing substances, polyethylene plastic film, mist, and fog systems, together with other new technology came into being.

In earlier years, those involved with plant propagation and other skilled horticultural occupations in the United States were mostly immigrants from Europe. In Europe, practical horticultural knowledge had evolved through the ages by trial and error and was handed down from one generation to the next. The skill and ability that propagators had was acquired through long apprenticeships which usually started when they were young boys. Craftsmanship which they had to offer was usually basic in aspect, highly work intensive, but productive.

Much of the great progress in plant propagation made during recent years can be credited directly to this great organization, The International Plant Propagators' Society. This association has brought together those involved with the scientific investigation of plant propagation and those concerned with the more practical aspects of commercial plant production, and all have benefitted greatly.

OLDER METHODS OF SEED TREATMENT

Throughout the years botanical institutions such as the Arnold Arboretum received seeds from many parts of the world. Such seeds often had dormancies that were not understood. At the Arboretum in the older days the method of treating seeds that had barriers to germination was basic. They were sown in shallow clay pots called seed pans which were then placed on a greenhouse bench. If they had not germinated by autumn they were transferred to an out-of-doors cold frame where they would spend the winter. To prevent heaving and to discourage rodents they were covered with a mulch of coal ashes. In spring when the seed pans were returned to a warm greenhouse, germination would take place in some as the winter had satisfied the necessary cold requirement. If germination did not take place and the seeds still appeared sound they remained in the greenhouse for the summer. In autumn they would again be placed out-of-doors for a second cold treatment.

William H. Judd, the Arboretum's propagator at that time, had been trained in England and was following the method of treating seeds that he had learned there. These treatments, though cumbersome, no doubt led to the germination of some seeds both dormant and doubly dormant, whose barriers were not understood at that time.

SEED TREATMENT NOW

With the advent of polyethylene plastic film, the treatment of seeds with dormancies has been revolutionized. Seeds requiring periods of stratification can now be processed in a simple, efficient, and relatively work-free manner. The seeds are combined with about two or three times their volume of damp stratifying medium and the combination is put in a polyethylene plastic bag which is bound at the mouth with a rubber band to make it vapor tight. Polyethylene film has the property of being air permeable yet vapor proof, with the result that oxygen is available to the contents by diffusion. A properly sealed bag will not require attention during pretreatment no matter how long the period might be. Bags needing only one stage of treatment by cold are placed in a 40 °F refrigerator for the required time. Those needing two stages of treatment to overcome double-dormancy are placed on a greenhouse bench to undergo warm stratification after which they are transferred to a refrigerator to fulfill the second requirement. These procedures are not only simple, foolproof and effective, but so much less labor intensive than the older methods of treating seeds. A card file arranged in chronological order, if checked each week, will assure that the various movements of the seed bags are accomplished at the proper time.

PRETREATMENT OF *CORNUS KOUSA* SEEDS

Preparing Cornus kousa seeds for germination is a simple matter. When prepared as described above and placed in a 40 °F refrigerator for three months, they will be ready to germinate. However, seedlings vary greatly in character, with some being far more desirable than others. Softwood cuttings root readily and therefore vegetative propagation of selected clones by cuttings would be far more satisfactory.

PRETREATMENT OF HAMAMELIS SEEDS

Hamamelis seeds are doubly-dormant and require two stages of pretreatment to be prepared for germination. Five months of warm followed by three months of cold treatment has been satisfactory. However, the warm period can be modified by lengthening if it

then leads to sowing at a more favorable time, such as during the lengthening days of spring.

PROPAGATION OF *HAMAMELIS*—THEN AND NOW

On checking a number of old and very old references concerning the vegetative propagation of *Hamamelis* species, we found that through the years grafting, budding, and layering were the recommended procedures.

In August of 1973, I attended the Annual Meeting of the International Plant Propagators' Society, Region of Great Britain and Ireland, held at Berkshire College of Education, Early, Reading, Berkshire. A paper was presented pertaining to the budding of *Hamamelis*. In the discussion that followed, we learned that in Britain at that time this subject was propagated by budding and grafting using *H. virginiana* as understock. We also learned that seeds and seedlings of *H. virginiana* previously imported from the United States were becoming unavailable in Europe, and there was much concern about the future propagation of *Hamamelis* in Britain.

Fortunately, this is not a serious problem, for experience at the Arnold Arboretum with 22 taxa indicates that all *Hamamelis* can be rooted from cuttings in high percentages, which can them be induced to survive the first winter.

PROPAGATION OF *HAMAMELIS* BY CUTTINGS

A hybrid of *Hamamelis japonica* × *H. mollis* appeared at the Arnold Arboretum some years ago and was named *Hamamelis* × *intermedia* 'Arnold Promise'. It was put on the Arboretum's distribution list, and that gave us an opportunity to work on the propagation of *Hamamelis* by cuttings. Grafting and budding were avoided because of understock problems that can arise.

In our first attempt, cuttings taken on 28 June 1961 led to the rooting of 118. They were potted on 15 September and later transferred to our cold storage unit for the winter. When it came time to plant them out, they were all dead.

Some plants that propagate by softwood cuttings present a survival problem during the first winter. They go into dormancies from which they never recover. Among these are the various taxa of *Hamamelis*.

First winter loss was averted when the cuttings were not disturbed after they had been rooted in plastic flats. When rooting had taken place, the cuttings were left undisturbed in the flats and hardened off. In autumn the flats were transferred to our cold storage unit, where the temperature is maintained at about 34 ° F.

In about 3 or 4 months the flats were returned to a warm greenhouse where new growth soon appeared.

In recent years the Arboretum has imported new *Hamamelis* hybrids from Europe. Plants which arrived were always grafted. At the earliest opportunity, we rooted these from cuttings and always with a high percentage of success when they were processed as described above. Softwood cuttings collected in June and semi-ripe wood gathered throughout July have all rooted in high percentages. Root-inducing formulations containing IBA at the rate of 8 mg in a gram of talc were used. Wounding the cuttings on one side was tried and discontinued as the roots arose only from the bases of the cuttings.

PROPAGATION OF *BUXUS* AND *HIBISCUS*: A REVIEW—1940s TO 1980s

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I mention first-off that I do not consider myself an expert or an authority regarding either *Buxus* or *Hibiscus*. This is not to detract from their worthiness nor my appreciation, just a matter of circumstance. We have propagated and grown *Buxus* at John Vermeulen & Son for well over 40 years primarily from stem cuttings and in the 1950s were doing *Hibiscus syriacus* cultivars by whole root grafts but none since due to changing our product lines with the times. I believe both should have wider and more serious attention. Perhaps this review will help encourage that.

BUXUS

The genus *Buxus*, boxwood, is not native to North America. Literature variously claims some 30 to 70 species in western Europe, Mediterranean regions, eastern Asia, northwestern India, tropical and South Africa, and Central America. Discussion here will be limited to *B. microphylla* and *B. sempervirens*.

The trade and gardening public generally consider boxwood to be small, low, compact, and slow growing. Broadening the knowledge and uses promises much gain horticulturally and commercially, i.e. the larger *B. sempervirens* forms with some growing to 50 ft.

Although the hardiness factor has limited their use, recent selections can now be used in colder climates. Dirr (5) mentions three *B. sempervirens* cultivars, 'Inglis' and 'Pullman' to -20° F and 'Northern Find' to -30° F. In the 1950s former faithful member Joe Foucek of Sunnyside Nurseries in Troy, Illinois selected and grew a boxwood that was very hardy, kept a very good winter color and made up rather rapidly. I suggested he call it 'Sunnyside' and we listed it as such first in our 1964/1965 catalog as *B. microphylla* var. *koreana* 'Sunnyside'. Another introduced by Eastern Shore Nursery of Maryland is *B. microphylla* var. *japonica* 'Green Beauty'. It has withstood -22° F in our nursery and maintains excellent green winter color. Sheridan Nurseries of Mississauga Ontario, Canada offers four very hardy forms, 'Green Gem', 'Green Mound', 'Green Mountain' and 'Green Velvet', which Joerg Leiss (19) advises were selected from among 500,000 progeny of chance seedlings of *B. sempervirens* and thought to be crossed with

B. microphylla var. *koreana*. They are also drought resistant. Scarff's Nurseries (28) of New Carlisle, Ohio introduced *B. microphylla* var. *koreana* 'Wintergreen' (which they advise is now botanically known as *B. sinica* var. *insularis* 'Wintergreen') as an extremely hardy form.

Propagation. Larson (18), Leiss (19) and Roe (28) and others admit no spectacular advances in *Buxus* propagation in the 40 year period discussed here. Leiss writes "In the 1940's. . . nurseries in Europe did not even handle *Buxus*. Cemetery gardeners had hedges planted deep and. .rooted shoots were ripped off. . ." "When I came to Sheridan Nurseries *B. microphylla* var. *koreana* was the mainstay. Cuttings were made in glasshouses from a single year's growth. It took two years for them to develop. . .sand was used as a medium. *Buxus microphylla* var. *koreana* was also grown from seed with uniform populations and selections made for green color and particular habits."

Propagation at Scarff's is by stem cuttings starting in September. Roe and Sommers (28) gave us details in their 1988 paper to this Society. At our nursery we propagate by stem cuttings in late summer-early fall, after cuttings have hardened and before serious frost desiccation. Cuttings are stripped; treated with #2 Hormodin; inserted in flats containing granulated Canadian peat, clean sharp sand, horticulture grade perlite (1:1:1, v/v/v); and placed under intermittent mist until rooted. Tom McCloud at Appalachian Nursery takes 2- to 6-in. semi-hardwood cuttings from September 1 to 15, strips lower leaves, treats with Dip'N Grow (1 to 15, v/v) sticks in flats containing peat, perlite and styrofoam flakes (2:1:1, v/v/v), heats the medium starting October 15th to 60 to 65° F, mists, and gets 60 to 80% success.

Fraser Hancock (10), propagator at Sheridan Nurseries, advises: We use a similar system for about ½ of our crop of 300,000 cuttings (4 cultivars) using a raised sand bench with a white-poly tunnel covering. Cuttings are stuck September through October 31, and treated with 0.8% IBA in talc. These cuttings take 1½ years to root and results in 60 to 80% rooting. The other half go in sand and perlite beds in the greenhouse in December with bottom heat 65 to 70° F and rooting 90 to 95% in 8 weeks. Rooted cuttings are hardened off and moved to the field in spring. In the poly tunnel he prefers mature basal tissue and removes soft tips as these die in winter with the dead tissue subsequently causing fungal problems. The poly is shaded throughout, vented in summer.

At Monrovia Nurseries, Azusa, California, Dennis Connor reports all *Buxus* are propagated from 1½ in. softwood cuttings most of the year. These are washed in baths of 15 ppm chlorine then 200 ppm Physan, receive a quick-dip in 1000 ppm IBA, are stuck in flats with pasteurized mix of ROS peat, redwood sawdust, and plaster sand

(4:1:1, v/v/v), and placed under mist in outdoor beds in full sun. Bottom heat is kept at 80 °F. Rooting takes about 6 weeks.

I found the following discussions in previous IPPS Proceedings:

1954 Steavenson using mist over flatted cuttings in unshaded open beds. (31)

1955 De Groot using Chloromone on winter and summer cuttings (3)

1956 Hancock rooting summer cuttings with the Burlap Cloud method (11) (the method was updated in 1988 by grandson Fraser Hancock) (9)

1960 Kester dealing with stratification requirements for seed propagation (17)

1961 Piringer using supplemental light to enhance rooting (27)

1963 Hess reported *Buxus* response to long days is variable (14)

1965 Good and Tukey on leaching resulting from mist applications (7)

1965 Wott and Tukey on the influence of nutrient mist on rooting (34)

1966 Nelson on the role of bottom heat on root initiation (25)

1977 Milbocker using controlled environment in a humid chamber (23)

1983 Morgan and Colbaugh on the influence of sanitation treatments (24)

1988 Roe and Sommer discuss hardiness, new cultivars, and rooting of cuttings (28)

The Boxwood Bulletin of the American Boxwood Society, P.O. Box 85, Boyce, VA 22620, carries articles on *Buxus* propagation in the following volumes 2 (3,4), 3 (1), 6 (2), 8 (1), 13 (2), 14 (1), 16 (1), 20 (3), 22 (4), 23 (2), 25 (2), 27 (2, 4), 29 (1).

Research. Cdr. P.D. (Swede) Larson at the Blandy Experimental Farm of the American Boxwood Society (ABS) (18) states there is confusion and misinformation regarding origin of most cultivars, and that most being worked with show different responses to various factors applied in propagation. He states: 1) with *B. sempervirens* 'Suffruticosa' there may be 150 different unrecognized cultivars that could respond differently; 2) comments that *Buxus* cuttings root rather easily indicating experience with limited or confined groups. Interestingly, he observes that cuttings root best when taken from the top ⅓ of the plant. He urges a much greater research participation over a wide geographical area with a wide selection of cultivars to arrive at perhaps 20 or so outstanding cultivars having sufficient commercial potential so as to increase their popularity and use.

The ABS has cooperated with and partially funded research by Dr. Thomas Banko of VA Truck and Ornamental Research Farm of Virginia Beach, VA. Some of this work he has kindly consented to have included in this paper hoping to generate additional cooperation and support. His goal is to determine rooting response relative to times of cutting selection. Research reported here was done in 1985-86. About the 1st and 15th of each month, April, 1985, through March, 1986, 100 cuttings were taken from each of 5 subjects, *B. microphylla* var. *koreana, B. microphylla* var. *japonica, B. sempervirens* 'Suffruticosa', *B. sempervirens* and *B. harlandii.* All plants were mature and in full sun. Buxus sempervirens 'Suffruticosa' cuttings were 6 cm (2½ in.) long, others 10 cm (4 in.). All were stripped at basal end. Fifty cuttings received a 5-second dip in K-IBA, 4000 ppm. Fifty cuttings received no treatment. Twenty cuttings of each of the five subjects, 10 treated and 10 not treated, were stuck in flats containing a mix of pulverized pine bark and coarse perlite (1:1, v/v) and placed in a glass house kept to 60° F. There was no bottom heat and cuttings received 5 sec. of mist every 5 min. Cuttings were lifted after 20 weeks. The results:

Treated Cuttings: (optimum rooting times)

B. microphylla var. *koreana:* best mid-May to mid-September, poor mid-September through January and moderately well February 1 to mid-May

B. microphylla var. *japonica:* best mid-June through mid-September, poor through winter, better in April

B. sempervirens 'Suffruticosa': best July through October, poor during winter, better February through April

B. sempervirens: best mid-December through mid-April, also early July through early October, poor mid-October through early December

B. harlandii: uniformly rooted close to 100% throughout the year

Untreated Cuttings: All were similar to treated cuttings, however treated cuttings had more and stronger roots; also the optimum rooting periods were narrowed, *B. harlandii* rooted close to 100% except in October through November.

HIBISCUS

Of the 150+ species worldwide I will focus on *Hibiscus rosa-sinensis*, the Zone 9/10 Chinese hibiscus, and *H. syriacus*, the Zone 6 rose of Sharon or shrub Althea. *Hibiscus syriacus* and cultivars,

being hardy, were discussed in early I.P.P.S. meetings. Chadwick (2) in 1953 reported on storage vs. no storage on rooting of hardwood cuttings; in 1962 Halward (8) reported on the use of dormant scionwood and using side or veneer grafts with 1 year mature scionwood on *H. syriacus* in winter-spring; Whatley, Thompson and Williams (33) in 1966 tell of beneficial effects of using dimethyl sulfoxide (DMSO) as a carrier or synergist for auxins in the rooting of softwood cuttings; in 1969 Carville (1) recounted highly successful rooting of softwood cuttings under outdoor polyethylene tents. In 1979 Loach (20) reported decreased rooting at very low light levels under mist. Currently Tom McCloud of Appalachian Nurseries, Waynesboro, PA is taking 4 to 6 in. softwood cuttings July 1 to 15; leaving 2 to 3 leaves; not wounding; treating with Dip'N' Grow 1 to 20; sticking in peat and vermiculite (2:1, v/v) in a shaded greenhouse bench without bottom heat, under mist, and averaging 80 to 90% rooting.

With the expansion of IPPS memberships to moderate and tropical climates more work began to be shared with the less hardy (Zone 9/10) *H. rosa-sinensis*. Roller (29) reported grafting procedures at Cartwright Nurseries, Winchester, Tennessee in his 1964 paper at Sacramento, California. In a recent letter he recalls 30 years ago rooting in sand or any of the commercial mixes using new firm, but not hard, wood leaving 2 to 3 leaves, using 25% Chloromone or #2 Hormodin and just enough mist to keep leaves from wilting. He states budding was not difficult and was successful when he budded on green, soft shoots.

Hess (12, 13, 15) used *H. rosa-sinensis* in rooting cofactor research in 1959, 1961 and 1965. We have had papers from Walters (32) on cuttings, grafting and budding in 1967; Macdonald (22) on the effects of lighting on propagation in 1969; grafting was also discussed by Palmer (26) in 1973 and Scott (30) in 1975 and 1976. Also in 1976 de Lance (4) reported on the effects of bottom heat; in 1984 Kelety (16) told us about propagation and container culture in Texas; and in 1985 we heard how they do it "down under" from Wellesley Eden (6) in his paper, "*Hibiscus* Propagation in Cool Climates".

A wealth of information is given us by Bruce Macdonald (22) in his book *Practical Woody Plant Propagation for Nursery Growers.* He covers mother plants on page 513, seed treatment, page 45; hardwood cuttings, page 307; heated bins as an alternative to conventional grafting and budding on page 322; the Melfert unit container for rooting cuttings on page 210—the unit being a 'padded envelope' the padding being a growing medium with cuttings rolled individually in each envelope; different grafting types on pages 511, 517, 518, 563,578 and 587; and machine grafting on page 196.

Current practice at Monrovia Nurseries, Azusa, California as given by Dennis Connor advises taking 2½- to 3-in. semi-softwood cuttings all year, leaving one leaf which is cut in half, and washing in baths of 15 ppm chlorine then 200 ppm Physan. After a quick basal-end dip in liquid IBA at 1,000 ppm the cuttings are stuck in flats containing a pasteurized mix of perlite and peat-moss (9:1, v/v). Rooting occurs under intermittent mist over 80 °F bottom heat in a greenhouse, with air temperature kept at 85 to 90 °F, in about 4 weeks.

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INTEGRATED PEST MANAGEMENT RESEARCH AND IMPLEMENTATION IN MASSACHUSETTS

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The Nursery IPM Program in Massachusetts has just completed its second season. During this time the goals of the program have been to: determine the key pests of Massachusetts nurseries; find the best methods for monitoring these pests; and find ways to better manage pests through the implementation of IPM techniques. The program includes scouting major crops at seven cooperating nurseries located throughout the Commonwealth.

As part of the IPM project, we also conduct experiments to provide additional information about the management of key pests.

ROOT WEEVIL RESEARCH

Black vine weevil (*Otiorhynchus sulcatus*) is a major pest in Massachusetts nurseries. Recently, strawberry root weevil (*Otiorhynchus ovatus*) larvae have also been found to cause significant damage. The significance of these pests lead to several investigations to improve the management of root weevil pests.

Monitoring Black Vine Weevil Adults. Growers commonly time their spray schedules for black vine weevil based on calendar date estimations of adult emergence or when signs of adult feeding (leaf notching) are first detected. Although pit-fall traps have been recommended for monitoring adult black vine weevils (7), Massachusetts growers rarely used traps for monitoring weevil populations, and found that looking for signs of adult feeding was easier than maintaining the traps.

We investigated the use of burlap traps, trap-boards, and visual inspection to determine the most accurate means of early detection of adult black vine weevil activity in nursery crops. Burlap traps and trap-boards were selected because they are simple to construct and are maintenance free (4, 6), which might make them more attractive to growers than pit-fall traps. The traps were placed under *Taxus* plants in a commercial nursery and were inspected twice each week for adult weevils. Plant foliage was also inspected for signs of recent feeding.

Burlap traps were the most effective method for detecting adult black vine weevil activity (Table 1). Signs of adult weevil presence in a block were first detected through the use of burlap traps 81% of the time. Burlap traps were also more attractive as resting places

for weevils (Table 2), with an average of 6 weevils caught per burlap trap, compared to 1 weevil per trap-board. Further investigations are planned to determine whether burlap traps can be used to estimate weevil populations in nursery fields.

Table 1. Efficacy of monitoring methods for detection of adult black vine weevil

Monitoring method	Percent first detection of adult black vine weevil activity
Foliar inspection	14 9 ± 10.1
Trap-boards	4 2 ± 4 2
Burlap traps	81 0 ± 11 2

Table 2. Efficacy of burlap traps and trap-boards for monitoring adult black vine weevil

Trap	Ave number of adult black vine weevils collected per trap
Burlap trap	6.5 ± 3 0
Trap-board	1 2 ± 0 2

Burlap traps are now used in the Massachusetts IPM program to monitor black vine weevil and strawberry root weevil adults. In addition, a fact sheet containing information on the use of burlap traps was sent to Massachusetts nurserymen (6).

Controlling Black Vine Weevil Larvae Using Nematodes. Infested *Euonymus fortunei* radicans, growing outdoors in 2-gal containers in a Massachusetts commercial nursery were treated with three nematode strains: two strains of *Heterorhabditis* sp. (HL 81 and HP 88) are one strain of *Steinernema carpocapsae* (NC All). The applications were made on three dates in May and June (Table 3) and the nematodes were applied at a rate of 1 million nematodes/m^2 of container medium surface. Efficacy of the treatments was determined by the number of black vine weevils that successfully completed metamorphosis and emerged as adults from the container medium (the plants were covered with cheesecloth netting to keep emerging adult weevils in the containers and to exclude migrating weevils).

All nematode preparations were successful in reducing the black vine weevil population, and the nematode strains were equally effective in controlling the weevils (Table 3). Additional experiments will be conducted to determine the effect of container medium temperature of nematode efficacy

Table 3. Effect of nematodes on the incidence of adult black vine weevil emergence from container-grown *Euonymus fortunei* radicans

Nematode strain	No. weevils/container[a]
Untreated check	0 4 a
Heterorhabditis sp	
HL 81	0 2 b
HP 88	0.1 b
Steinernema carpocapsae	
NC All	0 1 b

[a] Means followed by the same letter are not significantly different as determined by Duncan's Multiple range test, P = 0 05

Insecticide Efficacy for Controlling Strawberry Root Weevil Adults. Strawberry root weevil larvae have been found in large numbers infesting hemlock and arborvitae and larval feeding has been associated with the death of hemlock plants in Massachusetts nurseries. The adults have been found infesting hemlock, yew, rhododendron, and arborvitae. Significant damage from the adults has not been noted in Massachusetts, although adults can damage arborvitae by girdling the stems (3). Since there is relatively little published information on strawberry root weevil, a laboratory experiment was conducted to determine the efficacy of several pyrethroid insecticides and Orthene for controlling strawberry root weevil adults in hemlock (*Tsuga canadensis*) fields. To ensure complete foliar coverage, hemlock twigs were submersed in insecticide solutions. The cut ends of the twigs were then placed in small vials filled with tap water to inhibit desiccation of the plant tissue. Twigs were placed in cages containing five adult strawberry root weevils. In addition to the hemlock, each cage also contained a cotton ball that was kept moist with tap water to supply adequate water to the weevils. The effect of the insecticides were evaluated from 2 through 20 days after treatment (DAT). Weevils were considered injured if they behaved atypically as compared to untreated weevils; i.e., if they had diminished coordination when walking or were moribund. The percent dead insects and percent total injury (injured + dead insects) were used to evaluate insecticide efficacy.

Within 2 DAT all the insecticides except Asana and Mavrik significantly injured strawberry root weevil (Table 4). However, some of the weevils that were initially injured by the insecticides recovered, so that by 20 DAT only Tempo 2, Orthene, and Orthene + Danitol caused significant injury. Also, weevils that recovered did not resume feeding on treated foliage and mortality may have been higher if the weevils did not have access to moisture from the cotton balls. Weevils exposed to untreated twigs fed on the foliage throughout the duration of the experiment. (Under field conditions,

where environmental conditions are harsher than the lab., mortality may also be higher.) Only Orthene and Orthene + Danitol caused significant mortality. Since Orthene and Orthene + Danitol were equally effective in controlling strawberry root weevil while Danitol alone was ineffective, mortality resulting from Orthene + Danitol may be caused by Orthene.

Table 4 Efficacy of insecticides for controlling adult strawberry root weevil (laboratory study)

Treatment	Rate lb AI/100 gal	2 DAT % mortality	2 DAT % total injury	10 DAT % mortality	10 DAT % total injury	20 DAT % mortality	20 DAT % total injury
Untreated	—	0 (NS)	0 e	7 c	13 c	27 bc	27 cd
Asana 1 9 EC	0 05	0	10 de	3 c	3 c	17 c	17 d
Ambush 2 EC	0 2	0	27 bcd	3 c	27 c	20 c	47 bc
Tempo 2	0 03	0	83 a	17 bc	60 b	47 b	57 b
Mavrik Aquaflow	0 16	0	7 de	3 c	17 c	17 c	20 d
Danitol 2 4 EC	0 4	0	30 bcd	13 c	17 c	17 c	33 cd
Orthene 75 S	0 75	0	43 b	60 a	93 a	100 a	100 a
Orthene 75 S + Danitol 2 4 EC	0 5 + 0 2	0	33 bc	33 b	83 ab	100 a	100 a

Data transformed to arcsine $\sqrt{x}$ before ANOVA Means within columns followed by the same letter are not significantly different (Waller-Duncan K-ratio t-test, K = 100) (NS) = not significant

Of the insecticides used in this experiment, only Orthene and Mavrik list strawberry root weevil as a target pest. Based on the results of this experiment, Univ. Massachusetts Cooperative Extension is recommending Orthene for control of strawberry root weevil adults infesting hemlock.

WEED MANAGEMENT

There is limited data on the competitive ability of weed species in nursery crops. However, as more information is generated on the tolerance of specific nursery crops to various levels of weed infestation, nursery managers can use the information to determine whether additional herbicide applications are needed or to determine the frequency of hand or mechanical weeding that will be needed to prevent weeds from reducing crop growth.

Common Groundsel Interference in Nursery Crops. Common groundsel (*Senecio vulgaris*) is considered particularly troublesome in container-grown nursery crops because it begins growing in containers stored in overwintering houses prior to spring applications of preemergence herbicides. Common groundsel seed also germinates in late summer and early autumn in both containers and field-grown crops, when many spring-applied preemergence

herbicides are no longer active. Although common groundsel is frequently found in northern nurseries, its effect on the growth of nursery crops has not been established.

