Propagation Media and Rooting Cuttings of *Eucalyptis grandis*

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Cuttings of *Eucalyptus grandis* placed in four different propagation media, sand, peat, perlite or a mixture of sand, peat, perlite (l:l:l v/v/v), showed best rooting in the mixture. Examination of the physical characteristics of the four media suggested that relatively high moisture content may be more important that high air content for maximum root formation. Sterilizing the propagation medium did not improve rooting percentage but did increase the number of roots.

INTRODUCTION

Rooting of cuttings is influenced by the type of propagation medium used. The physical structure of the materials can affect the micro environment around the base of the cutting, particularly in respect to air and moisture content; both factors are known to influence root formation on cuttings (Hartmann and Kester, 1975; Loach, 1988).

Cuttings of *Eucalyptus* species are reported as having been successfully rooted in a range of media, including peat, sand, vermiculite, rockwool, loam and mixtures of some of these (Chaperon, 1983; Cunningham and Geary, 1989; Geary and Lutz, 1985, Reuveni, et al., 1990; White, 1986). The reasons for using these media have not been given and the physical characteristics that contribute to their success or failure as propagation media have not been described or discussed.

Nursery hygiene, also, is important for successful production of large numbers of rooted cuttings New cuttings are susceptible to stem infection and their treatment with fungicides is a recommended part of nursery practice However, there does not appear to have been any published evaluation of the need to sterilize propagation media to reduce pathogen activity.

In the experiments reported in this paper, cuttings of *Eucalyptus grandis* Hill ex Maid were rooted in four different media with different air and moisture contents. The rooting response was evaluated in relation to physical characteristics of the media. The effects of media sterilization on rooting of *E. grandis* cuttings was also examined. All work was done using the glasshouses and facilities at the Plant Culture Facility, Australian National University, Canberra.

MATERIALS AND METHODS

The cuttings were from container-grown *E. grandis* stock plants of a single clone. The stock plants were greenhouse grown at 15°C night, 25°C day under natural photoperiod and irradiance, and pruned to maintain a single stem to 50 cm high with many lateral shoots.

To study the effects of medium composition on rooting, four different media were used. coarse river sand, European peat, perlite, and a mixture of peat, perlite and sand (1:1:1 v/v/v). Each was measured for volumetric air content and total moisture content using techniques described by Handreck and Black (1989).

Trials commenced in February 1990. Cuttings were prepared from the basal sections of 10 week old shoots. Each shoot had four leaf pairs. The two basal pairs were removed and the upper leaves cut in half. The base of the cutting was at a point immediately below a node and the basal two centimetres of the cutting were treated with liquid 8000 ppm IBA (10 second dip) The IBA solution was allowed to evaporate before the cuttings were inserted into the propagation media Pots containing the cuttings were placed in a propagation unit with basal heating (20°C), humidity control (85%) and air temperature control (20°C night, 30°C day).

Eight weeks after sticking, the percentage rooting, number of primary roots per rooted cutting, and dry weight of the root mass per cutting were determined.

In the medium sterilization study, cuttings were set in sterilized and non-sterilized mixtures of peat, perlite, and sand (1:1:1 v/v/v). The sterilized mixture had been autoclaved (120°C for 30 min at 95 kPa). The cuttings were prepared in the manner previously described. Seven weeks after sticking cuttings were assessed as described above.

RESULTS

Rooting of cuttings was influenced by the medium used, and the best rooting (83%) was observed in the peat, perlite and sand mixture (Table 1). Cuttings in peat rooted better than those in perlite or sand.

Root number and root-mass dry weight per rooted cutting also varied with medium Cuttings in the peat, perlite, and sand mixture clearly had more roots and a larger root-mass dry weight than cuttings in the perlite or the sand but the differences from peat were less pronounced (Table 1). Root mass per rooted cutting in the mixture or the peat was about twice that for cuttings in perlite or sand.

Table 1. Rooting response of *Eucalyptus grandis* cuttings in four media with different air porosity and moisture contents

Media	Rooting[1] (%)	Primary root number per rooted cutting	Root mass per rooted cutting (mg)	Volumetric air porosity (%)	Moisture content (%)
Peat Perlite Sand	83	2 3 a[2]	44 a	11	55
Peat	40	1 9 ab	42 ab	20	60
Perlite	25	1 4 bc	22 bc	39	42
Sand	20	0 4 d	19 c	8	25

[1] 40 cuttings per treatment

[2] Within a column numbers followed by different letters are significantly different at the 5% probability level

The successful peat, perlite, and sand mixture had a moisture content of 55%, relatively high compared to that of the least successful sand, which had a moisture content of 25% (Table 1). However, the air-filled porosity of these two media was similar (11 and 8% respectively) and much lower than that of the peat and perlite (20 and 29% respectively) These results suggest that water content may be more important than air content as an influence on rooting of *E. grandis* cuttings In contrast there seemed to be no relationship between air porosity and rooting percent. The air porosities of the peat, perlite, sand mixture and the sand were similar yet cuttings in the mixture rooted approximately four times better than cuttings in the sand (Table 1)

Sterilizing the propagation medium did not change rooting percentage but did increase the number of roots produced. The cuttings in the sterilized medium had

Table 2. Rooting response of *Eucalyptus grandis* cuttings to sterilized and non-sterilized propagation media (peat, perlite, sand 1 1·1 v/v/v)

Treatment	Number of cuttings	Rooting (%)	Primary roots per rooted cutting	Root mass (d w t) per rooted cutting (mg)
Sterilized	40	95	4 9 a[1]	9 a
Non-Sterilized	40	95	1 9 b	12 a

[1] Within a column, numbers followed by a different letter are significantly different at the 5% probability level

an average of 4 9 primary roots, compared to 1 9 on cuttings in the non-sterilized medium (Table 2). Roots in the sterilized medium, although more numerous, were smaller than the roots in the non-sterilized medium

DISCUSSION

Rooting percentage and root growth of *E. grandis* cuttings varied with the type of propagation medium used. This indicates the need to carefully evaluate media for their suitability for striking cuttings of eucalypts Our studies have shown a mixture of peat, perlite and sand to be superior to any of these materials used alone. Possibly other media with physical characteristics similar to the mixture of peat, perlite and sand would be suitable and they could be made using other materials such as bark, sawdust, rice hulls or vermiculite, provided the final product has a suitable water content

Our results have indicated that for eucalypt cuttings the propagation medium should have a water content of at least 50 percent. However, as Loach (1985) suggests, it may not be possible to quantify exactly what moisture content is ideal as this may vary according to the type of propagation facility used (mist or fog) or the season in which the cuttings are rooted (winter or summer).

The relationship between successful rooting and water content of the medium is consistent with the contention of Grange and Loach (1983) that for optimal rooting, stem tissue must not loose water. Water is lost from stem tissue by transpiration through leaves and can be replaced by uptake through the stem base, so long as water is present and freely available in the medium around the base of the stem (Leakey, 1985).

Our trials comparing sterilized and non-sterilized media suggested that microbes antagonistic to root formation or development were present in the non-sterilized medium. Microbial activity in the non-sterilized medium may have acted to break down the applied IBA before it could act on responsive stem tissue or the microbes may have infected and inhibited growth of emerging root primordia. Whatever the explanation, the result of media sterilization was a very fibrous root system highly suited to production of eucalypts in small containers. If one or two dominant roots grow in a spiral fashion around the walls of the container, field establishment problems of eucalypt seedlings can result. This problem can be minimized if the plant has a fibrous root system and our results have shown such a root system can be produced on eucalypt cuttings propagated in sterilized media.

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Aboriginal Food Plants, Their Propagation and Interest for Today's Nursery Trade

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It is my contention that we present day Australians are now beginning to place prehistoric Aboriginal culture in a unique and special place associated with the heritage values of this continent. I believe that the time is right for the nursery trade and therefore plant propagators to accept that there is public interest in those plants which were used by Aboriginal people. The developing interest in those plants used by the first Australians for perhaps longer than 50 thousand years can only grow as more knowledge, understanding and appreciation of Aboriginal culture increases

Aboriginal people through experiment and expediency developed an extraordinary knowledge of the indigenous flora Besides the obvious use for food, plants were also needed for medicine, ceremony, art, weapons, poisons, snares, daily utensils, shelter, and transport.

It has been shown that Aboriginal technologies for obtaining food varied across regions of the continent. However, as food procurement strategists, the Aboriginal people developed methods comparable in complexity to those of several other indigenous groups (Satterwait, 1980). This argument negates therefore the previously held tenet of a people with relatively simple technologies.

I believe that there is a need to help promote plants for their essential Aboriginal association and this should be done with sensitivity for the Aboriginal culture and care for accuracy in the presentation. It is necessary to translate this interest within contemporary Australian society for things 'Aboriginal' and, as a corollary, for the nursery industry to accept this interest as a challenge and one of the future directions for the plant buying public.

It is my observation that people who participate in 'Aboriginal trail walks', such as the one in place at the Australian National Botanic Gardens, Canberra, develop feelings towards the plants displayed that add a new dimension of importance to the plants themselves. This is an aesthetic dimension for the participant that relates to the plant's history and interaction with humankind. The past associations and importance for the Aboriginal people are transferred to a significance for today's observer.

In the context of a plant propagators' conference, and the industry which it serves, I wish to project these relatively unpromoted plants for their special place in human history. The plants chosen to illustrate the discussion are a few of many examples from temperate Australia.

Interest in the natural environment, and the conservation issues that such interest generates, is not a passing phenomenon Indications are that this awareness and concern for the environment will redirect our priorities and lifestyles in the future. I do emphasize the importance of an historical perspective in decision making relating to contemporary issues.

We have, by and large, lost our ability to 'capture' most of our food needs today. In our home gardens a narrow range of food plants in no way emulates the gathering of the variety of bush foods available to Aboriginal hunter/gatherers in the past.

It is not my intention to detail all the properties or qualities sought from plants by Aboriginal people Suffice to say that for those species chosen to provide food, the plant parts were mainly fruits, seed, nectar, roots, and leaves, as well as pith and gum. Such information is derived from studies of the ethnographic record and field research; valuable literature on the ethnobotany of southeastern Australia has been contributed by: J. Backhouse, S. Bowdler, Smyth R. Brough, J.B. Cleland, P.J.F. Coutts, J. Flood, E.D Gill, B. Gott, B. Hiatt, G S. Hope, R Jones, R. Lampert, J H. Maiden, I McBryde, D.J. Mulvaney, and N. Peterson. This literature is readily available in Australian libraries.

In line with the aims of this conference, propagation information is provided where available. The indigenous plants chosen to illustrate this theme are, I believe, relatively unknown to the nursery industry and have ornamental potential. The latter evaluation, however, I must admit is a subjective one.

If the examples chosen are already recognised as familiar native plants of the catalogue, do not be put off. If sought, there are hundreds of equally valuable Aboriginal plants needing promotion, many of which have great potential for garden use. Some are highly ornamental, but also endangered because of the small size of naturally occuring populations

I do not seek or expect a revolution, or even significant early changes in the direction of Australian gardening. I am sure that there will be no loss of interest in the petunia, the camellia or the rose in the forseeable future, nor am I advocating that this should be so.

It is likely, however, that the concerns for, and understanding of, Australia's remaining 'natural' environment will grow for many people over time. This in turn should promote a wider interest in the plants known to have been useful for Australia's Aboriginal people, and allow a few to find a niche in gardens. Their owners will justifiably feel proud of their heritage values relating to the prehistory of this continent.

Pittosporum phillyraeoides DC , native apricot
Family. Pittosporaceae
Aboriginal use: gum, fruit, medicinal.

A shrub or tree to 17 metres (but usually less) with drooping branches. The small yellow to white five-petalled flowers are scented and occur from July to November. The decorative orange fruit, 10 to 12 mm long, is ovoid and opens to reveal sticky red seeds (Costermans, 1981). The species occurs in all Australian mainland states, generally in relatively dry habitats.

Propagation is by cuttings or seed. No pretreatment is necessary for seed, which germinates in 17 to 24 days when sown in summer. Rooting success may exceed 45% for cuttings treated with 500 ppm IBA and 500 ppm NAA.

Solanum simile F. Muell., oondoroo
Family: Solanaceae
Aboriginal use: fruit.

There are about 1400 *Solanum* species worldwide, chiefly in tropical and subtropical zones. Australia has 87 endemic species and a further 23 have become naturalised. They occur in all but saline, alpine or aquatic habitats and several species contain steroidal alkaloids which may be considered toxic (*Flora of Australia*, 1982).

Solanum simile is one of 24 *Solanum* species listed by Peterson (1979) for their use by Aboriginal people It is an erect shrub to 2.0 m and grows in sandy, sometimes alkaline soils, often in association with mallee *Eucalyptus* woodlands. Typically, the flower has a violet corolla which is shortly lobed. The globular purplish fruit is 15 mm in diameter.

Propagation is by seed or cuttings, the latter usually taking from 18 to 30 days to root, with 75 to 100% success when using 500 ppm IBA and 500 ppm NAA. Seed in one sowing took 90 days to germinate; several other native *Solanum* species germinate in from 6 to 30 days.

Gahnia melanocarpa R Br , black-fruit saw-sedge
Family: Cyperaceae
Aboriginal use· leaves, shoots, flowers, seeds.

This clumping perennial herb to 2.5 m high by 1 to 2 m wide but usually less, is one of 23 Australian endemic *Gahnia* species These bold plants have narrow, channelled leaves to 1.5 m long. The flowers are cream and the characteristically hard fruit is brown-black *Gahnia melanocarpa* occurs in rainforests of Queensland, New South Wales and Victoria and is typically associated with swamp conditions

Propagation is by seed or division, the latter however being difficult if the reduced sections are too small. If divisions do die back, suckering may follow and lead to recovery. Seed may require pretreatment or take up to 19 months before germination occurs. Other species, notably *G sieberiana*, may germinate in 40 days.

Eustrephus latifolius R. Br., wombat berry
Family: Smilacaceae (Philesiaceae)
Aboriginal use. roots.

A slender, scrambling and twining shrub with leaves having fine longitudinal veins. The flowers are pink with fringed petals. The handsome fruit, 8 to 14 mm in diameter, is orange and splits to reveal 3 to 12 glossy black seeds which mature from July to September. *Eustrephus latifolius* occurs from North-East Queensland to Eastern Victoria in forested moist, usually coastal habitats. It is, however, tolerant of dryness when established

Propagation is usually by seed, which when sown during winter and spring may germinate in 30 to 45 days. In spite of its status as a monocotyledenous plant, cuttings of *E. latifolius* root relatively easily. A recent propagation gave 56% success using a range of IBA hormone dips.

Lomandra longifolia Labill., spiny-headed mat-rush
Family. Xanthorrhoeaceae
Aboriginal use· leaves, shoots, flowers, nectar

There are about 50 endemic Australia *Lomandra* species. This species is a clumping and tufted perennial herb with separate male and female plants The leaves are strap-like, flat or slightly convex, about 1/2 to 1 metre long, and with a distinctive 2 or 3 toothed apex. The flowers have yellow to cream petals, purplish to yellow sepals, and appear in spring. *Lomandra longifolia* occurs in eastern Australia including Tasmania. It is found in a range of habitats (*Flora of Australia*, 1986).

Seed needs no pretreatment and germination may occur from c. 19 to 32 days Divisions of established plants should not be reduced in size to very small sections or overpotted.

Enchylaena tomentosa R. Br., barrier, or ruby saltbush
Family: Chenopodiaceae
Aboriginal use: fruit.

Ruby saltbush is a low-spreading sub-shrub with woolly procumbent stems. The leaves are green to glaucous and hairy. The spectacular small fruit are about 5 mm in diameter and colours range through green, yellow and red as they mature This species occurs in all Australian mainland states, especially in semi-arid and arid zones, and is tolerant of many soil types, including those that are saline *Enchylaena tomentosa* is also drought and frost tolerant.

Propagation is by cuttings or seed Fog or low rates of mist are desirable for cuttings, which root in about 4 weeks. IBA at 500 ppm and NAA at 500 ppm will give 60% or greater success rates. Viable seed germinates in approximately 4 days if summer sown or in 25 days in winter.

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Integrated Pest Management for Greenhouses

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INTRODUCTION

The greenhouse environment provides optimum conditions for plant growth; these conditions also favour many plant pests and diseases Pesticides are frequently required to control these problems, but in Australia there is little published information on the safety requirements specific to their use.

The occupational health and safety legislation introduced throughout Australia in recent years highlights the health and safety concerns employers have for their staff. Pesticides when used in greenhouses can undoubtedly pose increased hazards to either the pesticide operator or other staff via exposure factors arising from the confined air space and contact with surfaces associated with greenhouse operations.

This paper outlines key principles of pest management in greenhouses. The main emphasis of these principles is upon occupational health and safety aspects, and the use of integrated pest management to minimise the hazards of pest control. A means is provided for reducing the use of pesticides in greenhouses. The advantages to be gained include reduced public concern about pesticide use, reduced hazards to staff, greater flexibility in staff resources and the potential for reducing costs.

PRINCIPLES FOR SAFE PEST CONTROL IN GREENHOUSES

In the greenhouse environment, if pesticides are necessary, it is important to reduce the potential for pesticide exposure, and to reduce the hazards to all staff who work in the greenhouse.

1) **Integrate Pest Management.** Where possible use biological control agents and other non-chemical control methods in preference to only using pesticides.

2) **Pesticides.** Choose the least toxic pesticide which has proven effectiveness against the pest organisms. Consideration should be given to the possibility of pesticide resistance developing through repeated use of one pesticide.

3) **Safety Procedures and Protective Equipment.** Develop correct safety procedures and use appropriate protective equipment.

4) **Accident Prevention.** Instigate measures to avoid accidental events which could lead to the exposure of staff to pesticides.

5) **Build Safety into the Work Environment.** Provide a work environment that meets suitable safety standards including: pesticide storage, washing and showering facility, and regular medical checks.

6) **Sound Training.** Educate staff in the need for the above measures, and train in the correct procedures.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) is a strategy that has existed in horticulture and agriculture for thousands of years. Today, IPM is proving to be advantageous for park and nursery management organizations. Recently, the ACT Parks and

Conservation Service in Canberra has developed IPM programs for the maintenance of formal gardens and greenhouse plants (Carmody et al., 1981; Nazer and Clark, 1986).

IPM is the compatible use of all means of pest suppression including mechanical, biological, chemical and natural control in a systematic fashion (Rhoads, 1985). It refers to a broad and commonsense approach to pest management.

The IPM approach is not anti-pesticide but uses ecological knowledge of pests and diseases to implement safe and economical control measures. A basic premise of IPM is that broad cover sprays of pesticides not only affect the population level of the pest, but also that of beneficial organisms which provide suppression of pest populations.

The ACT Parks and Conservation Service has developed a system of integrated pest management which is based on three major guidelines

1) The presence of a pest organism does not necessarily indicate a pest problem
2) Consideration should be given to all available pest control strategies
3) The immediate elimination of a pest is not essential, but pest population levels must be kept within acceptable limits.

In following the IPM approach, selective pesticides are used to reduce pest population levels only when non-chemical methods are not achieving the desired result. Non-chemical methods include biological control agents, chromotropic traps and effective hygiene practices The main factors which limit the development of IPM programmes are outlined by Spooner-Hart (1989).

Richardson (1977) considers that sufficient information is available in Australia on the biological control of greenhouse pests for the practice to be commercially developed. At least one Australian firm is investigating the commercialisation of several suitable biological control organisms, but only two are available at present. For example, the Service purchases the predatory mite *Phytoseiulus persimilis* for use in controlling two spotted mite in its glasshouses. Releases are made annually in early summer.

The Service also makes use of several naturally-occurring biological control agents in its IPM program as shown in Table 1. Under the IPM program particular attention is paid to making sure that pesticide applications do not destroy these agents, many of which are easily killed by pesticides.

Every effort is made to choose pesticides which are relatively non-toxic to the predator. Occasionally, it has been necessary to make additional releases of the predator mite if it has been eliminated inadvertently by pesticides or by natural causes. When the use of a pesticide which is toxic to the predator is required, the effects on its population level are minimised by spot treatment of plants, or groups of plants.

Attention is paid to soil sterilisation and plant hygiene practices to reduce pest and diseases occurrence. Outbreaks of soil-borne diseases which can develop during propagation are prevented by regular application of fungicides.

PESTICIDES

Selection of a pesticide for use in a greenhouse should take into account toxicity, residual life, effectiveness, aspects of known pest resistance and compatibility with integrated pest management programs All pesticides approved for general use in greenhouses of the Service are Schedule 5, 6 or Exempt pesticides (AGPS

Canberra, 1982) with short residual life.

Whenever possible, the use of more toxic or long residual life pesticides (e.g. Schedule 7 or fumigant pesticides) is avoided In the case of fumigants, licensed operators may be necessary, and safety measures and training of a higher level required.

The pesticides presently used in the Service greenhouses to control commonly encountered pest problems are shown in Table 1.