Common groundsel interference was determined in container-grown boxwood (*Buxus microphylla* var. *koreana* 'Wintergreen'), euonymus (a variegated sport of *Euonymus fortunei* var. *radicans*), and Sargent juniper (*Juniperus chinensis* var. *sargentii*). Bare-root liners of each species were planted in 1-gal and 2-gal containers. One month later, three-week-old groundsel seedlings were transplanted into the containers at rates of 0, 1, 2, 3, and 4 weeds/container. Any additional weeds that germinated in the containers during the experiment were removed by hand. Nursery crop growth index (Tables 5 and 6) was used to determine the effect of groundsel interference on the growth of the nursery crops. Growth indices were measured 0, 2, 4, and 6 weeks after transplanting (WAT) the groundsel seedlings. The experiment was terminated after the 6 WAT measurement since the groundsel plants had set seed and some had begun to senesce by 6 WAT. The experiment was conducted in a polyhouse where the temperatures were maintained between 75° F (day) and 65° F (night).

Common groundsel did not interfere with the growth of euonymus, but reduced the growth of boxwood 2 through 6 WAT. The decrease in boxwood growth was linear at 4 and 6 WAT (Table 5). There was also a linear decrease in juniper growth at 4 and 6 WAT (Table 6).

Table 5. Effect of common groundsel and container size on the growth index of 'Wintergreen' boxwood

	Mean growth index (cm)[a]			
Treatment significance	0 WAT[b]	2 WAT	4 WAT	6 WAT
Weeds	NS[c]	**	**	**
Linear	—	NS	*	*
Quadratic	—	NS	NS	NS
Container size	NS	*[d]	*[d]	NS

[a] Growth index is determined by (height + width 1 + width 2)/3. Width 1 and width 2 are measurements taken in north-south and east-west directions.

[b] WAT = weeks after transplanting common groundsel seedlings into containers.

[c] NS, *, ** = Nonsignificant or significant at P = 0.05 or 0.01, respectively.

[d] The interaction of weeds and container size was not significant at P = 0.05.

Table 6. Table 6. Effect of common groundsel and container size on the growth index of Sargent juniper

Treatment significance	Mean growth index (cm)[a]			
	0 WAT[b]	2 WAT	4 WAT	6 WAT
Weeds	NS[c]	NS	**	**
Linear	—	—	**	**
Quadratic	—	—	NS	NS
Container size	NS	NS	NS	NS

[a]Growth index is determined by (height + width 1 + width 2)/3 Width 1 and width.2 are measurements taken in north-south and east-west directions

[b] WAT = weeks after transplanting common groundsel seedlings into containers

[c] NS,*,** = Nonsignificant or significant at P = 0.05 or 0 01, respectively

Groundsel did not interfere with the growth of euonymus and was moderately competitive in boxwood and Sargent juniper. From this study and similar studies on the effects of weed species on nursery crop growth, a rating system can be devised to determine which weeds species are likely to compete with nursery crops. Growers can use this information to determine whether to tolerate the presence of certain weed species or whether action must be taken to prevent a significant loss of growth of the crop. From the available literature on weed competition in nursery crops, the following rating system was devised (Table 7):

Table 7. Competitive ability of weeds in nursery crops

Highly competitive[a]
Redroot pigweed (2)
Large crabgrass (2, 8, 9, 10)
Giant foxtail (8, 9, 10)
Baryardgrass (8, 9, 10)
Moderately competitive[b]
Common groundsel (6)
Prostrate spurge (1)
Slightly or not competitive[c]
Bittercress (11)
Common yellow woodsorrel (1)

[a] One or two weeds reduces crop growth as much as many weeds, or the relationship between crop growth reduction and weed numbers is quadratic.

[b] Crop growth continues to decrease as weed numbers increase

[c] Little or no reduction of crop growth occurs

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BENEFICIAL NEMATODES FOR BIOLOGICAL CONTROL OF INSECT PESTS

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INTRODUCTION

The major commercial nematode is currently named *Steinernema carpocapsae*, first collected and described in both the United States and Czechoslovakia in 1954. It has also recently been called *S. feltiae*, and *Neoaplectana carpocapsae*. The name *S. feltiae* has now been assigned to what used to be known as *S. bibionis*, so the distinction is important.

LIFE CYCLE

Juvenile steinernematids called infectives enter through natural openings on the insect body, often through the mouth. Once inside, they shed their protective skin, penetrate the gut wall and get into the insect's blood system, and secrete a toxin that rapidly kills the insect. At the same time, the steinernematids carry a special bacterium into the insect. Once in the blood system, the bacteria begin to multiply and also contribute to host death. The bacteria provide a food supply which supports the nematodes' sustenance and reproduction.

The nematodes enter their reproductive phase in the insect's blood system and subsequently grow and molt through a third and fourth juvenile stage before becoming adults. The adults mate and produce a first generation of nematodes that usually molts only three times and quickly creates a second generation of adults.

This is where the unique aspect of steinernematid nematodes becomes evident: when the insect cadaver becomes crowded with nematodes, the normal life cycle shunts into a long-term survival strategy (Figure 1) that allows the nematodes to survive until they can find another insect host. Second stage nematodes grow into "infective" nematodes, a non-feeding, survival stage with closed mouth, collapsed gut and thick skin that can even withstand some slow drying. Infectives can survive several years in the soil, wriggling toward chemical cues from insects, and attempting to enter the insects.

From our perspective, the infectives are the most important stage. They are the only stage that can attack and kill the insect and they allow a product shelf-life of at least 6 months. In aerated 50° F water they can be held for several years with little loss of viability. The infective stage has made it possible for several companies to produce them commercially.

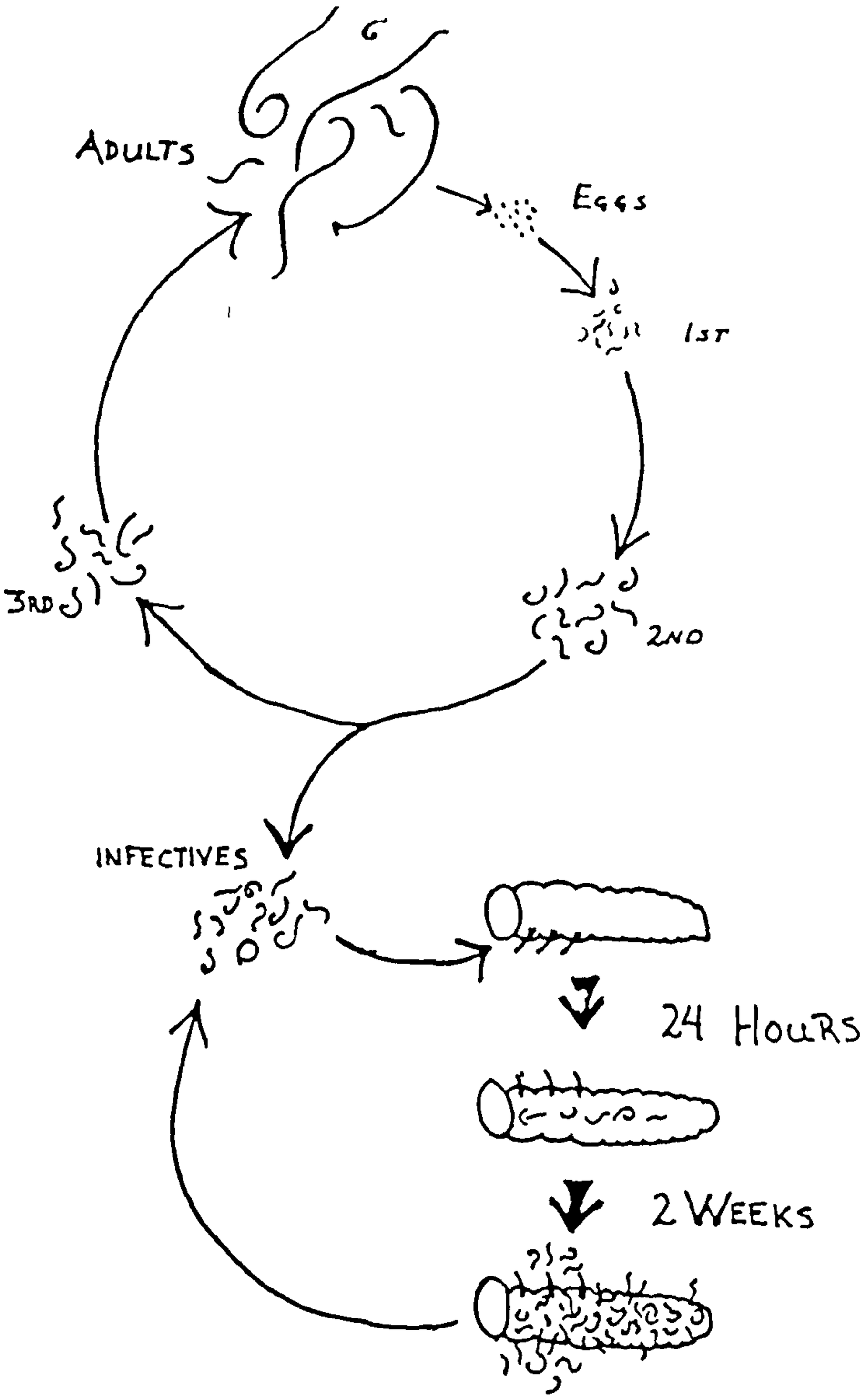

Figure 1. Life cycle of *Steinernema carpocapsae* nematode

PRODUCERS

The two major producers in the United States are BioLogic, a private firm founded in 1985 in Pennsylvania, and Biosys, a public California firm founded in 1983. Both firms produce billions of nematodes per year.

Biosys produces BioSafe™ as its homeowner package and BioVector™ as its bulk package. Both packages consist of the ''All'' strain of *S. carpocapsae.*

BioLogic produces ScanMask™ and EcoMask™. The ScanMask consists of the ''Umea'' strain of *S. carpocapsae*, which was originally isolated near the Arctic circle in Sweden, hence the name ''Scan'' (for Scandinavia), ''Mask'' (Swedish for nematode). ''ScanMask'' is more climatically adapted to colder northern soils, noticeably larger than the ''All'' strain, and more expensive to produce. ''EcoMask'' is a hybrid comparable in length, price and temperature tolerance to the ''All'' strain.

EFFECTS ON NON-TARGET ORGANISMS

These nematodes have been termed beneficial because they have no ability to harm warm-blooded animals since they cannot tolerate high temperatures. The next question an organic grower will ask is ''What about earthworms?'' Tests of immensely high numbers of nematodes against earthworms resulted in healthy earthworms.

ENVIRONMENTAL CONSTRAINTS

Nematodes are most successful for those who respect their constraints. They are extremely sensitive to ultraviolet light. For this reason, we recommend that applications be made early in the morning or in the evening.

Although infectives can withstand controlled drying, they are harmed by sudden drying and have had very erratic success in dry environments. The best results to date have been in moist environments: against black vine weevil and other soil insects in pots and cranberry bogs, against grubs in well-watered lawns, against wood and cane borers in their tunnels, and against fungus gnats in greenhouses. Perhaps the problem here is that the nematodes need a film of water to move down into the soil and hence avoid radiation.

Like moisture, temperature affects the nematodes ability to move towards its host and away from dryness and sunlight. Moderate temperatures are optimum for their survival and activity. Different strains have different temperature ranges. The ''All'' strain is effective from 60 to about 86° F whereas the ''Umea'' strain is active down to 50° F. The reported optimum temperature for nematode activity and growth is about 75° F.

Soil type affects the nematodes' mobility also. They move most easily through moisture films in coarse sand (but drying could present problems here) and have the most difficulty moving through clay and silty clay loam. Thus success may be limited in soils with very small pore spaces.

APPLICATION

Sprays are the most popular form of application. People have successfully used conventional pump sprayers, hose-end sprayers, and fertilizer injectors, as well as watering cans. The soil is wet down before application to give the nematodes a water film to move in. Then, a suspension of the nematodes is sprayed out with constant agitation and all the screens off the nozzles. It is important to water the nematodes in again after the application. This washes them off foliage that they may have become stranded on. A squeeze bottle, shaken frequently, works well for squirting nematodes into holes of wood borers.

APPLICATION SITE

One interesting field study showed just how important nematode placement could be. When Dr. Albert Pye of BioLogic was researching control of *Hylobius abietus*, a weevil like the Pales weevil, on pine in Sweden in the 1970's, he found that dipping an entire tray of plugs into an agitated nematode suspension had much greater effectiveness than spraying the nematodes onto the soil surface after the plugs had been planted. On later examination, he found that the nematodes had slipped down the sides of the plugs in the plug trays, and been able to enter the plugs from all angles. In contrast, the soil surface application had only one surface treated, a surface exposed to ultraviolet light.

APPLICATION TIMING

Timing can be extremely important in determining the kill on a single pest generation. The nematodes are not as effective against non-active insect stages such as pupae. Thus a treatment applied during the pest's pupal stage will allow the adults of that generation to emerge. The nematodes could only start killing pest larvae after those adults had laid their eggs and new larvae hatched. In contrast, an application timed for the pest's larval stage would kill the pest before it pupated and not allow the next generation of adults to emerge.

CONCLUSIONS

Success in using *S. carpocapsae* for pest control depends on careful attention to keeping them alive. They must not be subjected to quick drying, or to ultraviolet radiation. Other factors that affect their effectiveness are temperature, soil texture, application site, and application timing.

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COMPOSTING FOR FIELD AND CONTAINER GROWING

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Composting of organic wastes for mixing with soils has been a fundamental principle of land use since farming began. Our nursery and many others have always applied manures or other decomposed organic materials to fields before planting new crops. Even though adding organics to soils has been long-practiced, it is only within the last couple of decades that the composting process has been defined, quantified, and documented in a manner every farmer can use.

More than 20 years ago, the decline of dairy farming in our region was becoming obvious. And because our business was expanding rapidly, we were forced to search for new sources of organic material to supplement the declining supplies of cow manure, our primary soil additive. Every B&B plant we harvested from our land took with it some of our topsoil; without the addition of new organic matter to each field before replanting, our already thin New England soils would soon consist largely of clay or gravel and consequently be of diminishing crop value. Additionally, we were beginning to grow many crops in containers and were trying to determine the optimum container medium. The various container-growing mixes we had tried lacked uniformity and failed to effectively support good growth or allow proper drainage. It was thus imperative that we find new economically feasible ways to increase our supply of dependable organic raw materials.

About 1970 we established an arrangement with one of the larger towns next to us that operated a municipal leaf collection program. We took all of their leaves every fall in exchange for a nominal credit for purchases of our plants. While this arrangement worked well, the 2000 to 3000 cubic yards we composted annually was never enough to meet our needs. We were unsuccessful in attempts to get leaves from other towns primarily because the cost of separating leaves from other waste was not economical for them. In order to stretch our meager supply, we began decreasing the amount of compost and organics we added to our soils. As a substitute, we increased our use of chemical fertilizers in combination with summer and winter cover crops. For several years this appeared to be a successful strategy.

The advent of environmental awareness in the 1970's was extremely timely and fortuitous for our nursery. The availability of organic products began to increase dramatically as disposal costs escalated. Within a very few years it became an economic necessity

for more towns to separate leaves and other products (newspaper, wood chips and grass clippings) from their waste stream. In many areas it had even become illegal to dispose of leaves and other organics in a landfill. The opportunities to get these organics at low cost increased and incentives to compost waste were created. At the same time, our creative use of organic waste products helped the public perceive that we offered a solution to a major trash disposal problem.

Our composted leaves soon proved to be a superior medium for most container crops when mixed with equal parts sand and composted bark. This mixture is consistent year to year, is rendered largely weed-free from the heat of the composting process, retains sufficient moisture to allow good root growth, drains quickly to prevent root damage, has a pH of about 6.0, accepts fertilizer and herbicide applications properly, and creates minimal "interface" problems for the customer when the roots are set into the landscape. We began to use this medium exclusively in the 1970's, and still rely upon it as our basic mix.

Thanks to these changes we have increased our supply and usage of compost products four to five fold over the past dozen years. Weston Nurseries currently composts over 40,000 cubic yards of various materials every year; our leaf composting operations have grown to nearly 20,000 cubic yards including the grass clippings and yard sweepings we accept from landscapers throughout the year. We still buy all the cow, horse and large animal manure we can get, and mix it with leaves or wood/paper waste to stretch the final product. Wood chips and sawdust are compostable by themselves, and we buy all the reasonably-priced material available that we have space for. We have also bought finished compost from commercial and municipal sources and have experimented with hen manure.

But the variability of these materials and the sheer volume available have created some new and unexpected situations. In an effort to quickly add organics to our soils, we recently began spreading upwards of two to three inches of compost on the ground and plowing it in to a depth of about ten inches prior to planting our crop. The situations we have encountered undoubtedly result from our fervor to rapidly improve the organic content of our depleted soils.

Using these newly-available composts we have experienced some remarkable changes on a number of crops. We have produced a dramatic improvement in the root quality of juniper, *Euonymus alata* and *E. alata* 'Compacta', *Forsythia*, most *Viburnum*, *Syringa*, and many other types of deciduous shrubs. Shade trees also respond well, especially *Acer rubrum* and the normally fast-growing species. Even some of our lepidote rhododendrons have

responded with improved root and shoot growth, provided the pH is properly maintained. Regulation of pH with compost can be effective and theoretically can eliminate the need to add limestone, although we have had some difficulties doing it consistently.

On the negative side we have observed two types of problems: those of soil-structure (physical), and the chemically-related ones. Physically, excess soil aeration and soil-moisture saturation both result when too much compost is added all at once or when the organic materials are incorporated too close to the time the crop is planted. The air spaces in excessively-aerated soil reduce the ability to provide proper support for the plant and cause inadequate mating of roots to the soil. This results in rapid dehydration of roots of the new plants, especially if conditions are dry. By the time the soil settles, many roots are dehydrated and the plants are weakened. Application of additional water would normally help stabilize and rejuvenate drought-stressed plants. But the overly-large proportion of organic matter added to the soil retains too much water for effective support, promotes decay in the damaged tissue, and can cause further injury by depriving the roots of air. The weakened plants that do survive are susceptible to damage from insects and disease as well as the normal transplanting and environmental stresses.

The chemical-type problems we have experienced involve mostly ericaceous plants such as *Rhododendron, Kalmia, Pieris, Enkianthus*, and *Vaccinium*, along with a few crops of *Pinus* and *Taxus, Viburnum sieboldii*, and *Hamamelis*. These problems include unexpected pH elevations, abnormally high levels of potassium, phosphorus and calcium, apparent deficiencies in iron, manganese, and zinc, and a number of others that still defy definition. These became evident as crops began to show chlorotic foliage, inferior root systems, and general lack of vigor. Using soil tests and tissue sample analysis our nursery Extension advisors recommended a number of corrective actions including applications of urea and sulfur or ammonium sulfate to the soil, and spraying iron, magnesium and zinc chelates on foliage. The problems still appear unresolved because the growing season had ended by the time we had finished the treatments, so we expect to apply chelates of iron, manganese and zinc to the soil the following spring.

Another chemical situation occurs when partially-composted organics are incorporated in soils. The addition of water to these soils causes heat buildup, generates ammonia toxicity to roots, or creates deficiencies of nitrogen and other elements. Often the effects are unnoticed until damage to the crop has occurred. To further complicate the issue, it is often difficult to determine whether or not the compost has stabilized.

As we become increasingly involved with these adjustments, a number of conclusions became apparent. It is very difficult to get an accurate and representative soil sample in the field; the results of the tests are open to diverse and often contradictory interpretations. There are very few guidelines for proper fertility standards for many crops. It is expensive and time-consuming to apply corrective treatments after the crop is planted, and monitoring progress is extremely difficult. Perhaps the clearest lesson of this situation is that we should have properly tested the soil and refrained from planting until the conditions were determined to be optimum for the specific crop. Most clearly, any profit we may have made on these crops has disappeared, and we will consider ourselves fortunate if we can save part of the crop.

In our zeal to utilize our new-found organic "riches" we made a number of unfortunate assumptions. In retrospect I am glad the situation is not worse and that we have a nursery large enough to absorb the crop losses. It is also fortunate that we confined the use of the new compost products to field crops rather than risking our container production as well. I feel confident that we will resolve these problems and end up with a better understanding of compost use for future crops. I certainly hope that this discussion of our problems will help other growers to learn from our mistakes and avoid similar situations in their operations.

In no way do these problems undermine our basic conviction that composting is of utmost value to the nursery industry. The composting of organic wastes and the utilization of products that are deemed undesirable create some unique opportunities for our industry. Not only can we profit economically but we have excellent opportunities to demonstrate that we are true practicing environmentalists. We must, of course, learn how to effectively utilize these new resources that are being presented to us. When we do, not only will we vastly expand our economic well being, but we will look good in the eyes of the public and the people outside the industry who largely determine our destiny.

Table 1. pH comparisons of various composted materials at Western Nurseries, fall 1990.

Material	pH
Water	6 0
Peat moss	3 5
Sawdust	6 0
Composted wood chips	6 8
Composted mixed bark	6 8
Composted pine bark	4 2 - 6.5
Leaves composted for appx one year	5 2 - 6.3
Container-growing media	5.6 - 6.8
Container media for ericaceous crops	4.5 - 5.0
Potting media for newly-propagated crops	4.7 - 5 5
Partially-composted cow manure	8.0
Composted cow manure/wood chip/paper mix	7.0
Partially-composted horse manure	8 4
Composted hen manure	8 8
"Merrimack" compost. brewery waste, wood chips, and municipal sludge	7 2

Thursday Afternoon, December 13, 1990

The afternoon session was convened at 1:20 p.m. with Michael L. Byers, serving as moderator.

THE USE OF BUBBLE-PAC FOR THE OVERWINTERING OF ROOTED CUTTINGS

HOWARD W. BARNES

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Bubble-pac has the potential of eliminating some, if not all of the problems associated with microfoam. To begin with, bubble-pac is ½ air and possesses many of the insulating benefits of microfoam. It has found some use in the glass greenhouse industry by being applied to the inside of the glass to provide insulation that is clear. Unlike microfoam, it does not tear easily and it has a proven long life expectancy. We have used the same pieces repetitively for 5 years, and it is still usable.

While an important part of the over-wintering process, bubble-pac is not an answer in and of itself. Effective overwintering of cuttings can only be accomplished by efforts having been started during the spring and summer. Several principles should be followed to insure effective overwintering of cuttings with a minimum of losses. At Moon Nurseries the methods used are as follows:

1) Cuttings should be taken as early as possible with an emphasis placed on cold-sensitive plants such as *Viburnum carlesii* 'Compactum', *Acer palmatum* cultivars and cuttings of plants from more southern latitudes. Some researchers have found that early rooting of cuttings enhances the ability of the rooted cuttings to over-winter (14, 16,18).

Once our cuttings are rooted, they are removed from the mist, hardened-off by being placed on the floor in a ventilated, air-inflated poly house. It is important to stress that all of our cuttings are direct stuck, so that no transplanting after rooting is necessary as the transplanting of cuttings after rooting can lead to serious overwintering losses (14).

2) After rooting, cuttings receive regular attention with the exception that they are not fertilized. It has been shown that nitrogen, especially in the ammonium form (NH_4^+) is detrimental to many newly-rooted cuttings during the overwintering phase (2, 14,16).

3) Reducing water and in some cases withholding water will cause an increase in the rate of vegetative maturity (2, 18). Vegetative maturity is one of the first steps towards the fall-conditioning of cuttings for winter.

4) High hormone levels used during rooting and the use of NAA (naphthaleneacetic acid) may cause extended dormancy such that cuttings will not releaf in the spring (15).

5) A natural reduction of photoperiod is necessary for proper hardening before winter. If the cuttings are artificially illuminated to induce rooting or growth this extended photoperiod has to be reduced gradually to mimic natural conditions (1, 18, 19). This process should be started during warm weather and allowed to follow into cool weather.

6) Cuttings should be exposed to increasingly cold temperature so that a sufficient stage of dormancy can be reached (2, 6, 7, 18, 19). We have found that temperatures as low as 28° F can be tolerated by most hardy plants, if the change is gradual.

7) Once all of the above factors have stimulated acclimation of the cuttings, they are watered heavily, weeded if necessary, and allowed to drain for 1 to 2 days. Fungicides to control *Botrytis* are applied and generous amounts of rodent bait packs are distributed amongst the cuttings (2, 6, 7, 11).

8) Half-inch bubble-pac is applied directly over the cuttings with the bubble side down and it is allowed to overlap the edges so that it lays flat on the ground. The bubble-pac is immediately covered with 70% milky poly which is also extended over the edges so that it too lays flat on the ground and seals the cuttings in (2, 6, 7, 12, 13, 20) Figure 1. The white poly covering reduces temperature fluctuations caused by sunlight (2, 10, 11, 18, 20). Also desiccation is prevented by sealing the plants in a plastic envelope. Desiccation is a significant cause of death in rooted cuttings. By being sealed underneath the covering, the water vapor pressure deficit can be eliminated (9, 19). Finally, ground heat is trapped underneath these blankets and this serves to insure against cold damage (2, 10).

9) The timing of the covering process is usually carried out after 2 or 3 frosts within the greenhouse (2, 6, 7). In our region, this usually coincides with the Thanksgiving holidays. It is hoped that by this time most of the leaves of the deciduous plants will have abscised or, at the very least, turned color. Evergreen cuttings should have stopped all terminal growth and buds will have set.

10) Once the cuttings are sealed, no heating within the greenhouse is necessary. The greenhouse fans and vents are set to come on at 50 °F to prevent heating during the daylight hours.

11) Cuttings remain under this type of enclosure until March 1st. It is imperative that cuttings not be allowed to break dormancy prematurely (2, 6, 7, 9. 17) while underneath the covers as severe

Figure 1. Several beds of rooted cuttings covered with bubble-pac and milky poly.

damage can occur with harsh spring frosts. Often periodic checks are necessary to determine proper timing for cover removal. A good indication of when to remove the covers is if flower buds are breaking dormancy, as flowers will form long before the leaves will appear. If blossoms do appear, it is time to remove the covers.

ADVANTAGES TO BUBBLE-PAC

1) Cheaper than microfoam, $0.11/sq ft versus $0.05/sq ft

2) More durable than microfoam, very difficult to tear or rip, with a life expectancy greater than 5 years if kept in the dark when not in use.

3) Bubble-pac is as effective as microfoam for overwintering. Plants such as *V. carlesii* 'Compacta', *Cornus florida* 'Rubra' and *Chionanthus pygmaeus* can be easily overwintered under bubble-pac.

4) Root growth of many species will occur under the bubble-pac during the winter. Understock being held for grafting will often have ample white active roots so that grafting can commence immediately upon being removed from the covers.

5) Because the bubble-pac is completely sealed, winter desiccation can be eliminated.

6) Some work at our nursery indicated that fall grafts of *Prunus*, *Hamamelis*, and *Betula* can be successfully overwintered under bubble-pac.