Table 1 Pesticides and non-chemical methods used for pest control in ACT Parks and Conservation Service greenhouses

Pest/Disease	Pesticide	Non-chemical control method
Container plants:		
Two-spotted mite (*Tetranychus urtiacae*)	Propargite (Omite)	[1]Predatory mite (*Phytoseiulus persimilis*)
Mealybug (*Psuedococcus* spp)	Dimethoate (Rogor) or Maldison (Malathion) either alone or combined with White Oil (Albarol) Omethoate (Folimat)	[2]Mealybug ladybird (*Cryptolaemus montrouzieri*)
Scale insects	As per mealybug control	
Aphids (*Myzus* spp)	Pirimicarb (Pirimor) or Dimethoate	[2]Parasitic wasp (*Aphidus colemani*)
Whitefly (*Trialeurodes vaporariorum*)	Dimethoate or Maldison	[2]Parasitic wasp (*Encarsia formosa*) [2]Yellow sticky traps
Caterpillars	Carbaryl (Septene)	[1]Bacteria (*Bacillus thuringiensis*) (Dipel)
Cuttings and Seedlings:		
Grey mould (*Botrytis cinerae*)	Iprodione (Rovral) or Benomyl (Benlate)	
Damping off, stem and crown rots (*Rhizoctonia* and *Sclerotinia* ssp)	Iprodione, Benomyl or Quintozene (Terrachlor)	
Damping off and root rots (*Pythium* and *Phytophthora* ssp)	Propamocarb (Previcur) or Fesetyl (Aliettr)	
General Control:	Polyphenol (Biogram) for periodic disinfestation of greenhouse fixtures	Steam sterilization of soil, hygiene practices, roguing of infected plants, selection of resistant plants

[1]Commercially available

[2]Not commercially available but are utilised whenever possible.

SAFETY PROCEDURES

The use of pesticides in greenhouses presents special problems, and demands great care to ensure their safe use. Ventilation in greenhouses is frequently kept to a minimum to maintain desired temperatures and humidity. As a result any chemical fume, mist or dust may remain in the air for a considerable period of time. It is also difficult for personnel to avoid contact with plants and other pesticide-treated surfaces.

The accompanying procedures of the ACT Parks and Conservation Service are currently followed in the greenhouses. They were developed in consultation with pest control specialists and greenhouse management staff to meet the specific needs of the Service. These procedures are unlikely to be automatically applied but the approaches which have been adopted may assist others in dealing with their own special problems. The need to develop procedures to fit the specific requirements of different operations is stressed, as is the need to accompany the introduction of the procedures with adequate training and a system which enforces them

PROTECTIVE EQUIPMENT

Whilst the directions of a pesticide label must be followed in all cases, there is a surprising lack of product information relating to the safe use of pesticides in confined spaces. *The Manual of Safe Practice in the Handling and Use of* Pesticides (AGPS Canberra, 1980) strongly recommends protection by either supplied air respirators or canister type respirators when using highly toxic volatile pesticides in greenhouses It otherwise provides only basic guidelines for use of protective equipment in this situation.

The items of protective equipment listed below may be prescribed on pesticide labels, and where this is the case the items <u>must</u> be used. It is important to ensure that clothing and protective devices used conform to the relevant Australian Standards. The Manual of Safe Practice in the Handling and Use of Pesticides explains in detail aspects of the use of the following items: overalls, gloves, aprons, footwear (impervious type), goggles and face shields, and respirators. Correct selection, use and maintenance of protective equipment can eliminate or at least minimise possible hazards.

There are two basic approaches to respiratory protection, air purification through filtration of contaminants, and the supply of uncontaminated air from an external source, such as a compressed-air container. Protection against hazards normally encountered in greenhouse pesticide operations can usually be obtained by using filtration devices. Further discussion of protective equipment is provided by Nazer and Clark (1986).

MODEL FOR GREENHOUSE PESTICIDE PROCEDURES

Pesticides. Only pesticides approved by the greenhouse manager should be used. Refer to the manager if other pesticides are considered necessary.

Label instructions on the pesticide container must be followed in all cases. Do not use unlabelled pesticides.

Application warning. During and for at least 12 hours after pesticide application a **'Warning No Entry - Pesticide Use In This Area'** notice must be displayed at the entrances to the greenhouse.

After large-scale pesticide application the greenhouse must be closed and locked against unauthorised entry for at least a 12-hour period.

If spot spraying or drenching of individual plants or groups of plants is carried out, a notice or coloured label must be placed on treated plants. Where coloured labels are used a notice must be displayed at the greenhouse entrances indicating that these plants have been treated and if necessary the pesticide/s used.

Greenhouse entry

1) Following large-scale application:

A) **During 12-hour period:** If entry is necessary before the 12-hour period has expired then appropriate protective clothing including respiratory protection (i.e. the same type of items used when applying the pesticide), must be worn.

B) **After 12-hour period:** Entry is permitted after 12 hours if greenhouse ventilation has been continuous for the 12-hour period following spray application.

Before entry is permitted to a sealed unventilated greenhouse, the greenhouse must be thoroughly ventilated, if possible by forced draught ventilation. The ventilation period should be at least several hours and certainly strong fumes of pesticides should not be noticeable.

2) Following spot spraying or drenching:

A) **During 12-hour period:** Entry during this period should be avoided if possible. It is not necessary to wear protective clothing provided treated plants are avoided, and strong fumes of pesticide are not noticeable.

B) **After 12-hour period:** Entry is permitted. If strong fumes of pesticides are noticeable the greenhouse must be ventilated.

Protection of Staff: A thorough washing down of all surfaces with water (including plants and pots) in the vicinity of sprayed plants should be performed prior to allowing people to handle the treated plants.

Protective Clothing and Devices: *Refer to the greenhouse manager for information on types, uses and change intervals of cannisters and cartridges used in respirators.*

When undertaking large-scale pesticide application, it is essential to use a full-face canister respirator or an air-stream hood.

When spot spraying a small number of plants an agricultural respirator hood or face shield and respirator fitted with two cartridges should be used. When drenching with fungicides it may not be necessary to use respiratory protection: however, the breathing of any fumes or spray must be avoided.

Waterproof overalls for large-scale pesticide application. Cotton overalls are suitable for spot spraying and drenching.

Waterproof gloves and footwear should be worn.

Fumigation in greenhouses needs special equipment and training. Contact greenhouse manager.

General precautions. Refer to Pesticide Safety Codes of Practice and the pesticide label.

Special care should be taken to avoid pesticide contamination of ancillary equipment, where such contamination could later be transferred to staff.

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Twin Scale Propagation of Amaryllis Bulbs

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HISTORY

Amaryllis is the common name applied to hybrids and cultivars derived from various species in the genus *Hippeastrum*. They are from the family Amaryllidaceae (included in Liliaceae), and were from the genus *Amaryllis* when the initial hybridization was begun at the turn of the 18th Century. Later, when the genus *Amaryllis* was divided and these species were shifted to *Hippeastrum*, amaryllis was retained as a rather confusing common name

CULTIVATION

Hippeastrum species are mostly native to South America with some in western Africa Hybrids of the Andean and temperate South America species are justly credited as being very hardy bulbs able to grow well in a very wide range of conditions Amaryllises are winter dormant, flowering in mid to late spring (October/November), with leaf growth occurring with or immediately after flowering. Strong leaf growth then follows until mid to late autumn. In contrast, the "true" amaryllis, *Amaryllis belladonna*, is South African, summer deciduous, and blooms in late summer when leafless.

Mature bulbs generally have two flowering stems, about 40 to 60 cm tall, each with 4 to 6 flowers about 20 cm across. Colours range through all shades of red, orange, pink, and white, and include bicolours, and yellow

Wet winters can be hazardous to bulb health, so most commercial open-ground growers lift mature bulbs in late autumn and store them indoors for sorting and sale. Young bulbs are evergreen until they reach maturity They are normally left to grow under plastic cover for the first winter, greatly increasing bulb size.

PROPAGATION

Natural propagation is by offsets. Some cultivars average less than one offset per bulb per year, however the average is about 1.5 to 2. This makes the time lag for increasing stock rather lengthy and has led to development of more rapid methods of multiplication using tissue culture and twin scale production. One of the largest suppliers in the world, Hadeco Bulb Co in South Africa, uses tissue culture to remove detectable viruses, and then twin scale propagation for multiplication.

The largest bulbs, those with a circumference of roughly 26 cm or greater, are selected for twin scale propagation. Not only can greater production be achieved from larger bulbs, but they will have definitely flowered the previous year so that rogues will have been removed. Leaves are removed and bulbs are lifted in late autumn After lifting the bulbs are stored in racks or trays in drying rooms until surface dry. Drying takes up to 2 weeks and the bulbs will lose about 20% of their weight. This is very beneficial for twin scale propagation, as the scales of the bulb lose much of their crispness and become more flexible and less likely to snap.

Hygiene is important to prevent the spread of viral diseases. I use two knives — a medium kitchen knife and a standard grafting knife (without budder). The sap of amaryllis is quite slimy, so after each bulb the knife used is wiped with clean paper, and the blade placed in methylated alcohol (spirits) while the other knife is in use. After removal of the blade from the alcohol, the residual alcohol is burned off the blade. There is some debate as to the effectiveness of this treatment

The roughly pear-shaped bulb is tailed—removing the roots and root plate to the bottom of the outermost scale—starting with the kitchen knife. It is important for success that all scales remain attached to root plate. Next, the bulb is topped, removing the neck of the bulb to the beginning of its bulge. The dry onion-like outer scales are next peeled off along with any damaged fleshy scales. Damage normally shows as pink bruising, which mostly occurs from rough handling. The bulb is then cut into quarters by cutting through the centre of the root plate to the top of the bulb. Each quarter is then cut into 3 or 4 'chips', again from the centre of the root plate to the top. This results in 12 to 16 chips (rather like a segmented orange). The procedure can stop here, as is commonly done when multiplying smaller bulbs such as *Narcissus* spp.

Each chip now consists of rows of scale segments attached to the root plate. At this stage it is often easier to prepare and use the smaller knife. The knife is used to carefully cut out unwanted bulb parts The next season's leaves will already be formed and are to the centre of the bulb. They are very thin, sometimes very faintly green with vertical veins and are removed. Flower buds (1-5 cm tall) will also have been formed, and will be towards the middle of several chips and must be removed. Any offshoot initiations should also be removed, as they will normally have been cut. Brown, rotten patches between chips are normally the rotten base of the previous season's flower stems. These look alarming, but only need to be removed.

Finally, starting from the outside, each chip is cut into twin scales by running the blade between each pair of scales and cutting through the root plate. The aim is to work to the centre of the chip with each twin scale having a proportion of root plate. With the exception of the outside twin scales, any that crack from the root plate should be discarded. Also, it is often better to leave the centre group of 3 or 4 scales together as they are less successful than the outer scales. This procedure gives 50 to 80 twin scales per bulb. Each is capable of producing a new bulblet, with outer twin scales often producing 2 to 3 bulblets. An experienced operator can prepare 5 to 6 bulbs per hour.

The twin scales are placed in baskets to heal (become nearly dry to touch, about 1 to 2 hours) before being treated with fungicide. A 0.2% benomyl dip for 1 to 2 min has been most recommended and given me my best results. Some success has been achieved with sodium hypochlorite at 0 7%, but results have been erratic. No treatment will result in nearly complete failure.

The most popular medium is slightly moist vermiculite, achieved by adding 1 5 litre of water to each 10 litre of vermiculite It is important that the medium not get any wetter, as rotting will result. The twin scales are mixed into the vermiculite at a fairly thick rate (about 1 2 ratio), so that each twin scale is just separated from the next by medium.

The medium is poured into trays ('stores' as they are called) to a depth of about 10 cm. Clean recycled polystyrene fruit boxes are ideal, as they can be stacked and still allow some air movement. Trays should be kept in a warm area (about 25°C) with high humidity, not in direct sunlight, and covered with plastic if air movement is too great Trays should not be placed under mist although fog may be good. The aim is to protect the twin scales from drying out, yet not allow them to become wet

Several other methods are in use. Some propagators put the vermiculite/twin scale mixture in sealed plastic bags. I always find that half the bags end up as fungal nightmares, but others swear by this system. Another good method is to use 15 cm deep trays, with about 5 cm of moist potting mix topped by vermiculite, into which the twin scales are inserted. With this method it is important that the scale bases not be pushed into the potting mix as they will begin to rot. The advantage of this latter method is that roots can grow into the potting mix and early bulblets can become established.

Within days the twin scale edges begin to turn red— this is a healthy sign If they turn pink, it is an indication that rotting has begun, and a suggestion that the medium is too moist or that the fungicide treatment was not effective. It is generally considered that if the twin scales are still alive and healthy after 2 weeks then the procedure has been a success. Shortly after this a trained eye can observe bulblet initiation on the root plate either on the edge or in between the pairs of scales. The outside twin scales will produce more bulblets in a much quicker time than will inner twin scales. Large-scale operators often separate the two types and store them in separate trays. Bulblet development may take up to 12 weeks, and after this time bulblets can be planted out. Roots and leaves will soon be formed. It takes 3 to 4 years to reach a 2-flower stem sized bulb, but in that time 50 to 100 bulbs have been produced from each parent bulb.

AMARYLLIS AS A SALE PLANT

Open-ground growers currently realize about $6 to $10 wholesale for each dormant amaryllis bulb. This compares to $1 to $2 for hippeastrums. At Swanes Nursery we plant to trial the sale of amaryllis as young plants in small pots, using mature flowering plants as displays. Amaryllis can be forced into early flower from late winter (July) by the use of heated rooms, or delayed slightly by cool storage Amaryllis bulbs can flower in 4 to 6 weeks when exposed to light and temperatures consistently above 20°C Such treatments can result in display plants for about a 5-month period. There is currently a small demand for flowering plants in containers.

Due to the higher production costs of amaryllis it is important to select cultivars that are distinctively different from the common garden types. My favourite cultivars are:

- 'Apple Blossom'— pale pink fading to white centre, softly fragrant
- 'Basuto'— deep red
- 'Bold Leader'— bright red
- 'Carnival'— red and white striped, (difficult to sell, like garden types)
- 'Milady'— deep pink
- 'Intokazi'— tall pure white
- 'Summertime'— deep pink with white centres

Twin scale propagation can also be applied to many other bulbs. I have used it successfully with *Lycoris africana* (syn. *L. aurea*) (yellow nerine), *Muscari* sp. (yellow grape hyacinth), *Haemanthus coccineus* (blood lily) and *Nerine* cultivars. It is also used for ×*Amarine*, a relatively new generic cross between *Amaryllis belladonna* and *Nerine bowdenii*. Success is likely with many other tunicate bulbs

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The Rooting of *Daphne odora* Thunb. Cuttings in a Hydroponic Propagation System

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INTRODUCTION

Rooting hormones (auxins) promote root initiation on cuttings Dip applications of the auxin indolebutyric acid (IBA) at concentrations up to 6000 ppm are commonly used. In aeroponic systems (systems which use regular misting of the root zone with nutrient solution) it has been shown that cuttings will root equally well when continuously exposed to low auxin concentrations in the solution misting the cutting bases (Nir, 1980).

Oxygen is essential for root formation to take place (Zimmerman, 1930). The propagation medium used for cuttings must therefore have the correct balance between available water and oxygen. Failure to achieve this balance can result in stress either in the form of dehydration or anaerobic conditions. Such stress in the rooting zone can result in collapse and death of the cutting. The aerial part of the cutting is protected from dehydration, usually by misting or fogging.

The Ein Gedi Aero-hydroponic System developed by Soffer (1989) has been adapted successfully for propagation. It uses a combination of aeroponics and water culture (root zone immersed in a flowing nutrient solution). Good strike rates have been achieved without the use of aerial fog or mist. The nutrient solution becomes the vehicle by which auxins and other substances are delivered.

This paper describes a hydroponic propagation system based on the Nutrient Film Technique (NFT) (Cooper, 1979). Our studies were conducted to determine strike rates and root growth after different exposure times to a low concentration of IBA and the effect of solution temperatures on rooting performance. The test plant, *Daphne odora* Thunb., is an evergreen shrub with strongly-perfumed flowers and it is normally propagated from semi-hardwood cuttings during summer to mid-autumn in a sand:peat mixture (Poynton, 1977). Rooting usually occurs after 6 weeks.

MATERIALS AND METHODS

The hydroponic propagation modules were assembled using plastic-lined galvanised channels 2.4 m long, 7.5 cm high and 10 cm wide The channels were filled to a depth of 5.5 cm with black polypropylene beads, 4 mm long by 3 mm in diameter. The channels had a slope of 1:20 and at the lowest point the beads were retained by a wad of shadecloth

A submersible pump was used to pump the solutions from a 50 liter plastic drum through 13 mm tubes into the top end of the channels. Plastic jets delivered the solution at 1.2 l/min. The solution was recycled into the tank with considerable splash to aid aeration. All modules were set up in a 50% shade house and each was individually covered with 50% shade cloth, supported on wire hoops, to reduce light and increase humidity. Because the shade house had an automatic sprinkler system which operated for 10 min twice daily, the channel outfalls and drums were covered with black plastic to prevent excessive dilution from the overhead irrigation and to exclude light. Two studies were conducted with cuttings of *D. odora*.

Study 1

To determine if exposure time to IBA influenced rooting and subsequent performance of the plant. Three modules were used:

1) Control— tap water only.
2) Tap water containing 10 ppm KIBA (potassium salt)—renewed weekly.
3) Tap water only—this module was used to receive cuttings at regular intervals from module 2.

Cuttings were harvested on 10/2/90 from 7-year-old stock plants, grown hydroponically in bags of scoria, and were stored in a refrigerator at 1 to 3°C for 3 days. Tip cuttings approximately 8 cm long with 5 to 6 leaves were inserted into the beads in the channels to a depth of 4.5 cm. Fifty cuttings were placed in module 1 and 130 in module 2. After 1, 3, 10, 16 and 31 days, 19 cuttings were removed from module 2, washed, labelled and transferred to module 3. On day 21, all cuttings were assessed for signs of rooting and then returned to their respective module. Eight rooted cuttings were selected at random for a final assessment on day 37; numbers of roots, maximum root lengths, and dry weights were determined. The roots were dried for 4 days at 80° C in a forced draught oven.

Five rooted cuttings from each treatment were transplanted into plastic-wrapped rockwool cubes (75 x 75 x 65 mm high) on 18/4/90. These were maintained in the shade house to become established before being transferred to a dark, cold room at 7°C for 6 weeks. They were then moved to an environmentally controlled greenhouse and grown in hydroponic channels until 3/9/90 when total shoot length was measured. For statistical analysis, the shoot-growth data from treatments 0-1, 3-6, 10-16 and 31-37 days were grouped together.

Study 2

To determine if solution temperature influenced the performance and rooting of cuttings. Two modules were used:

1) Heated 2) Not heated

This experiment was started on 26/9/90 with 21 semi-hard cuttings being placed in each module. These cuttings were obtained from plants grown out of season. Module 1 was heated using a 300 Watt submersible fish tank heater and a minimum temperature of 21° C was maintained. The temperature of module 2 fluctuated with the ambient temperature which varied between 4 and 33°C during the course of the experiment. Both modules has 10 ppm KIBA in the systems for 16 days. A visual assessment was made on 23/10/90 and number of roots and maximum root lengths were measured on the 7/11/90. All data were statistically analysed using Genstat V

RESULTS AND DISCUSSION

Study 1. Exposure of cuttings to KIBA accelerated root formation The 21-day assessment showed that only 2% of the cuttings in the water-control had formed roots, compared with 50 to 74% for cuttings exposed to KIBA (Table 1).

An analysis of variance was carried out on root number, maximum root length and root dry weight In all cases the data showed a peak in the 10 to 20 day region. There was an optimum exposure time to KIBA, after when root initiation was inhibited.

Table 1. The effect of exposure to IBA on rootıng performance of *Daphne odora*

Exposure (days)	Rooted 21 days (%)	Rooted 37 days (%)	Root number 37 days	Max root length (mm) 37 days	Root dry weıght (mg) 37 days
0	2	74	20 9	9 0	7 4
1	60	63	17 4	32 9	20 6
3	60	68	22 9	36 9	34 1
6	60	79	25 1	35 2	36 1
10	74	79	28 8	44 6	59 6
16	60	68	25.1	33 1	31 3
21	50				
31		63	22 6	27 3	21 0
37		68	20 1	16 6	20 1
LSD 5%			9 6	15 9 2	7 72

The length of tıme that cuttıngs were exposed to KIBA influenced the subsequent growth of rooted plants. When plants were grown on for a full growth flush ıt was found that shoot growth was sıgnıficantly reduced where the cuttings had been exposed to KIBA for longer than 30 days (Table 2).

The experiment was repeated ın 1991 and the results supported the findıngs from thıs study, with exceptıon that root number was not sıgnıficantly affected by exposure tıme.