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Dale G. Deppe served as moderator for the following *Helpful Hints: Problems and Solutions* Panel. Papers by: John Larson, Brian M. Decker, Ned D. Rader, Robert P. Kuszmaul, Jamee Nirider, and David C. Ruppert were part of that panel.

HORMONES: NOT ALWAYS NECESSARY

JOHN C. LARSEN

Bailey Nurseries, Inc.
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Do we always need to use a rooting hormone when rooting cuttings? I think the answer is no. Through trial and error over the last eight to ten years, we, at Bailey's, have cut our use of rooting hormones by 25 to 35%.

The main reason we experimented without dipping cuttings in a hormone was to reduce labor cost in the planting of cuttings. Without having to dip cuttings, we figured we would spend about 20 to 30% more time planting instead of dipping cuttings. There is also a cost savings in the amount of IBA that is used.

Our process to determine if a cutting gets dipped or not is fairly simple. Any new taxa on which we do not have information are all dipped the first year. The second year, a small trial of undipped cuttings is tried. If that is successful, the third year we do a larger trial; up to 25 to 50%. After the third year, if we feel comfortable with our trial results, we do not dip that plant.

There are some other factors you might want to consider when dipping cuttings. If you have only a short amount of time to root your cuttings you might want to dip even if they are an easy rooter.

Another factor is timing. If the cuttings are taken a little later than you like or are harder cuttings than you like, you might want to consider dipping when you normally would not. This deals more with softwood cuttings.

I would suggest doing some trials of undipped cuttings if you are dipping all of your cuttings. I think you will find the time savings in not having to dip cuttings very substantial. I also think you can develop a well-rooted cutting that has not been dipped and is properly cared for.

THE BEST PROPAGATION FLAT IS NOT FLAT

BRIAN M. DECKER

Decker Nursery Co.
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Decker Nursery is a company specializing in propagation. We root cuttings from both dormant hardwoods and summer softwoods. The majority of our propagation is in the Kadon plastic flat. A major concern in cutting propagation is insuring sufficient drainage to reduce decay. This problem is particularly acute in the summer as we use an automatic mist system to prevent desiccation. Often we have many different species/cultivars of cuttings in the same area, all of which receive the same amount of mist. This inevitably results in excessive water on plants with low mist requirements. Often we experienced either decayed or wilted cuttings as it was always a running battle of sufficient mist versus wet flats.

At this point I would like to explain a physical property of all liquids called surface tension. This is a property of liquids that tends to draw the surface molecules together, thereby forming droplets. Also surface tension holds droplets together to somewhat resist the forces of gravity. An example of this is the "mound" of water that rises over the top of a completely full glass of water. Without surface tension the water surface would be flat.

We noticed that when propagation flats were lifted and removed from the mist bench, they were usually carried at a slight angle. This resulted in water dripping out of the flats at the lower end, usually down the front of the person carrying the flat. We came to the conclusion that if the flats are slightly tilted in the mist bench, excess water concentrates on the downhill edge. The concentration of water and the effects of gravity become greater than the water's surface tension and excess water constantly drips out of the flat. A good example of this would be two identical sponges that are equally saturated. Place one on a flat screen and one on a slightly tilted screen. After a few moments the tilted sponge will have retained less water.

Three years ago we began to tilt all our summer propagation flats. This has almost completely eliminated losses of cuttings due to excess water, allowed us to use excessive mist on unusually hot days, and reduced the stress on the cuttings, resulting in a shorter time to produce roots.

We also tried this with our flats of winter hardwood cuttings but found it to be a negative factor. First, the cuttings are manually hand-misted instead of an automatic mist system. This results in little chance of excess water. Second, the tilt removed water so well that the uphill cuttings would dry out. We hope this hint might aid in your success with any cuttings sensitive to "wet feet"

WAIT! DON'T TRASH THAT POLY!

NED D. RADER

Ned's Nursery
Amanda, Ohio 43102

Don't trash that poly—yet! You can still find many uses for it. In this time of harvesting poly prices it behooves us to make the best possible use of petroleum-derived materials. I am talking primarily about the poly used to overwinter plants.

We use ours for at least two things: 1) as a covering for our summer softwood cutting propagation beds and, 2) to provide extra overwintering protection for softwood cuttings and small potted plants in flats in polyhouses, without the use of heaters. Instead of just discarding the poly that comes off our overwintering houses, we save it. We cut it into two pieces which are 12 x 100 ft. by slicing it lengthwise down the center with a knife before the poly is removed from the houses. Then we remove each piece, fold, and tie it into small bundles, and store it out of the sun.

Later in June, July, and August when it is time to root cuttings, we pull out a sheet of poly and after the cuttings are stuck into sand beds we cover them with white poly and seal up the bed. Thus we greatly reduce the amount of mist that needs to be used. By the time the cuttings are rooted the poly is beginning to sun rot, so we remove it and then trash it.

In the fall, as the time for recovering our houses for the winter draws near, we pull out another sheet and cover each bed of softwood cuttings or small potted material. We hold the poly in place by "tacking down" one edge with sand along the outer edges of the polyhouse, then we stuff the poly down around the plants to keep the wind from carrying it off until we can get the polyhouses covered for the winter. To keep the covered plants from molding under the poly blanket, we form half-inch conduit pipe into 12 in. high bows to hold the poly blanket off the tops of the plants. Then in November we finish the job of winter covering by applying two layers of new poly to each house. Insulation is achieved by the use of a pole blower which forces air between the two layers of poly. During the coldest days and nights of winter when the temperature goes down to 15° F and below we pull the poly blanket over the beds making sure it touches the ground in the aisle to insure a good seal, thus keeping the cold out and trapping the ground heat in. These blankets can then be pulled open on days when temperatures are above 40° F. I have found that by doing a good job of sealing around polyhouses and doors, and with this extra poly blanket, the temperature never goes below 25° F even during a -20° F windy storm. Thus you can reduce overwintering heat bills on softwood cuttings and small potted material.

OUR OVERWINTERING TECHNIQUE PROMOTES CROP UNIFORMITY

ROBERT P. KUSZMAUL

D&B Plants
Armada, Michigan 48005

Environmental inconsistencies during the overwintering process lead to perimeter growth suppression in nursery stock. Altering this process helps to sustain consistent conditions, allowing uniformity to be retained.

Our product at D&B Plants consists of 127 taxa of woody ornamental plants, vegetatively propagated by cuttings. These cuttings are rooted under intermittent mist in either sand beds or plug trays, and then transplanted into 2½ in. peat or 4 in. plastic pots. They are then overwintered for spring shipping.

Our overwintering practices encourage plants to acclimate naturally until late November in southeastern Michigan. Then the 14 x 96 ft hoop houses are covered with two layers of clear 4-mil plastic. We are emphatic about the use of clear plastic for most of our plant material. Extended periods of humid, cloudy weather raise havoc with plants susceptible to fungal problems under white poly. The accelerated growth achieved under clear plastic also seems to give our liners an edge, when all the other spring factors are accounted for.

Crop uniformity under clear plastic can often be an elusive goal, primarily due to accentuated day and night temperature fluctuations. The use of a perimeter strip of styrofoam (10 x 1 in.) placed internally on the side walls, prevents a good deal of heat loss in the form of conduction, but still a marked growth suppression could be observed for 6 to 10 in. around the outer edge. Ideally, snowfall will occur in early December and leave its insulation blanket along the greenhouse side walls until early to mid May when plastic is removed.

A neighboring container operation simulated this natural insulation, by surrounding plant material with a two foot strip of microfoam around the perimeter, between hoop structure and containerized plants. Modifying this idea to fit our flatted material, a 15 in. strip of microfoam was stapled to the top of our side walls. When the double layer of inflated plastic is in place, the microfoam stands up nicely between the plastic and metal hoops, forming a neat little wall.

Knowing that the microfoam offered insignificant insulation, and that the primary heat loss from convection was not being addressed, we applied the microfoam to a single house and waited out the winter to make spring observations.

When shipping season arrived, the results were dramatic. Side to side uniformity that could not be explained by temperature moderation alone, was being influenced by another factor.

The following winter, more enthusiastically, several houses had perimeter walls installed. Throughout the winter and spring, more diligent observations were made. This buffer zone used to heat up dramatically on sunny days, due to its close proximity to the clear plastic. Now, with translucent walls in place, moisture levels, as well as temperatures are being moderated. This dual regulation provides a more even environment throughout the winter.

The results that second winter convinced us to use the perimeter walls in propagation houses as well as on less winter-sensitive material. Investing 10 or 12 dollars in labor and an expense of 25 dollars for the microfoam, which can be used for three years, provided a uniform environment to grow a consistent product.

For the coming March, as your plants are breaking dormancy, take note of any growth suppression along the outside edge and consider this simple suggestion for the next fall.

SUMMER SOFTWOOD CUTTINGS VS. WINTER HARDWOOD CUTTINGS

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We had a problem. A problem rooting what the industry traditionally considers relatively easy. In 1988 we were attempting to root *Cornus*, *Prunus*, and *Forsythia* under an intermittent mist system. Most other softwood cuttings were rooting very easily and with acceptable levels of success, but for several reasons we did not like the results we were getting with these plants. Defoliation, very weak root systems and stem rot seemed the norm.

We do not have a pad and fan system for summer cooling and began to reason that our timing for cuttings (June through July) coupled with the heat at that time of year was directly linked to our rooting problems. Since heat, mist, soil mix, and rooting hormones were working with the other plants, we decided it was time to rethink the situation in regards to the mentioned plants and their cultivars.

What we decided to do was not revolutionary to our industry. In fact, it was very simple; we had overlooked the obvious. We had overlooked an established industry standard of sticking hardwood cuttings with 72°F bottom heat during mid-winter. We had followed the thought that everything should and could be rooted under mist from summer softwood cuttings. Winter hardwood cutting production is now a very integral part of our propagation cycle. It has transformed a weak summer softwood program into a very successful and predictable year-round propagation rotation.

To accomplish our task we began by using silica sand but soon found that the shear weight of the sand flat was a big problem for handling. Cuttings rooted well in sand but were hard to determine irrigation needs. When we began transplanting from the rooting flats into our cell-paks we discovered that the sand flats had roots that were very fleshy and brittle. We lost such a large percentage of roots to the transplanting process it was as though the plants had to begin root regeneration all over again. The transplants made the shift but it took longer than we liked for them to become well-rooted into the cell.

Our primary rooting medium now consists of perlite or aged pine bark. In our first year we tried using some perlite as well as the sand. The advantage of perlite over sand is quite obvious—weight or lack of it. The perlite is still difficult to read in its need for irrigation but is somewhat more forgiving than sand. The porous nature of the

perlite is a big plus for the *Prunus* genus, as we consistently get the best results from the two together.

We get an excellent root system from perlite and see very little transplant shock. The transplant goes very well and we even find it necessary to root prune as we transplant.

Aged pine bark looks to be our best overall material for the future. It offers us an excellent moisture retentive medium as well as draining very nicely. Color and vigor are improved in all species and the root system is far superior. The bark produces a very fibrous and seasoned root system. This root system is extremely tough and durable, and does need a trimming at transplant. It also matures in the cell pak much faster than the others. Pine bark is excellent for the genus *Cornus*.

The cuttings are approximately 3/16 in. in diameter and 5 to 6 in. long for all species. Cuttings are dipped into a 1% IBA powder. They are then flatted into the desired medium for rooting on an inch spacing. Cuttings are generally taken from early January to mid-February. Bottom heat (72 °F) is maintained throughout rooting. Transplanting occurs as weather permits in the spring, normally mid-April to mid-May.

Probably the most dramatic difference, besides the increase in rooting percentage success, is the time that it now takes us to produce a saleable container-grown plant. What used to take us 24 months to produce a saleable #3 container, now takes us 18 months. This schedule applies to all species mentioned. *Forsythia* would be the first to finish its growth cycle, followed by *Cornus*, then *Prunus*. All do finish on schedule.

Timing rotation: 18 months
- Cuttings taken 1-1 to 1-30 (1-1 to 1-30 = Jan 1st to Jan 30th)
- Transplant (to a 2½ x 3 in. deep Nu-pot) 4-15 to 5-1
- Transplant (to a –3 container) 6-15 to 7-1
- Finish 6-15 to 7-1 the following year

Timing rotation under old mist system: 24 months
- Cutting taken 6-1 to 7-15
- Transplant (to Nu-pot) 8-1 to 5-1 the following year
- Transplant (to #3 container) 6-15 to 7-1
- Finish 6-15 to 7-1 the following year

Plants used in this study and their 1990 rooting percentages.

Cornus × *baileyi*	98%
C. alba 'Elegantissima'	75%
C. alba 'Gouchaultii'	89%
C. sericea 'Cardinal'	83%
C. sericea 'Flaviramea'	99%
C. sericea 'Kelseyi'	57%
Forsythia × *intermedia* 'Lynwood'	82%
Prunus × *cistena*	74%

OLD FASHIONED WEED CONTROL

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The intent of this paper is to give an overview of a complete program of weed control. There is no intent to make statements of scientific fact, proven or otherwise.

One of the biggest pest control problems for the nurseries is weeds. Weed control must be properly addressed if quality plant material is going to be produced.

Post-plant weed control is then the primary concern. It should be noted that what is done to a field before the nursery crop is planted can pay big dividends after the crop is in.

I will discuss both pre- and post-plant weed control and how they work together for good weed control. Also, I hope to convey the need for means other than chemicals for a complete control program.

While post plant weed control is the major concern, what we do to the nursery fields, pre-plant is also very important. Good cultural practices on unplanted nursery fields will do much toward long term weed control. A program of cover cropping, along with the use of post emergence weed control chemicals and cultivation will control weed seed populations and reduce the need for extensive use of chemicals once the fields are planted to nursery crops.

The use of cover crops can also help the tilth and fertility of the soil, cutting down the need for as much chemical fertilizers to increase plant growth. This pre-plant program will also help to keep the top soil in the fields during fallow times.

No matter how good a job of weed control is done pre-plant to a field, weed control after the nursery crop is planted will be a full time concern. Weed control is especially important during the first two growing seasons as the plants are becoming established.

I have found that a successful weed control program should include both chemicals and mechanical cultivation. Dormant season application of pre-emergent chemicals along with the use of some post-emergent chemicals and a good cultivation program will lead to the successful control of most weed problems. It should be noted that the mechanical program should include hoeing. Hoeing helps to clean out around each plant, allowing more sunlight to the leaves and moisture to reach the root system, especially when the plants are young. Hoeing is a good way to totally clean up a field of weeds that the chemicals did not control. Cultivation should not be overlooked as an important part of a good weed control program. It is good for the plant material and good for the soil.

We have found that hoeing has eliminated the need for the use of pre-emergent herbicides during the growing season!

Along with the establishment of a weed control program is the control of costs. Chemicals are expensive and, if not used properly, can also be damaging to the environment and plants. While the use of mechanical weed control will cut down on the use of chemicals and their cost, there are costs involved with hoeing and cultivation. The costs of fuel and repairs as well as labor costs need to be considered.

I feel that a well thought out weed control program for the nursery will include the use of both chemical and mechanical means of weed control and that they can be used together in a cost-effective manner. The long term results of such a program will result in better quality plant material. Also, we can all feel better about how we as nurserymen are effecting our environment.

A planned program of timely use of herbicides and cultivation practices as well as pre-plant weed control will result in a very satisfactory weed control program.

DEFOLIATION OF MESERVE HOLLY IN STORAGE

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During the last 10 years, the Meserve holly (blue holly) cultivars have become well known and quite popular. Not only are they very attractive and rugged, but they are surprisingly free of diseases and pests that afflict other members of the genus *Ilex*. However, in the North there is one pesky problem that the commercial grower faces and that is occasional defoliation, both in the propagation stage and when container-grown hollies are coming out of winter storage.

Let me start with a brief review of defoliation in propagation and in the storage of rooted cuttings in heated houses. All of the genus *Ilex*, be it *I. opaca, I. crenata,* or *I.* × *meservae*, are sensitive to buildup of ethylene in closed structures, which is the actual culprit that causes the leaf drop. The problem usually shows up beginning in November through December when the heated houses receive only occasional ventilation. To prevent this problem we have moved the propagation of the Meserve hollies back from October to August and early September when they can be easily rooted under mist in open structures. In order to fight off the danger of ethylene buildup we take extra steps in the holly house where the flats with rooted cuttings are carried through late fall and early winter. These cuttings usually flower profusely from the end of October through early November. This is a critical period. The cuttings will have to be sprayed frequently with Benlate to prevent an outbreak of *Botrytis*, but more important, this heavy flowering will set off the vicious circle of ethylene release. To prevent this buildup we keep our holly house quite cool; the median temperature is at 42 to 50 °F while we ventilate systematically to bring in fresh air daily.

In order to accomplish this ventilation, a small pole blower has been attached to the back wall of the hut. This blower is connected to the circulation pump of the Biotherm hotwater heating system. The few times that the circulation pump comes on during each night the pole blower gets activated and will bring in outdoor air which will prevent the buildup of ethylene.

Now I would like to discuss defoliation in storage huts. Let me state here first that I do not know whether ethylene concentrations play a significant roll in storage huts. In my experience most, if not all, defoliation of Meserve hollies in winter storage is caused by damage or kill of the root system due to lower than tolerable temperatures in the medium. Ever since Dr. Havis of the University

of Massachusetts published his report on "Tolerance of Plant Roots in Storage" we at Roemer Nursery have taken special steps in storing our substantial inventory of container-grown Meserve hollies. The critical range of cold hardiness of the root system for *I.* × *meservae* is the 20 to 23° F range in the container medium. Conventional hut covers of opaque poly will not prevent container temperatures from dropping to those readings during extended severe cold spells. In the mid-1970s we experimented with the different covers that are used as solar blankets, sometimes referred to as liners. During one single winter we ran controlled tests with microfoam and clear and opaque poly. Clear poly is next to useless since the heat will radiate out through it on cold nights. The various types of foam blankets give excellent cold protection but there are definite disadvantages: high cost, short life, and the awkwardness of the covering process and of the removal of the foam sheets. We settled on the annual use of 20 to 24 ft wide 2 mil opaque poly for the liners which has given us reliably good protection for our hollies.

Now for a short explanation of how we arrange the blankets. Most of our houses run east-west. Prior to introducing the blankets to a hut we consolidate the containers in such a way that there is a two foot open area along the kickboard on the south side and a one foot corridor along the north side. We drape the opaque liner, loosely folded, in this north corridor prior to the actual covering of the huts during mid-November. We will then wait until either the first outbreak of severe winter weather or the week before Christmas before we pull the blanket over the plants following a heavy irrigation. Workers moving through the south corridor will finish this rather simple operation by tucking the poly under some of the pots. This south corridor with its air space and two opaque layers of poly becomes a welcome buffer against the increasing sun exposure during February. At our location we remove the holly liners around March 1st.

At this time, I would like to give a brief over-view of our general overwintering procedures since they differ significantly in some important details from those of most container growers in our area. We consider the winter storage huts as extensions of our heated propagation houses and we treat them as such. Unlike most nurseries we will ventilate the huts as much as possible all winter. From Thanksgiving until the shipping season starts in mid-March the Dutch doors on both ends of the huts will be open whenever weather conditions permit during the daytime; temperature, sunlight, and overcast naturally play a roll. But if, for instance, the winter is rather moderate, the huts will be open, especially during the day, fully half of the time. We feel that maintaining as even a temperature range inside the huts is far more important than trying to maintain as high a humidity as possible.

Next we emphasize frequent, heavy winter irrigation; partly to offset the constant ventilation, but more important to drive out any frost buildup in the containers during January and February. Between Thanksgiving and the first week of March we average 3 to 4 heavy irrigations of 1-1½ in. each. For example, here in northern Ohio we will usually get our coldest, sustained winter weather sometime between Christmas and mid-January and, in most cases, get some kind of January thaw thereafter. The moment the outdoor temperature goes up to or above 36° F we will immediately start our most important heavy irrigation. We will literally flood the huts. The benefits are threefold: the large amount of water will drastically speed up the thawing process; the saturated containers will take much longer to freeze up again come the next severe cold spell, while the heavy irrigation will leach out any salt buildup. We are not concerned about leaching out all nutrients since we are using a coated slow-release fertilizer. If we are lucky enough to get 4 to 6 days above freezing after such an irrigation the bulk of the frost will have thawed out and we are in good shape to handle the next severe cold spell.

Now back to the problem of preventing defoliation of meserve hollies in storage. I am the first to admit that in some of the mild winters we have lately experienced, and depending on one's location in the Northeast or Midwest, using solar blankets on Meserve hollies might not always be necessary. But in that case frequent ventilation and timely heavy irrigation might still be a good method to prevent root damage and defoliation. However, the use of the solar blanket is still the only certain way to prevent root damage and subsequent leaf drop. Keep in mind that once 3 or 4 gal. hollies sustain rather severe defoliation it is virtually impossible to regain a profitable quality plant.

Another factor that should not be overlooked is the importance of the proper spacing of the plants in storage, particularly the larger sizes. Setting the cans too close can cause disease problems or severe yellowing and subsequent dropping of the leaves. 'Blue Prince' holly, for instance, is rather susceptible to this problem. However, this type of leaf drop is not nearly as dangerous as the one caused by root damage.

There have been sporadic problems with severe defoliation in container-grown 'China Girl' and 'China Boy' hollies, bedliners as well as landscape plants. Even though these two clones are quite hardy, they tend to grow late into the fall; these soft shoots will then show tiny cracks caused by frost and *Botryosphaeria* will infect the plants in late March and early April causing severe leaf drop and branch dieback. Two to three applications of Benlate-manzate beginning the end of April through May will stop this problem.

We at Roemer Nursery have been using the solar blanket method for 15 years and we have come to the conclusion that this method is indeed cheap insurance to protect a high quality crop winter after winter.

SEED STORAGE FOR THE COMMERCIAL PROPAGATOR[1]

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INTRODUCTION

Commercial propagators routinely produce a diverse mix of seedlings, yet the volumes of the *Proceedings of the International Plant Propagators' Society* have remarkably little advice on seed storage. Most propagators plant freshly-collected seeds or store seeds only briefly before planting. But there may be advantages to storing seeds for future use. This report will consider some of those advantages, summarize pertinent reports on seed storage for landscape plants, and present some personal experiences with germination of stored seeds.

ADVANTAGES OF SEED STORAGE

For plants that are normally propagated from seeds, seed storage allows propagators to overcome year-to-year fluctuations in seed production. Many species, such as apples, oaks, and pines (12), produce good seed crops at irregular intervals. Seed storage may also be used to spread out the production of plants from seed lots of especially high quality or from those that are difficult to reobtain.

For species that are normally propagated vegetatively (excluding cultivars), storage can preserve seeds that may eventually be grown to replace diseased or declining stock plants. Some viral diseases are not transmitted by seed (16), and periodic replacement of stock plants with new seedlings may improve propagation success, not only by reducing disease, but also by restoring juvenility (2). Stored seeds can also serve the propagator as a bank for generating future genetic variability to develop improved selections.

STORAGE CHARACTERISTICS

Though the seeds of different plant species have widely different storage characteristics, seeds of most temperate landscape plants have similar responses to changes in storage temperature and

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humidity. These seeds are said to display "orthodox" (10) storage characteristics. For orthodox seeds, longevity increases with decreasing storage temperature and humidity (at least to 5 to 10% seed moisture) (4).

There are two main groups of temperate landscape plants that have seeds that do not follow the orthodox pattern. "Recalcitrant" (10) seeds quickly lose viability when dried or frozen. It is difficult to store these seeds for more than a few months, even under highly controlled conditions. Many recalcitrant species are tropical, but common examples encountered by the commercial propagator include chestnut, oak, and silver maple (3, 15). The second group is made up of species whose seeds have no dormancy and a short life at temperatures above freezing. This group includes most species of willow and poplar (18). However, these seeds can be stored for up to 3 years at -10 to -20° C (14, 18).

Useful references describing the storage characteristics of seeds of common landscape plants include *Seeds of Woody Plants in the United States* (12), *A Revised Table of Seed Storage Characteristics* (3), and *Seed Manual for Ornamental Trees and Shrubs* (4). Other resources include reports by Plummer *et al.* (9) and Stevens *et al.* (13) for western range plants and by Grześkowiak *et al.* (5) for rosaceous rootstocks.

PREPARING SEEDS FOR STORAGE

Evaluations of the storage life of seeds of many species have indicated that vigorous seed lots store the best (1). Therefore, a propagator should collect and process seeds for storage under carefully controlled conditions to maximize quality. Seed lots not collected and processed by the propagator may have encountered unfavorable conditions between the time collected and the time received. Samples of seed lots of unknown quality should be germinated before storage is attempted.

Recommendations on seed collection, drying, and cleaning vary by species. Detailed instructions can be found in *Seeds of Woody Plants in the United States* (12), *Collecting, Processing and Germinating Seeds of Wildland Plants* (17), *Seed Manual for Ornamental Trees and Shrubs* (4), and in recent reports by Lee (6), Luke (7), and Schaff (11). One should also note that seed lots destined for storage should not be scarified by using physical abrasion or chemical agents for this will significantly reduce longevity.

IDEAL STORAGE CONDITIONS

Storage of recalcitrant seeds for more than a few months is difficult. *Seeds of Woody Plants in the United States* (12) and *Seed*

Manual for Ornamental Trees and Shrubs (4) both describe techniques for high-humidity storage of such seeds. These same references (4, 12) also give advice on the storage of orthodox seeds. Dried seeds can either be stored in airtight containers, reducing the need for humidity control in storage, or they can be stored in containers that allow seed moisture to equilibrate with the surround air (17). Practical seed storage of landscape plants with orthodox seed storage characteristics can be accomplished under refrigeration (3 to 5 ° C) for periods of up to five years (4). If dried seeds are not stored in airtight containers, the relative humidity of the storage area should be held below 40% (4).

PERSONAL EXPERIENCES

The North Central Regional Plant Introduction Station in Ames, Iowa routinely stores ornamental seeds as part of its germplasm collections. The Station has stored this collection at 4 ° C and 40% relative humidity since the 1950's. Most seed lots of landscape plants were of unknown quality when stored. Over the last 6 years, I have been trying to germinate many of these samples to regenerate populations and to find new materials for the NC-7 Regional Ornamental Trials.

Because stored seed lots may have different germination requirements than do fresh ones (7,8), and given that there are few recommendations for ideal germination treatments for many species I have tested, the failures that I have experienced in germinating stored seed lots may not necessarily reflect their true viability. With that in mind, I would like to share a list of the successes. Table 1 lists species that have been germinated from seed lots stored at least 5 years, along with the germination percentage, if it could be calculated. In some cases, the date when the seed lot was collected is known. If the collection date is unknown, the date received was noted. Such seed lots are actually older than indicated in Table 1. Table 1 is a diverse list with the legume and rose families well represented. The longevity of hard-seeded legumes is widely documented (12), but the ultimate longevity of many of the other species is unknown.

Table 1. Species whose seeds are successfully germinated after storage for at least 5 years.

Species	Sample year	Germination year	Percent germination
Acer campestre	Received 1975	1986	1
Amelanchier ovalis	Collected 1975	1986	15
Caragana arborescens	Received 1972	1987	26
Celtis australis	Collected 1975	1984	60
Celtis caucasica	Collected 1959	1987	24
Celtis sp	Collected 1959	1987	4
Cercis canadensis	Collected 1971	1984	62
Crataegus monogyna	Collected 1969	1986	34
Crataegus laciniatus [syn. *C. orientalis*]	Collected 1969	1986	1
Crataegus pinnatifida	Collected 1960	1987	1
Cytisus commutatus	Received 1966	1984	unknown
Cytisus decumbens	Received 1966	1984	unknown
Fraxinus anomala	Collected 1984	1989	64
Fraxinus ornus	Received 1976	1984	71
Hovenia dulcis	Received 1981	1987	25
Jamesia americana	Collected 1984	1990	unknown
Ligustrum vulgare	Received 1975	1985	unknown
Ostrya carpinifolia	Received 1974	1987	5
Petteria ramentacea	Collected 1975	1984	unknown
Physocarpus opulifolius	Received 1966	1986	1
Pinus bungeana	Received 1981	1987	6
Pinus nigra	Received 1975	1984	unknown
Rhamnus sp.	Received 1974	1986	3
Staphylea colchica	Collected 1971	1988	8

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CONSIDERATIONS FOR MICROPROPAGATION OF PLANT CHIMERAS

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Abstract. A woody periclinal chimera, *Rhododendron* 'President Roosevelt', was micropropagated to study *in vitro* bud development Shoot tips were best for maintaining phenotypic stability, while leaf and floret explants gave segregated variant shoots A new chimera was captured with a reversed variegation pattern Periclinal chimeras have good potential to serve as micropropagation models, aiding in refining techniques applied to other cultivars. Phenotypic stability during micropropagation was possible in these and other chimera cultures

INTRODUCTION

This paper is partly based on a project that took place at Clemson University from 1987 to 1989, involving the micropropagation of the woody periclinal chimera, *Rhododendron* 'President Roosevelt'. Our goal was to better understand the *in vitro* bud development of a woody plant. Also included are observations of chimeras in culture at the tissue culture lab at Losely Nursery.

Plant chimeras are comprised of two or more genetically distinct layers of tissue growing adjacently in the same plant. Chimeras have been discussed in a previous IPPS article (6). Periclinal plant chimeras, with whole cell layers being genetically distinct from other whole cell layers in the apical meristem, are the most stable type of chimera. Periclinal chimeras, the topic of this paper, are maintained true-to-type by formation of axillary buds and shoots, which retain the special organization of the chimeral meristem. The formation of adventitious shoots off such plants usually results in segregation to a solid phenotype. There are quite a few horticulturally important plants which are periclinal chimeras (11). The most obvious chimeral trait is leaf color; other traits include flower color, epidermal structures, fruit color, and chromosome number. In theory, a plant could be chimeral for any trait; these traits need not be limited to only those we can visually detect.

Recent work on tissue culture of herbaceous periclinal plant chimeras has shown that these plants often do not behave stably

in vitro. Chimeral segregation has occurred in a number of systems, including pinwheel flowering African violets (*Saintpaulia ionantha*) (4), variegated strawberry plants (*Fragaria vesca*) (7), *Chrysanthemum* (2), and *Episcia* (3). Few reports exist on the culture of woody periclinal chimeras, however (1, 8, 10).

MATERIALS AND METHODS

Young budded (plants with flower buds) stock plants of *Rhododendron* 'President Roosevelt' were obtained from Bruce Briggs, Briggs Nursery, in 1987. Two studies were performed. One study involved culturing *in vivo*-derived florets, shoot tips, and vegetative buds, and *in vitro*-derived leaves, buds, and shoot tips on Woody Plant Medium (WPM) (5), 40 μM (8 mg/l) 2iP, 3% sucrose, and 0.15% Gelrite (Kelco, San Diego, CA) at pH 5.3. Explants were subcultured at 5 to 6-week intervals for about 7 months. The second study examined the effects of growth regulators on the resulting phenotypes of multiplying shoot cultures. Five 10-mm-long true-to-type *in vitro*-derived shoots per treatment were cultured on WPM, 3% sucrose, 0.15% Gelrite with 20, 40, 80, or 160 μM (4, 9, 16, or 32 mg/l) 2iP in combination with 0 or 0.5 μM (0.1 mg/l) IBA, or with a control treatment of no growth regulators. Three consecutive subcultures were done at 5-week intervals, after which shoots were transferred to growth-regulator free WPM, 3% sucrose, 1.2% Difco Bacto-agar, and 0.2% activated charcoal for one month prior to determination of phenotypes. The growth regulator experiment was done twice.

RESULTS AND DISCUSSION

Best Explant for Chimera Culture. The best explant for maintenance of a true-to-type culture was an explant containing a pre-existing meristem. *In vitro*-shoot tips were the best explants in this study (Table 1). No variegated shoots were observed in cultures of 'President Roosevelt' initiated from leaves or florets. All of the shoots from florets apparently were adventitiously regenerated. In contrast with this result is the case of chimeral pinwheel flowering African violets where true-to-type plantlets were produced from whole inflorescences (4). In *Hosta sieboldiana* 'Frances Williams', some chimeral plantlets were obtained from floret explants (9).

Effect of High Multiplication Rates. The highest multiplication rates for 'President Roosevelt' occurred on 40 μM 2iP (Table 2); this optimal level of cytokinin also resulted in the lowest percentage of true-to-type shoots. Indeed, the addition of any level of 2iP resulted in a reduction of the percentage of true-to-type shoots, relative to

Table 1. Percent true and percent variant microcuttings from six explant sources of *Rhododendron* 'President Roosevelt' cultured on WPM with 40 μM 2iP.

Explant source	Number of microcuttings	Percent true	Percent variant
In vivo source			
Floret	112	0	100
Vegetative bud	566	6.2	93 8
Shoot tip	70	21 4	78 6
In vitro source			
Shoot tip	263	50.2	49.8
Axillary bud	62	17.7	82.3
Leaf	142	0	100

Table 2. Percent true and percent variant microcuttings during shoot tip culture of *Rhododendron* 'President Roosevelt' on nine combinations of 2iP and IBA[1].

Treatment (μM) 2iP	IBA	Total shoot number	Percent true	Percent variant
0	0	10	100.0	0
20	0	199	40 7	59 3
20	0 5	86	61.6	38.4
40	0	385	36.4	63.6
40	0.5	189	53.4	46.6
80	0	184	57.1	42 9
80	0 5	106	50.0	50 0
160	0	172	55.8	44.2
160	0.5	42	59.5	40 5

[1] Totals of two experiments, 5 original shoots/treatment per experiment

the control. During these experiments, all shoots were subcultured each time; i.e., the green variants were not selectively removed from the cultures. Over time, the faster growth rate of these green shoots could result in a completely segregated culture. With observant selection against such variant shoots (in stock cultures) it was possible to keep the culture multiplying and true-to-type. Very high 2iP levels stunted shoot growth and, in the case of 160 μM 2iP with 0.5 μM IBA, were toxic.

Potential for Off-Types. As propagators, we want to use methods of increasing plants which give us clonal copies of the starting material. Of course, we also like to keep an eye out for something new, whether it be a promising seedling, an interesting sported branch, etc. During culture of periclinal chimeras, an infrequent reversal, or rearrangement, of the original variegation pattern may occur. One such reversed shoot appeared in a stock culture during this project, named *R.* 'Carolina Jewel'. This cultivar is evidently very stable *in vitro*, but occasionally produces entirely yellow variant shoots. The flower color of 'Carolina Jewel' is not yet known.

Effect of Vitrification on a Chimera Culture. A problem with culturing 'President Roosevelt' shoots on Gelrite was vitrification of some shoots, which obscured the variegated leaf pattern. This was reversible by putting Difco Bacto-agar into the medium. Even though the vitrification process itself apparently did not change the phenotype of variegated shoots, it did allow the potential for inadvertent subculture of similarly appearing green shoots, and thus could lead to subsequent loss of the chimeral condition. Experience with other variegated plants, such as *Rhododendron* 'Carolina Jewel', *Cornus kousa* 'Snowboy', and *C. kousa* 'Gold Star' has indicated this phenomenon occurs in a variety of plants.

Stabilization of Periclinal Chimera Cultures. Can periclinal chimeras be stabilized during micropropagation? Based on the cultures I have worked with, the answer is yes. Cultures of *R.* 'President Roosevelt' have been maintained for almost four years. Cultures of the new chimera, *R.* 'Carolina Jewel', have been stable for 2½ years. A variegated dogwood, *C. kousa* 'Snowboy', has been stable and multiplying in culture for seven months. A new variegated miniature rose sport has multiplied true-to-type for over one year. Based on our experience with periclinal chimeras, it is evident that they can be stabilized and multiplied with success. Attention to detail concerning the appropriate culture medium and subculture technique is essential, but this should be true for every plant in culture.

Use of Periclinal Chimeras to Test Techniques. The results of this study show that plant chimeras are useful for determining the best explant source. Also, even at low cytokinin levels in the medium, adventitious shoot formation does take place to some extent. The highest percentages of variant shoots were found on the optimal 2iP concentration. This should tell us that, certainly in the case of chimeral plants, we need to consider reducing multiplication rates, or else run the risk of ending up with aberrant cultures.

Interesting areas for further exploration using shoot cultures of periclinal chimeras include: effects of various light intensities, use of various vessel types, response to refrigeration, variations of solidifier kind and concentration, and different methods of culture subdivision.

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PROGRAMMING TISSUE CULTURE-PRODUCED PLANT PERFORMANCE

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Abstract. The field performance of tissue culture-propagated strawberry plants can be manipulated by the addition of plant growth regulators in the culture medium. The addition of abscisic acid or paclobutrazol tended to produce more reproductive organs The addition of benzyladenine and gibberellins tended to produce more vegetatively vigorous plants. These results, along with data from endogenous abscisic acid determinations and light micrographs of treated meristems, further describe possible causes of *in vitro*-induced rejuvenation

REVIEW OF LITERATURE

Tissue culture (TC) propagated strawberry plants perform more like juvenile seedlings (JS) than adult plants propagated by runners (RP). Runnering is increased, flowering is delayed and susceptibility to diseases is altered (6). The cause of this phenotype is unknown. Gibberellic acid (GA) has been implicated in floral inhibition, enhanced runner development and juvenility (2), but no GA is included in any stage of strawberry *in vitro* propagation media. Benzyladenine (BA), a cytokinin included in the proliferation subcultures, has been implicated in both juvenility (3) and increased bud activity in field-grown strawberries. In a previous experiment, abscisic acid (ABA) concentrations were lower in TC-propagated and JS day-neutral strawberry plants, when compared to adult RP-plants (5). ABA is known to reduce lateral bud break and it has reduced rooting in tissue-culture strawberry explants. Therefore, reduced ABA content in TC-propagated plants would explain their increased lateral bud activity and ease of rooting. We now report three experiments where the effects of ABA, BA, GA and paclobutrazol (a GA biosynthesis inhibitor), supplied in the culture medium, are correlated with subsequent greenhouse performance of TC-propagated strawberry plants.

MATERIALS AND METHODS

'Fern' (Expts. 1 and 2) or 'Tribute' (Expt. 3) day-neutral strawberry runner meristem-tips were sterilized and subcultured on various plant growth regulators (PGR) in a Murashige and Skoog medium. Paclobutrazol and GA (both at 10 μM) were filter sterilized and added to the TC-medium after autoclaving, while BA and ABA at 5 μM and 0.5 μM, respectively, were added before

autoclaving. A no PGR control was also included in some experiments. Ten to twelve plants per treatment were established in the greenhouse and various growth variables were measured for up to 20 weeks. All measurements were analyzed by ANOVA and LSD at 5%.

Treatments for Experiment 1 included three consecutive subcultures on two levels of ABA or two levels of BA in factorial combination. Data are presented only for the treatments at 5 μM BA and 0.5 M μABA, alone and in combination (BA + ABA). Lower concentrations gave intermediate responses and no interactions occurred. Other treatments in this experiment were JS and adult RP plants. Data on number of inflorescences, runners, and branched crowns per plant at 16 weeks after propagation in the greenhouse were used to determine the relative proportion of vegetative vs. floral meristem development (Table 1).

Table 1. The effect of propagation type and *in vitro* applied plant growth regulators on the percentage meristem development at 16 weeks after propagation.

Treatment and propagation type	Percentage runners	Percentage crowns	Percentage inflorescences
Seedlings	65	25	10
TC-BA	54	29	17
TC-control	41	23	36
TC-BA + ABA	34	24	42
TC-ABA	19	21	60
Adult runners	19	20	61
LSD (5%)	10	8	7

Experiment 2 included one subculture on one PGR and a subsequent subculture on a different PGR. The PGRs used are given in Table 2. All PGR concentrations were as above. Data was cumulatively summed after 16 weeks.

Experiment 3 was a PGR X polyamine factorial in which *in vitro* treatments were applied for three subcultures and subsequent greenhouse growth was monitored for 16 weeks. ABA or BA treatments were combined with either no polyamines or filter sterilized putracine, spermadine, or spermine at 1 mM.

RESULTS

In Experiment 1, control TC-propagated strawberry plants dedicated a greater percentage of their meristems to vegetative growth (runners and branched crowns) than adult RP-plants (Table 1). In contrast, JS plants were more vegetative than TC-propagated plants. ABA acted as an anti-rejuvenation hormone while BA tended to rejuvenate plants, i.e. make them more vegetative.

Table 2. The effect of various PGR treatments in two subsequent subcultures on the number of runner plants and number of inflorescences produced by TC-propagated plants within 16 weeks *ex vitro*.

First culture PGR	Second culture PGR	Number of runners produced	Number of inflorescences produced	Inflorescence to runner ratio
BA	Control	6.7	1.8	0.27
BA	ABA	5 3	2.4	0.45
BA	GA	12.3	1 2	0 10
BA + ABA	Control	6.6	2 0	0.30
BA + ABA	ABA	7 6	2 5	0.33
BA + ABA	GA	16 8	1 5	0.09
Paclo	Control	2 3	2.3	1 00
Paclo	ABA	1 0	4 3	4.30
Paclo	GA	8 4	1 8	0.21
LSD 5%		2 1	0 9	—

In the second experiment, paclobutrazol- and ABA-treated TC-plants were more adult-like while GA increased the proportion of vegetative meristems (Table 2). A single subculture on GA increased runnering by a factor of 2 to 4. The addition of GA in the second subculture had the largest overall effect.

In Experiment 3, ABA again enhanced 'Tribute' day-neutral flowering. At 16 weeks of greenhouse growth, ABA-treated TC-produced plants produced 1.5 inflorescences per plant while BA-treated plants produced 0.1 inflorescence per plant. BA-treated TC-produced plants had only slightly more runners than ABA-treated plants over 16 weeks *ex vitro* (BA = 13.0 runners; ABA = 10.7 runners). The same treatments were applied to 'White Pine', a short-day cultivar. Flowering was not induced by ABA treatments; however, BA again slightly stimulated runnering (BA = 15.7 runners per plant; ABA = 13.7 runners per plant). Polyamines had no significant effect on plant performance.

DISCUSSION

In terms of TC-produced plant runnering and/or flowering, ABA and paclobutrazol added in tissue culture media produce more adult plant responses while GA and BA produce a response more typical of JS. Similar results were obtained in three separate experiments in our laboratory (5). In one experiment, the ABA content of TC-produced, JS, and RP plants was measured. When compared to adult RP plants, endogenous concentrations of ABA were lower in TC-propagated and JS strawberries at 3 and 7 weeks after propagation. At 15 weeks, all ABA levels were equivalent.

Based on the above information, changes in ABA physiology in TC-produced plants seems to be at least partially responsible for

their rejuvenation. ABA does not effect runnering to the extent GA and paclobutrazol do, so it is possible the GA physiology changes during *in vitro* culture as well.

The causes of these changes are unknown. ABA is thought to be synthesized or resident in chloroplasts and chloroplast function and number are reduced *in vitro*. ABA inhibitors, like fluridone and norflurazon are being tested for their effect on TC-induced rejuvenation and juvenility.

A possible explanation for the observed treatment effects is that early differences in photosynthetic rates between PGR treatments gave some plants a developmental advantage that is maintained over the study period. While ABA and paclobutrazol treatments yielded more adult plants and had higher net photosynthesis on a leaf area basis, there was no correlation between rejuvenation and photosynthesis on a whole plant basis. This contrast arises because leaves on BA- and paclobutrazol-treated plants were much smaller than GA- and ABA-treated plants (5).

In contrast, correlation between leaf form, plant behavior and meristem anatomy was found (4). The flattened apical meristems of ABA- and paclobutrazol-treated plants were typical of pre-floral differentiation stage meristems. ABA- and paclobutrazol-treated plants had more adult trifoliolate leaves (5). GA- and BA-treated plants had elongate meristems and more juvenile monofoliolate leaves. Thus, meristem pattern evidently continued for a period of time *ex vitro*. The larger response to second subculture treatments, in comparison to those in the first subculture (Table 2), could be interpreted as the last PGR which fashions *in vitro* meristem morphology will be the one controlling plant behavior. This continuation in plant developmental pattern evidently took place in TC-rejuvenated plants where endogenous ABA concentrations in the meristem are reduced. If ABA is important in developmental changes, then TC-produced plants may be matured more rapidly when exposed to conditions like short days and drought stress that increases ABA level in plants. TC-produced raspberry plants are very sensitive to short-days suggesting that they are very sensitive to increases in endogenous ABA. In addition, the water stress of acclimatization *ex vitro* temporarily raised the ABA levels of TC-produced plants (5).

Finally, it is important to realize that short-day TC-produced strawberry plants, when grown under non-inductive conditions, did not flower in response to added ABA. Short-day RP-plants also did not respond to added ABA (1). Thus, there is a level of control of flowering not affected by these hormones under the conditions of our study.

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SWEETGUM TISSUE CULTURE

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American sweetgum (*Liquidambar styraciflua*) is found naturally from as far north as Connecticut, southward into Florida and as far west as Texas. It can also be found in montane regions of Mexico and Central America. Due to the expansive and climatically diverse native range of this species, numerous ecotypes have been reported that exhibit greater frost tolerance, greater cold hardiness, differences in response to photoperiod, and differences in date of spring bud break and fall leaf retention (4, 8, 9). Great variation also exists in a number of ornamental characteristics, such as fall foliage color, fruitlessness, and form.

Sweetgum is commonly propagated by seed, but genetic variation and seed source variation make sexual propagation less than ideal in many instances. When asexual propagation must be used to propagate any of the numerous sweetgum cultivars, propagators usually have to employ grafting onto seedling rootstocks, since cutting propagation is rarely viable on a commercial level. Although grafting of sweetgum selections is usually very successful, grafted plants are not always the best landscape plants. Rootstocks often sucker freely, and cold-hardy cultivars, such as 'Moraine', grafted onto seedlings from southern seed sources, may survive a northern winter well, while the rootstocks freeze out from under the scions. In addition, grafted plants are still plagued by the variability imparted to them by the rootstock. Genotypes selected for non-invasive root systems, for example, cannot be propagated by grafting.

Micropropagation offers the propagator a viable and attractive alternative to grafting when one is asexually propagating sweetgum. Several unique aspects of *Liquidambar* should be kept in mind when one attempts to micropropagate this genus, and these will be outlined in the sections that follow. Most of my work has been with cold hardy cultivars, *L. styraciflua* 'Moraine', and *L. styraciflua* 'Variegata', and *L. styraciflua* 'Rotundiloba'. The difficulties I have experienced in working with these cultivars appear to be most pronounced in these, and other, northern types and less of a problem with clones of southern origin or with juvenile material.

Explant and Sterilization. Shoot tips harvested from actively growing shoots are a principal means of initiating shoot proliferating cultures of many woody species, including sweetgum (7). Shoot tips collected in the spring respond better than those collected in the summer and early fall (93% survival vs. 10% survival, respectively) (7).

Brand and Lineberger (1) have used lateral buds to initiate shoot proliferating cultures of mature-phase tissue. Lateral buds taken from the fifth or sixth node from the apex of an expanding shoot are in the proper physiological state to initiate *in vitro* growth and, in my experience, are superior to shoot tips. Buds taken with a shield of stem tissue initiate cultures readily, and rarely display the necrosis and need for rapid initial transfer typical of shoot tip explants. Within 2 to 3 weeks after explantation, the primary bud and two collateral buds begin to expand.

Initial sweetgum explants can be readily surface sterilized in a 10% Clorox solution for 15 min., followed by sterile distilled water rinses. Contamination rates for greenhouse-grown material collected in the spring can be expected to range from 5 to 10%. I have encountered occurrences of what appear to be endophytic bacterial contamination.

Shoot Proliferation. Woody Plant Medium (3) is the most suitable medium for sweetgum shoot proliferation. Murashige and Skoog medium (MS) (5) does not support acceptable sweetgum growth, often inducing necrosis and browning. A number of cytokinins have been tried with sweetgum, with benzyladenine (BA) at concentrations at or close to 1 mg l^{-1}, producing the greatest number of usable shoots. Shoot proliferating cultures of *Liquidambar* develop what I have termed "long shoot-short shoot" growth. What typically develops is a clump of a dozen or so short shoots, with 3 to 5 longer, well-expanded shoots. Short shoots are difficult to handle when they are treated as microcuttings.

Numerous treatments were tried on sweetgum that are known to enhance shoot elongation in other species, but none worked satisfactorily with *Liquidambar*. Gibberellic acid, various carbohydrate sources, low light levels, low cytokinin levels, and charcoal all failed to stimulate usefully significant shoot extension and concomitant leaf expansion. Addition of charcoal, removal of BA, or long subculture cycles stop shoot growth and stimulate rooting and the formation of a well-defined terminal bud.

Perhaps the best way to prevent the cessation of shoot growth and enhance shoot extension is to transfer cultures to fresh medium at 3 to 4 week intervals. Longer periods between subculture arrest the growth momentum of the shoots and send the culture into a

state which is somewhat analogous to "summer dormancy". A suggested transfer protocol to optimize formation of large microcuttings entails transfer of cultures to fresh medium after 3 weeks, followed by another transfer to fresh medium after 3 weeks and harvest of microcuttings after 5 weeks of growth on the last medium. The unharvested portions of the culture can then be put back into the cycle at the beginning.

The pH of shoot proliferation medium should be maintained at 5.2 or 5.3 and sucrose, at 2 or 3%, should be used as the carbohydrate source. A number of agars, including Sigma, Difco Bacto, and TC agar have worked well as solidifying agents for sweetgum cultures when used in the range of 0.6% to 0.8%. Gelrite or Phytagel used as solidifying agents result in poor quality cultures. Liquid culture of sweetgum results in severe vitrification and "lettuce-leaf" if shoots are immersed in the medium. Valuable cultures contaminated with bacteria can be successfully grown on polyester batting "barges" soaking in liquid medium. This type of culturing washes away damaging bacterial populations from the shoot clusters (without inducing vitrification) and enables production in cases where contaminated cultures would be killed or inhibited on agar solidified medium.

Environmental conditions which support good growth of *Liquidambar* cultures are: 23 to 25 °C; 14 to 16 h photoperiod; and 20 to 40 μE m^{-2} s^{-1} produced by cool white fluorescent lamps.

Culture Storage. Shoot proliferating cultures of sweetgum can be easily stored under refrigerated temperatures. I have stored shoot proliferating cultures of seedlings and named cultivars in the dark at 4 ± 2 °C continuously for 6 years without any loss of vitality when cultures are returned to typical culture conditions. Stored cultures continue to grow slowly under dark, refrigerated conditions, and develop etiolated, "spaghetti"-like growth. Cultures quickly green, and resume normal growth when retrieved from storage. Optimally, cultures should be transferred to fresh medium every 5 to 6 months during storage, but can go for 12 months or longer between transfers without serious losses in viability.

Microcutting Rooting and Plantlet Establishment. Sweetgum shoots produced *in vitro* can be easily rooted, either aseptically or under non-sterile conditions, and will go on to produce healthy plantlets. Even if they are short, robust shoots with thick stems and leaves along the entire length of the shoot make better microcuttings than long, spindly shoots with only a whorl of leaves at the apex.

Rooting microcuttings under non-sterile conditions can be an easy way to obtain sweetgum plantlets. With a pre-dip in 200 mg l^{-1} indolebutyric acid (IBA), rooting percentages of 70 to 90% for

mature material can be obtained (2). *In vitro* rooting is generally more consistent than non-sterile rooting, but is more resource-intensive. Half-strength salts are superior to full-strength salts (7), and I have rooted hundreds of sweetgum microcuttings using half-strength WP medium.

For juvenile shoots, the addition of IBA at 0.5 mg l^{-1} to the culture medium yields optimum rooting (7). For mature shoots, IBA in the range of 0.5 to 1.0 mg l^{-1} supports excellent root initiation, with the higher concentrations decreasing the time until rooting and increasing the number of roots per shoot. Providing microcuttings with auxin for a 3 to 4 weeks period, followed by transfer to hormone-free medium, enhances root initiation and subsequent root growth and elongation (1).

Acclimation of rooted sweetgum plantlets is usually accomplished by gradually reducing humidity and increasing light intensity. Sweetgum plantlets can be acclimated to the greenhouse by providing 7 days in shaded intermittent mist, followed by 7 days in a shaded greenhouse, or by substituting the week of intermittent mist with a gradual opening of the humidity chamber (1). During the rooting process, microcuttings form what is analogous to a summer dormant bud. Careful handling of acclimated plantlets is important, to insure growth of the apical bud and survival of the plants. It is best to acclimate plants when the daily photoperiod is increasing and relatively long; this means bringing rooted plantlets to the greenhouse in late winter to late spring. Plantlet survival in the spring and summer can be expected to be approximately 90% or better, but could be considerably lower than 50% in the winter. The use of HID lamps to extend the photoperiod will not overcome poor performance of plantlets in the winter, indicating that high light intensity, along with long photoperiods, are necessary to initiate growth in young plantlets. Ample fertilizer and water during the post-acclimation period also helps to induce a new flush of growth.

Once acclimated plants have resumed growth in the greenhouse, they can be expected to reach heights of 1 to 1.5 m and have stem calipers of 12 to 14 mm in 5 to 6 months, under accelerated growth conditions (2). Sommer and coworkers (6) determined that plantlets grown outdoors in a nursery bed for one year attain heights and stem diameters suitable for field planting. I have overwintered over 500, 6-month-old tissue-cultured plants in an unheated polyhouse and survival was nearly 100%. After one growing season in a container nursery area, these plants reach heights in excess of 2 m. Numerous plants have been planted in landscapes and in test plots. All plants appear to grow normally and at a rapid rate. We have not seen any indications of suckering (often seen on grafted plants) or poor root systems on any micropropagated plants.