Study 2. Root zone warmıng had a sıgnıficant effect on the percentage rooted, time taken for roots to appear, maximum root length and root number of *D odora* cuttings (Table 3)

After 27 days a 95% strıke rate was achieved ın channels heated to a mınımum of 21°C, but none of the cuttings ın channels at ambient temperature showed visıble roots In both studıes IBA alone, wıthout heatıng achıeved 63 to 79% rooting, but 100% was achieved by the combınatıon of KIBA and root zone warmıng.

Table 2. The effect of perıod of exposure to KIBA on shoot growth ın *Daphne odora*

Exposure (days)	Shoot length (mm)
0-1	66 2
3-6	62 8
10-16	53 9
31-37	35 4
LSD 5%	28 5

Table 3. Effect of root zone warming (minimum of 21° C) on the performance of *Daphne odora* cuttings

Treatment	Rooted 27 days (%)	Rooted 42 days (%)	Root number 42 days	Maximum root length (mm) 42 days
Heated	95	100	25 0	88 0
Not heated	0	75	14 3	20 7
LSD 5%			7 6	18 4

CONCLUSIONS

Exposure to low concentrations of KIBA in a hydroponic propagation system accelerated root production, but did not increase the percentage of cuttings forming roots. Extending the time of exposure to KIBA beyond that giving maximum root numbers, root length and dry weight inhibited root growth. Prolonged exposure to KIBA during propagation retarded later growth. The combination of root zone warming and IBA raised the success rate of rooting to 100%

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How to Commercially Graft Grevilleas for Profit or Preservation

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The genus *Grevillea* contains 251 described species, 247 of which occur throughout most of Australia; two of these species overlap into Papua New Guinea and a further five overlap into nearby islands Within Australia, the only areas without grevilleas are central western N.S W., part of Tasmania and the near Great Australian Bight between Adelaide and east of Esperance (Wrigley and Fagg, 1989).

Certain *Grevillea* species are at risk due to a restricted distribution. This may have occurred naturally due to soil type or through habitat destruction by livestock and development, or the spread of non-endemic diseases such as *Phytophthora cinnamomi*.

The disease problem can be circumvented through use of *Grevillea robusta* as a rootstock. Grafting allows large-scale production of rare species.

REASONS FOR GRAFTING

There are several reasons for grafting grevilleas:

1) To allow a species to be grown in an environment in which it will not grow on its own roots This is best achieved by grafting it onto an adaptable rootstock such as *G robusta* For example, this rootstock would be used for growing species from arid areas in more tropical coastal locations.
2) To allow species with a low tolerance of root rot pathogens to be grown in infected soils on a more tolerant rootstock
3) To create unnatural shapes for landscape use such as weeping standards, standards, mini-standards, "ball on a stick" and mounded type plants.
4) To allow for the relatively quick vegetative multiplication of rare species, thereby increasing the chance of preserving the species.
5) To allow commercial production of larger numbers of plants than is possible by approach grafting. It is now possible to offer a reliable supply of the forms listed in 3 above.

MATERIALS AND METHODS

Emphasis is placed on scion stock plant, rootstock and grafted plant nutrition. This is achieved through the use of foliar sprays and slow-release fertilisers.

Scion material is selected for a specific stage of growth, leaves clipped and then surface sterilised in sodium hypochlorite (100 ppm) Scalpels are used to give a clean cut on whip grafts to achieve the greatest chance of graft success Grafts are wrapped with two layers of Novix IIR lab film and the rest of the scion wrapped with a single layer of the film to prevent desiccation.

Grafts are placed in a fog house because the post graft environment is just as important as the above factors for success. Relative humidity is maintained at a minimum of 76%. Temperature fluctuations do not seem to have any effect, even though daytime maximum may exceed 40°C.

RESULTS AND CONCLUSIONS

Through the above mentioned methods of preparation, grafting and environmental control, it has become possible to economically produce reasonably large numbers of high-quality grafted plants (Table 1)

Table 1. List of successfully grafted *Grevillea* species [1]

G angulata	*G glauca*	*G phanerophlebia*
G asteriscosa	*G goodii subsp decora*	*G pilosa*
G bipinnatifida	*G granulosa*	*G pilosa* subsp *dissecta*
G bedggoodiana	*G infundibularis*	*G. pinifolia*
G bracteosa	*G insignis*	*G repens*
G deflexa	*G intricata*	*G rivularis*
G drummondii	*G. johnsonii* x *G longistyla*	*G rudis*
G. dryandri	*G johnsonii*	*G scortichini*
G erinacea	*G lavandulacea*	*G shiresii*
G eryngioides	*G. leucopteris*	*G thyrsoides*
G floripendula	*G nudiflora*	*G tripartita*
G formosa	*G. paradoxa*	*G wickhamii*
G fulgens	*G pectinata*	*G wilsonii*

[1] Bot Ed Note· also see Elliot, W R , and D L Jones 1990 Encyclopedia of Australian plants suitable for cultivation, Vol 5, pp 14, 15, for more information on grafting of *Grevillea* spp and cultivars

These methods will also be employed to help preserve rare species through production of plants with increased vigor on tolerant rootstocks. This allows production of a large amount of high-quality scion material for further grafting.

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Phase Change Materials for Solar Heating of Greenhouses

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INTRODUCTION

Greenhouse heating frequently represents an important cost in nursery operations. Many greenhouses currently in use are of a European design and do not perform well under Australian conditions, particularly in terms of their energy requirements and ventilation performance Currently, methods of extracting and storing heat generated in the greenhouse itself, for later use for greenhouse heating, are being investigated. This is the basis of solar greenhouse technology

Recent research has led to the development of accurate methods of determining the rate of heat accumulation in greenhouses exposed to solar radiation (Garzoli, 1984). Air inside the greenhouse is heated by convective transfer from the floor, plants and other surfaces that absorb solar radiation. In conventional greenhouses, excess heat generated during the day is vented to waste; that is, once the greenhouse air is heated to above its required setpoint temperature, ventilators are opened to exhaust hot air and replace this with cooler outside air. In solar greenhouses, on the other hand, the hot air exhausted from the greenhouse is passed through a thermal storage medium where heat is transferred from the air to the thermal store, the cool air being returned to the greenhouse, forming a closed cycle In some cases a solar air heater is also incorporated into the system to augment the amount of heat delivered to the thermal store and to provide the air at a higher temperature, thus improving the rate of heat transfer between the air stream and the thermal store.

THERMAL STORAGE SYSTEMS

To date the energy storage systems for such solar greenhouses have consisted of pebbles or crushed rock. Such materials have the advantages of chemical inertness, reasonable heat capacity, high surface area to volume ratio that results in high rates of heat transfer at all air speeds, ready availability and generally low cost (depending on the transport cost). However there are a number of disadvantages that have proved to be a serious deterrent to the large-scale adoption of solar greenhouse technology. Recent research on phase change materials (PCM) (Brandstetter and Kneff, 1987) at the Australian National University has demonstrated their suitability for thermal energy storage systems for greenhouses. PCM offers considerable advantage over crushed rock, particularly its greatly reduced storage volume requirement.

PCM PROPERTIES AND ENCAPSULATION CRITERIA

The reason for the greatly reduced size requirements for PCM compared with crushed rock is its superior thermal capacity: it has a specific heat of 2 kJ/kg°C compared with 0.88 kJ/kg°C for basalt rock, but of far greater significance is its heat of fusion, which is about 190 kJ/kg for $CaCl_2 \cdot 6H_2O$ (calcium chloride hexahychate), with a phase change temperature of about 29.5°C. If the PCM is modified to provide phase change temperatures down to about 23°C, the heat of fusion is somewhat lower. The desirability of PCMs with a range of phase change temperatures from about 23°C to 29°C may be indicated as follows:

1) Suppose that the greenhouse operates without a separate solar air heater, i.e. sufficient heat is generated in the greenhouse alone to supply the nighttime requirement. In order to melt the PCM it would be necessary for the maximum greenhouse air temperature, at the top of the greenhouse, to be about 4 or 5°C higher than the phase change temperature. For example, a greenhouse operating at a daytime setpoint temperature of 26°C at plant level would be expected to deliver air at about 29°C at the ridge. Thus the melting temperature of the PCM would need to be about 24°C.

2) For a greenhouse with a solar air heater, it could be expected that air would be delivered to the thermal store at a temperature well in excess of 30°C. Thus it would be possible to use 29 5°C PCM, thereby taking advantage of the highest possible heat of fusion However, the air emerging from the thermal store would normally be too hot to return to the greenhouse. The preferred method of dealing with this situation is to use modules of PCM with different melt temperatures so that the air would cool on passing from the module with the highest melt temperature to that with the lowest, thereby emerging from the thermal store at a temperature suitable for return to the greenhouse.

3) When the direction of air flow is reversed for greenhouse heating at night the air is in contact with the hottest PCM module last, i.e. immediately prior to its re-emergence into the greenhouse, thereby maximising the efficiency of the greenhouse heating process and minimising the fan power requirement.

DESIGN OF PCM MODULES

In designing a PCM encapsulation system, the important considerations are:

1) Adequate energy storage capacity of the PCM.
2) Direction of the air flow relative to the PCM modules.
3) Sufficient surface area of the PCM modules to effect the necessary heat transfer between the air stream and the PCM.
4) Proper configuration and arrangement of the PCM modules so that resistance to air flow (and therefore fan power requirements) is minimised.

The design of the PCM encapsulation system takes account of a number of factors, including cost (of both the encapsulation material itself and the manufacturing process), chemical inertness, water vapour impenetrability, correct heat transfer characteristics, adequate strength, rigidity and robustness, and portability. The size and capacity of the system depends on the amount of energy that is required for greenhouse heating, the contribution from the greenhouse and solar air heater (if used), and the cost and availability of supplementary heat energy (i.e. gas, oil and electricity)

In the absence of solar radiation, the heating requirements of a greenhouse Q (in watts) is given by

$$Q = U'A_c(T_{ai} - T_{ao})$$

where U' is the heat loss coefficient, A_c is the cover area of the greenhouse, and T_{ai} and T_{ao} are the inside and outside temperatures respectively. The value of U' is generally taken as 9 for single glass or polyethylene, and 6 for double-skin houses.

These values can be reduced by about 35% if a good quality thermal screen is used. The rate at which heat can be removed from a greenhouse during the day, E (also in watts) is given by

$$E = \frac{A_{gi}[1 - (F_1 + F_2)]G_o\tau\alpha}{1 - (1 - \alpha)\rho_d} - (U'A_c(T_{ai} - T_{ao})$$

where A_{gi} is the floor area of the greenhouse; F_1 and $_2$ are factors that take account of absorbed radiation that is used in photosynthesis and stored in the floor, respectively; G_o is the solar radiation intensity on a horizontal surface; τ is the average transmittance of the greenhouse to solar radiation; α is the average absorptance of the internal surfaces to solar radiation; and ρ_d is the reflectance of the cover to diffuse radiation that has already been reflected from inside the greenhouse. The value of τ is normally assured to be 0.7 for a single-skin greenhouse and 0.6 for a double-skin greenhouse; the value of α is normally taken as 0 84; and ρ_d is 0.16 for a single-skin greenhouse and 0.25 for a double-skin greenhouse. From this analysis it is possible to calculate the collection efficiency of such a solar greenhouse, i.e., the amount of useful energy that can be extracted as a percentage of the incoming solar energy. Table 1 shows calculated collector efficiencies for a range of conditions likely to be encountered in parts of Australia.

Table 1. Calculated greenhouse collector efficiencies

Ambient air temperature (°C)	Solar radiation (W/m²)	Greenhouse collector efficiency (%) Greenhouse temperature 22°C: Single glazing	22°C: Double glazing	27°C: Single glazing	27°C: Double glazing
0	100	0	0	0	0
	250	0	1 6	0	0
	300	0	9 3	0	3 9
5	250	0	14 6	0	4 9
	300	0	20 2	0	12 0
	450	0	29.4	0	23.9
10	300	0	25 3	0	18 0
	450	4 9	32 8	0	27 9
	600	17 4	36.5	1 8	32 9
15	450	24 6	37 9	4 9	31 8
	600	32 2	40 3	17.4	35 8
	750	36 7	41 8	24 9	38 2

Where the calculated collector efficiency is zero, the rate of heat lost from the greenhouse is greater than the heat gained by the absorption of solar radiation The greenhouse is then not able to maintain the set point daytime temperature and no excess energy is available.

Mathematical expressions that describe the absorption of solar radiation in greenhouses are similar to those used for flat plate solar collectors. The amount of useful absorbed energy in a greenhouse is lower, however because.

1) The solar transmittance of the cover is lower.
2) The solar absorptance of the interior of a greenhouse (plants, floor and structure) is lower than that of a matt black or selective surface.
3) A significant proportion of the absorbed radiation is used directly by plants in photosynthesis or stored in the floor.
4) A greenhouse cannot be tilted to maximize the interception of beam radiation. Similarly, rates of heat loss are greater in greenhouses because the cover area is large compared with the floor area and because some ventilation loss is inevitable. Further differences in performance occur in a greenhouse because extraction of heat is possible only under conditions that satisfy the requirements of plants and because transpiration of the foliage results in increases in both latent and sensible heat. Although greenhouses have relatively low collection efficiencies and can deliver useful heat over a more restricted range of climatic conditions, they nevertheless have the capacity to generate significant amounts of heat because of their large areas.

Once the amount of energy to be stored has been ascertained, the quantity of PCM required can be calculated from its known energy storage capacity. The next aspect to be addressed is the design of the PCM storage system in modular form. The requirements of strength, rigidity, robustness and water vapour impenetrability are met by using high density polyethylene with a wall thickness of at least 2 mm. Tubular channels through the module allow for the passage of air and provide the surface area for the transfer of heat between the air stream and the PCM module.

Most processes that involve heat transfer between an air stream and a heat-absorbing surface require that either (a) the rate of heat transfer is maximized or (b) that a certain temperature is to be achieved at the end of the heat transfer process In each case, the criteria are satisfied by choosing a particular air flow rate In solar greenhouses, on the other hand, this is not the case. The air speed may be just above zero, for example, on a sunny morning when the greenhouse has just reached its daytime setpoint temperature and a very small amount of excess energy is available for storage On the other hand, air speed may be that corresponding to full fan speed in the early afternoon when solar radiation intensity is at its maximum and the rate of heat loss from the greenhouse is at its minimum because of the relatively high outside temperature Any air speed in between these two limits is also possible, in all cases depending on the required conditions in the greenhouse and the outside climate. PCM modules must therefore be designed to perform adequately under all conditions For a given air flow rate, maximum heat transfer occurs with long flow paths and small diameter air channels. Such conditions also result in a high fan power requirement. PCM modular design requires that these competing requirements should be adequately addressed. Provided that the air flow is always turbulent, the following relationship between the Nusselt (Nu), Reynolds (Re) and Prandtl (Pr) numbers has been shown to apply.

$$Nu = 0.023\, Re^{0.8} Pr^{0.4}$$

Considering each of these numbers in turn for this application.

(1) Nusselt number, $Nu = \frac{hD_e}{k_a}$ where h is the heat transfer coefficient; D_e is the equivalent diameter of each air flow channel = 4 × cross sectional area of channel/perimeter of channel; and k_a is the thermal conductivity of air.

(2) Reynolds Number, $Re = \frac{vpD_e}{\mu}$ where v is the velocity of the air; p is the density of air, and is the viscosity of air.

(3) Prandtl Number, $Pr = \frac{\mu C_p}{k_a}$ where C_p is the specific heat of air.

Thus, from the known properties of air, its velocity and the dimensions of the module the heat transfer coefficient h can be calculated and thence the rate of heat transfer. The accuracy of this relationship was verified in a series of wind tunnel experiments at the ANU (Dymond, 1990) Computer simulation of performance over a wide range of conditions suggests that optimum performance is achieved with air flow channels of about 20 mm diameter and an air mass flow rate per unit area of about 5 kgs per sec per m^2. Modules can be stacked end-to-end, side-by-side, or one on top of the other to give best performance in a given situation.

CONCLUSIONS

Significant energy savings are possible when excess energy generated in the greenhouse is stored for later use in greenhouse heating. PCM encapsulation systems in modular form represent a convenient and efficient form of thermal storage.

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Walnut Propagation Using Bench Grafting

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INTRODUCTION

The deciduous tree *Juglans regia* (English walnut) is of worldwide importance both for its edible nuts and valuable timber. Australia annually imports the majority of its walnut requirements from the USA and China.

Nurseries attempting to vegetatively propagate walnuts typically experience difficulties. Propagation from cuttings is generally not used because the results are too variable (Lagerstedt, 1981). Grafting and budding are more successful (Harrison, 1978, Graves, 1965), but in Australia, even these methods are often associated with low percentage take and inconsistent results Similar problems have been reported in other countries (Avanzato and Tamponi, 1988).

This research aimed to develop a successful walnut grafting technique which would enable nurserymen to rapidly supply the local industry with superior cultivars Work was performed over a period of two years (1988-89) using bench grafting in conjunction with a hot callusing device (HCD) (Lagerstedt, 1981). This device houses the graft union and produces localized heating (27°C) to promote callus development. Other plant parts are maintained at a cooler ambient temperature. For the current work a HCD was used which could accommodate varying rootstock diameters (Deering, 1989). The effects of time of grafting, type of scionwood and length of scion on the percentage 'take' are described

MATERIALS AND METHODS

One year old black walnut (*J. nigra*) seedlings with a stem diameter of 8 to 12 mm at a point 100 mm above soil level were used as rootstocks. For winter grafting, stocks were lifted, graded and stored in the open with the roots covered with nursery soil Rootstocks used for spring and late grafting were stored bare-root in sealed plastic bags at 0°C.

One-year-old lateral scions of the cultivar Franquette, with a diameter of 8 to 12mm, were collected from mature trees Fresh scions were collected within 72 hours of grafting. For spring and late grafting, scions were harvested in June, sprayed with fungicide, and placed in a sealed plastic bag at 0° C

The experiments investigated the following parameters with regard to their influence on grafting success:

1) Time of grafting:	May, July, August and October
2) Scion type:	**Woody scions** were obtained from the proximal half of one-year-old laterals and the internal pith was approximately 40% of the overall scion diameter. **Pithy scions** were obtained from the distal half of one-year-old laterals and internal pith was approximately 60% of the scion diameter.
3) Scion length:	Multibud scions (3- to- 4 bud scions) and single bud scions.
4) Scion treatments:	Fresh scions versus cool-stored scions.

Treatments consisted of ten replications and the proportion of successful grafts was analysed by a generalized linear model using Genstat 5.

Rootstock shoots and roots were pruned prior to grafting. The scions and rootstock shoots were surface sterilised with 70% ethanol or 70% methylated spirits. The grafting knife and secateur were also sterilized regularly. A splice graft was used with the slanting cut on the scion made opposite a bud (Figure 1). The cut on the rootstock was made to match the scion and both were tied tightly with plastic grafting tape, leaving the lower scion bud exposed. The exposed cut end of the scion was sealed with grafting wax, and the grafts transferred to HCD for 15 to 30 days. Plants were removed from HCD as soon as scion buds began to swell and elongate, and were planted directly into a field nursery during cool overcast weather. For the rest of the growing season plants were given standard field nursery treatment.