Shoot Organogenesis from Leaf Tissue. When tissue of a particular sweetgum genotype is limited, shoot organogenesis from leaf pieces offers an means of rapidly increasing propagation stock. Shoot organogenesis requires relatively high levels of BA (2.5 mg l^{-1}), but is very reliable, both with greenhouse- and *in vitro*-produced leaves. The risk of producing "off-type" plants through adventitious shoot formation on leaves appears to be low. Shoot organogenesis on leaves has been thoroughly described (2).

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Thursday Evening, December 13, 1990

The Fortieth Annual Banquet was held in the Gold/White Hall of the Stouffer Tower City Plaza Hotel, Cleveland, Ohio.

Peter Vermeulen gave the invocation as a poem he wrote in honor of the 40th anniversary celebration:

A Dream, A Theme, A Team Supreme

The scriptures declare that "to seek is to find".
Though it speaks of a sharing of a different kind it applies just as well, and
is tried and true that to truly excel one must think and then do.
It was that kind of spirit in our founder, Jim Wells who had a mind for the
future that in all great men dwells, a mind that had vision, the kind that
foretells of great things to happen, and all doubt dispels.
There's another great truth we should learn and keep — that as one sows, so
shall one reap And yet another, for all to know and believe — that when
one asks from the heart one shall surely receive
For forty years now our Society's dare to each of our members is to seek and
to share. As we travel our lives, may our work and our dreams ever
reflect that most worthy of themes.
From humble beginnings our I.P P.S. name has achieved the honor of world-
wide acclaim because of a selfless desire to show to others the knowledge
that God did bestow.
For all wisdom and knowledge come from above and are given to us to share
them with love.
So we thank you Lord for each vision and dream — past, present and future,
of each on our team of layman and scholar and researcher, all who have
stirred in their hearts and answered the call to improve what was given,
and with brotherly care did practice our motto—

"TO SEEK AND TO SHARE"

1990 RESEARCH GRANT

DR. DEBORAH McCOWN: On behalf of the Research Committee and the members of the Eastern Region of the International Plant Propagators' Society, I would like to present this years Research Grant Award. This year's grant is $2,000.

The committee received six excellent applications and had a difficult time selecting the single grant application to receive the award. If your grant was not the one selected, I encourage you to resubmit it this year. I would encourage all members to submit proposals they believe of interest to plant propagators. The application form is only one page and the value of the 1991 grant is $4,000.

This year's Research Grant has been awarded to Dr. Patricia S. Halloway, Associate Professor of Horticulture, University of Alaska at Fairbanks. Dr. Halloway's proposal is titled: Vegetative Propagation of the lingonberry, *Vaccinium vitis-idaea.*

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Dr. Steve Still made the following Fellow Award presentations.

EASTERN REGION FELLOW AWARDS

During early 1990 the Executive Committee of the IPPS Eastern Region finalized plans for the Eastern Region Fellow Awards. This prestigious award was created to honor Eastern Region members for contributions to the Region and to plant propagation.

Fellows of the Region are to be recognized for outstanding contributions to plant propagation in one or more areas. These include leadership in plant propagation in industry or in the areas of teaching, research, or extension activities related to plant propagation. Contributions to Region functions are also considered.

Recipients of the Fellow Award must be active members of the Eastern Region with at least 10 years of membership. Any Eastern Region member may make one or more nominations of an individual(s) for the award.

Tonight it is my pleasure to present the first class of Fellows of the Eastern Region—International Plant Propagators' Society.

Our first award recipient is **Dr. Len Stoltz.** In the academic area Len has taught plant propagation at the University of Kentucky. He was one of the earlier pioneers in tissue culture in the Eastern Region. I am sure that many of you remember his presentation on how to develop a practical tissue culture lab in your kitchen. Len served many years as the Editor for the Eastern Region. He served as the Eastern Region President in 1983-84.

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Our first award recipient is **Dr. Len Stoltz.** In the academic area Len has taught plant propagation at the University of Kentucky. He was one of the earlier pioneers in tissue culture in the Eastern Region. I am sure that many of you remember his presentation on how to develop a practical tissue culture lab in your kitchen. Len served many years as the Editor for the Eastern Region. He served as the Eastern Region President in 1983-84.

Our second recipient is **Kathleen Freeland.** Kathy's career in plant propagation has spanned several states. She has been an

energetic propagator at Weston Nurseries, the Chicago Botanic Garden, and Midwest Ground Covers. In 1987-88 Kathy served as our Eastern Region President. She presently serves as the International Director for the Eastern Region. Kathy is to be commended for her extra work in maintaining the direction of the Eastern Region following the unfortunate death of our friend, David Hamilton.

Our third recipient of the Fellow Award is **Wayne Lovelace.** Wayne has given a number of presentations on practical and innovative propagation and cultural procedures utilized at Forest Keeling Nursery. When I was at Kansas State University, I took my nursery production class to Forest Keeling and Wayne was always an enthusiastic promoter of the nursery industry and the importance of plant propagation. Wayne served as the Eastern Region President in 1979-1980.

The forth recipient to receive the distinguished Fellow Award is **Ralph Shugert.** Ralph's participation in the International Plant Propagators' Society certainly meets the sharing motto. He has been sharing his knowledge since the 1950s. During that time he has presented 22 talks to the Society. He has been a fixture as one of the facilitators for the Question Box. Ralph served as Eastern Region President in 1967-68 and as the International President in 1971. He has been the only Historian of the International Plant Propagators' Society.

Our final recipient this evening is **Dave Dugan.** As we learned at Tuesday's lunch, Dave has been an active member of the Society since its first meeting in 1951. During that time Dave has served on numerous committees and was the president of the Eastern Region in 1968-69. In 1990 he was a very active member of the local site committee. Dave has introduced to the industry 'White Angel' crabapple and 'Sunspot' euonymus.

Dr. Phil Carpenter made the Award of Merit presentation.

EASTERN REGION AWARD OF MERIT

Wayne Lovelace received the Award of Merit at the 40th Annual Meeting of the Eastern Region-International Plant Propagators' Society. Wayne is currently Vice-President and General Manager of Forrest Keeling Nursery, Inc. in Elsberry, Missouri. Wayne joined IPPS in 1963 and has served the Eastern Region in many capacities including President during 1979-80. He has been local site committee chairman for the annual meeting and currently is co-chair for the 1992 meeting that will be held in St. Louis. He is a past member of the International Plant Propagators' Society Board of Directors. Wayne has presented many papers at the annual meetings and continues to be a very active supporter of IPPS.

Wayne was born in Missouri on January 13, 1936, and obtained his education in the ''show me'' state. He received his BS degree, majoring in horticulture, from the University of Missouri in June, 1958. Since being a student at the University of Missouri, Wayne has continued to support education at the college level. He has been the University coordinator for the Missouri Association of Nurserymen, Horticulture Department Advisory Council of the University of Missouri, Co-chaired the Technology Task Force on Rural Missouri 1995 Challenges and Issues, and served on the Agricultural Leadership of Tomorrow Advisory Council.

Besides the activities associated with the University of Missouri, Wayne has been active in State Government having served on the Governor Bond's Task Force on Rural Development, Governor Bond's and Governor Ashcroft's Council on Agriculture, and Senator Bond's Advisory Committee on Agriculture. He also has been a member of the Missouri Financial Advisory and Resource Management Support Board of Directors.

Wayne has been very active in his professional organizations and besides serving as Eastern Region-IPPS President he has been President of the Missouri Association of Nurserymen, President of the Wholesale Growers of America, and he has been on several American Association of Nurserymen committees, including the Education, the Nursery Exposition, and the Long Range Planning committee.

Wayne has received numerous awards including the Wholesale Growers of America New Ideas Award, the University of Missouri Alumni Citation of Merit Award, and the Missouri Nurserymen ''Nurserymen of the Year''. In 1990 Wayne was elected a Fellow of the Eastern Region-International Plant Propagators' Society.

Wayne's wife, Judy, was present at the Eastern Region-IPPS Banquet when the Award of Merit was presented. Congratulations to Wayne for a well-deserved Award.

PROPAGATION OF VINES

TOM KIMMEL

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Although many vine species and cultivars have been in and out of our production we will concentrate on a select group of eight genera which are hardy at least to Zone 5: *Clematis, Hydrangea, Actinidia, Ampelopsis, Campsis, Lonicera, Parthenocissus,* and *Polygonum.* These comprise approximately 7% of our total nursery output. Many more vines which are primarily considered groundcovers, such as *Euonymus fortunei* and *Hedera helix* cultivars, will not be considered here.

At Twixwood Nursery we prefer vegetative cutting techniques as a method of maintaining cultivars or superior strains. This gives us control over inventory and allows us to increase numbers quickly either by maintaining adequate stock plantings or by late winter forcing of containerized material for cuttings.

In order to obtain a high quality product we strive to take our cuttings from pest and disease free stock. We also strive to provide a clean work area as well as treat our propagation houses with Green Shield™ (general greenhouse disinfectant) at a rate of ½ oz/gallon of water. The primary pest problems are two spotted spider mites and to a lesser degree aphids. Pests are controlled with a rotating spray schedule of three to four miticide/aphicide combinations on a seven to ten day schedule during the growing season. Clematis wilt can be a problem and is caused by an unspecified fungus. We apply preventive drenches of benomyl and Chipco 26019 on a rotating schedule during the growing season. This is done every two weeks. Leaf spot on *Parthenocissus* can be a cosmetic problem and is controlled with a zinc-based chemical. *Hydrangea anomala* subsp. *petiolaris* and *Polygonum aubertii* have been found to be susceptible to high E.C.'s (electrical conductivity) in the potting soil, particularly in the hot summer growing season. Liquid fertilizer, (ammonium nitrate/potassium nitrate at 3.0 mmho) is applied at every other watering and the E.C.'s of the soil are monitored so as not to exceed the 0.35 to 0.4 mmho. Leaching is done as a corrective measure.

Our *Clematis* production begins approximately mid-March and continues until about mid-June. The vines are cut from containers overwintered in unheated polyhouses. Cuttings are taken in the early morning and stored in a cooler if necessary until ready to process later that day. The vines are processed into two node cuttings, discarding the very tender tip. The basal leaves are cut off and ¼ in. of the stem is left below the bottom node. Cuttings are

stuck in an open flat filled with a perlite/sand mix (1:1, v/v) using #8 Hormex rooting powder. Trays are watered shortly after sticking. At the end of each day the trays are hand drenched with benomyl at a rate of 2 tbs to 1½ gal water. The use of bottom heat and an intermittent overhead mist system has worked best for us. We use a Maplewood vortex type fine mist nozzle hanging 6 ft above the plant surface set to mist at a rate of 8 sec every 20 min. In approximately four to five weeks the cuttings are removed from the mist and are ready to be potted two to three weeks later.

Hydrangea anomala subsp. *petiolaris* production begins in mid to late April. Timing is very important as cuttings must be taken from new growth when the leaf is approximately ½ its mature size. Cuttings are taken from containers overwintered in unheated polyhouses. The cutting consists of both the apical and the lateral buds. Lateral buds are cut so as to include part of the old wood. Cuttings are stuck in an open flat filled with BP4 Stronglite mix (composted pine bark, vermiculite, perlite, peat) using #8 Hormex rooting powder. These are placed under intermittent mist and bottom heat again using the Maplewood mist nozzles 6 ft above the plant surface at a rate of 8 sec every 20 min. It takes approximately three to four weeks for root initiation to occur, and they are ready to pot in another three to four weeks.

The bulk of our vine production starts in June when our main crew beings work. Vines included are: *Actinidia arguta, Ampelopsis brevipedunculata* 'Elegans', *Campsis radicans, Lonicera japonica, Parthenocissus* species, and *Polygonum aubertii.* We take herbaceous softwood cuttings from stock plants. All cuttings are two to three nodes and 3 to 6 in. long depending on the vine. We use #3 Hormex rooting powder and stick directly into 2¼ in. pots filled with BP4 Stronglite mix. Flats are placed under intermittent mist. We begin at a rate of 8 sec every 5 min for the first week, then switch the clocks back to 8 sec every 10 min. After callusing and root initiation, the clocks are moved back to 8 sec every 20 min until they are moved out of the mist. We do not use bottom heat.

ENCOURAGING BUD BREAK IN NEWLY-ROOTED SOFTWOOD CUTTINGS

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Abstract. Studies were conducted with several tree species to characterize the effects of stock plant etiolation, stem banding, and post-propagation $GA_{4/7}$, BAP, and STS sprays on the establishment and growth of rooted softwood stem cuttings. Stem banding promoted bud break and shoot growth while etiolation reduced bud break in *Carpinus* and *Malus* 'Spring Snow'. $GA_{4/7}$, but not BAP, was effective in promoting both bud break and shoot growth BAP reduced the $GA_{4/7}$ effect. STS promoted bud break and shoot growth of *Carpinus* at 1 and 5 mM, and bud break of *Syringa* at 5 mM. These methods should permit the wider use of stem cuttings for the production of those species which exhibit post-propagation shoot dormancy.

INTRODUCTION

The rooted cuttings of many tree and shrub species enter a period of dormancy following propagation (3). Pellet and Heleba (7) noted this for *Betula papyrifera* and *Forsythia mandschurica*. We have observed this post-propagation dormancy in many species, including beech, hornbeam, lilac, and oak (unpublished data). Not only does this sort of dormancy slow production, but also cutting survival over the first winter can be very low, unless additional shoot growth is produced and allowed to harden-off before overwintering (3, 9, 10). Obtaining shoot growth before overwintering has been shown to promote survival in Japanese maple, red flowered dogwood (2) and English oak (9). Treatments which have been applied to stimulate bud break and shoot elongation on rooted cuttings include night interruptions (8), defoliation (2), and foliar sprays of gibberellic acid (5, 9), cytokinin (4), or promalin, a mixture of gibberellic acid and cytokinin (4). These treatments could be useful in growing a larger plant in the first year following propagation.

Very little work has been done to characterize the effect of stock plant treatments to cutting propagation on subsequent cutting survival and growth. Behrens (1) found that shading the stock plant by 50 to 60%, which increased rooting success, actually reduced bud burst and shoot growth in cuttings of *Acer palmatum* 'Atropurpureum'. The following studies were conducted to characterize the effects of stock plant etiolation, stem banding, and post-propagation growth regulator treatments on the establishment and growth of rooted softwood stem cuttings of several woody plant species.

MATERIALS AND METHODS

The methods described below encompass several experiments utilizing stock plant etiolation and/or stem banding. For further information regarding the use of these stock plant treatments the reader is referred to (6) or is invited to contact the authors for a reprint packet.

Stock Plant Treatments: Etiolation was applied to dormant stock plants of *Carpinus betulus* 'Fastigiata', *Corylus colurna, Malus* 'Spring Snow', and *Syringa reticulata* 'Ivory Silk'. Stock plants which were just breaking bud were enclosed in a black cloth structure excluding 99% of ambient light. Shoots were allowed to grow to 5 to 10 cm before the cover was removed, and the shoots were allowed to green for up to 4 weeks before cuttings were taken. Shoots of these four species, as well as shoots on stock plants of *Franklinia alatamaha* and *Malus domestica* 'M.9' and 'MM.106' clonal rootstock, were banded with a 2.5 cm wide strips of Velcro™ applied to the base of the current season's growth. In treatments where hormone was applied with the band, the opened band was pressed into a thin layer of Hormodin #3 [0.8% indole-3-butyric acid (IBA) in talc]. Bands were left in place for up to four weeks and removed at the time the cuttings were taken.

Cutting Treatments. After harvest, cuttings were prepared to a length of 5 to 8 cm with 2 to 3 leaves per cutting, treated with a basal 5-sec dip of IBA in 50% aqueous ethanol, and allowed to dry for 5 to 10 min before sticking in a medium of peat:perlite (1:2, v/v) under intermittent mist. Rooting proceeded for 4 to 6 weeks before being assessed then rooted cuttings were potted-on. Plants were grown in a medium of perlite:peat:sandy loam soil (1:2:1, v/v/v) and fertilized weekly with 200 mg/l^{-1} 20N-10P-20K. Plants were grown under incandescent lamps suspended 3m above the stock plants and spaced 1m apart (4μmol s^{-1}m^{-1}), were used from 4 to 12 p.m. to extend the natural photoperiod to 16 hours.

Plant Growth Regulator Treatments. Gibberellic acid ($GA_{4\ 7}$; ProGibb, Abbott Laboratories, North Chicago, IL) was applied to rooted cuttings of *Carpinus, Corylus, Malus,* and *Syringa* at 250 and 500 mg/l^{-1}, alone and in combination with 10 mg/l^{-1} 6-benzylaminopurine (BAP). Silver thiosulfate (STS) was applied to plants of *Carpinus* and *Syringa* at 0, 1, or 5 mM. All sprays were applied to leaf-runoff, a rate of about 0.1 ml/cm^{-2}.

Growth Measurements. Percentage bud break as a percentage of rooted cuttings, and average shoot growth were measured periodically over the growing season.

RESULTS

The bud break of *Carpinus* was increased slightly in cuttings from banded shoots (Table 1). Initial etiolation decreased subsequent bud

break, but appeared to promote more shoot growth. The bud break of *Malus* 'Spring Snow' cuttings was not improved by banding, and actually was decreased by banding etiolated shoots. Shoot growth was reduced greatly in initially etiolated cuttings. Neither *Corylus* nor *Syringa* exhibited bud break or growth responses to stock plant treatment. The rooting of these species in response to stock plant etiolation and stem banding was presented by Maynard and Bassuk, this volume.

Table 1. Effect of stock plant treatments on bud break and shoot growth (cm, in parentheses) of *Carpinus betulus* 'Fastigiata' and *Malus* 'Spring Snow'[1]

		Bud break (%) (cm growth in parentheses)	
Stock plant lighting	Stem banding[2]	*C. betulus* 'Fastigiata'	*Malus* 'Spring Snow'
Light-grown	No-band	32 (1.4)	75 (5.2)
Light-grown	Band - H3	54 (2.1)	55 (4 9)
Light-grown	Band + H3	50 (4.6)	80 (5.8)
Etiolated	No-band	23 (3.6)	64 (1.9)
Etiolated	Band - H3	37 (2.5)	25 (1.8)
Etiolated	Band + H3	34 (4.3)	36 (1 8)

[1] Bud break and growth measured after 100 days Percentage means are based upon 32 plants, shoot lengths on only those plants which broke bud
[2] Abbreviations H3-Hormodin #3 (0.8% IBA in talc)

The rooting and after-growth of *Franklinia* and *M. domestica* 'MM.106' in response to stem banding and 4 levels of IBA at sticking is shown in Tables 2 and 3, respectively.[1] Though banding actually decreased rooting response somewhat in *Franklinia,* it partially reversed the IBA inhibition of bud break. Banding increased the rooting of *M. domestica* 'MM.106' over the entire range of IBA applied, while IBA at 2000 mg.liter^{-1} inhibited the rooting percentage of non-banded shoots. Previously banded *Malus domestica* 'MM.106' showed large increases in bud break and shoot growth 4 to 8 weeks after potting.

Table 2. Effect of stock plant treatments on rooting (%) and root number per rooted cutting (in parentheses) of *Franklinia alatamaha* and *Malus domestica* 'MM.106'[1].

IBA conc. (mg liter^{-1})	*Franklinia alatamaha*		*Malus domestica* 'MM.106'	
	Non-banded	Banded	Non-banded	Banded
0	96 (8)	87 (9)	5 (-)	24 (2)
500	100 (91)	96 (89)	60 (4)	72 (6)
1000	100 (127)	96 (124)	88 (9)	93 (9)
2000	100 (100)	96 (106)	56 (10)	93 (15)

[1] Percentage means are based upon 25 cuttings (*Franklinia*) or 5 replications of 6 cuttings (*Malus* 'MM 106')

[1] These results are also published in *J Environ. Hort.* 9(1). 40-43, 199.

Table 3. Effect of stock plant treatments on bud break (%) of *Franklinia alatamaha*, and on bud break (%) and shoot growth (cm, in parentheses) of *Malus domestica* 'MM.106'[1].

	Franklinia alatamaha		*Malus domestica* 'MM 106'			
	4 wks after sticking		4 wks after potting		8 wks after potting	
IBA conc. (mg liter^{-1}	Non-banded	Banded	Non-banded	Banded	Non-banded	Banded
0	88	97	0 (-)	86 (2)	0 (-)	100 (8)
500	28	44	32 (3)	86 (3)	73 (7)	86 (13)
1000	3	11	0 (-)	67 (4)	6 (11)	75 (14)
2000	3	11	0 (-)	28 (6)	0 (-)	60 (13)

[1] Percentage means are based upon 23 to 25 cuttings (*Franklinia*) or upon 7 to 25 plants (*Malus* 'MM.106'), shoot lengths on only those plants which broke bud

Shoots of *M. domestica* 'M.9' were banded for 0, 5, 10, 15 or 20 days prior to propagation. Rooting was allowed to proceed for 36 days and bud break was assessed over a 3 month time following propagation. Shoot lengths were measured after 5 months (Table 4). The rooting responses to increased banding time were dramatic, and banding for 15 days or longer before propagation promoted higher bud break and shoot growth after 71 days.

Table 4. Effect of length of stem banding treatment on rooting response, bud break, and final shoot growth of *M domestica* 'M.9'[1]

	Rooting response after 36 days		Bud break (%) days after transplant			Final shoot
Days of banding	Percentage	Roots/ rooted cutting	36	71	106	length (cm)
0	49	1 4	1	24	39	8
5	55	1 1	0	24	31	6
10	72	2 2	4	37	43	8
15	85	3.6	3	50	67	14
20	88	5 2	0	56	66	12

[1] Rooting percentage means are based upon 5 replications of 12 cuttings, bud break percentage upon number of transplanted cuttings Root number and shoot length determined from rooted cuttings or growing plants, respectively.

$GA_{4/7}$ treatments stimulated bud break in rooted cuttings of *Carpinus*, *Corylus*, and *Malus* 'Spring Snow,' but not *Syringa* which broke bud 100% following natural defoliation during propagation (Table 5). The addition of 10 mg liter^{-1} BAP reduced the bud break of $GA_{4/7}$ treated *Carpinus* and *Corylus*, but not *Malus* shoots. Shoots lengths also increased with $GA_{4/7}$ treatment though, again, this effect was reduced for all species, except *Malus*, by the addition of 10 mg liter^{-1} BAP. STS promoted bud break and shoot growth in *Carpinus* at 1 and 5 mM, and yielded greater shoot lengths in *Syringa* at 5 mM.

Table 5. Effect of growth regulator treatments on bud break (%) and shoot growth (cm, in parentheses) of four woody ornamental tree species [1]

Growth regulator	Conc [3]	Species[2]			
		C b 'F'	C c	M 'SS'	S r 'IS'
control	0	24 (2 4)	17 (8 5)	63 (0 9)	100 (4 2)
$GA_{4\ 7}$	250	40 (4 1)	—	—	100 (8 3)
	500	38 (5 8)	58 (11 6)	70 (4 4)	100 (10 2)
$GA_{4\ 7}$ + BAP	250 + 10	32 (3 8)	—	—	100 (5 7)
	500 + 10	27 (4 8)	42 (8 7)	69 (5 9)	100 (9 7)
STS	0	35 (1 7)	—	—	100 (3 0)
	1	60 (2 9)	—	—	100 (3 4)
	5	64 (3 9)	—	—	100 (7 5)

[1] Bud break and growth measured after 100 days (after 30 d for *Corylus colourna*) Percentage means are used upon 32 plants, shoot lengths on only those plants which broke bud

[2] Abbreviations C b F - *Carpinus betulus* 'Fastigiata', C c - *Corylus colourna*, M 'SS' - *Malus* 'Spring Snow', S r 'IS' - *Syringa reticulata* 'Ivory Silk'.

[3] Control, $GA_{4\ 7}$, $GA_{4\ 7}$ = mg/l [1], STS = mM.

DISCUSSION

These studies suggest that stem banding to promote rooting can have a dramatic effect on subsequent bud break and shoot growth. Stock plant etiolation also benefits rooting, but appears to reduce bud break in the months following propagation.

$GA_{4,7}$, but not BAP, was effective in promoting both bud break and shoot growth when applied as a foliar spray. The reduction in the GA effect by BAP supports the observations of Wooley and Wareing (11), who noted that when GA and BAP, which each promoted bud release, were applied together they completely inhibited lateral bud growth in *Solanum* cuttings. The promotive effect of STS, an ethylene action inhibitor, on bud break and shoot growth suggests that these growth phenomena are somehow inhibited by endogenous ethylene. Ascertaining this possibility would require verification in additional studies using ethylene synthesis and action inhibitors, and quantifying endogenous ethylene in rooted cuttings. We have a project underway which will examine the usefulness of STS in reversing the inhibition of bud bread and shoot growth resulting from IBA application to stimulate adventitious root formation in cuttings.

These studies confirm that there are numerous methods by which we may promote the after growth of rooted tree and shrub stem cuttings. It is hoped that this will contribute to greater success in the use of stem cuttings for the production of those woody plant species which exhibit post-propagation dormancy.

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A COMPARISON OF JUVENILITY IN SEEDLINGS, MICROPROPAGATED, AND MACROPROPAGATED PLANTS[1]

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Characteristics of plant juvenility as described in the literature include ease of rooting, vigorous growth, and heavy basal branching (1). Micropropagated rhododendron, in our experience, provide an excellent example of juvenile growth in a clonal propagule. In contrast, our traditional cuttings or macrocuttings are often difficult-to-root, slow-growing and demonstrate little basal branching resulting in the need for extensive pruning. Since we are a commercial nursery, our experience is largely with named cultivars, consequently no parallel could be drawn with seedling populations. Considering our hypothesis that the growth pattern of micropropagated plants is an expression of juvenility, we designed an experiment to compare micropropagated rhododendron with seedlings, the most juvenile, and macrocuttings, presumably the most mature. Because we needed seed for this comparison, we were limited to rhododendron species and these species had to be available as micropropagules. Thus, we selected the native and commercially important species *Rhododendron vaseyi* and *R. prinophyllum* as test plants. The objective of this study was to explore the juvenility of microcuttings by comparing their growth with seedlings and macrocuttings on the bases of ease of rooting, degree of basal branching, and growth rate of shoots produced.