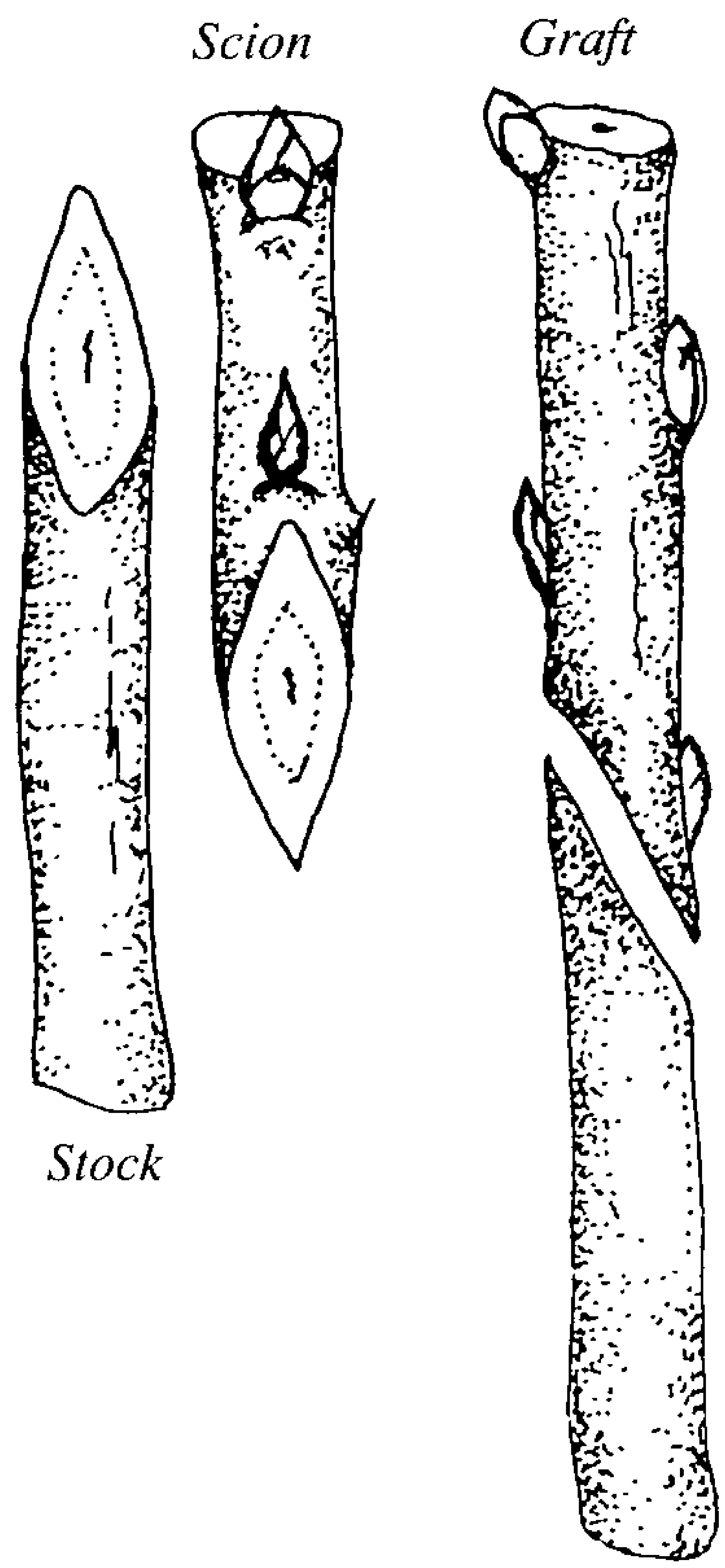

Figure 1. Walnut splice grafting.

RESULTS AND DISCUSSION

Table 1 presents data only for grafting with scions collected and used fresh, i.e. within 72 hours. There was no significant difference between woody and pithy scions. Multibud is obviously better than single bud. However, the rate of success with single-bud scions was such that in the situation where scionwood is limited, use of this type of scion might be warranted. Success rate increases through the dormant period and reaches a maximum in October, which is just before (2 to 3 weeks) natural bud break, i.e. when catkins begin elongation prior to terminal bud swell. Avanzato and Tamponi (1988) also reported highest success with late grafting.

Table 1. Effects of treatments on grafting fresh 'Franquette' scions.

		Successful grafts (%)
Scion type	Woody	59
	Pithy	60
	Significance	NS
Scion length	Multibud	71
	Single bud	47
	Significance	1%
Time of year	May	45
	July	45
	August	65
	October	82
	Significance	1%

Data in Table 2 are for both fresh and cool-stored material. Because no effect of scion type was found in the earlier analysis (Table 1), data for scion type were pooled for the second analysis. Multibud scions were significantly better than single bud scions and later grafting time was the most successful.

Cool storage of scions and rootstocks improved the percentage 'take' (Table 2). Over the period from July to October the percentage 'take' of fresh material increased from 45 to 82% and that of cool-stored material from 67 to 92%. Although cool-stored scions and rootstocks were always superior, perhaps the major benefit of cool storage can be achieved when grafting is done in winter or early spring. Graves (1965) also reported that greatest success was achieved following cool storage of walnut scions at 1°C for 10 weeks prior to grafting.

Use of the HCD in this experiment produced satisfactory grafting results. Where 'Franquette' scion material was tested, both pithy and woody scions could be used successfully. Three- to four-bud scions produced consistently better results than single-bud scions. Grafting was generally best done late in the dormant season but grafting time could be extended and results improved by cool storage of plant material.

Table 2. Effect of treatments on grafting fresh and cool stored 'Franquette' scions.

		Successful grafts (%)
Scion treatment	Fresh scions	64
	Cool stored scions	80
	Significance	1%
Scion length	Multibud	80
	Single bud	64
	Significance	1%
Time of year	July	56
	August	72
	October	87
	Significance	1%

ACKNOWLEDGMENTS

The author wishes gratefully to acknowledge Mr. Bill Thompson, Mr. Graeme Thomson, and Ms. Pearl Benn for their valuable contributions.

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Optimizing Root Initiation by Controlling Exposure to Auxin

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The time of exposure to medium containing 10 µM IBA to achieve maximum rooting (96%) of papaya (*Carica papaya*) shoots *in vitro* was 3 days. One hundred percent root initiation was obtained with neem (*Azadirachta indica*) shoots after exposure to 10 µM IBA for 4 days. For coffee (*Coffea arabica*) shoots rooted *in vivo*, 15 h exposure to 100 mgl^{-1} IBA was optimal in terms of rooting percentage. In lieu of transfer to hormone-free media after 3 days (papaw) or 4 days (neem), good root initiation was achieved by 3 or 4 days dark incubation with medium containing 10 µM IBA and 10 µM riboflavin before transfer to the light, or overlaying of medium containing 10 µM IBA with100 µM riboflavin after 3 or 4 days light incubation.

REVIEW OF LITERATURE

Auxins are used to promote adventitious root initiation *in vitro* (Torrey, 1976). Shoots are usually left on media containing auxins for three or four weeks before transfer. However, it has been known since 1937 that root elongation is inhibited by auxins, such as, IBA (Went and Thimann, 1937). Auxins were also shown to have a dual effect (promotion of root initiation but inhibition of root elongation) in cuttings of *Azukia* (= *Lablab purpureus*)(Mitsuhashi-Kato, et al., 1978) and pea (Mohammed and Eriksen, 1974; Went, 1939) and *in vitro* with apple rootstocks (James, 1983). Thus, there are two distinct phases of adventitious root formation: root initiation, when auxin is essential; and root emergence and growth, when auxin is not required or in inhibitory.

Experiments described in this paper were undertaken to determine the optimum length of exposure to IBA for root initiation *in vitro* of papaya and neem, and for rooting *in vivo* of tissue cultured coffee shoots. In a subsequent experiment, exposure to exogenous IBA is controlled by the addition of riboflavin, which rapidly reduces IBA levels in light (Drew, et al., 1991).

MATERIALS AND METHODS

Effect of Time of Exposure to IBA on Rooting. Papaya shoots were established *in vitro* and multiplied using techniques described previously (Drew, 1988; Drew and Miller, 1989; Drew and Smith, 1986). Axillary shoots, 5 to 10 mm in length, were cultured on rooting medium (RM) containing M (medium) concentrations of minerals and growth factors as described by DeFossard (DeFossard, et al., 1974), without riboflavin, plus 10 µM IBA and 2% sucrose. Fifty replicate explants were removed at intervals (Figure 1) and transferred to hormone-free DS (Drew and Smith, 1986) medium. Control plants were placed on hormone-free DS medium at day 0, or were left on the medium containing IBA for 28 days. Root initiation was assessed daily, and the time required for shoots to reach 50% rooting was calculated. The maximum rooting percentage was the final rooting percent on day 28.

Neem shoots were established in culture using nodal explants from glasshouse-grown plants which were grown from seed obtained from India. Apically dominant shoots were grown on hormone-free MS (Murashige and Skoog, 1962) medium and multiplied by dissection into nodal sections. Actively growing axillary shoots were placed on MS medium plus 10 μM IBA, and 3% sucrose. Twenty replicates were removed on days 2, 3, 4 and 5, and placed on hormone-free MS medium. Control plants were placed on hormone-free medium at day 0 or left on IBA medium for 21 days.

Coffee plants were established *in vitro* using techniques described by Dobson (Dobson, 1991). Axillary shoots, 1 cm in height with 3 pairs of leaves, were dissected from nodal sections and placed in tubes containing 2.5 ml of 100 mgl^{-1} IBA solution. Twenty-four replicates were removed after 5, 10, 15, 20 and 30 hours and planted in peat, perlite and polystyrene foam beads medium (1:1:1, v/v/v). A control treatment was not exposed to IBA, but planted directly into the potting mixture. The plants were maintained in a perspex cabinet at >90% RH with 40% natural light. After 5 weeks, plants were removed from the potting mixture and roots were assessed.

Effect of Riboflavin on Controlling Exposure to Exogenous IBA. The ability of riboflavin to break down auxin in the medium in the light, but not in the dark (Drew, et al., 1991), was utilized to control the length of time shoots were exposed to exogenous auxin. In treatment 1, papaya and neem shoots were cultured for 3 and 4 days respectively, on basal media (RM for papaya, MS for neem)plus 10 μM IBA, then transferred to hormone-free basal media (DS for papaya, MS for neem). In treatment 2, papaya and neem shoots were cultured on basal media (RM, MS) containing 10 μM of both IBA and riboflavin in total darkness for 3 and 4 days respectively, then transferred to a 16 h photoperiod. In treatment 3, papaya and neem shoots were cultured on basal media (RM, MS) plus 10 μM IBA under 16 h photoperiods. After 3 and 4 days respectively, 3 ml of an autoclaved solution containing 100 μM riboflavin was injected from a sterile syringe onto the surface of the agar in each container. Fifty-one replicates were used in each treatment, cultured on 30 ml of medium in 250 ml containers, with 3 shoots in each container. Root initiation was recorded daily.

All tissue culture media contained 8 g l^{-1} Difco bacto-agar and had pH adjusted to 5.6 with 0.1 M KOH before autoclaving at 121°C for 15 min. Cultures were incubated as 25±1° C with cool white fluorescent tubes providing a light irradiance of 55 μmol $m^{-2}s^{-1}$ for a 16 h photoperiod.

RESULTS

Effect of Time of Exposure to IBA on Rooting. Papaya shoots exposed to 10 μM IBA for 3 days before transfer to hormone-free medium had highest final rooting percentage (96%) and shortest time to root (Figure 1A). With neem shoots, 100% root initiation was obtained after exposure to 10 μM IBA for 4 days, and time to 50% root initiation was minimal after 5 days exposure to IBA (Figure 1B). Exposure to IBA for 21 days (neem) or 28 days (papaw) resulted in excess callus production on the base of the shoot and short callused roots with no lateral branches.

Time of exposure to IBA also affected root initiation with tissue-cultured coffee shoots rooted *in vivo*. Fifteen hours exposure to 100 mg l^{-1} was optimal in terms of

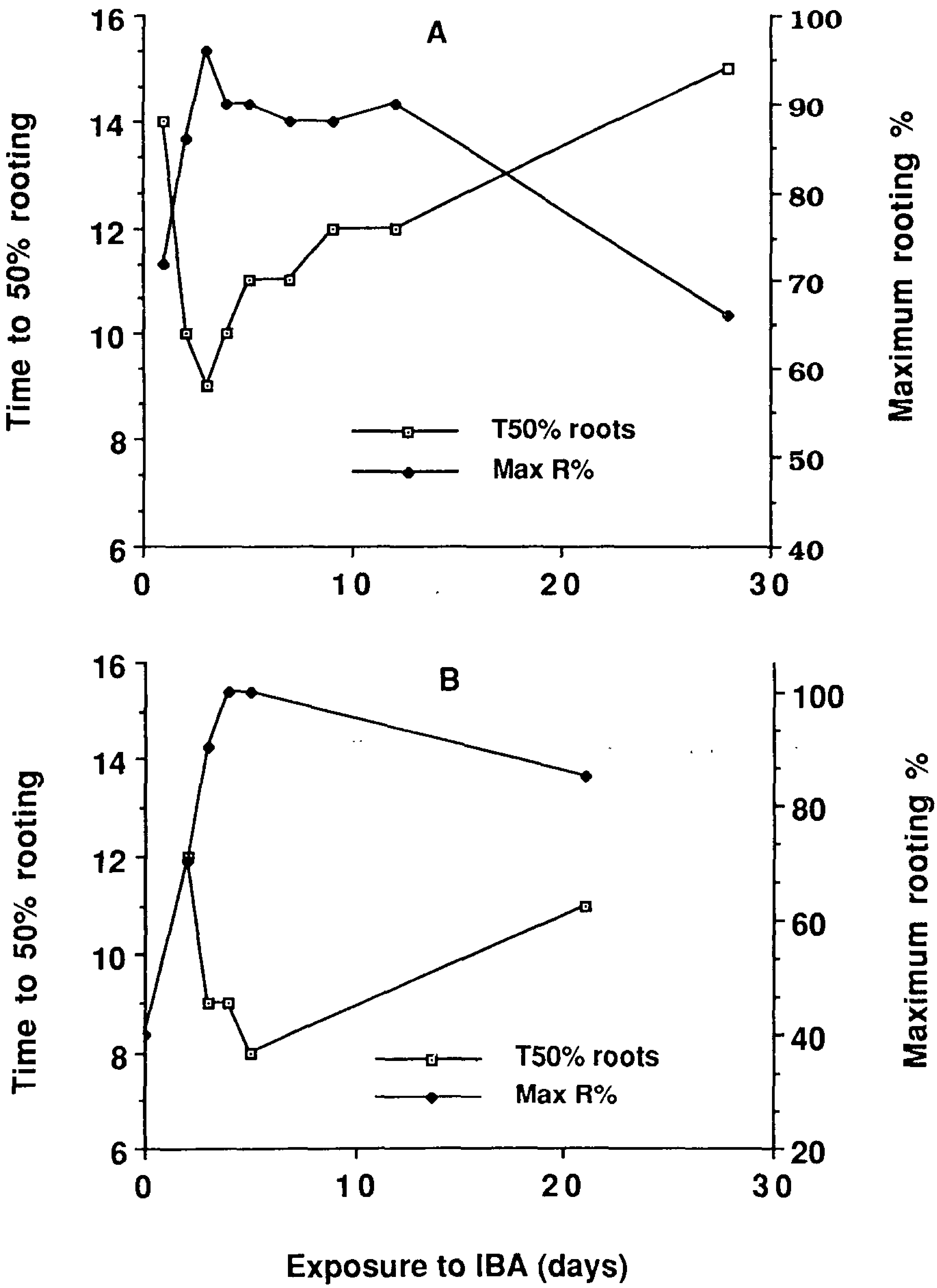

Figure 1. The effect of time of exposure to medium containing 10 μM IBA before transfer to hormone-free medium, on rooting *in vitro* of papaya (A) and neem (B). No papaya shoots rooted on control treatment (0 days). T50% roots = time to 50% rooting, MAX R% = maximum rooting percentage. Results are means of 50 replicates for papaya and 20 replicates for neem.

rooting percentage (92%), and 20 hr as assessed by mean root number per shoot (Figure 2).

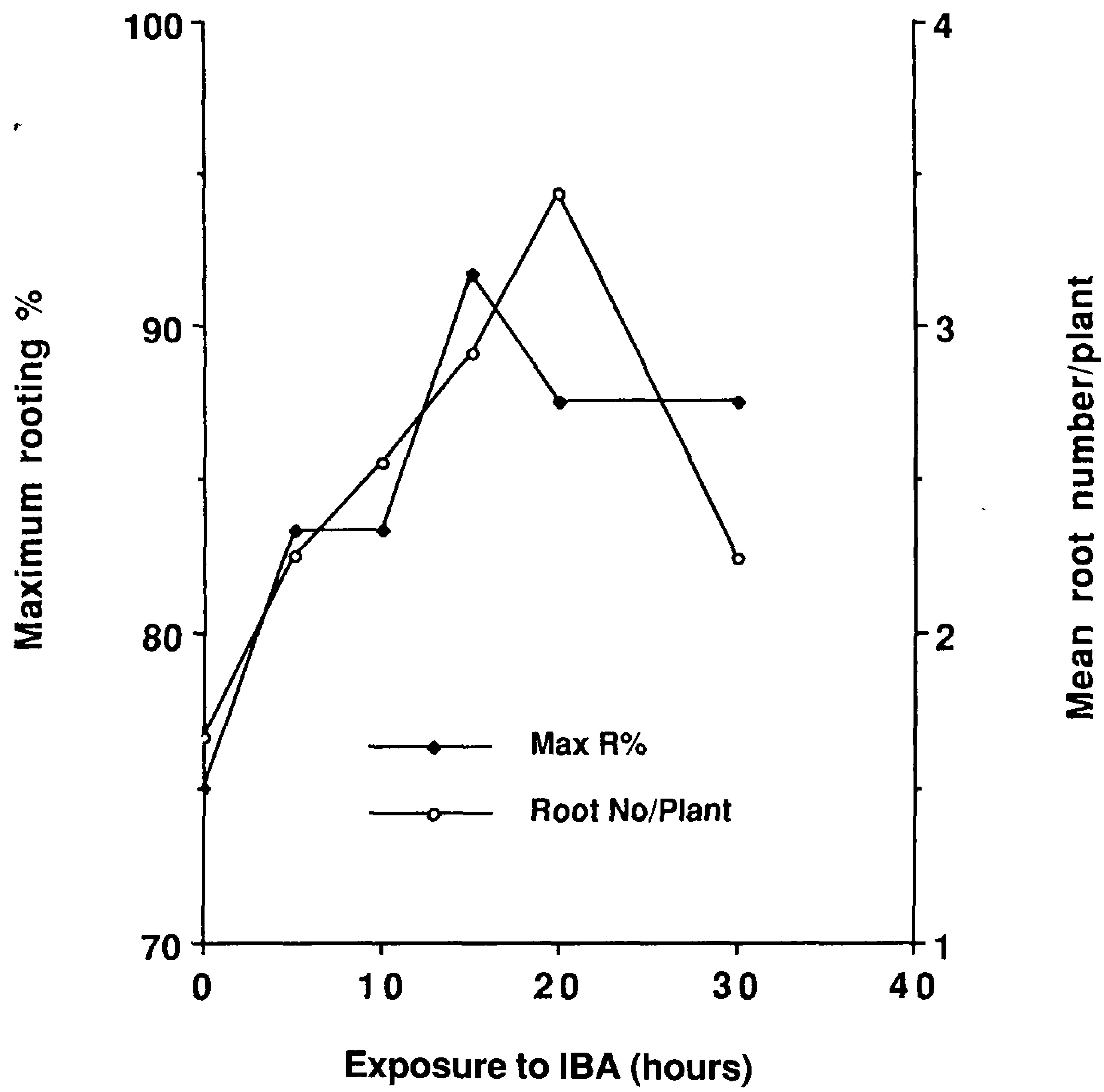

Figure 2. The effect of time of exposure to 100 mg l^{-1} IBA prior to planting, on *in vivo* rooting of coffee shoots which had been multiplied *in vitro*. T50% roots = time to 50% rooting, MAX R% = maximum rooting percentage. Results are means of 24 replicates.

Effect of Riboflavin on Controlling Exposure to Exogenous IBA. Papaya shoots transferred to hormone-free medium after 3 days (treatment 1) gave highest rooting percentages (Table 1), but high rooting percentages were also achieved by incorporation of riboflavin in the medium and exposure to light after 3 days dark incubation (treatment 2), and by overlaying medium with riboflavin on day 3 (treatment 3). Neem shoots showed little difference between treatments in terms of rooting percentages (Table 1). Papaya shoots which were not transferred to hormone-free medium were smaller and had short thick roots, and neem shoots from cultures in which riboflavin was injected onto the surface of the agar had some callus at the base of the explants.

Table 1. Root initiation of papaya and neem *in vitro*.

	Treatment		
	Transfer to hormone-free medium[1]	Dark incubation[2]	Riboflavin overlaid onto medium[3]
Papaya:			
Percent rooted after:			
14 days	92	80	78
28 days	98	88	88
T50 (days)	9	10	10
Neem:			
Percent rooted after:			
14 days	93	90	91
T50 (days)	8	8	9

[1] Shoots transferred from a medium containing 10 µM IBA to a hormone-free medium.
[2] Shoots on a medium containing 10 µM IBA and 10 µM riboflavin, cultured in the dark then transferred to light.
[3] Shoots on a medium containing 10 µM IBA cultured in the light, then overlaid with 100 µM riboflavin. These manipulations were done on day 3 for papaw and day 4 for neem, using 50 replicates per treatment. T50 = time to 50% root initiation.

DISCUSSION

Improved commercial micropropagation systems could be developed for many species if optimum time of exposure to auxin was determined and shoots subsequently grown on auxin-free media. The optimum time of exposure to IBA for papaya *in vitro* has been shown to be 3 days, and 4 days for neem (Figure 1). For micropropagated coffee shoots which can be rooted *in vivo*, a pretreatment of 15 h exposure to 100 mg l^{-1} IBA was optimal for rooting.

Transfer of plants to hormone-free media may be uneconomical for commercial practice. However, exposure to auxin can be controlled by addition of riboflavin to the medium. Drew *et al.* (1991) showed that IBA concentration in media could be decreased rapidly when media containing riboflavin were placed in light. This reduction did not occur with dark incubation (Drew, et al., 1991). Thus cultures can be incubated in darkness on media containing both IBA and riboflavin before being returned to light where the riboflavin will photooxidize the auxin, or cultures can be maintained in light and the media then overlaid with riboflavin solution.