MATERIALS AND METHODS

Seed was collected in October, 1989 from native, established plants of *R. vaseyi* and *R. prinophyllum*. In December, the seed was sown according to Dirr and Heuser (2). In early February, seedlings were transplanted to flats containing standard potting mix and were then maintained in an accelerated-growth house as described by Knuttel and Benoit (7). Temperature averaged 25 °C; relative humidity (RH) averaged 70%. Baseline growth measurements were taken of shoot length and mean width as determined by leaf span. Number of basal branches was recorded. Subsequent growth measurements were conducted at bi-weekly intervals.

[1] The advice and assistance of D D McCown, Knight Hollow Nursery, Madison, Wisconsin, were essential to the completion of this work

Macrocuttings (stem-tip cuttings) of *R. vaseyi* and *R. prinophyllum* were taken in early June from the same plants that provided the seed. The cuttings were handled as described by Knuttel and Addison (6).

The microcuttings were provided by Knight Hollow Nursery (Madison, Wisconsin). The maintenance medium consisted of Woody Plant Medium (8) solidified with 4g/l gelrite + 1.4 g/l agar mixture, supplemented with 8 μM 2iP. Since hormone "carry-over" had been suggested as a possible cause of the heavy basal branching, individual tips (approximately 0.5 cm with bases cut off and discarded) were grown for 8 weeks prior to shipment. The microcuttings were received by Knuttel Nursery in mid-March and inserted into flats containing fine-consistency sphagnum peat. Microcuttings were rooted in a pit-house with average temperatures of 25 °C and RH 70% in a 16-hour photoperiod. Rooted microcuttings were transplanted to standard potting mixture in June and grown in the accelerated-growth house. Baseline growth measurements were taken when rooted microcuttings and seedlings were as close to equal size as possible. Growth rates and number of basal branches were recorded at bi-weekly intervals.

Data on rooting was reported as the percentage of cuttings rooted; growth rate as an index (average of height and width). Data on basal branching was reported as the percentage of plants exhibiting basal branching.

RESULTS

Ease of Rooting. Microcuttings rooted with greater frequency than macrocuttings (Table 1). Also, based on the time from propagation to rooting, the microcuttings rooted faster.

Table 1. The percentage of propagules (variable sample sizes) that rooted and the time, in weeks, from propagation to rooting.

Species and source	Rooting (%)	Time to rooting (weeks)
R. prinophyllum microcuttings	51	3
R. prinophyllum macrocuttings	4	8
R. vaseyi microcuttings	23	4
R. vaseyi macrocuttings	3	10

Growth Rate of Shoots Produced. In general, the growth rate of the micropropagated plants most closely resembled that of the seedlings (Figures 1 and 2). *R. prinophyllum* (Figure 2) was more uniform in growth than *R. vaseyi* (Fig. 1) and therefore provides an appropriate example of growth rate, which will be discussed later. Although the growth rate of the micropropagated *R. prinophyllum* most closely resembled that of the seedlings, the micropropagated plants were even more vigorous. This vigorous response continued through the duration of the experiment (Fig. 2).

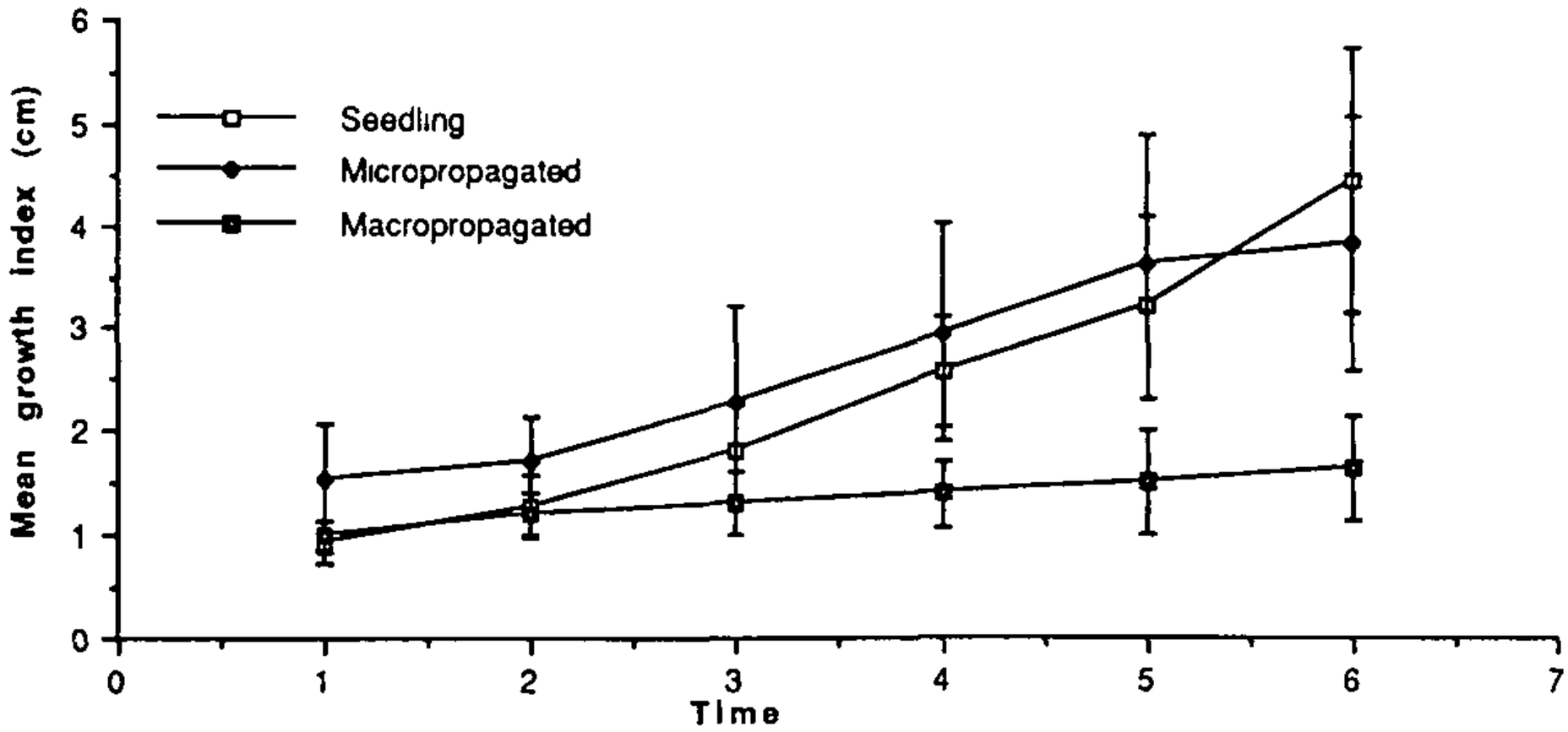

Figure 1. The growth index (average of height and width) of 3 different types of *R. vaseyi* propagules. Measurements were taken at 2-week intervals; data is reported at ± one standard deviation.

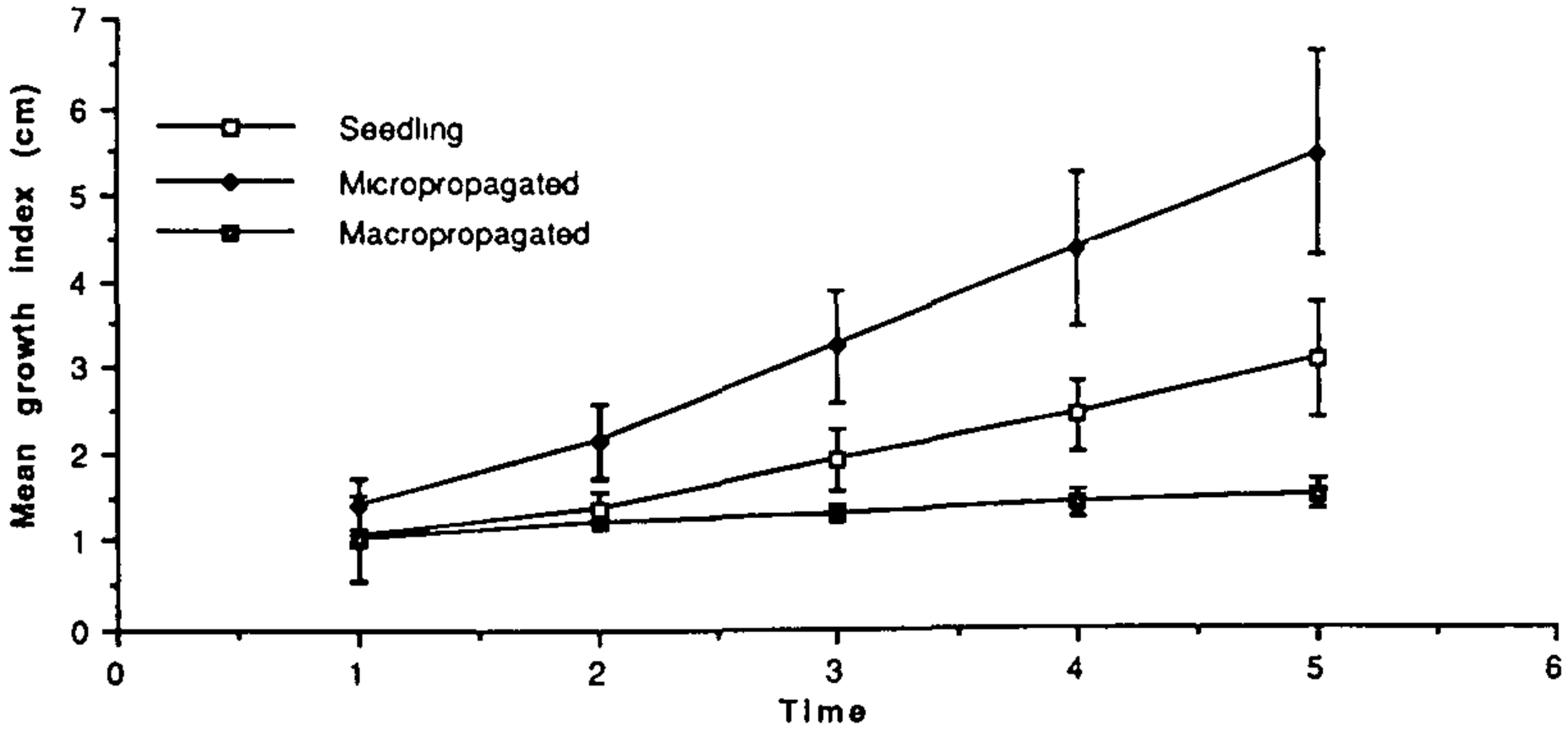

Figure 2. The growth index (average of height and width) of 3 different types of *R. prinophyllum* propagules Measurements were taken at 2-week intervals; data is reported at ± one standard deviation.

Basal Branching. For *R. prinophyllum*, basal branching occurred in 34% of the micropropagated plants, 6% of the seedlings, and 0% of the macropropagated plants (Table 2). *Rhododendron vaseyi* seedlings demonstrated basal branching (33%) but neither micropropagated nor macropropagated *R. vaseyi* demonstrated basal branching.

Table 2. The percentage of plants with basal branching; plants are from variable sample sizes

Species and source	Plants with basal branching (%)
R. prinophyllum micropropagated	34
R. prinophyllum seedling	6
R. prinophyllum macropropagated	0
R. prinophyllum micropropagated	0
R. vaseyi seedling	33
R. vaseyi macropropagated	0

DISCUSSION

The enhanced rooting ability and vigorous growth rate of the micropropagated plants in this study was consistent with our expectations.

Our results agree with similar observations on micropropagated plants with respect to rooting (3, 9) and growth response (4, 5). Also, the expected recalcitrance of the macrocuttings is typical of many species of rhododendrons.

The basal branching response of the two species was quite different. The *R. prinophyllum* microcuttings had higher levels of basal branching than the comparable seedling population. Hormone carry-over cannot be a logical explanation since bases of microcuttings in contact with cytokinin medium were removed and cuttings grown for an additional 8 weeks with no hormone. Another possibility is that, because the single plant that provided both the seed and the macrocuttings was not the same as the parent explant source for the microcuttings, the genetic predisposition of the two genotypes to produce basal branches may have been different. For example, in *R. prinophyllum*, the plant that supplied both the seed and macrocuttings may not normally exhibit a high degree of basal branching and the small number of seedlings that did show basal branching may be the result of heterozygosity due to cross-pollination.

No basal branching was observed on *R. vaseyi* microcuttings over the measurement period while 33% of the seedlings had basal branches. Interestingly, on our normal production of micro-

CONTAINER PRODUCTION OF HARD-TO-FIND OR HARD-TO-TRANSPLANT SPECIES

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The Ohio Production System (OPS), a method for rapidly producing container-grown whips, was first described in these Proceedings (1). The evolution and development of OPS is fully described in the August 15th, 1990 issue of the American Nurserymen, "Turning Copper Into Gold" (2). This article briefly describes the system, why it works, and it lists some benefits. Also, results from a 1990 species trial are presented and some OPS production challenges are discussed.

DESCRIPTION OF OPS

The following procedures are for Columbus, Ohio climatic conditions; if climatic conditions differ significantly from those of Columbus, Ohio appropriate modifications should be made. Between February 15 and March 15 seeds are sown in germination flats while rooted cuttings, either stem or tissue culture microcuttings, are potted in copper-treated one-gallon containers. Following germination, seedlings are transplanted to copper-treated one gallon containers when the first true leaves appear. On coarse-rooted species, the main root is pruned before potting. Our plastic containers are now being coated with Kocide 101 formulation of copper hydroxide at 100 g/l rather than cupric carbonate. We have switched from cupric carbonate for two reasons. First, copper hydroxide gives better root control than cupric carbonate and second, the Griffin Corporation (contact Mark Crawford at the Agricultural Chemicals Group, P.O. Box 1847, Valdosta, GA 31603-1847, (912) 242-8635) is pursuing EPA registration, through label expansion, for Kocide 101 as a root controlling compound. Registration is expected for spring, 1991. Also, Keiding, Inc (4545 West Woolworth Ave., Milwaukee, WI 53218, (414) 353-9790) plans to manufacture a copper treated fiber container for spring, 1991.

Plants are grown in a heated greenhouse until the last frost date, about May 15. The plants are moved outdoors under 70% shade for two weeks of acclimation and then upcanned to three-gallon, copper-treated containers. For the last three years, we have used Kord's 1109 copper-treated fiber container (Kord Products Limited, 390 Orenda Road, Bramalea, Ontario, Canada, L7M-1H4 (416) 791-2600. The plants are then grown under standard container production conditions. Good cultural practices must be maintained or OPS' growth potential will be lost.

propagated *R. vaseyi*, we remove the terminal on cuttings as soon as they are established in our potting medium. These "tipped" cuttings branch heavily. As with *R. prinophyllum*, the parent plant for the microcuttings was different than that for the macrocuttings and seed. The microcutting clone may exhibit a high degree of apical dominance or it is possible that basal branching is a later characteristic to develop. Further study will observe the long-term growth pattern of the micropropagated plants.

From a commercial standpoint, it is clear that micropropagation provides a viable source of plant material with the possible benefits of increased and faster rooting, vigorous growth, and heavy basal branching. Because some growth characteristics such as basal branching may be largely under genetic control, propagators should be aware that careful consideration must be given to source plants before isolation.

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We feel that the rapid growth occurs because: 1) 10 weeks are added to the growing season, 2) the copper-treated containers control root growth, eliminating or greatly reducing the need to root prune when plants are upcanned, and 3) the best cultural practices are maintained.

The advantages of OPS are rapid growth during the first year of production and, following transplanting, the ability to profitability produce difficult-to-transplant species (such as bur oak and black gum), and production efficiency. Production efficiency is increased because whips are produced in one year, rather than in three to five years. For instance, whip orders for fall, 1991 or spring, 1992 could be taken as late as March 1991. Therefore, a producer need sow only as many seeds or plant as many rooted microcuttings as they have orders for, rather than speculating on market conditions three to five years in advance. Two additional advantages are: increased crop uniformity (especially with tissue-cultured material) and the potential to offer plant material grown to customers' specifications.

1990 SPECIES TRIAL

During 1990, we grew 20 species and cultivars under OPS conditions. With three exceptions, *Koelreuteria paniculata, Amelanchier,* and *Betula nigra*, where repeated rabbit browsing kept plants short, growth was excellent (Table 1). The advantage of extending the growing season by 10 weeks is clear. For example, with red oak, the most growth and greatest increase in dollar value occurred during August (Table 2). Without the 10-week greenhouse period, plants would have reached this growth potential in late October; well after the first fall freezes.

CHALLENGES TO OPS

The Ohio Production System is ideally suited for species produced from seeds as well as species which also tend to be difficult to transplant and difficult to produce asexually. A problem with seed produced species is yearly variation in seed quality (both genetic and physiological) and quantity. Variation in seed quantity is caused by alternate bearing habit, common to many woody species. The only way to insure adequate supplies of consistent high quality seed is to establish and manage seed orchards or to purchase seed produced in seed orchards where the mother trees or clones have been tested for genetic superiority. Seed propagated crops can be uniform with respect to phenotype while still being genetically diverse.

Table 1. Percent of plants in given size categories at three times during the growing season and number of plants produced during the 1990 growing season. Plant heights are given in cm and ft.

		Percent of plants in given size class						
Species	Date	<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	No plants in study
Acer rubrum 'October Glory'	8/1	0	30	2	21	66	11	47
	8/21	0	0	0	0	4	96	
	9/21	0	0	0	0	4	96	
A. rubrum 'Red Sunset'	8/1	0	0	0	16	50	34	48
	8/29	0	0	0	0	0	100	
	9/21	0	0	0	0	0	100	
A saccharum	8/1	42	28	42	4	2	0	50
	8/30	7	18	28	22	22	2	
	9/21	5	7	19	28	21	20	
Betula platyphylla 'Whitespire'	8/1	0	0	20	75	5	0	18
	8/30	0	0	6	0	17	78	
	9/21	0	0	5	0	5	90	
Cercis canadensis	8/1	13	31	21	13	13	6	15
	8/30	0	0	0	7	67	27	
	9/21	0	0	0	0	13	87	
Fraxinus americana	8/1	45	35	17	3	0	0	50
	8/30	26	54	14	6	0	0	
	9/21	26	52	16	6	0	0	
Larix decidua	8/1	25	60	15	0	0	0	19
	8/30	0	37	53	10	0	0	
	9/21	5	17	28	44	6	0	
Liquidambar styraciflua	8/1	0	56	48	0	0	0	27
	8/30	0	0	0	15	74	11	
	9/21	0	0	0	7	22	71	
Malus × *zumi*	8/1	20	20	60	0	0	0	39
	8/30	15	0	5	27	54	0	
	9/21	13	2	3	12	18	52	
Malus 'Snowdrift'	8/1	47	19	31	3	0	0	36
	8/30	39	8	31	14	8	0	
	9/21	25	8	11	22	31	3	
Nyssa sylvatica	8/1	4	17	50	28	1	0 4	239
	8/29	2	0 4	7	27	50	14	
	9/21	3	0	1	3	39	54	
Quercus alba	8/1	100	0	0	0	0	0	5
	8/29	100	0	0	0	0	0	
	9/21	74	13	10	3	0	0	
A coccinea	8/1	94	6	0	0	0	0	39
	8/29	80	10	10	0	0	0	
	9/28	74	13	10	3	0	0	
Q. macrocarpa	8/1	46	49	4	0	0	0	78
	8/29	10	33	35	19	3	0	
	9/21	10	12	26	36	14	3	
Q palustris	8/1	57	43	0	0	0	0	96
	8/29	28	44	25	1	0	0	
	9/21	24	36	30	8	2	0	

Table 1. ***Continued***

Species	Date	Percent of plants in given size class						No plants in study
		<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	
Q rubra	8/1	10	16	38	29	7	0 3	289
	8/29	4	6	13	21	23	34	
	9/21	4	3	5	10	30	48	
Q shumardii	8/1	12	30	32	18	8	0	48
	8/29	6	4	27	23	25	15	
	9/28	4	2	6	10	19	58	
Q velutina	8/1	60	36	4	0	0	0	20
	8/29	40	30	20	10	0	0	
	9/21	20	24	32	16	4	4	
Taxodium distichum	8/1	2	13	84	0	0	0	55
	8/30	2	2	15	78	5	0	
	9/21	0	0	2	24	72	2	
Tilia cordata 'Greenspire'	8/1	0	0	0	13	47	40	40
	8/30	0	0	0	0	0	100	
	9/21	0	0	0	0	0	100	

Table 2. Value (in dollars) for various sized *Quercus rubra* (red oak) whips and value of 100 red oak whips at three times during the 1990 growing season. Dollar values, for unbranched whips, were calculated by multiplying the percent of plants in a given size category by the price per whip.

Size category	<60 cm <2 ft	61-91 2-3	92-122 3-4	123-152 4-5	153-183 5-6	184-244 6-8	
Whip price ($)	0 00	1 00	1 70	5 40	7 50	8 75	
DATE							TOTAL
8/1	0 00	16 00	27 20	156 60	52 50	0 00	252 30
8/24	0 00	6 00	22 10	113 40	172 50	297 50	614 50
9/21	0 00	3 00	8 50	54 00	225 00	358 75	649 25

Reliable seed supplies can be insured by learning how to even out the natural alternate bearing habit or by developing storage techniques so that seed from plentiful years, especially seed of species that produce recalcitrant seed, can be stored for use during years of light seed production.

Finally, before OPS can become profitable, a marketing plan must be developed. Whips produced under OPS conditions are similar, but not identical to, field-grown whips. An OPS grower must either adjust production practices so that OPS whips more closely resemble field-grown whips, or develop a marketing strategy which promotes OPS-grown material as an alternative, and in some aspects (such as transplantability) a superior alternative to field grown whips. The author feels the most successful way to market OPS grown material is as a superior alternative to field-grown whips.

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PROPAGATION OF *JUNIPERUS SCOPOLORUM* 'WICHITA BLUE' BY CUTTINGS

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Approximately 10 years ago, we decided to propagate *Juniperus scopolorum* 'Wichita Blue', from cuttings at Riverbend Farms. Our research pointed out that *J. scopolorum* cultivars were fairly difficult to root from cuttings and generally grafted. With all the outside information gleaned plus our own ideas, a recipe evolved that works for us. We presently produce this plant exclusively from cuttings. These cuttings are stuck in the same benches in our propagating polyhouse along with all our other evergreen cuttings.

'Wichita Blue' is a consistently good performer, disease and drought resistant, full in form, and exceptional in colour. This plant is always in demand, a classic blue upright juniper. We like to field-grow this plant to perfection.

Following is our procedure for the propagation of *J. scopolorum* 'Wichita Blue'.

Timing and selection. On November 20th, select 8 to 12 in. shoots from vigorous 2-year field-grown plants, containing new hard juvenile growth always dark at the base for 3 to 4 in. We use 2-year field plants exclusively as a cutting source. These 2-year plants have never been pruned, and the shoots make perfect cuttings. We use Felco #8 pruners and plastic pails for the harvest and take 1 to 2 days supply at a time.

Storage. All fresh cuttings from the field are put through a Benlate rinse at the rate of 1 tsp. Benlate per gallon of water. The cuttings are placed on a poly tarp on a cool barn floor and covered. This storage method provides excellent humidity and we add water as needed or snow if available. Occasionally during warmer weather, the tarped cuttings are placed on the floor of our cold storage and cooled down to 33° F.

Cutting Preparation. Cuttings are made approximately 8 to 10 in. long with hard dark wood at the base extending 3 to 4 in. up the stem into the softer top growth. The cutting resembles a scion used in grafting. We make a fresh basal cut, the bottom 1¼ in. is double slit wounded with the wound stopping 1/16 in. from the base to keep a firm bottom. The tops and sides of the cuttings are not trimmed.

Chemical Treatment. The hardwood base of the cutting is dipped 1½ in. into a fungicide solution at the rate of ½ tsp Benlate

in 7 oz of water. Cuttings are allowed to dry slightly, then dipped into a 1% (10,000 ppm) IBA, 1/2 in. deep, holding for 5 sec. We get our hormone from Plant Products, Brampton, Ontario under the name Stim-Root. We usually dip several cuttings at a time, filling a 20 x 14 in. plastic tray, before going to the polyhouse for sticking.

Propagation Facility. We use a 27 x 96 ft double poly house. One 8 ft wide central bench with two 4 ft wide side benches extend through the polyhouse. The benches are 32 in. high. The walkways are patio stones. We have black poly side skirts and landscape fabric bottom liners over the expanded metal bench bottoms. Each bench has a separate circulator pump and thermostat controlling a wood-oil boiler. Hot water provides bottom heat through 1½ in. pipes. We use no fans or mist.

Sticking Cuttings. Our medium is perlite and peat (3:1, v/v). We use a 1½ in. lath strip 42 in. in length for spacing between rows. The spacing in the row is approximately 1¼ to 1½ in. The space varies with the size of the cuttings and the cuttings lightly touch. A butcher knife is used to cut a slit to stick the cuttings. A 42 x 47 in. section of bench holds approximately 1,050 'Wichita Blue' cuttings.

Comments. We hand-water one to several times per day as required. Benlate at 1 tsp per gal of water is used approximately each 2 weeks. Our polyhouse is like a bag with little ventilation through the winter. The polyhouse is not shaded until spring. Our humidity through the winter is always high. However, at night the area is allowed to dry off considerably. We attempt to provide 68 to 70° F bottom heat as a minimum. We are not concerned with fluctuating diurnal and nocturnal temperatures. In fact, it may be an advantage. On sunny days with clear plastic, our circulator pumps are often off. I call this solar zone heating, a natural high.

As the days get longer and warmer, the apparently dormant cuttings freshen; this is a good sign. Later in early spring when light becomes stronger and temperatures rise, when ventilation and extra watering become a necessity, the cuttings will root. After the cuttings are rooting overall, we give a weekly feeding of 10-52-10 until ready for potting.

We stick the 'Wichita Blue' cuttings first, starting November 20th, and pot them last often in June. Our 1989/90 records show 81% success for 13,000 cuttings stuck in November and 10,590 potted in June.

Our recipe has produced fine crops of rooted 'Wichita Blue' plants that have gone through our system and provided our customers with top quality plants. This procedure works very well for some other upright junipers. Try a 3-sec dip ¼ in. deep for *J. virginiana*, and *J. chinensis*. These evergreens usually root faster than the *J. scopolorum*.

EFFECT OF LIGHT QUALITY ON GROWTH OF *IN VITRO* CULTURED ORGANS AND TISSUES

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It has been widely shown that *in vitro* microenvironmental culture conditions such as light, temperature, and moisture, may alter tissue response. A literature search showed several studies on light intensity and photoperiod but light quality has not attracted much research attention.

Photomorphogenetic effects of certain light spectral bands are mediated by pigments such as phytochrome, blue, and near UV photoreceptors. The physiological processes that underlie *in vitro* photomorphogenetic effect expression may be various but strictly connected to the degree of tissue differentiation. When microcuttings, shoot apexes, and leaves are concerned these processes involve mainly apical dominance physiology, dormancy induction, and/or bud opening and root induction and formation. With undifferentiated tissue such as callus, cells, or protoplasts we may obtain induction and formation of organs such as roots and shoots and somatic embryos.