Experiments described in this paper show how optimum time of exposure to auxin can be determined to maximize root initiation. The beneficial effect on rooting of transfer of papaw and neem to media without hormones, can be economically achieved by using exogenous riboflavin and light. These techniques may be applicable to a wide range of species.

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In Vitro Factors Affecting Plant-Out Performance of Micropropagated Plants

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INTRODUCTION

There is a direct relationship between plant-out success and the quality of the product coming out of the micropropagation laboratory. As with other forms of plant propagation (cuttings, grafts and seeds), success rate is dependent on the health and pre-treatment of the stock plants.

With any new technology, it takes a while to identify the factors affecting quality and then how to go about manipulating these variables to maximize quality. In this paper I will present what I consider some of these variables, and my personal observations over the eight years I have been in commercial plant micropropagation.

My observations will be confined to three topic areas: 1) growth rate, 2) light intensity, and 3) relative humidity.

GROWTH RATE

Plant growth *in vitro* requires a carbon source (sugar) in the medium. When plants are transferred to a medium without an added carbon source they do not grow and are usually dead within a few weeks, indicating they have a negative carbon balance. Grout and Millan (1985) found that with strawberry plantlets "carbon fixation by leaves produced in vitro is low, insufficient to sustain growth autotrophically, and does not increase significantly during the acclimitization period following transplanting. Leaves that developed after transplanting fix relatively high levels of carbon 7 days after emergence, allowing continued whole plant growth, and show a significant increase in fixation subsequently" This shows that *in vitro* leaves serve as an energy store until the plants had new leaves capable of maintaining the carbon balance. One of their conclusions for improved transplanting was to maximize the rate of new leaf production following plant-out.

Similar conclusion can be made for roots. Even if the plants have produced functional roots in culture, all the root hairs will be removed with the agar. So if we have actively growing root tip meristems prior to plant-out, within a short period of time the plants will have functional roots.

My application of these conclusions has led to the production of plants such as the *Grevillea* in Figure 1, left. This plant, 10 days after plant-out, will have 1 to 3 new leaves and 10 mm of new root growth with root hairs, as in Figure 1 right.

Time on Delivery Media. There is a finite quantity of nutrition in micropropagation media. The effect of this on plant growth is best summarized by Figure 2. This shows an initial acclimitization phase, then rapid growth until nutritional deficiency starts, then a gradual reduction in growth rate until, finally, zero growth. What we need to do is identify the time to the peak in the curve, and plant-out then.

Figure 1. The ideal *Grevillea* 'Robyn Gordon' to plant-out (left), and 10 days later.

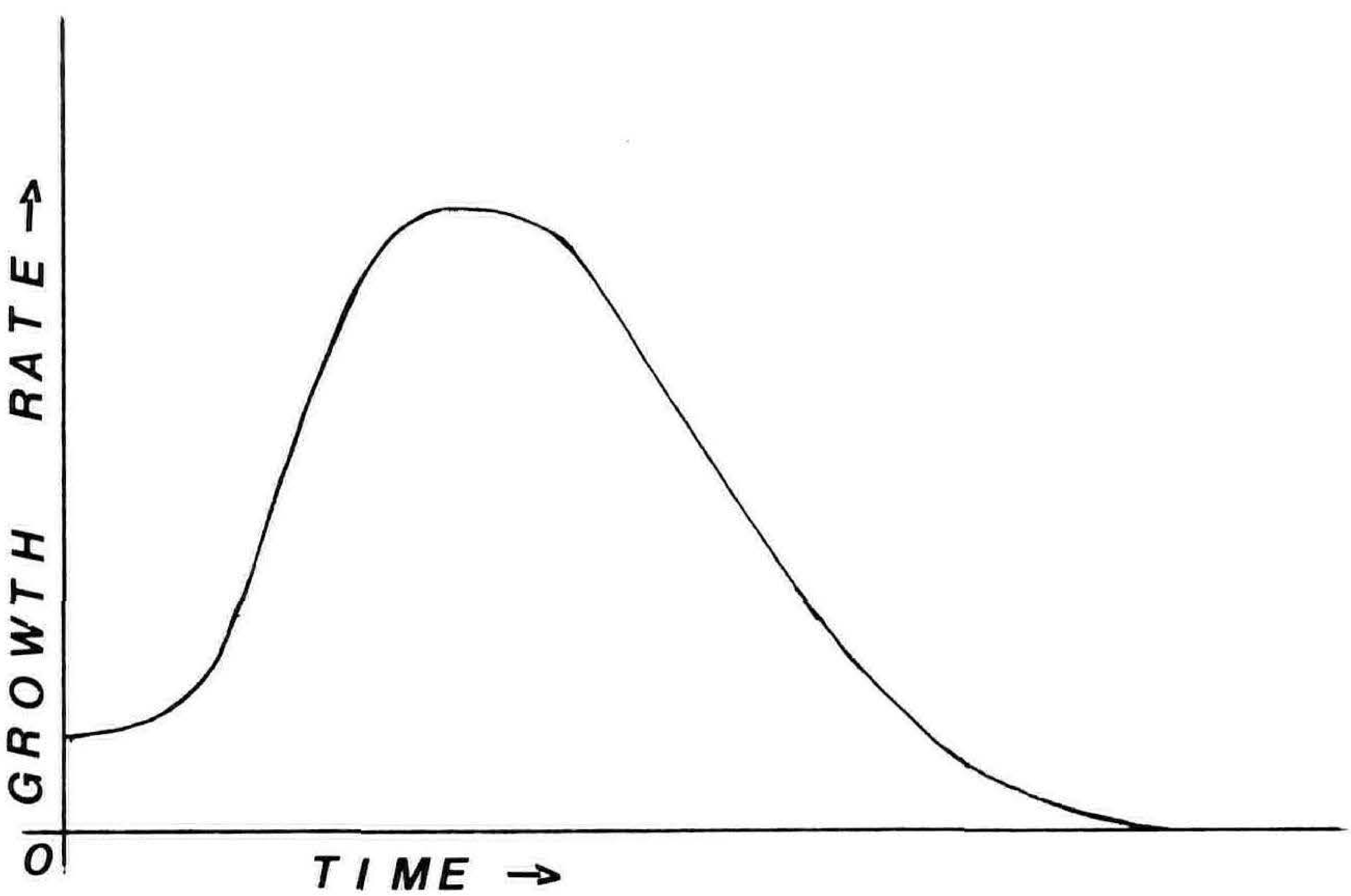

Figure 2. Growth rate verses time, for plants grown in finite nutrition.

I did an experiment with *Syngonium podophyllum* 'White Butterfly' to examine the effect of length of time spent on the delivery medium on plant-out performance.

The experiment consisted of 96 plants at each of three ages on delivery media (3, 5 and 7 weeks). They were planted into a peat and fine polystyrene mixture, (1:1, v/v) placed on a 25° C bench, with mist for the first 5 days.

Figure 3 shows the plants just before plant-out. The following were noted in this research:

1) Plants on the medium at 3 weeks have new leaves unfolding.

2) There is a considerable difference in size and root length between the 3 and 5-week plants while plants grown for 5 and 7 weeks are similar in size.

3) All the 7-week plants have 1 or 2 of the lower leaves yellow and dead, indicating that they have run out of nutrients and have a negative carbon balance.

Four weeks after plant-out we went through and counted the losses, from the 96 of each age - none for 3 weeks, eight at 5 weeks and fifteen at 7 weeks. Another significant observation was the number of "runts" where the plants were smaller and the new leaves were not much larger than the ones before. The number of "runts" were two, eleven and twenty respectively. The "runts" were obviously not in good physiological health, and just managed to make it through the shock of plant-out.

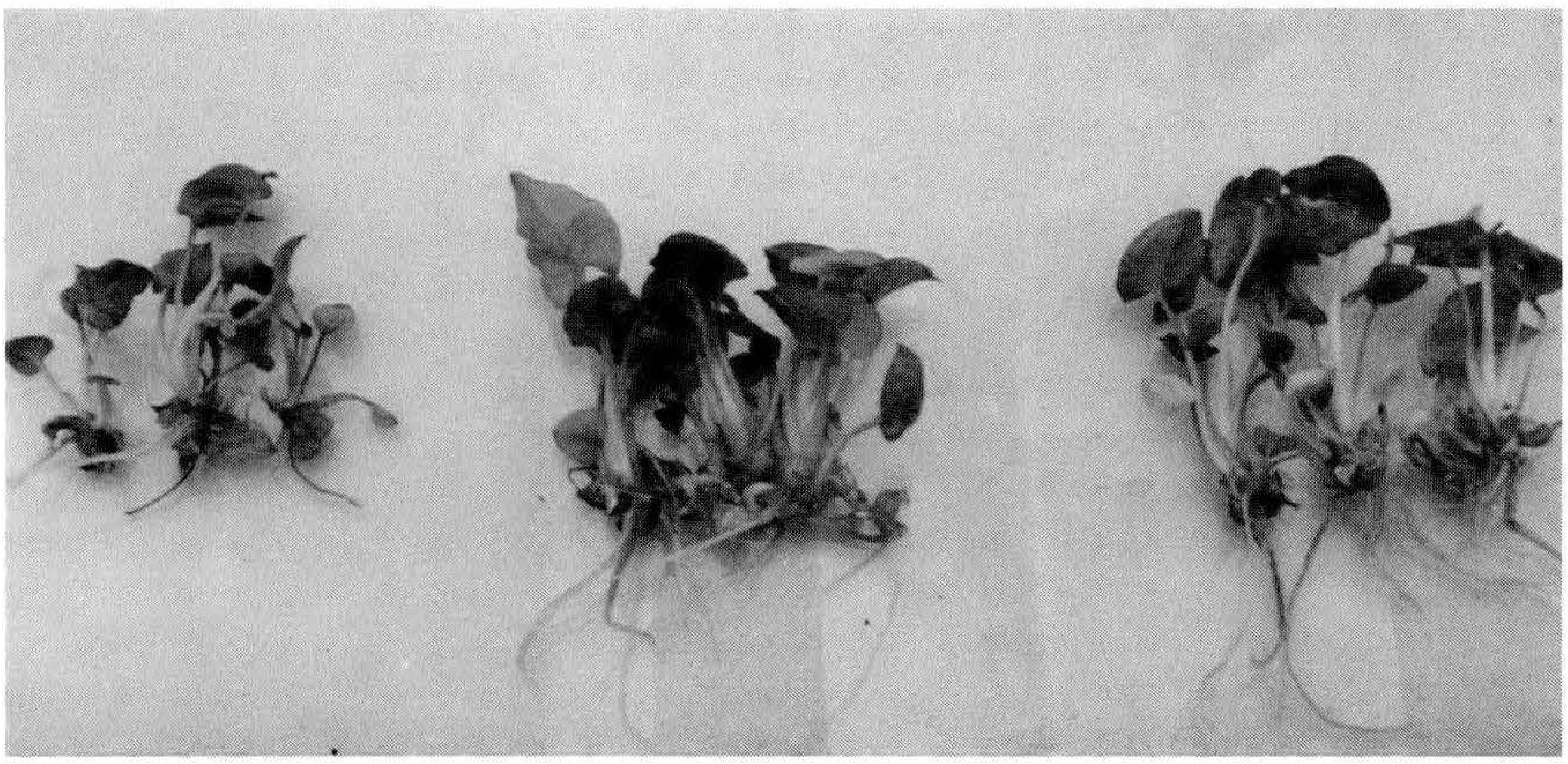

Figure 3. Appearance of *Syngonium podophyllum* 'White Butterfly' after varying time on delivery media. Left to right: 3, 5 and 7 weeks.

From these results it appears that the best time to plant-out *Syngonium podophyllum* 'White Butterfly' under our laboratory conditions, would be at 3 weeks.

Contamination. Nutritious sugary micropropagation medium, as well as being good for growing plants will, also grow most microorganisms. These compete with the plants for nutrients in much the same way as weeds compete with plants in pots (except that they can not be manually removed).

The effects of a contaminant microorganism varies with the organism, severity of the infestation, and whether or not it is producing a toxin. As a basic generalization, if the contaminated *in vitro* plants are smaller than non-contaminated ones, incubated for the same period of time, the contaminating organism has reduced the growth rate.

Age of Motherstock. In the same way as poorly watered and fertilized plants make poor sources of cutting material, cultures left too long between subcultures produce inferior plant-out material.

I have noticed that cultures left unworked for several months usually require 2 to 3 subcultures before they perform as well as those that are regularly worked. This I have put down to the loss of juvenility.

LIGHT INTENSITY

Although photosynthesis is not an important source of energy for the plants, light levels do have a marked affect on their morphology *in vitro* Haramaki (1971), using gloxinias, found that increasing light levels up to 3,200 lux produced progressively larger plants with greater leaf size, while at 10,700 lux there was little growth, and leaves were smaller and discolored.

I have noticed similar responses in my laboratory. Figure 4 illustrates the effect of light levels on *Gerbera jamesonii in vitro* and, as you can see, my results agree with those of Haramaki. When these plants were planted out as per the *Syngonium podophyllum* 'White Butterfly' above, after 4 weeks none out of the 32 plants incubated under 1500 lux had died, while 18 of 32 at 300 lux were dead.

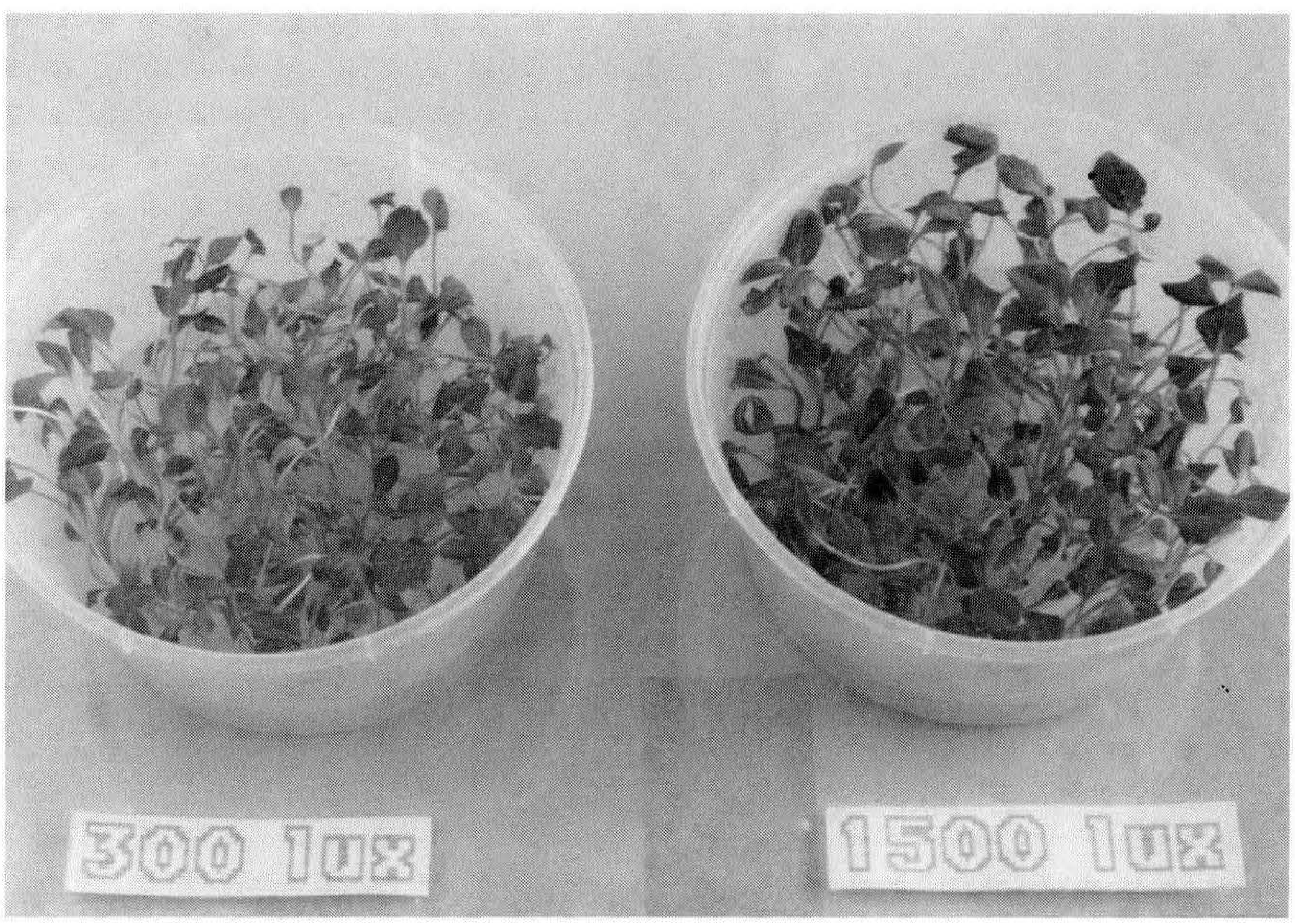

Figure 4. Appearance of *Gerbera jamesonii* cultures after incubation under varying light levels. Left to right: 300 and 1,500 lux.

I undertook the same experiment using *Spathiphyllum* 'Petite'. The best plants were produced at 300 lux, while those under 1,500 lux were smaller, with smaller, paler leaves, and less root development.

From these results it appears that optimum light levels for each crop need to be experimentally determined.

RELATIVE HUMIDITY

In the culture vessel there is very high relative humidity because it is a capped vessel with water in the bottom. This results in a number of deleterious physiological effects:

(1) Condensation droplets form on the container walls and top. When a leaf or shoot tip touches the container, it traps this condensation, which can lead (especially in woody species) to a drowning of this organ.

(2) This high relative humidity can produce vitrified (glassy) plants, where the stems and leaves are translucent, thickened and brittle. These plants are impossible to plant-out successfully.

(3) Woody plants have a major problem with shoot tip die-back (necrosis). Barghchi (1987) attributed this to the high relative humidity reducing transpiration by the leaves, which resulted in reduced water uptake and reducted uptake and translocation of certain minerals that are dependent on the transpiration stream for transport to the shoot tip.

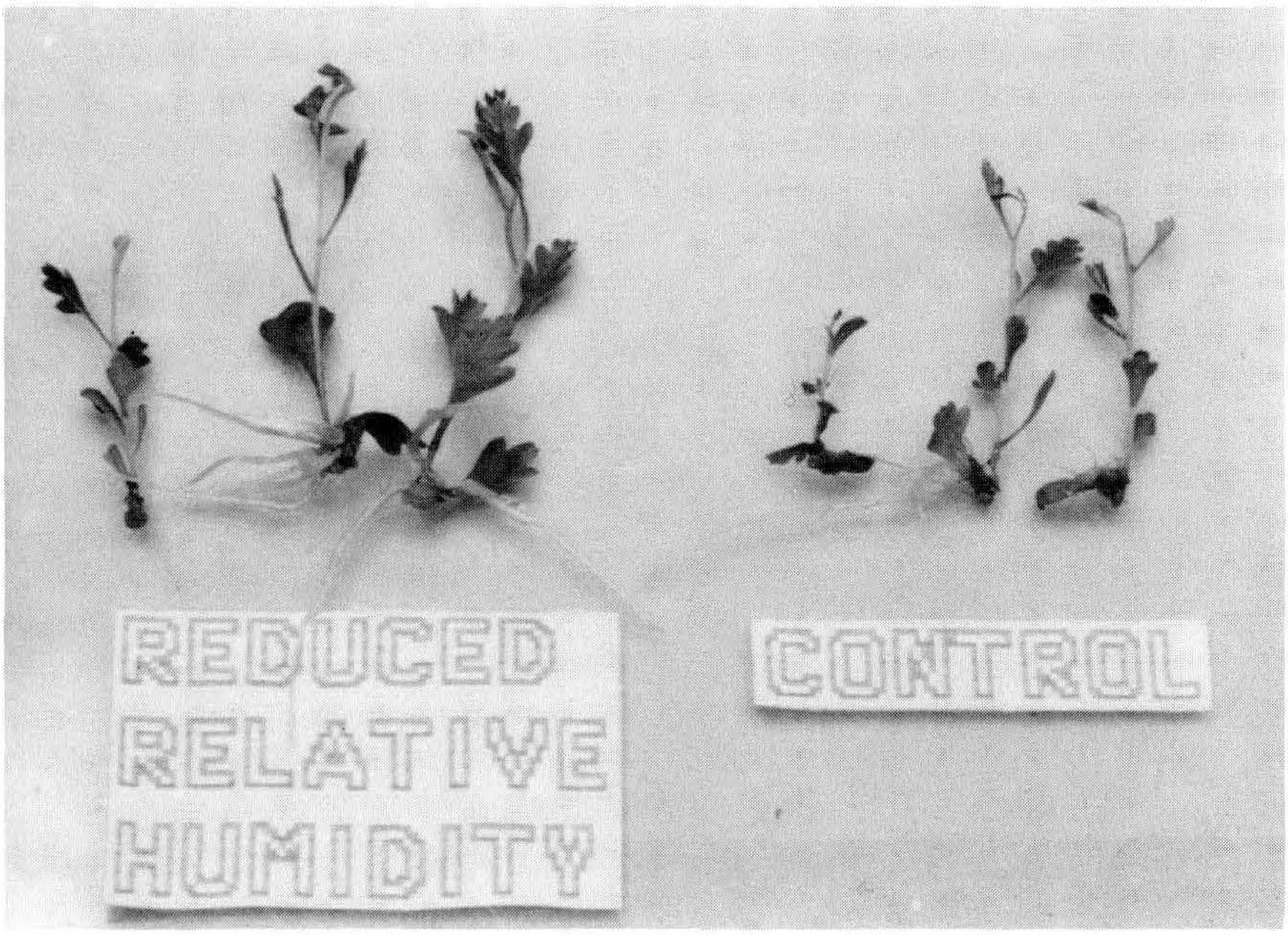

Figure 5. Appearance of *Grevillea* 'Robyn Gordon' after incubation under reduced relative humidity, compared with control.