Because of different protocols and methodologies among *in vitro* systems, the effects observed under various light conditions are often contradictory and difficult to compare. The purpose of this review is to indicate, on the bases of knowledge available today, the most important physiological and technical aspects related to quality of light applied to *in vitro* cultures.

EFFECTS OF LIGHT QUALITY ON DIFFERENTIATED TISSUES

Shoot Proliferation and Shoot Quality. Research has recently shown that light quality can be considered a means for influencing morphogenesis of *in vitro* cultured tissues. Light quality may work by modifying the efficacy of added growth regulators as well as affecting the endogenous hormonal balance of the tissue. Therefore it could perhaps be manipulated to induce a physiological balance favorable for a desired growth response and it may be possible to maintain it as long as wanted.

Among the various growth responses, shoot proliferation is particularly interesting for micropropagation; it is based on cytokinin induced release from apical dominance of axillary buds. That apical dominance might be affected by light conditions has been accepted for many years (8). Two light qualities, red and

blue, are able to stimulate shoot proliferation; their efficacy seems to be related to the presence in the tissue of specific pigments. Various species have been shown to respond to red light and others to blue. Finally, there are plants which give similar responses to the same light quality but probably, as already suggested, it mainly depends on the experimental procedures followed.

Red Light. Red light was the first shown to stimulate shoot proliferation. Phytochrome is the active photoreceptor sensitive to red and far-red light. In its active form it seems to alter the endogenous hormonal balance in favour of reducing apical dominance and increasing lateral shoot development. The earliest work on this subject was done by Tucker (23) who showed that five minutes of far-red light after 16 h of fluorescent light inhibited the opening of axillary buds in *in vivo* tomato plants. The formation of abscisic acid in or near the buds, as a consequence of increased auxin synthesis in the apex and young leaves, was indicated as the cause of reduced buds development.

Similar results were obtained *in vitro* by continuous irradiation with far-red light. Trials were carried out by Baraldi et al. (1) to study the effect of phytochrome on GF 655/2 plum shoot proliferation *in vitro*. The authors did not obtain any increase of proliferation rate (Figure 1) with or without BA in far-red light conditions and the result was similar to that detected in darkness. However, white, red and blue light treatments displayed higher and very similar promoting effects.

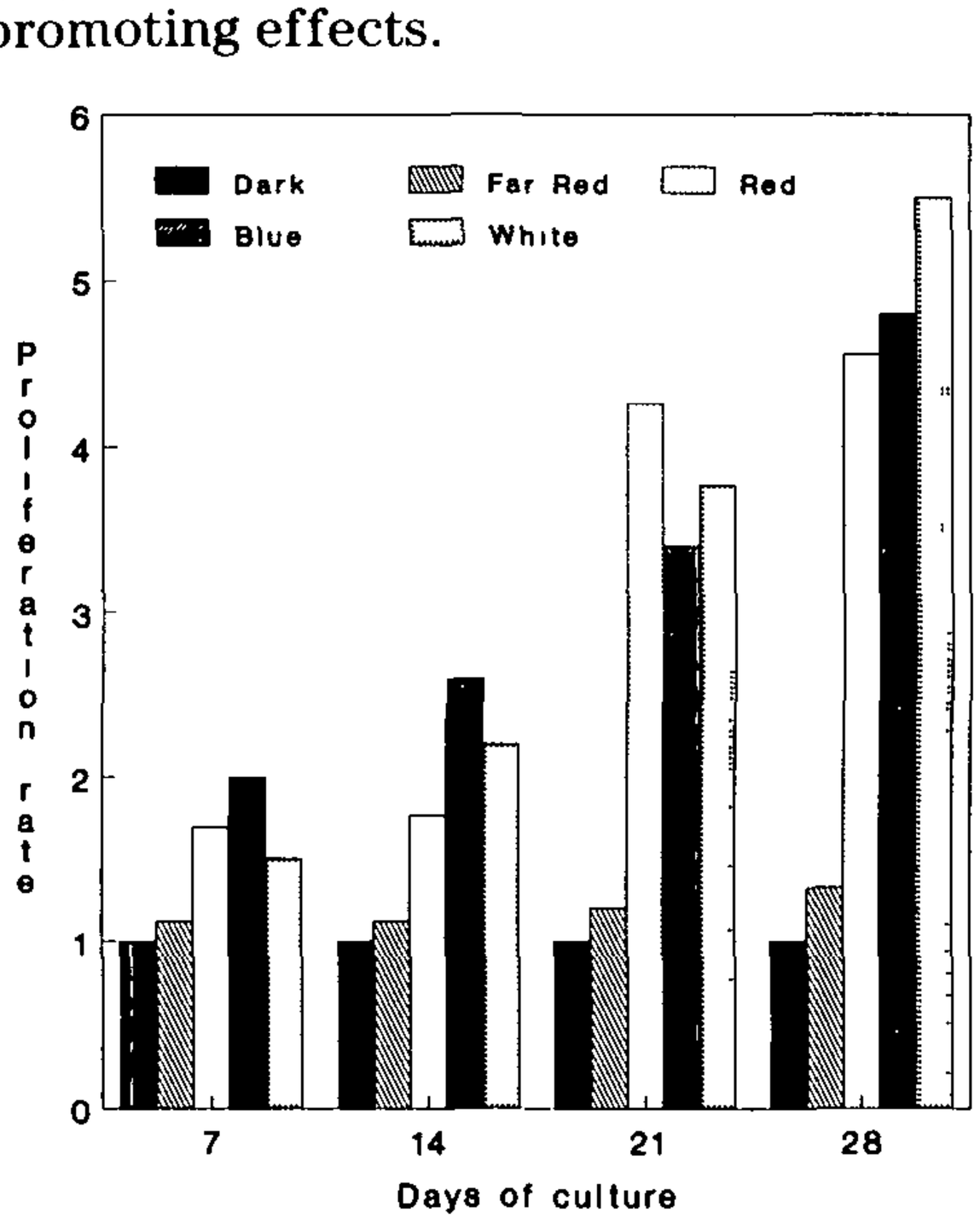

Figure 1. Effect of light quality on proliferation rate of GF 655/2 plum (modified from Baraldi et al 1988)

A similar response was induced on spirea (15) by red light while blue induced a lower proliferation rate than white light (control). The authors (14, 15) observed an interaction between cytokinin and red light. Subculturing over a long period under white light at both high and low cytokinin concentrations caused a reduction in proliferation rate. This negative trend was reversed when red light was applied which also reduced cytokinin requirement.

The interaction between cytokinin and radiation has not yet been definitively demonstrated. Neither blue, red or white light had any enhancing effect on plum rootstock GF 655/2 proliferation in the absence of cytokinin in the culture medium (1); a similar response to that induced by far-red light was seen. With BA in the medium the three above mentioned radiations caused considerable enhancement of proliferation. With red light the new shoots were more numerous and of higher quality compared to those produced under far-red light. However, in other research incorporation of 2iP into the medium eliminated the promotive effect of red light (18).

It is worth noting that phytochrome seemed to react to HIR and LIR in a trial carried out on microcuttings of peach rootstock GF 677; white light induced a higher production of shorter shoots compared to those produced in blue and red light (Table 1). When red light was applied at two levels (15 and 40 μmol m^2 sec^{-1}), the number of shoots produced at the lower one tended to be greater but the performance of the explants did not change (13).

Table 1. Effect of different light qualities on some parameters of GF 677 microcuttings

Light treatment	Proliferation rate	Shoots longer than 1 cm (%)	Internode length (mm)
White (a)	7.1 b	28 0 a	1 54 a
Blue (a)	2 4 a	40 0 b	2 37 b
Red (a)	3 5 a	40 1 b	2 71 b
Red (b)	5 2 ab	43 2 b	2 69 b

(a) = 40 μmol m^{-2} sec^{-1}, (b) = 15 μmol m^{-2} sec^{-1}

Finally, attempts to modify phytochrome activity by 15 min treatments of low-intensity red or far-red light at the end of 16 h of white light had no influence on the proliferation rate of azalea (5) and MrS 2/5 plum rootstock (6). Nevertheless two interruptions of the dark period with red light caused an increase in the dry matter in the latter species (Table 2).

Table 2. Fresh and dry weight of MrS 2/5 shoot cluster as affected by one or two red light interruptions of dark period in a photoperiod of 16 h light and 8 h dark

Light treatment	Fresh weight (g)	Dry matter (%)
16/8	2.4 ns	5 7 a
16/8 (1 red light)	2 1 ns	6.3 ab
16/8 (2 red light)	2.3 ns	7 1 b

Blue light. Not every species responds to red light with proliferation. Chee (2, 3) observed that as well as enhancing shoot size, blue light also increased proliferation rate in grape cultivars by about 50% more than red light. These results led the author to suggest that a blue photoreceptor, not phytochrome, was involved, hence determining a blue light-induced inhibition of apical dominance.

The use of high pressure sodium vapor lamps with *Potentilla* and *Spiraea* (15) raised the proliferation rate and increased shoot length; the effect of these lamps on grape was to diminish proliferation (16). Red light had the same effect on *Spiraea*. Blue light induced shorter shoots when BA concentration in the medium was low (0.25, 0.5 mg/l), whereas at 1 mg/l, shoot length was similar to that of the fluorescent light of the control (16). The opposite response in grape was found by Chee (3) and may depend on a specific response to morphogenetic induction.

The difference between results from sodium and fluorescent lamps may be explained by the differences in their spectra since light from a fluorescent lamp has more blue radiation than that from a sodium lamp which emits more red light. The physiological effect of these wavelengths is confirmed by the fact that blue and far-red radiations inhibit lettuce seedlings and hypocotyl segments lengthening; this effect is reversed by GA_3 treatments and red light (21, 22).

Growth and morphology were dramatically affected by light quality also in potato plantlets; incandescent lamps induced longer stem length but smaller leaf area, number of leaves, and fresh and dry weights, than those recorded with a light quality as determinated by cool white + Agrolite fluorescents and cool white fluorescent + incandescent combinations (19).

Other light qualities. Research in progress in our Department seems to indicate that other light qualities different from red and blue are also able to influence shoot proliferation (12). As shown in Figure 2, yellow light increased the number of shoots more than the other light qualities. In another trial green light caused highest proliferation. It is still to be verified if it was the cause, but spectra

of both light qualities displayed a well developed peak at 550 nm. Shoot quality also was improved by green and yellow light.

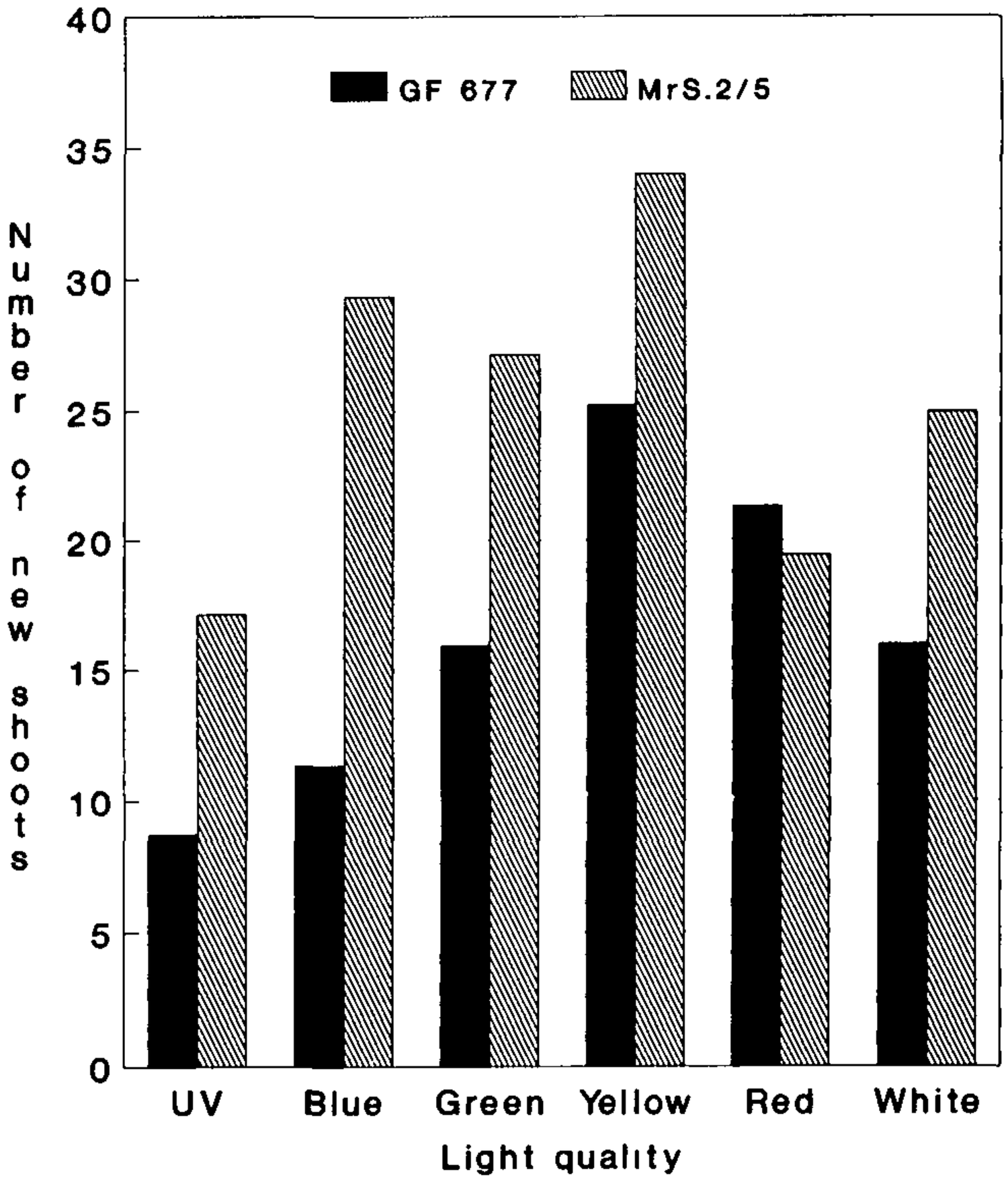

Figure 2. Number of new shoots occurring on primary explants as influenced by different light qualities

Shoot Rooting. Little research information is found on the influence of light quality in *in vitro* rooting. Trials on grape (4) showed higher shoot rooting percentages with red light; moreover this radiation increased the number of roots per shoot and gave a greater total root length per shoot compared to blue light. A similar trend was seen by the same author under cool white lamps instead of daylight lamps. This was perhaps because of the higher proportion of red irradiance in cool white lamps. Red light

stimulation of root development was also observed on undifferentiated callus tissue such as with *Helianthus tuberosus* (10).

The effect of NAA and red radiation on root induction appeared independent for *Prunus* GF 655/2 (1). Under red light the addition of NAA to culture medium had no effect on rooting which was 100%. By contrast, under far-red light without NAA, rooting fell to about 10% but rose to 100% with the addition of auxin to the medium. Under white and blue light and in the dark, rooting was conditioned by the presence or absence of auxin in the medium, which would seem to indicate that phytochrome affects metabolic processes concerning root induction.

Enhancement of rooting by red light in comparison to white and blue was also observed for MrS 2/5 with 55, 37, and 35% rooting, respectively (12).

The effect of light on root elongation *in vitro* was also studied in *Dracaena fragrans*. Root elongation in blue and red light was promoted almost as well as in corresponding white light intensity, while in far-red light root elongation was inhibited as well as in darkness (24).

Light Quality Effect on Callus Growth and Organogenesis. Light in the near-ultraviolet (371 nm) region of the spectrum inhibited callus growth as observed in embryo cultures of *Pseudotsuga menziesii* (9), and in tobacco callus cultures at 16 h/day irradiance above 150 μW cm^{-2}, whereas irradiance of 24 μW cm^{-2} was promotive (20). UV again inhibited growth at irradiance of 40 μmol m^{-2} sec^{-1} in *Actinidia deliciosa* callus cultures (Figure 3), when sucrose, fructose, and glucose were used as energy sources in the medium (13). Similarly, near-ultraviolet light showed a negative effect on shoot initiation in tobacco callus cultures (20).

Growth and shoot formation in tobacco callus were stimulated by treatment of blue light (467 nm) at irradiance from 100 to 500 μW cm^{-2} for 16 h day (20); shoots were also produced when cultures were exposed continuously for 5 weeks to blue light at a high irradiance of 1550 μW cm^{-2} (26).

Compared to green and red light or darkness, continuous blue light (450 nm) for 3 weeks at 1500 μW cm^{-2} increased the fresh weight of the pith callus of *Pelargonium zonale* (25). In carrot callus (17), on the other hand, blue light depressed growth and red and polychromatic light enhanced it as revealed in the higher mitotic division rate of callus cells. Red light applied to callus produced by pine embryos also induced formation of adventitious shoots (7); callus from kiwi fruit leaves (11) gave the best performance in terms of callus growth rate (Fig. 3 above) and shoot organogenesis (Fig. 3 below).

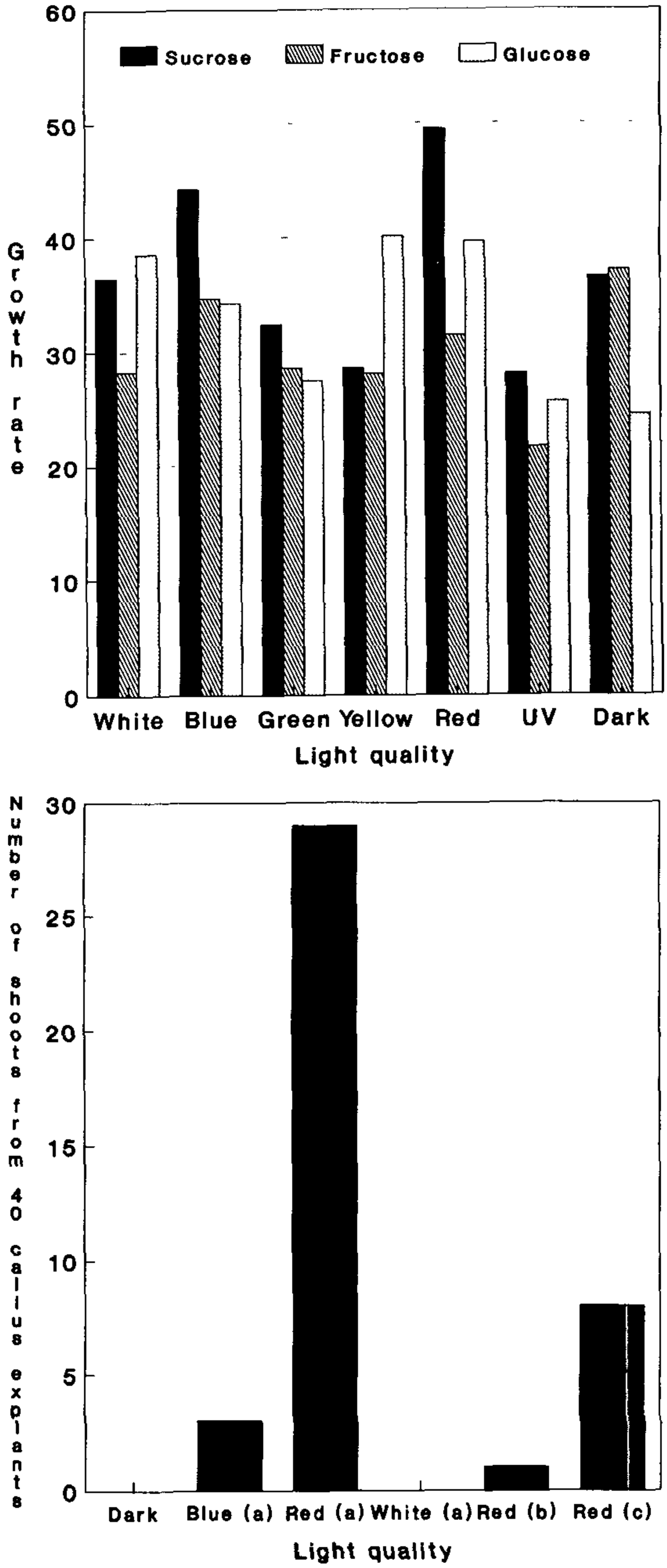

Figure 3. Effect of light quality on growth rate (above) and shoot regeneration (below) in *Actinidia deliciosa* callus. (a) = 40 μmol m^{-2} sec^{-1}; (b) = 15 μmol m^{-2} sec^{-1}; (c) = 5 μmol m^{-2} sec^{-1}.

CONCLUSIONS

Available results so far are not conclusive for practical applications. Variability of response according to species and light quality is a stumbling block on the way to understanding the physiological mechanisms involved in a particular growth performance. It has been shown that no one light quality is effective for all species and all objectives of *in vitro* culture. Much carefully planned research will have to be conducted using standardized experimental methods and characterizing genetic material, which is probably the principal source of non-uniformity in response.

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EASTERN REGION QUESTION BOX

The Question Box Session was convened at 9:50 a.m. December 14, 1990 with Ralph Shugert and Bruce Briggs serving as moderators.

MODERATOR SHUGERT: How do you root *Picea glauca* 'Conica'?

DAVE BAKKER: I presented a paper on that in an earlier meeting. [EDITOR'S NOTE: See volume 33:415-417 for details].

MODERATOR SHUGERT: Has anyone had much success rooting beech cuttings?

BRIAN MAYNARD: We have successfully rooted beech using our etiolation technique. [EDITOR'S NOTE: See volume 36:599-604 for details].

MODERATOR SHUGERT: Propylene glycol, recreational–vehicle water system antifreeze, has been recommended as a carrier for IBA in the previous 2 years' meetings. I found that one brand, "Easy Going RV Antifreeze", is 75% water (even though the list of ingredients doesn't list it). It also has potassium hydrogen phosphate and a pink dye. I am sure that other brands are also full of unwanted materials. Before using RV antifreeze I recommend that it be cleaned up by distillation. The water boils off at a little over 100° C and the propylene glycol boils around 175° C.

BILL BARNES: Yes there are variations and you must follow the above suggestion or find a brand that is suitable at 50%. It should be a 50% propylene glycol mixture, not 40% as some are. IBA will not dissolve in 40% but will in 50%. This product is not labeled so it is a trial and error process.

MODERATOR SHUGERT: Is the Cole Nursery selection of *Ilex verticillata* 'Nana' the same as 'Red Sprite'?

NED RADER: I believe that it is the same plant.

EDITOR'S NOTE: The following response to this question was mailed to me after the meeting by Richard A. Larson. "One of the most comprehensive treatments of *I. verticillata* and cultivars occurred in an article by Dr. Michael Dirr, "To Know Them Is To Love Them" [*American Nurseryman* 8/1/88]. *Ilex verticillata*

'Nana' originated from Hampden Nurseries, Hampden, Massachusetts. True to its name 'Nana' is a compact selection of the species attaining a height and spread of only three to five feet. Beside its low growing habit it produces heavy crops of bright red fruits that are visibly larger than those of the species and most other cultivars. Dirr notes that 'Nana' is also sold under the names 'Red Sprite' and 'Compacta'.

Our observations at The Dawes Arboretum confirm this fact. We currently have 'Nana' and 'Red Sprite' growing next to each other. The groups appear identical in fruit size, color, and growth habit.''

MODERATOR BRIGGS: What is the exact time of year you take your French tarragon cuttings and do you use any rooting hormone?

GEORGE KIMMEL: Use softwood cuttings.

MODERATOR BRIGGS: What is the description of *Viburnum* 'Emerald Triumph' in the Center for the Development of Hardy Plants poster in the Exhibit Room?

VOICE: I believe that it is a *Viburnum lantana* selection.

MODERATOR SHUGERT: Question for Bill Woodrubb. In discussing the own-root *Gleditsia* propagation, what cultivars were used in your work?

[EDITOR'S NOTE: Refer to his paper in this volume.]

MODERATOR SHUGERT: Does anyone know of a good treatment or propagation technique to deter latent alternaria and other stem rots from cropping up in flats of *Dianthus* × *allwoodii* cultivars? Stock appears to be clean, is stuck in straight sand in a fog polyhouse and Banrot-treated. Often cuttings root and die shortly thereafter.

GEORGE KIMMEL: Benlate should control it.

MODERATOR BRIGGS: How long can a plant be listed as patent applied for (PAF)?

ELWIN ORTON: PAF has no legal status but simply tells someone that you have applied for a patent. They can propagate that plant but if your patent comes through they cannot sell the plant and would be held liable for any plants sold.

MODERATOR BRIGGS: Does applying Casaron for weed control inhibit rooting of boxwood cuttings?

RALPH SHUGERT: At Zelenka Nursery we have had no problem.

MODERATOR BRIGGS: What is the safest herbicide to use after transplanting rooted deciduous cuttings from plug trays to sandy loam liner beds? Ronstar and Devrinol give reasonably good control, but I suspect growth suppression. The biggest weed problems are chickweed and common groundsel. Would Treflan or Surflan be better?

RALPH SHUGERT: Rout out of the bag at 1/2X (50 lb/A), water in thoroughly (1/4 in., seal).

MODERATOR SHUGERT: Question for Murray Alward. Your mix is quite open and I doubt subject to much root rot. If 'Wichita Blue' does not get *Phomopsis* tip blight, why do you treat with Benlate so often?

MURRAY ALWARD: Because we are successful and it has always been part of our treatment.

MODERATOR SHUGERT: Question for Carol Glenister. How tolerant are nematodes to low substrate temperatures in overwintering pot liners under tunnels? Do they go into a dormancy situation if they do not have a host also at low temperatures? Should a grower apply nematodes as a prevention?

CAROL GLENISTER: I am in favor of applying as a preventative in the fall. The nematodes will be present in the spring and timing will not be as critical. They can tolerate the low substrate temperatures.

MODERATOR BRIGGS: Question for Carol Glenister. Could taxus bareroot liners be dipped into a nematode solution just before planting and have a lasting preventive action for black vine weevil?

CAROL GLENISTER: The nematodes will last one year in the soil. The liners can be dipped and I think it will be a good idea to try. You will need to prevent the nematodes from drying out as that will kill them. The root will also grow out from the initial treated area.

DAVE BAKKER: What about using a gel as a carrier for the nematodes? [EDITOR'S NOTE: Dave Bakker is planning to test the gel idea].

MODERATOR BRIGGS: What is the most hardy form of variegated sweetgum?

VOICE: I believe that the 'Variegata' cultivar is one of the hardiest forms of the species. We grow it in our arboretum.

MODERATOR SHUGERT: When growing pyracantha in containers, what practices should be followed in order to get a heavy fruit set?

BRUCE BRIGGS: You have to have 2-year old wood to get berries.