A technique for reducing relative humidity, by placing the culture vessel on a surface 3 to 5°C cooler than the incubator temperature was tested (P. Debert, Personal Communication). The water vapor condensed on the bottom of the container, with a gradient of decreasing relative humidity up the container. Using this technique we have been able to almost completely remove any of the above problems. Figure 5 illustrates the effect of reduced relative humidity on *Grevillea* 'Robyn Gordon'. The plants and their individual leaves are larger, and there is no tip necrosis.

CONCLUSION

A good simile for the transition stage between *in vitro* and *in vivo* is a level road with a fully laden truck building up speed to get up a hill. This is our plant ready for the planting out. If it reaches the base of the hill just as it gets full momentum up it will get up and over without loosing too much speed. If it reaches the hill after some slowing down, for whatever reason, it will lose this momentum, have to drop to a lower gear or gears and will take a long time to get back to speed — if it ever does.

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Mechanisation of the Tubing Operation in a Commercial Propagation Nursery

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Commercial tube production is a relatively labour intensive operation when compared to production in general nursery containers. This is due mainly to the fact that a very large number of units need to be produced to be economically viable. Although trays and pallets are used to convey tubes through the nursery *en masse*, there are several stages at which each unit needs to be handled individually—the cutting/dibbling stage, the tubing stage, and possibly grading for sale.

This paper details our efforts as a specialist tube nursery to mechanise the tubing stage, using a potting machine. We were aiming to achieve several objectives:

1) To increase the production output per person.
2) To decrease the time allocated to potting.
3) Achieve these goals with unskilled labour.

There are several potting machines available, each slightly different in its operation. We looked at two machines, the Javo and the Tolley Plantmaster.

The Javo, as is the case with most potting machines, overfills the empty container with mix, brushes it level, then drills the required size hole in which to place the plant.

The Tolley Plantmaster uses a different method of operation. The cutting is planted at the same time that the container is being vibrated and filled with potting mix.

We found the Tolley Plantmaster method better suited to our application of filling small containers, such as 50 mm and 75 mm tubes, and this is the potting machine we acquired. It was also necessary to purchase a bulk feed hopper as the Plantmaster has no mix storage capacity.

METHODS

We operate our machine using two operators and the work table is timed to index every 2.8 seconds. At the first station the operator places an empty tube into one of the four pot holders with his/her right hand. The container then moves on to the second station where the planting operator holds a cutting in the empty tube while it is being filled with mix from the funnel head. The second operator usually removes the cutting plugs from the cell trays with the left hand while the right hand is doing the planting. As the left hand has the quicker of the two operations, it is possible to build up a reserve of cuttings in the left hand and this gives the operator time to grade out any dead or poor cuttings but always having a supply to feed to the right hand doing the planting. Initially most operators attempt the complete operation with one hand. If, however, they select a cutting with no roots, there is insufficient time to select another and place it in the tube before it is filled with mix. The planted tube then moves on to station 1 again where the first operator removes the planted tube with the left hand and places an empty tube in the holder with the right hand.

The planted tubes are packed into a wire tray that holds 100 tubes. We have a bench which holds two of these trays at an angle of 30° to help prevent the tubes from spilling over. Once the trays are full, they are placed on a motorised barrow which is fitted with a pallet designed to hold ten wire baskets. When the pallet is full, the potting machine is switched off and the plants are taken to where they are to be grown-on. Each tray is then individually placed into rows on a gravel growing bed and the empty pallet is returned to the machine to be refilled. The newly potted tubes are watered-in.

RESULTS

Increased production output per person was not easy to achieve. In the initial stages we were striking cuttings in community pots or trays and much time was spent knocking out these cuttings before planting on the machine could commence. Also, trying to plant at high speed with a bare-rooted cutting can be difficult and a lot of misses result.

After trials using paper pots and various cell tray systems, we found the 198 cell Growing Systems Tray to be the most suitable for our production system. Once the cuttings have rooted, the trays are 'popped' on a peg board and this makes removal of the plugs quick and easy. The compact root plug is very easy to plant at high speed. Production output increased as a result.

We found that an 8 hour potting day was tiring and became monotonous day after day. Good potting rates were achieved early in the day but the rate dropped off as the day progressed. After trying various ways to improve, we finally settled on our current system of operation. We now have a maximum 4-hour shift for any two operators in one day. Approximately 3 1/2 hours in the 4-hour shift is available for potting.

At the start of the shift one operator assembles a supply of tubes and trays and also barrows out the cuttings to be tubed and 'pops' them on the peg board. The other operator makes 1/2 cubic meter of mix in the soil mixer and places it in the bulk feed hopper. For the system to work, it is important that all of the mix is used during the shift, allowing for any following shifts to duplicate the operation. We use various mixes for different plants and the operation is disrupted if a mix needs to be made part way through a shift.

We tube approximately 3,200 tubes per mix in a 4-hour shift. Using this system, it is possible to produce approximately 6,500 tubes in an 8-hour day for two people i.e. 16-man hours. This rate effectively doubled what we were achieving with the average person tubing by hand and improved by 1,500 to 2,000 tubes on what we had been achieving on average on the potting machine previously. This system therefore allows for a large number of units to be potted in peak periods by working additional shifts. It allows us to rotate staff around their various jobs to eliminate the problems associated with employing and training staff for short seasonal peaks.

We have been moderately successful in achieving these results with relatively unskilled labour. A completely unskilled operator can master the first station where the tubes are placed on and off the machine and be up to full speed within a few hours. The planting operation, however, appears much more difficult and we have found only the most proficient staff in the nursery are able to perfect the technique. The operator needs to develop more skills to plant on the machine than would be needed for hand tubing.

CONCLUSIONS

We found repairs and maintenance costs were negligible when compared to the number of units produced. The major wearing parts are the elevator chain, sprockets, and bearings with a total replacement cost in parts of around $400.00. All are readily obtainable.

At faster potting speeds it is easy to plant cuttings too deep or too shallow or at an angle. A standard of quality needs to be set and must be monitored closely to ensure the level of quality required is being maintained. At higher speeds the machine tends to whip soil out of the tubes as they index to the next station and this needs to be adjusted for with mix levels in the machine and also moisture content of the mix. The planting operator controls these factors and this is where experience and technique are required to perform the operation satisfactorily, and to maintain quality.

Probably the most important thing to realise is that the potting machine is only one part of the overall potting production system and a continuous work flow can only be achieved if the supply of materials both to and from the machine is adequate.

The machine sets the pace in the potting system and forward planning to ensure that sufficient potting mix, pots, cutting plugs and growing area are available is essential if delays are to be avoided. The process of integrating a potting machine into an individual nursery situation may take months or even years of changing methods before maximum efficiency is obtained.

We have a number of planned modifications to further improve efficiency. It is our intention in the future to palletise the operation by lowering a completed pallet of 10 wire trays onto the growing bed and then pot onto additional pallets. We are also experimenting with various cell trays in an effort to improve or eliminate our existing 'popping' operation; use of conveyors would further assist material supply.

Improved efficiency in the use of potting time and labour can be achieved by mechanising the tubing operation. However, the potting machine is only one part of the overall system. Other nurseries need to examine their individual operations to assess the viability of installing a potting machine.

Simple Methods of Micropropagation

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Many Australian tree species can be readily micropropagated using simple techniques and low-cost facilities. This enables the advantages of micropropagation to be integrated into propagation programs. Advantages may include very high multiplication rates, freedom from pests and pathogens, cheap and reliable transport across quarantine barriers, reliable inoculation with symbiotic microorganisms, and long-term storage of clones *in vitro*. The simple methods of micropropagation described in this paper are worth testing for other species. They can be readily integrated into most existing nursery operations.

INTRODUCTION

Micropropagation has a number of advantages over propagation of plants by conventional cuttings. These include:

- Higher multiplication rates per unit area.
- The ability to easily maintain cultures, once decontaminated, free of pests and pathogens for long periods.
- Cheap transport across quarantine barriers or between nurseries for growing-on of plants close to markets.
- The ability to inoculate plants with specific mycorrhizal fungi or other symbiotic microorganisms which are beneficial to survival and growth after planting.
- The ability to manipulate many more factors in the medium and the environment than is practicable with cuttings.

In Australia, and elsewhere, many commercial micropropagation laboratories exist as specialized facilities with a high capital cost, supplying micropropagated plants to other nurseries for growing-on and marketing.

Plant propagators are very innovative and test numerous propagation techniques to produce plants cheaply. However, micropropagation has been considered to require special skills and expensive facilities, and the technique is not generally used (even on a small scale) by most commercial nurseries. This situation has arisen because in many cases there are poor links between micropropagation researchers and the plant propagation industry. However, some researchers are notable exceptions to this rule (de Fossard and Bourne, 1977).

In addition, the application of micropropagation in the plant propagation industry is hindered by researchers who make unrealistic claims about multiplication rates and the performance of clones over seedlings (Australian Science Technology Newsletter, 1990).

This paper discusses how you can use microrpopagation techniques in your nursery with your plants, and minimal additional facilities. Propagation managers can then assess multiplication rates and other critical factors first-hand, in order to make decisions on whether to use specialized facilities or laboratories for large-scale micropropagation. Most plants that can be readily propagated by cuttings can be readily micropropagated.

SIMPLE METHODS

Micropropagation involves four basic steps:

1) Shoot surface sterilization and establishment.

2) Shoot multiplication by repreated subculturing of shoots onto new medium. Cultures can be maintained for long periods of time (years) in this way.

3) Selected shoots are rooted *in vitro* on a rooting medium or set as microcuttings using conventional procedures.

4) Hardening-off and growing-on of rooted plants.

These techniques, and several others, are covered in standard texts such as Plant Propagation by Tissue Culture (George and Sherrington, 1984) and Plant Propagation - principles and practices (Hartmann and Kester, 1983). In principle, micropropagation is similar to propagation by stem cuttings from a block of clonal mother plants. With micropropagation, shoot cultures represent the block of clonal mother plants which produce shoots for rooting *in vitro* or for setting as microcuttings.

1) **Surface sterilization.** Shoots can be readily sterilized in dilute solutions of domestic bleach (about 0.5% chlorine). About 10 to 15 minutes is enough time for most species but you will have to experiment. Shots are then rinsed once or twice in sterile water.

2) **Media formulations.** Many species can be propagated on just a few basic media (George et al., 1987; Hartney and Svensson, 1990) which are readily available as pre-packed mixtures from commercial suppliers (Flow, Sigma, Gibco). Some of these pre-packed formulations contain organic growth factors and plant hormones or these can be added separately if you wish to conduct your own experiments.

In our laboratory we have been able to propagate all of the species listed in Table 1 on only two basic media (Hartney and Svensson, 1990). Many of these species were previously very difficult to micropropagate.

3) **Containers.** Take-away food containers, petri dishes and a wide range of plastic and glass containers are suitable. Aluminium foil and some plastics can substitute for lids of containers.

4) **Growth environments.** We have grown cultures on window ledges, in shade houses (about 80% shade) and on shelves illuminated by one or two fluorescent tubes. Care must be taken not to grow cultures under very high light levels as this will cause the plants to overheat (because of the greenhouse effect in miniature); 10% to 20% full sunlight is ample. Accurate temperature control is not essential for many species.

5) **Laboratory equipment.** Expensive laboratory items are not essential. Transfer chambers for subculturing shoots from one medium to another under sterile conditions can be made out of fish-aquariums with plastic covers and sleeves (Figure 1). Such still-air chambers can be readily sterilized by spraying a dilute chlorine solution (about 1% chlorine) over the work area. Domestic pressure cookers can replace autoclaves for sterilization of media, and simple pH meters or indicator solutions are adequate for small-scale operations.

6) **Environments for rooting and growing-on of plants.** Many species develop roots when they are set as microcuttings in standard misting beds, fog houses or plastic enclosures as used with traditional cuttings.

Table 1. Number of clones of various species micropropagated under various conditions.

Species	Under commercial conditions	Under research conditions	Presently recalcitrant	Rooted ex vitro*
Acacia auriculiformis	4	3	1	
A. maconochieana	1			
A. mangium	6	5		
A. stenophylla	2			
Allocasuarina verticilliata	1			y
Casuarina glauca (= C. obesa)			1	
Chrysanthemum cinerariifolium (= Tanacetum cinerariifolium)	2			y
Eucalyptus aggregata	1			
E. andrewsii subsp. *campanulata*			1	
E. annulata	1			
E. blakelyi		2	1	
E. camaldulensis	42	11		y
E. curtisii	1			
E. deglupta	1			y
E. desmondensis	1			
E. diptera	1		1	
E. ficifolia		1		
E. grandis	4	3		
E. gillii	*1*			
E. globulus subsp. *bicostata*		1	1	
E. globulus subsp. *globulus*	1	6	2	y
E. macrandra	1			
E. marginata	6			
E. melliodora	1			
E. nitens		20	2	
E. nitens x *E. globulus*	2	1		
E. ochrophloia		1	1	
E. ovata		1	1	
E. pileata	1			
E. rudis	1			
E. tereticornis	1			y
E. viridis	1			
E. wandoo		4	5	
E. yarraensis		1		y
Flindersia brayleyana		2		
Melaleuca alternifolia	7			y
M. bracteata	4	1		y
M. cajuputi		1		
M. decora			1	
M. eleuterostachya			1	
M. glomerata	1	2		
M. halmaturorum	2	2	1	
M. lanceolata	1	3	1	
M. lateriflora subsp. *lateriflora*	4	1		
M. quinquenervia			1	
M. thyoides	3	2		
Pinus radiata		20		y
Populus deltoides		2		y
P. deltoides x *P. nigra*		3		y
Simmondsia chinensis		2		
Toona australis		1		
TOTALS	**105**	**103**	**22**	

* = successfully rooted outside of culture

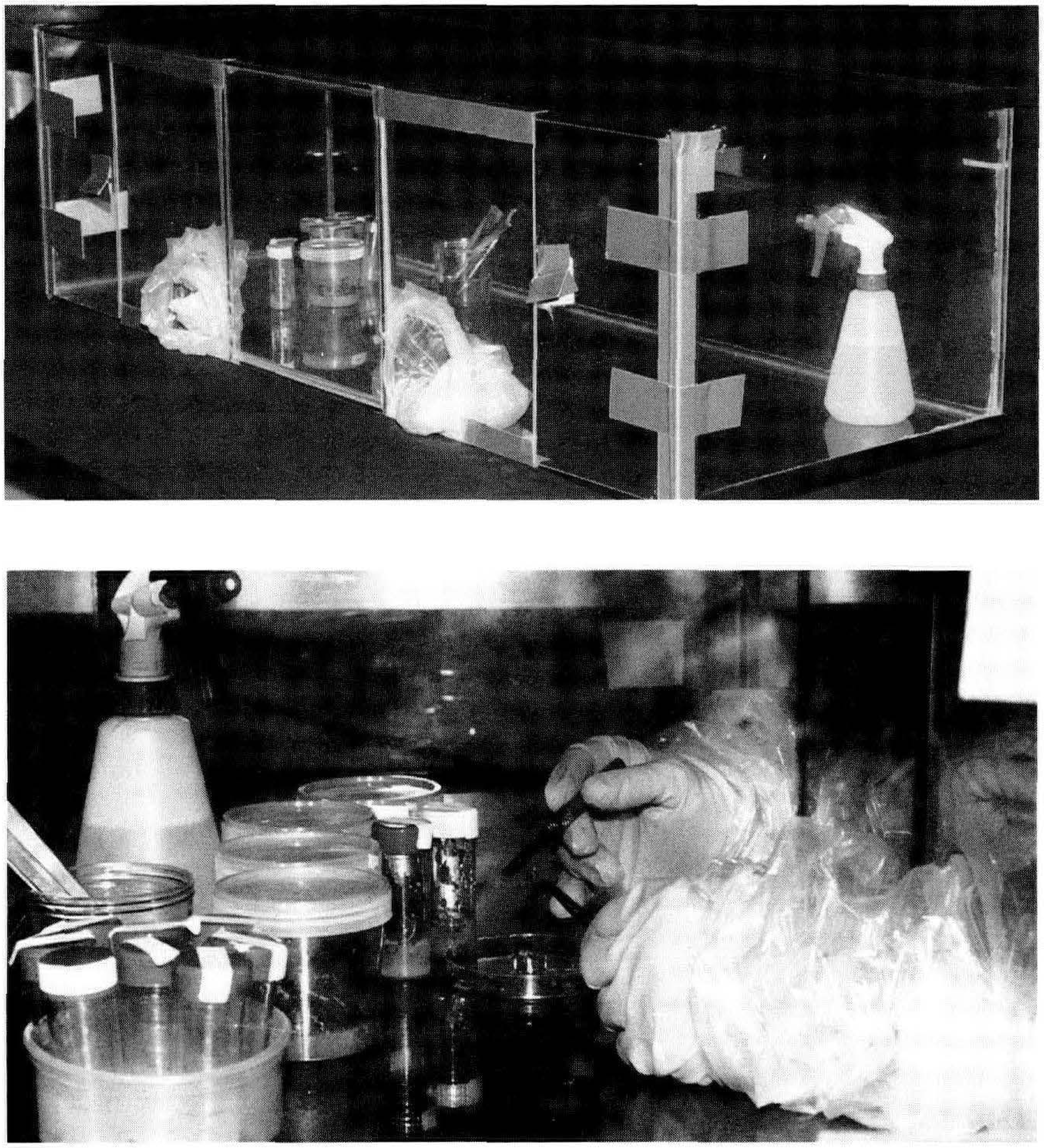

Figure 1. A transfer chamber made from a modified aquarium.

However, micropropagated plants and shoots in culture are growing under high-humidity conditions and they are much more sensitive than standard cuttings to water stress. Shoots or rooted plants in culture can be hardened by allowing water to evaporate from the container. This is simply achieved by covering the container with plastic food wrapping (e.g. 'Glad Wrap', 'Seal Wrap') as many of these are permeable to water vapour (Figure 2). In addition, growing cultures at a higher light intensity prior to hardening-off is often an advantage.

Plants can be grown-on in bean-sprout containers with standard potting mixtures (Figure 3). These containers enable adequate shoot and root growth prior to placing plants in standard nursery trays.

Figure 2. Containers covered with plastic film to enable hardening-off of rooted plants.