PHILIP MOREAU: The secret is to use very large cuttings and run them through because you will only get berries set on 2-year old wood.

NEW PLANT FORUM, JACK ALEXANDER, MODERATOR

PETER VERMEULEN: Rhododendron (azalea) 'Whitestone' was selected and later named by the late Paul Vossberg when Horticultural Research Director for the Westbury Rose Co , Westbury, NY Paul selected it sometime in the 1940s, I believe at a hobbyist garden in Whitestone, Long Island, NY. He frequently extolled its virtues but did not find an opportunity to introduce it Cuttings given to Peter Vermeulen in the late 1970's were propagated and then inadvertently neglected and left growing in flats set in open beds with no cover. They stayed there two winters along with other less important surplus liners In the spring of 1980 I believe 'Whitestone' was the only survivor after a rigorous winter. We decided it worthy of further attention and introduction.

We believe 'Whitestone' to be hardy in Zone 5b and 5a with protection. The plant is a strong grower with a medium to tall bushy habit. Leaves are large, medium green. Flowers are full hose-in-hose pure white with light greenish throat, prominent stamens and about 2 in. in width They are borne profusely in dense clusters completely covering the plant

Propagation is by softwood cuttings. It is available this year in limited quantities primarily to prove its worth over a wide area.

TIM BROTZMAN: *Acer* 'White Tigress' is most likely a hybrid of garden origin, presumedly with *Acer tegmentosum* as one of the parents. 'White Tigress' has reached a height of 25 to 30 ft and 20 ft wide with three primary trunks after 30 years.

The outstanding ornamental quality of this plant is the green bark with white striations that develops on 2nd year wood and lasts for many years. Other outstanding ornamental features include. an annual growth rate of 2 to 4 ft, winter color of new growth a maroon-red; autumn leaf color a rich butter yellow, and winter hardiness is at least -20° F without twig damage. Our 30 year old tree still has pronounced stripes, though reddish-brown colors begin to replace the greens and whites Without the formation of corky bark, this tree is prone to sun scald when used in exposed sites. However, 'White Tigress' has extremely rapid overgrowth of wounds and can heal up as fast as any tree we have grown.

Cuttings taken in late June/early July, wounded on two sides and treated with 0.8% IBA talc root easily in sand. Soft terminals are usually removed

WAYNE MEZITT: *Cornus kousa* 'Ed Mezitt' was selected in the early 1970's by Edmund V. Mezitt from a 5 to 6 year-old seedling block of *C. kousa*. The seedling block resulted from open-pollinated seed of *C. kousa* × *C kousa* var. *chinensis*.

When planted in a sunny location, the new shoots are distinctly purple. The new leaves remain a bronze color until about the time flower bracts open in June. Foliage gradually turns to a normal dark green in June and all summer until changing to orange-red in October Lower sun levels result in less colorful spring foliage

The white flower bracts are well-overlapped and persist for about 3 weeks in June. The flower is about 2½ in. across and flowering is profuse. The red fruit in October is ¾ to 1 in. in diameter

Plant stature is wide and upright, attaining about 20 ft at maturity. Bark exfoliates attractively once the stems grow large enough—3 to 4 in. diameter.

We have grafted on seedlings of *C. kousa* understock and are now rooting with high percentages in mid-July in a fog house. We direct-stick in a sand-perlite mix in Rootrainer 32's. Rooting is similar with treatments of 1, 2, 3, or 4% Hormoroot and Dip'N'Gro 1:10, v/v. We overwinter undisturbed in a 32°F hoop house and plant in open field beds the next spring.

This spring we decided to change the name from 'Terrace' (for its planting location) to 'Ed Mezitt' because it has proven so consistently superior to other cultivars/seedlings we grow. We expect to offer it for sale in 1993. For more information contact Chris Rogers at 508-435-3414 weekdays.

MARK WIDRLECHNER: Russian peashrub, *Caragana frutex*, is worthy of greater use in the Upper Midwest and Great Plains, where Siberian peashrub, *C arborescens*, has performed well Native from southern Russia to Siberia and hardy to Zone 3, Russian peashrub is shorter than the better known Siberian peashrub, growing 6 to 8 ft tall and 10 ft wide.

It has larger flowers and darker green foliage than Siberian peashrub The bright butter-yellow, pea-shaped flowers grow to 1 in long and appear in May and June. They also attract hummingbirds. Each leaf consists of four leaflets, which have a smooth upper surface and measure about 3 to 4-in. long.

According to the late Dr. Donald Hoag of North Dakota State University, Fargo, in his book *Trees and Shrubs for the Northern Plains,* Russian peashrub is also apparently more resistant to insect attack than *C. arborescens.*

This plant's only disadvantage is its strong tendency to sucker, which is a problem when it is used as a specimen However, when used in mass planting with turf maintained to the base of the plants, this suckering tendency is not a serious problem.

Suckers developing within the shrub add to its fullness, those that develop outside the plant's perimeter can be removed during routine mowing. Drastic renewal pruning, which requires cutting back all branches close to the ground, may occasionally be needed for long-established plants and should be performed when plants are dormant.

The shrubs growing on the Iowa State University campus in Ames appear fuller and more showy in flower than other Russian peashrub plants we have seen We are not sure whether this effect is due to genetics or to the site on which the shrubs are growing.

Russian peashrub is easily propagated from seed, which can be scarified mechanically or by using sulfuric acid and then soaking them in water for 24 hours. We have collected seeds from the population on the ISU campus. Seed samples are available from ISU's North Central Plant Introduction Station, Ames, IA 50011 at no charge upon written request.

GARY KOLLER: *Tilia japonica* subsp *insularis* (*T insularis*) There is a need to continually test new species of trees as potential candidates for urban or street tree use One worthy of a review is *T japonica* subsp *insularis* which has attracted attention for the following reasons The tree at the Arnold Arboretum (AA 10859-A) was introduced in 1919 by E.H. Wilson and is the oldest tree of this species in North America It stands 45 ft in height and the first limb arises at six ft above soil level The branches arise with a horizontal spread or slightly uplifted angle from the main trunk and are spaced in such a way that the tree is more thin and open than is typical for a linden This openness allows ample light to reach soil level providing a good

environment for grass which grows directly to the trunk and would allow many herbaceous perennials to compete as plants of the under-story. Unlike most lindens there is no evidence of basal sprouts. This tree is distinctive because of the way it retains delicate beige colored fruiting bracts into early winter and for a light tan-brown colored trunk which is very different than *T. cordata* which tends to be a brownish-black In winter the light bark color and decorative fruit stalks provide the tree with a delightful visual appeal making it stand out among the other lindens with which it grows at the Arnold Arboretum

DAVID R. DUGAN: *Euonymus fortunei* 'Moonshadow' United States plant patent #6127 is a selection of variegated *Euonymus* that has better yellow leaf color and lower growing habit than any other hardy variegated *Euonymus* cultivar available. It was discovered at Dugan Nurseries, Inc in Perry, Ohio 'Moonshadow' was selected from a chance sport found growing on *E fortunei* 'Sunspot'. It was observed that two nodes growing in the middle of a branch on 'Sunspot' showed much more yellow area and far thinner green leaf margins than the parent plant From a single cutting made from these 2 nodes, the original plant of 'Moonshadow' was rooted The original plant of 'Moonshadow' was observed for several years and exhibited genetic stability and did not tend to revert to 'Sunspot'

The leaves of 'Moonshadow' are a lighter yellow than 'Sunspot'. The leaf margins are rimmed with a very thin band of green. The leaf margins are wavy, giving the plant an overall textured effect that is very ornamental. The stem internodes are very short, from ¼ to ½ in. causing the plant to be very short and dense. The stems are the same light yellow as the leaf centers, but are generally hidden by the dense foliage The growth habit of the plant is slightly broader than it is tall. 'Moonshadow' matures at 1 to 2 ft wide and tall Neither flowers nor fruit have been observed on 'Moonshadow' This is a broadleaf evergreen and the leaves from previous years are very persistent.

This plant can be used as an accent or border plant. It maintains good leaf color in full sun to partial shade If planted by a wall, the branches do tend to climb but they do not fasten securely. Plant 'Moonshadow' where its bright color and low growing habit will be an asset to the landscape the year round.

'Moonshadow' has exhibited excellent winter hardiness. It has tolerated temperatures to -20° F in Perry, Ohio. When planted in a windy location the leaves may be stripped away above the snow line in winter but the buds are winter hardy I can safely recommend this plant for all climates in the United States, and those areas in Canada within the old U S.D.A hardiness Zone 4 (or new U S D A hardiness Zone 4-A)

'Moonshadow' is easy to propagate, as are most of the evergreen *Euonymus*. Stick cuttings in a well-drained medium such as perlite. Rooting hormone is not required, but Hormodin #2 may enhance the results Rooting of greater than 90% is typical. Cuttings may be taken any time the plant is not covered with soft new growth Avoid the period between April 1 and June 1 In summer, root the cuttings outdoors under intermittent mist with 30% shade. Remove them from the prop house as soon as roots are formed to avoid fungus problems. In winter, root the cuttings at 70° F Water sparingly to keep the medium moist to avoid fungus problems.

Euonymus fortunei 'Thunderbolt', United States plant patent #6128 is a selection of variegated *Euonymus* that exhibits more vigor and better flower and fruit character than any other hardy variegated *Euonymus* available It was discovered at Dugan Nurseries, Inc. in Perry, Ohio. 'Thunderbolt' was found as an entire plant growing among a block of 2 year old *Euonymus fortunei* 'Sunspot'. The plants were growing their second summer in a 2 gallon container The 'Thunderbolt' plant was more than twice the size of the surrounding 'Sunspot' plants. The 'Thunderbolt' plant was heavily covered with flowers while none of the surrounding 'Sunspot' plants had any flowers. In fact, flowers are rarely found on 'Sunspot' until the plants are 6 to 7 years of age, and then, only a few flowers can be found on a plant. The original plant of 'Thunderbolt' was observed for several years and exhibited genetic stability and did not tend to revert to 'Sunspot'.

'Thunderbolt' has a smaller area of yellow variegation in the center of each leaf, and the leaves were 2 to 3 times larger than 'Sunspot' leaves The leaves are 2 to 2½ inches long and appear to be mostly green with a ragged ''bolt'' of yellow along the center vein The texture is very thick and glossy The stems are very thick and are yellow striped with green The internodes are from 2 to 4 in long giving the plant an open texture which shows off the variegated stems nicely The growth is slightly broader than it is tall. 'Thunderbolt' matures at 3 to 6 ft wide and tall This is a broadleaf evergreen and the leaves from previous years are very persistent.

The flowers of 'Thunderbolt' are effective from May 15 to June 15 in Ohio's climate. The compound flowers are born profusely all over the plant and are light yellow-green in color. The fruits ripen to bright orange in September and are ornamental through December in Ohio's climate The contrast in color between the dark green leaves and the bright orange fruit is especially striking.

'Thunderbolt' can be used as an evergreen hedge, a windbreak, a screen, or may be planted as a specimen where there is a large area where its flower and fruit character may be enjoyed. If planted by a wall, the branches do tend to climb but they do not fasten securely Plant 'Thunderbolt' wherever you need a colorful, vigorous, broadleaf evergreen.

'Thunderbolt' has exhibited excellent winter hardiness. It has tolerated temperatures to -20° F in Perry, Ohio When planted in a windy location the leaves may be stripped away above the snow line in winter but the buds are winter hardy I can safely recommend this plant for all climates in the United States, and those areas in Canada within the old U S.D.A hardiness Zone 4 (or new U.S D.A. hardiness Zone 4-A).

'Thunderbolt' does not root as easily as most evergreen Euonymus. Stick cuttings in a well-drained medium such as perlite Rooting hormone such as Hormodin #2 is recommended. Rooting of 50% to 70% is typical. Cuttings may be taken any time the plant is not covered with soft new growth. Avoid the period between April 1 and June 1 In summer, root the cuttings outdoors under intermittent mist with 30% shade. Remove them from the prop house as soon as roots are formed to avoid fungus problems In winter, root the cuttings at 70° F. Water sparingly to keep the medium moist to avoid fungus problems.

ALAN JONES: *Amelanchier laevis* 'Majestic' Plant Patent 7203. The Allegheny shadblow is the best of all the Amelanchier species for landscape and street tree use. The large, clean foliage resists foliage diseases and the fall color is excellent. Majestic Shadblow was selected from a large nursery population of Amelanchier laevis seedlings for its many superior qualities.

It bears trusses of very large, wide petaled flowers creating a cloud of pure white flowers in early April. The large, leathery foliage is red when it opens and then expands to become dark green at maturity. It is not affected by the leaf spot diseases which cause other species to defoliate in humid summers. The leaves turn a rich scarlet color in the fall.

Majestic is an exceptionally vigorous grower reaching 20 to 25 ft and young trees develop twice the height of ordinary trees in the same period of growth Its strong, vigorous growth make it exceptionally good for street tree use where growing space is limited. Grown in clump form, it makes a showy flowering tree beautiful both in the spring and in the fall.

With the disease problems affecting our native flowering dogwood in many areas, shadblows are rapidly increasing in popularity. No seedling strain can match the vigor and beauty of the Majestic Shadblow. It is hardy to Zone 4.

Malus hupehensis 'Cardinal' Plant Patent #7174. This hybrid crab apple is one of the few red flowering crab apples which is truly resistant to apple scab fungus and mildew that defoliate other red crabs growing in humid areas It is a cross between 'Strawberry Parfait' crab apple and 'Crimson Cloud' It forms a broad headed small tree 15 ft tall. It is covered with bright red flowers in late April. The foliage is red and remains unblemished on the tree throughout the summer.

The tree is flat topped at maturity like *M. hupehensis* and the foliage is glossy and attractive It bears small deep red fruits in the fall. Red crab apples are among the most beautiful of all the spring flowering trees but their landscape use is limited by summer foliage problems.

DALE E. HERMAN: Green ash (*Fraxinus pennsylvanica*) is a very winter-hardy tree species (USDA Plant Hardiness Zone 2b), which is native from south-eastern Canada into Florida and from east-central Texas into eastern Saskatchewan, Canada. This species is adaptive to soils varying in texture, structure, degree of compaction, moisture availability and pH. Green ash also tolerates wind exposure and is less susceptible to 2,4-D herbicide injury than such winter-hardy species as *Acer ginnala* (Amur maple), *A. negundo* (boxelder) and *Ulmus pumila* (Siberian elm).

Over fifty green ash collections were made in the Northern Plains in 1972-73. Plants were collected with the goal of introducing male, seedless clones with superior growth habit, foliage quality, growth rate and adaptation to the stressful climate of the Northern Plains. Each accession was propagated by whip grafting, field-planted in 1974 and data collected for ten years (1975-85) The trees were established under clean cultivation, grown in red fescue sod for the ten year data collection period and received no supplemental water or fertilization. Three final selections with markedly different growth habits and other superior landscape qualities were made in 1986. These were named and the Department of Horticulture and Forestry in collaboration with the NDSU-Research Foundation have made application for trademarking

Although evaluations did not involve direct research on pest susceptibility, the three introductions have been essentially free of pests to date All three male, seedless cultivars are readily propagated asexually by T-budding, whip or bark grafting They are available from several northern nurseries Average annual growth rate comparisons in the ten year study include. control green ash seedling trees (1.6 ft), Marshall's Seedless ash (1 4 ft), and average mean growth rate of the 73 ash accessions in the study (1 63 ft).

Fraxinus pennsylvanica 'Wahpeton', Dakota Centennial™ Ash, is a male, seedless fast-growing green ash cultivar with a growth rate of 2 4 ft annually over a ten year period. This cultivar produces an elliptical-pyramidal shaped tree, widening with age It tends to maintain terminal dominance with uniform scaffold branch arrangement. Bright, glossy green foliage becomes dark green and semi-glossy as it hardens Fall color is a deep yellow USDA hardiness Zone 3

Fraxinus pennsylvanica 'Rugby', Prairie Spire™ Ash, is a male, seedless green ash cultivar with an intermediate growth rate of 1.8 ft annually over a ten year period It is characterized by a striking, narrowly erect growth habit with terminal dominance and dense lateral branches, becoming narrowly pyramidal-elliptical with age. Bright, glossy green foliage becomes dark green and semi-glossy as it hardens, changing to an intense golden-yellow in autumn USDA hardiness Zone 3

Fraxinus pennsylvanica 'Leeds', Prairie Dome™ Ash, is a male, seedless green ash cultivar with a moderate growth rate of 1 4 ft annually over a ten year period. It is characterized by a very dense, distinctly oval form gradually becoming globose with age. Terminal dominance is not as strong as for the cultivars described above Thick, leathery, glossy green foliage becomes dark green and semi-glossy as it hardens. Leaves are retained six to nine days later in autumn than the above cultivars and become a deep yellow. USDA hardiness Zone 3.

Ussurian pear *(Pyrus ussuriensis)* (sometimes listed as Chinese pear) is native to northeast Asia and is the hardiest pear species. Sources of this species were grown in North America by N.E. Hansen (South Dakota) and F L. Skinner (Manitoba) in the early 1900s Over the years, hardy seed sources, particularly from the vicinity of Harbin, Manchuria, have been distributed in the northern United States and Canada, often referred to as Harbin pear In 1990, the USDA-SCS Plant Materials Center, Bismarck, North Dakota, released a hardy cultivar seed strain under the name 'McDermand', particularly for use in shelterbelt, wildlife and recreation plantings. However, no clonal introductions have been made for use in landscape settings Ussurian pear and Callery pear (*Pyrus calleryana* Decne) are reported to be the least susceptible species to fireblight.

It is important to note that Callery pear, as represented by numerous superior landscape cultivars, is very popular in the commercial landscape trade However, it is not winter hardy beyond USDA hardiness Zone 5. A hardy substitute pear for landscape use in the Northern Plains and Canada is needed and this accounts for the introduction of the attractive seedling selection of Ussurian pear described below The Department of Horticulture and Forestry in collaboration with the NDSU-Research Foundation have made application for trademarking

Pyrus ussuriensis 'MorDak' Prairie Gem™ pear, is a superior selection for landscape planting. Characteristics and qualities include a growth rate of 1 3 ft annually over a 16 year period (1973-89), densely and evenly branched; distinctly oval growth habit becoming globose with age, and clean, bright green, semi-glossy orbicular-ovate to ovate leaves The thick, leathery-textured leaves display excellent foliage quality throughout the growing season The superior quality of the scion cultivar is very noticeable when shoots arise below the graft from seedling Ussurian pear rootstocks The cultivar displays good resistance to fireblight, but it is undoubtedly not immune White flowers blanket the tree in spring Trees do not fruit unless a pollinator pear is nearby. This is advantageous, since the 1.3 in rounded yellow fruits are not of culinary value Readily propagated asexually by T-budding, whip or bark grafting USDA hardiness Zone 3 A limited number of plants will be available from a northern nursery in spring, 1991.

GALEN D. GATES: *Spiraea fritschiana,* although first introduced into cultivation in 1919, is a relatively unknown plant A native to central China and Korea, it develops into a full-bodied mound reaching a height of 3 to 4 ft It sports large white corymbs up to 5 in across and blooms in June when other small-statured, pink-flowered spireas are flowering

The fall color is excellent Being tolerant of shade, Fritsch spirea exhibits a bright yellow autumn color with only 4 to 5 hours of direct sunlight In full sun it becomes more orange-red Most fall color on *Spiraea* in the Midwest comes from the *S.* × *bumalda* group which is a dark red and not as showy Bright colored foliage has greater eye appeal and is more dramatic in the landscape

This plant is also tolerant of a wide range of soil types. It performs well in both well-drained and heavier soils. It thrives in our climate where temperatures regularly dip to -20° F and where snow cover is fleeting due to our strong winds and fluctuating temperatures. In fact this plant has survived -30° F with negligible damage It performs equally well in landscapes receiving high maintenance and areas of little or no care. The plant propagates easily from fresh seed or softwood cuttings treated with IBA in talc at 4,000 ppm

Allium thunbergii 'Ozawa', Ozawa onion, is a unique flowering bulb Unlike other bulbs which have foliage that turns brown shortly after flowering, this little gem sports its blemish-free foliage from March to October. It is one of the earliest perennials to emerge, keeping pace with *Narcissus,* and is relentless in hanging on to its foliage into the fall.

In addition to a high-quality, season-long leaf display, 'Ozawa' continues to flower into winter The globe-shaped purple flowers start blooming in September, brush off early frosts and maintain their color into January The scapes (or flower stalks) also take on a translucent orange glow starting in November. All these qualities in addition to its strong structural winter presence makes this truly a year round perennial

The plant is easily used to perk up a drowsy perennial bed in early spring and to extend its life at the end of the season It grows 12 to 15 in. tall, which is shorter than the species' 2-ft height The bulbs are best planted in spring at a depth of 3 in. Being an "onion" there is little that will bother it—from rodents to disease.

The species *A. thunbergii* is native to northeast Asia with 'Ozawa' originating in Japan. For a short period of time, this plant was incorrectly labeled 'Ozoke' but that seems to have been cleared up.

The plant multiplies very rapidly through bulblet production which makes it an excellent candidate for commercial use It is also diploid, so seed is a possibility for perpetuation of a similar plant, but this requires a mild fall and winter with the presence of a pollinator in order to develop viable seed.

Allium thunbergii 'Ozawa' is a remarkable plant which has numerous favorable traits and as yet no undesirable qualities that I have noticed

BRUCE BRIGGS: *Rhododendron* 'Scarlet Romance' is an outstanding new F_1 hybrid from Dr G Mehlquist. The parentage is 'Vulcan' × 'Chocolate Soldier'. Original testing of the plant was by Jim Wells (NJ) and by Jeremy Wells (NC).

The plant is flower-bud hardy to at least -25° F. 'Scarlet Romance' flowers in the first week of June, with 6½ in round trusses of 15 to 16 light red florets Medium green leaves are 4 to 6 in long. The plant is a dense grower and reaches a mature size of 4 ft tall by 7 ft wide.

The plant is being jointly introduced by J Wells Nursery (NC) and Briggs Nursery (WA).

SIDNEY WAXMAN: *Tsuga canadensis* 'Wind's Way' originated as a witches'-broom seedling. This selection, now 19 years old, grows at a more rapid rate than most of the more dwarfer forms I have named It is 13 ft tall, and 11 ft wide and has an annual growth rate of 6 in.

It is densely foliated and has horizontally arranged branches that start from the ground up. Its branch tips curve slightly down 'Wind's Way' is dark green and oval-shaped, requiring no shearing.

It was named 'Wind's Way' because of its swaying movement on windy days.

This selection would serve well as an accent plant or with a group as a highly effective screen.

Tsuga canadensis 'Cotton Candy' originated as a witches'-broom seedling whose growth rate is approximately seven inches annually. Its form could be described as a truncated pyramid lacking the upper point It is symmetrical and very densely foliated by layered branches that radiate uniformly outward. The slightly pendulous twigs have, in addition to its paired leaves, a third row of tiny leaves pointing forward along the top of each shoot The leaves, which are twisted, show their whitish undersides giving the appearance of whitish lines on each twig

'Cotton Candy' is a rugged plant with thick branching. Because it is widest at its base, its lower branches are not likely to die because of shading by the upper branches.

Pinus densiflora 'Low Glow' is a witches'-broom seedling with an annual growth rate of approximately five inches It is a low mound with short needles (1¾ in long) After five years it has grown 19 in high and 45 in wide

Whorls of needles at the tips of each shoot are distinct and with its bright yellow-green foliage 'Low Glow' offers a bright contrast when planted with other conifers.

Pinus strobus 'Old Softie' is a witches'-broom seedling that can, perhaps, best be described as looking like a miniature 'Sargent's' weeping hemlock This white pine grows four to six inches annually and, at the age of 27 years, is four feet high and seven and one half feet wide It has a soft green texture and is densely foliated and cloudlike with billowy branching

Pinus resinosa 'Ragamuffin' is a low, broad ground-hugging bundle of long needles It has an annual growth rate of five and one half inches and has grown to a height of two feet and a width of five feet in eight years Its foliage is bright green and along with its shaggy form offers an excellent contrast alongside other conifers This selection was also obtained from a witches'-broom. Giving plants a good descriptive name can be quite difficult, but with this selection, I had no problems

ELWIN ORTON: The six cultivars I wish to present are F_1 interspecific hybrids of *Cornus kousa* × *C florida* They are being propagated for introduction to

commerce as Rutgers University's answer to "dogwood decline." The first five listed have been patented and the sixth has "patent applied for" status. Plants of these six hybrids are very floriferous, with a floral display period intermediate to that of plants of the parental species, all are exceptionally vigorous and are reliably winter-hardy in U S D.A Plant Hardiness Zone 6A (-10 to 0° F); are highly resistant to infestation by the common dogwood borer, and exhibit moderate to very high field resistance to *Discula*, the incitant of dogwood anthracnose These six hybrids constitute our Stellar™ series of large-bracted dogwood. Five of the six hybrids bear white floral bracts, and one produces pink bracts. The first four listed below are more nearly similar to plants of *C. kousa*, being upright in habit. However, they do not exhibit the marked vase-shape typical of many plants of *C. kousa* when young, as the hybrids are fully branched and uniformly wide close to the ground The last two hybrids listed below are more nearly like plants of *C. florida*, as they are low and spreading in habit and flower earlier in May than do the other four hybrids Trees of all six hybrids exhibit flat leaves of a rich, dark green color.

Cornus 'Rutban' Aurora™ A highly vigorous, upright form with large, rounded, velvety, overlapping floral bracts Floral display commences mid-May in New Jersey.

Cornus 'Rutgan' Stellar Pink™. A highly vigorous, upright form with flower heads exhibiting rounded, overlapping bracts of moderate size and a beautiful, light pink, coloration.

Cornus 'Rutdan' Galaxy™ A highly vigorous tree of upright habit that bears flower heads with beautiful rounded, overlapping bracts of heavy texture At the start of the floral display, the bracts form a cup with a slight tinge of green, but the bracts soon become flattened and pure white.

Cornus 'Rutcan' Constellation™ A highly vigorous upright form with the earliest period of floral display of the upright hybrids. The bracts are long and separate, and provide a brilliant, white display even when observed from a considerable distance.

Cornus 'Rutfan' Stardust™. A small, low and spreading form that is heavily branched and foliaged right to the ground The showy, white, floral bracts are rounded and non-overlapping.

Cornus 'Rutlan' Ruth Ellen™ A vigorous, low and spreading tree that is considerably larger than those of Stardust™. The floral display of this cultivar commences about the time the floral display of most plants of *C. florida* ceases, and one day ahead of Stardust™, two days ahead of Constellation™, and five to seven days ahead of Aurora™, Galaxy™, and Stellar Pink™ The floral bracts of Ruth Ellen™ provide a brilliant white display even when viewed from a distance.