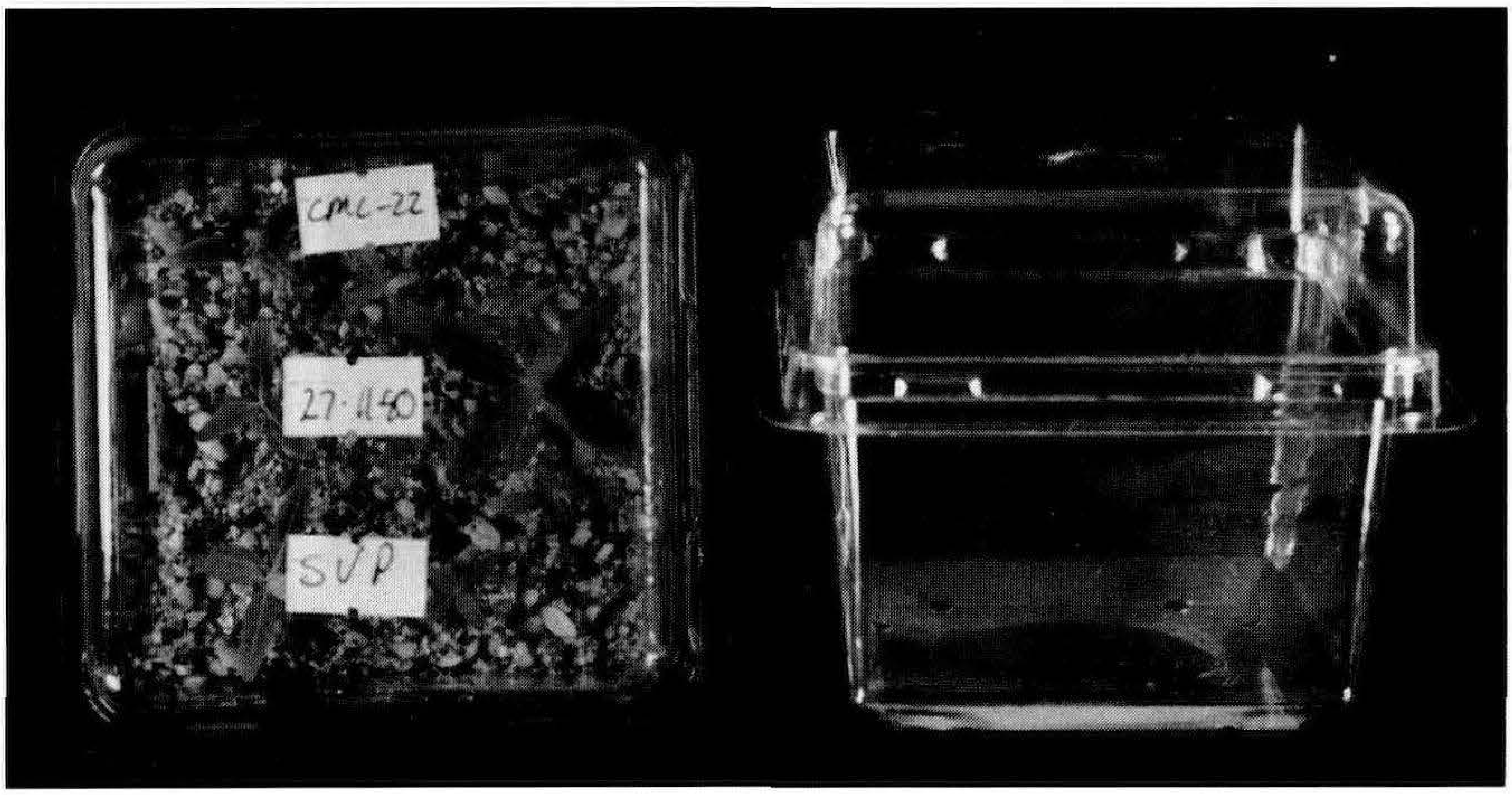

Figure 3. Rooted plants growing in 'miniature greenhouses' made from plastic food containers.

7) **Techniques for cutting shoots.** Sterile transfer and handling techniques are the most important tasks to master with microrpropagation. Test your handling procedures, instrument sterility and possible sources of contamination of cultures by exposing containers of microbial medium inside the transfer chamber.

It is amazing, when learning sterile transfer techniques, how many times you touch sterile surfaces and plants, and transfer contaminants to the cultures. With practice, careful examination of procedures, and with help from a competent operator, the skills of sterile transfer can be quickly learned.

Transfer of shoots to shoot multiplication medium is much faster and results in higher multiplication rates if clumps of shoots, rather than single shoots, are transferred to fresh medium (Figure 4). Single shoots at least 15 mm long are best for placing onto a rooting medium or setting as micro-cuttings. These single shoots can be selected from clumps of shoots or they can be encourabed by growing under low intensity light, or by adding gibberellins to encourage etiolation (George and Sherrington, 1984).

Rates of transfer using the above techniques should be equivalent to the rate of setting cuttings.

LONG-TERM STORAGE OF PLANTS

Shoot cultures growing rapidly require regular subsulturing at about monthly intervals. This is desirable if you want large numbers of shoots but it can represent a high labour cost if you are subculturing shoots only to maintain the line.

We have been able to store a large number of the species listed in Table 1 in a seed germination cabinet at 10° C, or as rooted plants *in vitro* at about 25° C for months or years (Hartney and Svensson, 1990). Under these conditions growth diminishes to a low level. Storage of cultures in such simple facilities may be easier than maintaining disease-free, clonal mother plants for cuttings propagation.

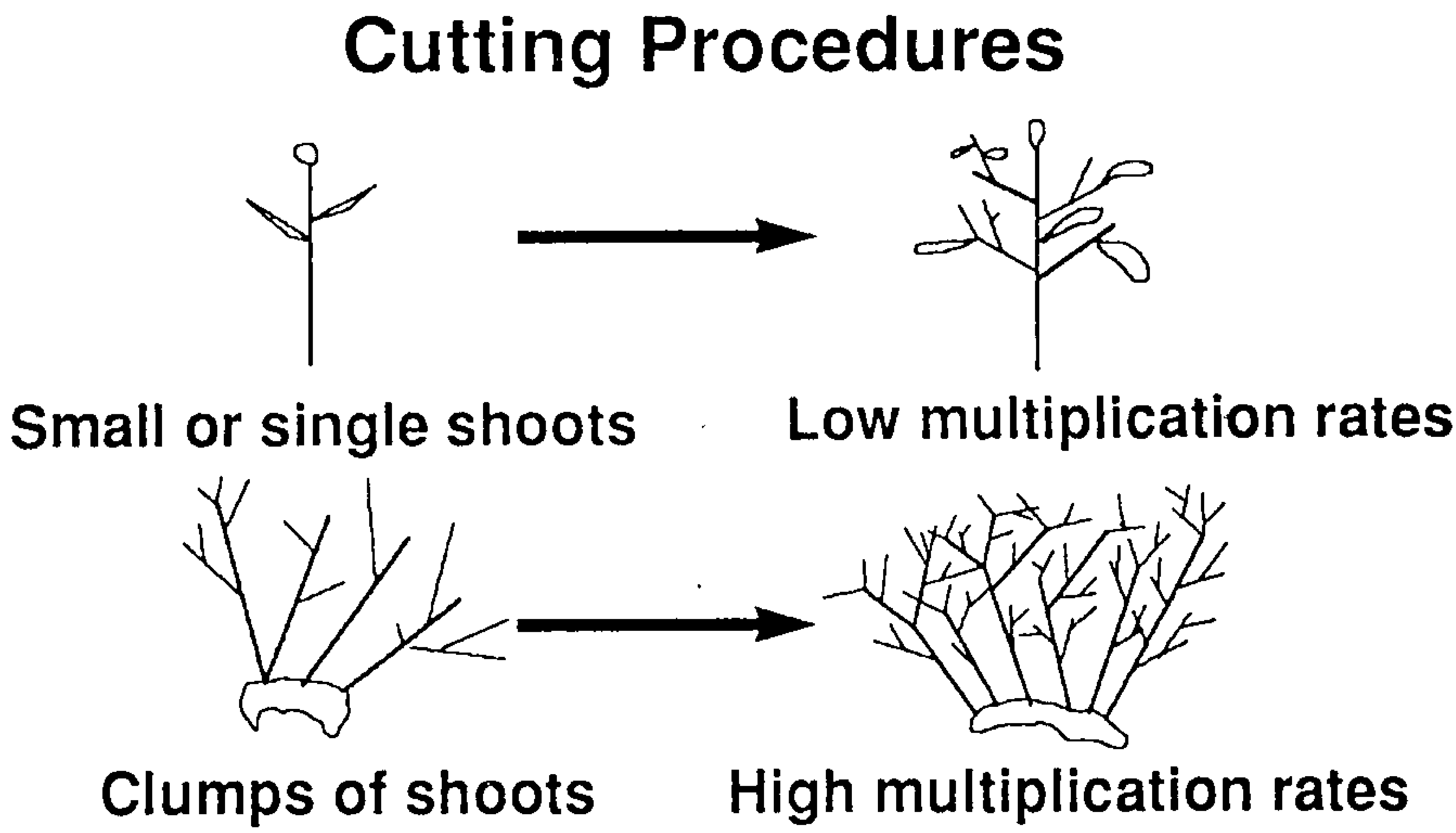

Figure 4. Diagram to represent cutting techniques to achieve high multiplication rates.

Long-term storage of cultures enables one to stock-pile plants to meet high seasonal demands such as for a restricted planting season or seasonal markets.

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Mechanization of Open Ground Seedling Production

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INTRODUCTION

Appletons' Tree Nursery grows a range of 350 species of deciduous trees and conifers. Production consists of two million, one- and two-year-old seedlings grown in open-ground raised seedbeds. Climatic conditions are very favourable for seedling growth with a long growing season and defined winter dormancy period. The soil is less ideal being a silt clay loam over compacted clay which results in poor drainage during heavy periods of rain.

We practice a fixed seed bed production system. Once a seed bed is established, all subsequent operations are carried out from the tractor alleyways and after a crop is lifted the seed bed is ripped and reformed. A fixed bed production system allows for improvement of the seed bed soil structure without the soil compacted by the tractor tyres being incorporated into the seed bed. This method of seed bed management has led to an improvement in soil structure over a 15 year period. Past practice was one of complete cultivation which resulted in ground having to be rested in grass leys.

Mechanization has two major benefits. Tedious and physically strenuous tasks are made more pleasant and seedling quality is improved by, for instance, the use of reciprocating and lateral-root pruning, and accurate fertilizer and chemical application.

Increased mechanization in nurseries often means that equipment is used when the soil is moist, resulting in compaction and structural degradation. However, various facets of seedling production in which mechanization helps solve problems and improve plant quality are described.

MECHANIZATION METHODS

Agricultural Tractor. The agricultural tractor is the most common item of mechanization on an open ground nursery. It is used to carry or pull numerous implements, carrying out a range of tasks. Tractors come in various sizes, but tend to suffer from either a lack of visibility, clearance or traction, or a combination of all three. Specialized models such as the Universal high clearance, the Poppard and the Hessel high clearance bulldozer are designed for specific tasks. There is need for a tractor with one metre clearance, four wheel drive and steer, hydrostatic drive for variable speed control with a centrally positioned cab.

Land Preparation. New growing areas are first mapped and levels taken to establish directions of fall. An excavator is used to dig soak holes in low lying areas that are back-filled with drainage aggregate. This allows free drainage through the clay and stops ponding in the subsoil. To aid runoff of excess moisture soil is moved and levelled to form a constant fall in one direction. The soil is rotaryhoed deeply. Any stones brought to the top are picked up using a stone lifter and used to form all-weather access on headlands. Prior to bed forming a contractor uses a one metre vibrating ripper tine. A steel plug is drawn behind the tine, forming a 75 mm cavity in the clay substructure, aiding free water movement down the profile.

Deep Ripping. A combination alleyway and bed centre ripper is used to a depth of 40 cm. This results in aeration and drainage away from the active root growing zone after heavy rain. An arched tool frame allows ripping of compacted alleyways during the growing season. Large diameter steel discs are mounted either side of each ripper; these cut the compacted bed edge and stop large clods peeling into the seed bed. Alleyway ripping helps control weeds and greatly aids penetration by the undercutter and subsequent wrenching.

Seedbed Preparation. Raised seedbeds are used to aid drainage and allow seedbeds to warm more quickly in spring. We use a modified Howard rotaryhoe with rippers and bedformer to form raised beds. The rotaryhoe when used at high rotor speeds has the ability to break up clods and leave a fine tilth on top of the seed bed. A pan can be created by the blades smearing the subsoil, but by mounting three tines immediately behind the blades, this is fractured allowing free drainage. The bedforming attachment takes soil normally left in the tractor alleyway and forms a 150 mm high seedbed.

A power harrow with bed forming has an advantage over the rotary hoe of stirring the soil profile, not mixing wet subsoil with dryer top soil. This is particularly useful in spring when moist soil conditions often delay sowing.

Where possible seedbeds are formed in the autumn during dry conditions. As weather conditions allow during the winter and early spring a Lilliston rolling cultivator is lightly passed over the formed seedbed breaking the crust and lightly cultivating. The bed is then lightly rolled before sowing. This method results in a much improved soil structure and seedling growth when compared with spring prepared seedbeds formed during moist conditions.

Seed Sowing. Achieving the correct seeding density is critical to the quality and profitability of a crop. The physical nature of the seed dictates largely the degree and type of mechanization which can be used.

In its simplest form a ridged roller is used to form drills into which seed of species, such as, *Juglans*, *Quercus* and *Fagus* is hand planted. The Egedal Sower is specifically designed to sow in drills variable shaped seed, e.g. that of *Acer* and *Carpinus*. The SISIS Lospread is a versatile sower able to sow a wide range of seed sizes both in drills and broadcast.

The Summit vacuum drill uses an air vacuum to suck individual seeds on to a drum, from which they are dropped into drills.

Sawdust Spreader. Sawdust is used as a seedbed covering to prevent capping. The trailer has a bin capacity of two cubic metres, enough to cover a 60 m row length of *Quercus* or 240 m of *Pinus radiata*. Depth of cover is varied by opening the bin hopper and increasing tractor speed. Both wet and dry fowl litter can be spread prior to seed bed formation.

A composted mixture of *P. radiata* needle humus and litter is lightly sieved over seedlings during the growing season. This results in enhanced mycorrhizal inoculation and seedling growth.

Reciprocating Undercutter. The object of mechanical undercutting is to produce seedlings with an active compact fibrous root system. This is achieved by removing part of the tap root which forces the plant to form many new fibrous roots. The aim of undercutting is to cut the taproot cleanly at a predetermined depth without disturbing the remaining root system. A 5 mm thick blade is hardened at 25 mm intervals. The serrations self sharpen and ensure a clean cut. It is important to have soil moisture near field capacity to reduce soil movement and plant stress. Irrigation after undercutting is advisable especially during periods of drying winds.

Lateral Root Pruner. Lateral root growth becomes especially vigorous after undercutting, as lateral roots grow into the lightly disturbed soil. A steerable linkage mounted tool frame has mounted to it nine horizontal coulters which sever lateral roots cleanly.

Wrenching. Wrenching, using either the reciprocating blade or fixed blade, is aimed at further severance of small roots and continued aeration to encourage a fibrous root system. A 125 mm wide blade is used for reciprocating wrenching and has the advantage of excellent aeration with little soil disturbance.

Fixed blade wrenchers use a thicker blade and, due to their robust construction tend to be used on deep rooting species, such as, *Juglans* and *Fraxinus*. They may also be used prior to lifting where maximum soil disturbance is required.

Seedling Lifters. Lifters allow seedlings to be easily removed from the seedbed, minimizing damage to the root system. The degree of soil agitation is normally adjustable and, depending on soil conditions and type of root structure, seedlings can be shaken to lie exposed on the soil surface. Where only part of a bed is to be lifted, trees are loosened, but left upright for harvesting at a later date.

Sprayers. The aim of any spraying operation should be to evenly apply the minimum amount of pesticide to produce the desired level of control. Applicators are divided into three main groups: Traditional pressure boom sprayers that rely on high pressure to force the mixture through nozzles in a wide range of droplet sizes; controlled droplet applicators that use a spinning disk to form evenly sized droplets (this method allows reductions in product rates, but has not been used extensively in its present format); and air-assisted sprayers that rely on a ducted air system to control the speed and direction of the droplet once it leaves the nozzle. Advantages of the latter are greater penetration of dense foliage, a large reduction in spray drift and the ability to use lower spray volume rates.

Fertilizer Application. Basal fertilizer dressing prior to bed forming is by a Vicon spreader using a 100 mm nozzle to place fertilizer only on the growing area. A Summit concentric roller spreader is used for all subsequent topdressing. This versatile spreader is able to handle powders, prills and granules. A ground wheel allows accurate calibration from 20 to 1000 kg per hectare.

Towards Improved Quality in Cut *Boronia*

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INTRODUCTION

The commercial cultivation of cut *Boronia*, which is largely confined in New Zealand to *Boronia heterophylla* (red boronia), is a relatively recent development in Australasia and Central America. Exports from New Zealand have been received favourably in several markets, particularly in Japan. However, production and postharvest information for cut stems is limited for *B. heterophylla* and practically nonexistent for other members of the genus.

The number of species readily available in New Zealand is not large but it does allow comparative evaluation of their suitability for cutting. The evaluation of these species was carried out according to modified standard criteria. (Salinger, 1985). These criteria were vase life, cutting season, form, growth rate, colour, physical character and pest/disease problems. The fragrance of *Boronia*, which can affect marketability and varies in strength and nature between species, was included as an evaluation criterion. Fragrance testing was carried out under controlled conditions as used for the testing of food and wine, the testers drawing upon their experience in these areas. Once a species shows potential as a cut flower, it is worthwhile examining other production and postharvest factors that can affect stem quality. Shading effects on production of *B. heterophylla* were examined as were postharvest treatments.

A GENUS OF CUT FLOWERING FOLIAGES

Nine *Boronia* spp. (excluding *B. heterophylla*) were evaluated for two spring harvest seasons. A clone known as 'Carousel' proved highly suitable over both seasons. *Boronia pinnata* showed great potential in the first season, but stem extension was not entirely satisfactory in the second season. This was also the case for *B. muelleri* 'Sunset Serenade' which was initially suitable but was less so in the second season. These two species were well accepted on the local New Zealand market. *Boronia megastigma* 'Lutea' was another species that had initial promise but the second harvest highlighted deficiencies.

Conversely the suitability of *B. crassipes* and *B. denticulata* was questionable in the first cutting season but improved in the second season. The increased maturity of the plants probably led to improved stem extension, correcting the first season deficiency. *Boronia fraseri* 'Southern Star' showed potential but was not entirely satisfactory and *B. crenulata* and *B. pilosa* 'Double' were completely unsuitable.

In conclusion, *B. denticulata*, *B. crassipes* and the clone 'Carousel' suggest good suitability with *B. pinnata* and *B. muelleri* 'Sunset Serenade' having some potential as cut lines, under New Zealand conditions.

THE INTERACTION BETWEEN LIGHT INTENSITY AND QUALITY

The significant effects of light intensity on plant growth and flowering are well documented (Conover and Poole, 1973; Craig and Walker, 1963; Armitage et al., 1987). Light reduction through the use of artificial shade promotes stem elongation and improves quality in some cut lines, e.g. *Chrysanthemum* [=Dendrathema] (Wilfrit et al., 1976).

Five shade levels, ranging from unshaded to 80% shade, were applied to a field planting of *B. heterophylla* using commercially available cloths. The trial aimed to represent a long term commercial planting with plant spacing of 50 cm in offset double rows. Results indicated that light reduction had no significant influence on stem extension under these conditions. The measurement of specific leaf area suggested that heavy shade may alter leaf characteristics. The effect of reduced light on the number of flowers per stem was important. Stems with the greatest number of flowers were on the unshaded treatment. The heaviest shade level had inferior flowering. Stems exposed to maximum light were found to produce the best quality cut material. This observation suggests that double row plantings do not favour optimum quality stems as half the plant is shaded by its nearest neighbours. Flowering would probably be superior in single row plantings that allow high light penetration to the entire plant.

A problem that occurs in spring-flowering foliages is the size of the vegetative shoot above the first flower. Shading increases the length of this unwanted vegetative tip.

VASE LIFE

The vase life characteristics of *Boronia* spp. are not widely known. An investigation was carried out based on postharvest principles that are well established (Reid and Kofranek, 1980; Halevy and Mayak, 1981). All trials were carried out in a controlled environment room in recommended standard conditions. Senesence occurred when flower and/or foliage degradation was clearly evident. The Salinger criteria (Salinger, 1985) for evaluating vase life were used.

The vase life of *B. heterophylla* in distilled water was 6.8 days. This was similar to that of *B. denticulata* at 7.0 days. The biocides 8-hydroxyquinoline citrate (8HQC) and a quaternary ammonium compound (Physan-20®) were used as vase solutions and as pulses. A solution of 200 ppm 8HQC maintained stems of *B. heterophylla* for 10.3 days and pulsing for 4 hours with 800 ppm 8HQC gave a vase life of 8.5 days. Physan-20® at 200 ppm resulted in a vase life of 9.4 days. *Boronia denticulata* vase life was also extended by 200 ppm 8HQC and 200 ppm Physan-20 solutions to 11.2 days and 9.4 days respectively.

A range of pulsing periods from 2 to 12 hours were tested. Evidence suggested that an 800 ppm 8HQC pulse was most effective for a minimum of 8 hours. The use of biocides, such as 8HQC and Physan-20, as solutions or pulses enhances water uptake, maintaining turgor and extending vase life.

Pulses of 800 ppm and 400 ppm 8HQC with sucrose were tested with stems of *B. heterophylla*. Sucrose concentrations of 2 to 30 g/l were used. These combination pulses were no more effective in extending vase life than the same pulses of 8HQC without sucrose. This suggests that sucrose does not extend vase life although it may assist in flower opening.

Ethylene damage can be a problem in some cut flowers, e.g. carnations (Reid et al., 1980). Pulsing with silver thiosulphate (STS) gives a degree of protection against ethylene damage and has been used to prevent flower drop in *Chamaelaucium* (Lamont, 1985). Pulsing with STS had little beneficial effect on the vase life of *B heterophylla* suggesting an absence of sensitivity to ambient and/ or endogenous ethylene.

In summary, biocide solutions and pulses were effective in extending vase life for *B. heterophylla* and *B. denticulata*. Pulses of sucrose and STS did not significantly extend vase life.

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Watering Container Plants Five Different Ways

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INTRODUCTION

Irrigation affects the growth and quality of container plants in nurseries. Factors of importance may be the frequency and intensity of watering, and the quality of the water supply. Of fundamental significance, however, may be the very way in which the water is delivered to the plants (Welsh, 1989) Many nurseries rely heavily on overhead sprinkler systems; at the same time there has been enthusiastic advocacy of subirrigation systems, such as, those incorporating capillary and ebb-and-flood methods. A container plant growing-on area was established in the open at the Nursery Research Centre in which different irrigation regimes could be compared.

There were a number of objectives that could be wholly or partially fulfilled by the use of the facility Firstly, it was intended as a demonstration area; a place where people from the New Zealand nursery industry could gather ideas and get a feel for the effects different irrigation methods (and other factors interacting with irrigation) could have in their production systems Secondly, there was a need to carry out applied research to assess the effects of, for example, irrigation, fertilisers and herbicides on plant performance. Thirdly, physiological measurements needed to be made to shed light on the reasons for differences in plant performance, and in this regard plant nutrient status and water relations measurements are in progress Lastly, there is a need to understand at a fundamental level the factors affecting the movement of water into and through the plants with a view to predicting how different irrigation systems are likely to perform under different climatic regimes.

For demonstration purposes the comparative irrigation facility has received considerable interest The results of some of our first growth trials are described below.

MATERIALS AND METHODS

A comparative irrigation facility was established at the New Zealand Nursery Research Centre in spring 1989 in which five different irrigation regimes (and treatments applied to plants within them) could be compared. Each of the irrigation treatments was applied to an area of approximately 7 5 m^2, these being contiguous and randomly assigned to positions with three blocks. The effect of one irrigation treatment on its neighbours was minimised by the use of low, transparent baffles and of guard rows surrounding a central area used for experimental plants. The facility was not covered and plants were grown under ambient conditions.

The five irrigation treatments were: 1) a constant water table capillary system in which pots were placed on capillary sand kept continuously moist, 2) an ebb-and-flood system in which the bottom 50 mm of the pots (which were raised up on wire supports) was submerged nightly for approximately 60 min before the water was drained away; 3) a drained capillary sandbed system in which the capillary sand on which the pots were stood was moistened twice daily (20-30 min) by surface emitters, the excess water draining away between each irrigation; 4) an overhead sprinkler system in which water was applied nightly (20-45 min) to plants standing on a drained capillary sandbed as in 3 above; and 5) an overhead sprinkler system as in 4 above except that the pots were placed on a course (10-20 mm) aggregate to deny the plants capillary watering

Two sets of experiments, each lasting approximately 6 months, were established on the comparative irrigation facility. In each case liners were potted into rigid plastic pots (2.5 l, 175 mm diam, RX Plastics Ltd, Christchurch, NZ) that had completely flat bottoms with holes designed for capillary uptake of water from moist, level surfaces. A standard peat and pumice potting mix (80:20, v/v) containing (unless otherwise indicated) Osmocote (Sierra Australia Pty Ltd, Australia) controlled-release fertilisers (N:P:K: 18:2 6:10, 8-9 mo, 1.44 kg/m^3; 14:6 1:11.6, 3-4 mo, 0.5 kg/m^3), PG Mix (Smiths Horticultural Distributors Ltd, New Zealand) (N:P.K:14.7:14.9, 1 44 kg/m^3) and finely-divided dolomite (3 kg/m^3). In general there were 3 external replicates (blocks) of all irrigation treatments and 3-5 internal (single plant) observations of each treatment within these. Data were subjected to analysis of variance and means taken as significantly different for $p<0.05$.

In the first experiment (established November 1989) plants of *Eucalyptus regnans, Raphiolepis umbellata* and a *Coprosma* cultivar were grown under the five irrigation treatments. Half of the plants were grown with the standard fertilisers added to the potting medium, the remainder receiving half of this amount. At the conclusion of the experiment the plant tops were harvested and measurements made of leaf area, and leaf and stem dry weights. In the second experiments (established May 1990) various treatments were applied to plants of *Coleonema pulchrum* 'Sunset Gold', *Photinia* × *fraseri* 'Red Robin', *Citrus limon* 'Meyer' and the *Coprosma* cultivar which had been supplied as liners heavily infested with liverwort *(Marchantia)*.

Plants of *Coleonema* were potted into the potting mix which had been amended by addition of different rates of dolomite (0, 1, 3,5 and 10 kg/m^3). The mix also had a liverwort inoculum incorporated (ca 10% v/v) which was of heavily infested material collected immediately prior to potting from the surface of the liner growing medium. Pots were placed on the constant water table capillary and the overhead drained irrigation systems. There were 3 blocks and 2 internal replicates. Liverwort coverage of the surface of the growing medium was recorded after 6 months and the tops of the plants harvested and dry weight recorded. Again using plants of *Coleonema* and the liverwort inoculum, five fertilizer treatments were applied to the potting medium· 1) the standard mix, 2) standard mix at half rate, 3) as for #1 without the 8-9 mo Osmocote, 4) as for #2 without the 8-9 mo Osmocote, and 5) no fertiliser (control). Plants were grown under the 2 irrigation regimes. Liverwort coverage of the surface of the growing medium was estimated on a 1-10 scale at the end of 6 months. Plants of *Photinia, Citrus* and *Coprosma* were potted into the experimental pots (on this occasion without the incorporation of a liverwort inoculum) and grown under two irrigation regimes (constant water table capillary and overhead drained systems) Immediately after potting, 7 preemergence herbicide treatments were applied to the surface of the potting medium. These involved 3 levels (the recommended or normal rate, half and double the recommended rate) of Rout Ornamental Herbicide (oxyfluorfen 2% and oryzalin 1%, Sierra Chemical Company, USA), 3 levels of Ronstar SG (oxadiazon 2% and simazine 0.5%, Rhone-Poulenc New Zealand Ltd, NZ) and a control with no herbicide added to the surface. Herbicides were applied as directed by the manufacturer. Plants were harvested at the conclusion of the experiment, shoot dry weights recorded and surface cover of liverwort estimated.

RESULTS AND DISCUSSION

The results of these trials are shown in the accompanying figures. These show that there were large differences between the irrigation methods in terms of plant growth. In general, any irrigation regime that delivered water to the base of the pot rather than to the growing medium surface gave better plant growth. Over a number of trials, including some not reported here, the constant capillary system outstripped the overhead drained system by 25-50%. Other systems were of intermediate performance (Figure 1).

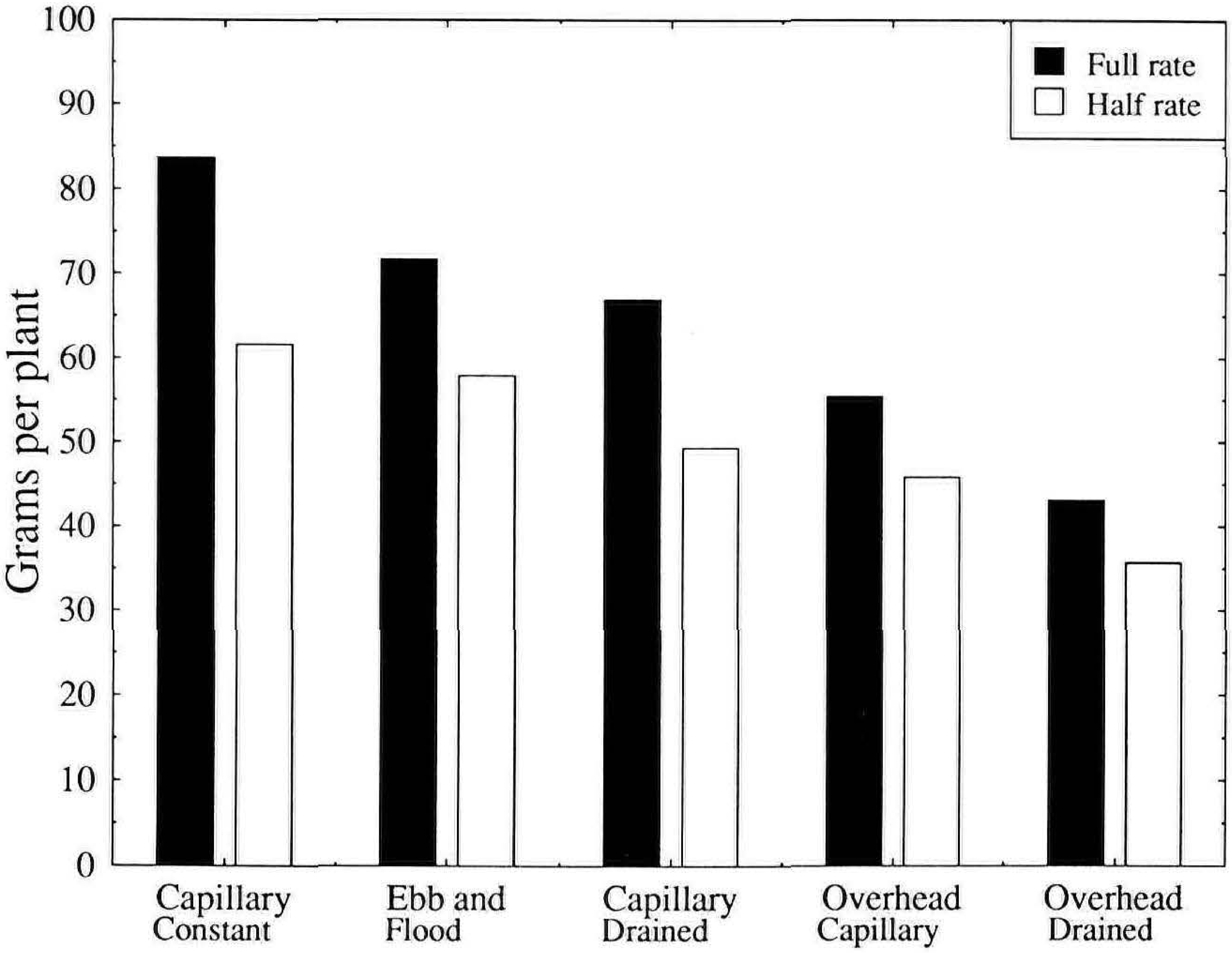

Figure 1. Effect of irrigation method and level of fertilizer on shoot dry weight of *Eucalyptus regnans.*

Liverwort growth on the surface of the potting medium could be a problem, particularly with plants irrigated by the capillary systems. Rout and Ronstar SG herbicides controlled this adequately for both constant capillary and overhead drained irrigation (Figures 2). The herbicides gave little evidence of toxicity to *Coprosma* and *Photinia* with plants in all herbicide treatments growing as well or better than controls. When treatments gave better growth than controls, e.g. normal rate of Rout applied to *Photinia*, presumably this was due to release of the plant from competition with the liverwort coupled with no undesirable effect of the herbicide on plant growth (Figure 3).

Not surprisingly, when liverwort was deliberately mixed with the potting medium, the higher the level of fertility the better the liverwort grew on the surface. Pots with no added fertilisers had the lowest levels of this weed (5 and 28% ground cover in overhead drained and constant capillary respectively). Increasing the level of dolomite in the mix to 10 g/l raised the pH to approximately 6.5. At this dolomite rate liverwort ground cover was reduced from 85-100% in the controls to approximately 65%, indicating that amendments to increase pH may be of use as part of a strategy to control this troublesome weed.

Coprosma and *Photinia* responded to the irrigation treatments as anticipated. However, the *Citrus* grew poorly under both experimental irrigation treatments and there was no significant difference between the treatments at the time of harvest. Growth of the *Citrus* was also significantly lowered by the herbicide treatments.

Large differences have been demonstrated as a result of the applied treatments. However, a slightly different or possibly a qualitatively different picture may have emerged had the treatments been applied in a different growing environment, for instance, with heavier rainfall or greater evaporative demand. Altering the specification for the treatments may also have led to different results. It is likely

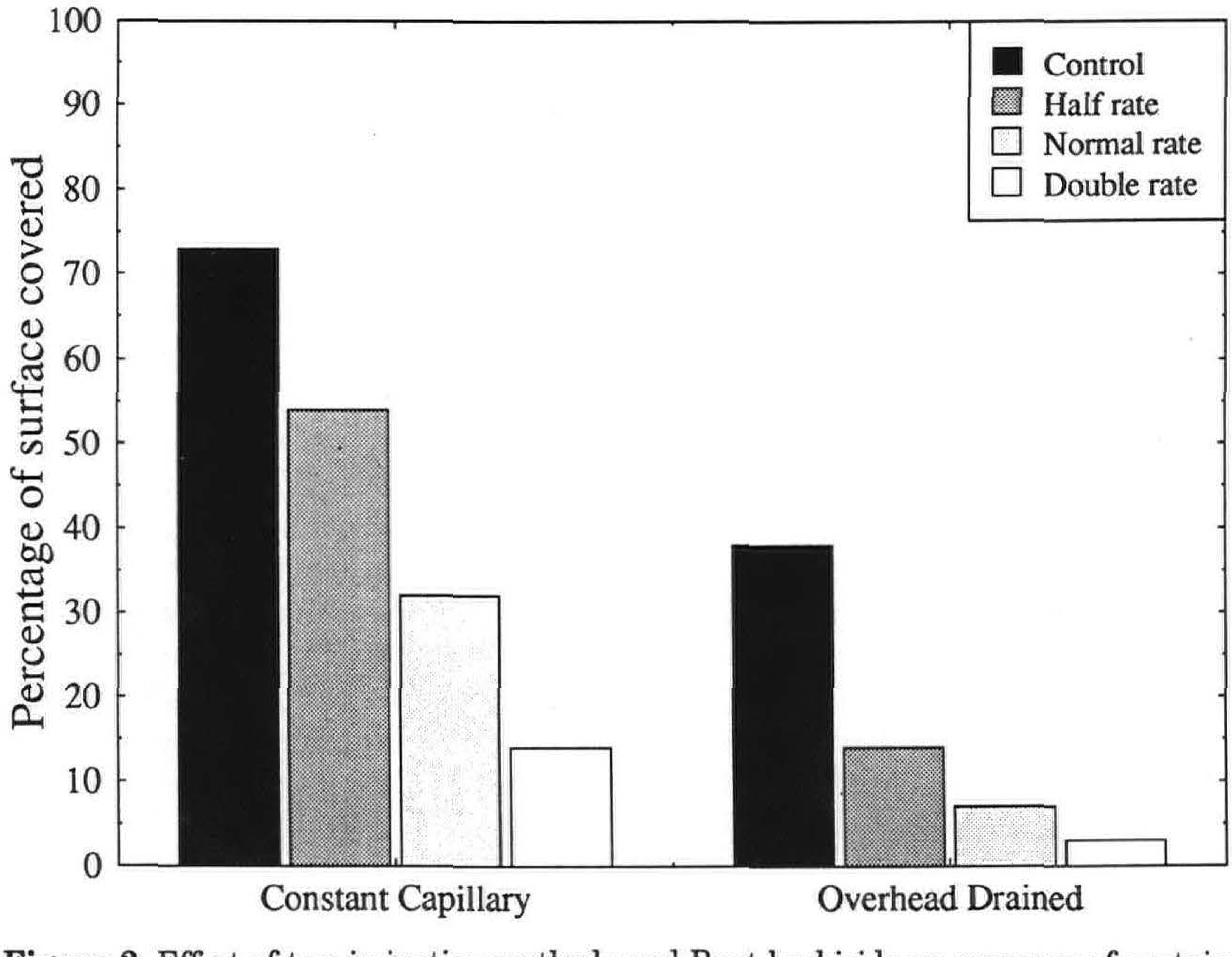

Figure 2. Effect of two irrigation methods and Rout herbicide on coverage of container medium surface by liverwort.

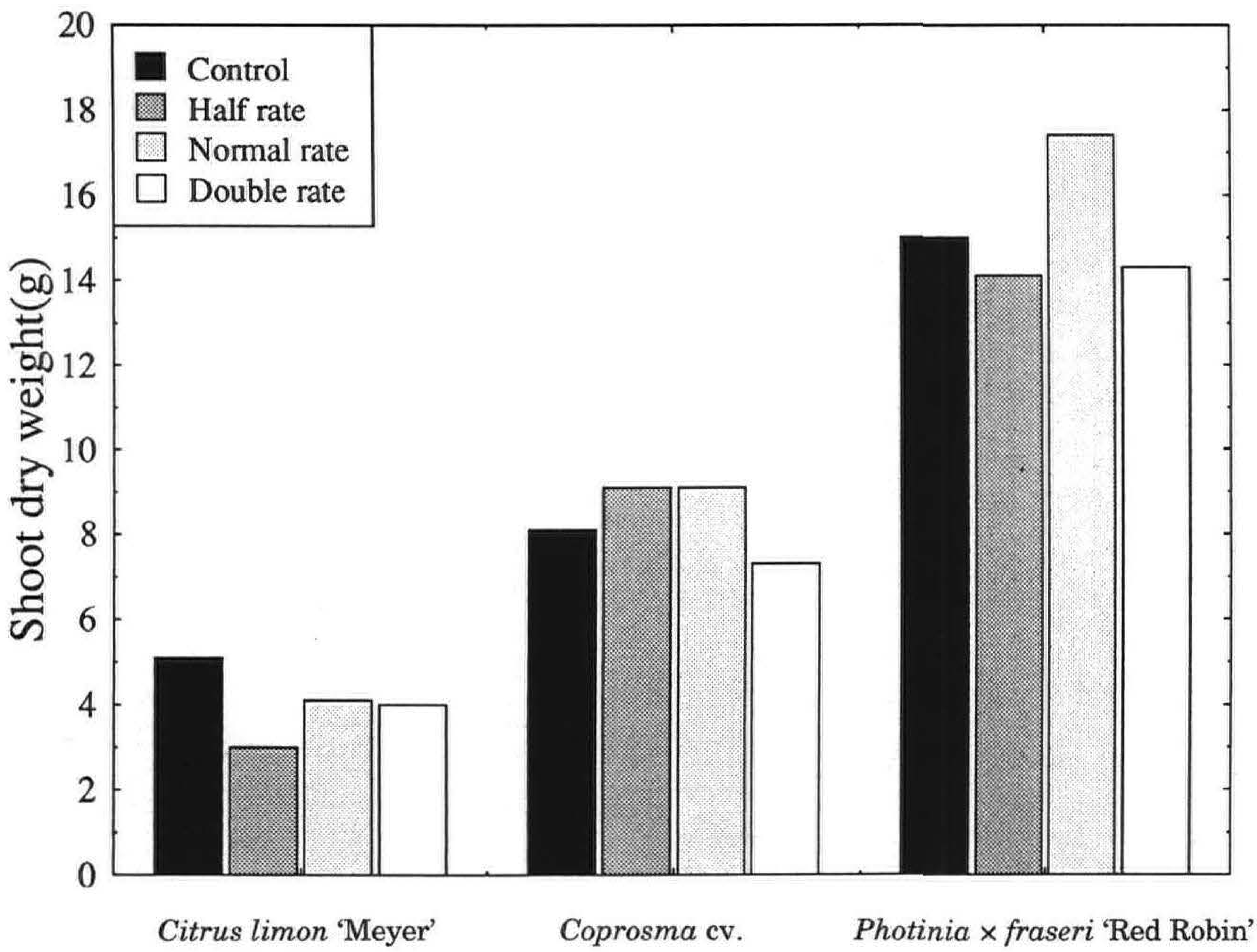

Figure 3. Effect of Rout herbicide on growth of three container plants.

that the better performance of the subirrigation treatments was due to less leaching of available medium nutrients. Water stress experienced between irrigation episodes was unlikely to have caused such depressed growth in the overhead irrigated plants.

It is clear that although the capillary systems have their advantages, especially the constant water-table system, there is still a need for fine tuning of the interacting factors including irrigation frequency, intensity and timing, growing medium, pot dimensions and the plant itself. In attempts to optimise these factors to promote plant growth and quality, there is a need to consider weed control and factors not covered in this paper, such as, cost of establishment, the hardening off of plants (Clemens and Jones, 1978) and rooting from the pot into capillary beds. For weed growth, standard hygiene practices will have a dominant role to play. Fertiliser formulations and levels appropriate to the irrigation system being used would also be beneficial.

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Propagation of Pittosporums by Cuttings

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INTRODUCTION

The demand for pittosporums (*Pittosporum* spp.) in New Zealand has never waned, and with the introduction each year of exciting new hybrids, this trend is sure to continue. They are grown predominantly for their almost endless range of foliage colours. Couple this with their adaptability either as a hedge, a trimmed container plant, garden specimen, a floristry crop or contrast plant in the shrubbery, and it is not surprising that many New Zealand nurserymen consider these plants their "bread and butter" crop.

PROPAGATION

Pittosporums can be propagated by many methods. These include seed germination (for many of the hedge grade species), tissue culture (for rapid multiplication although some cultivars can be unstable), grafting (for the hardest cultivars to propagate) and cuttings. The last is the commonest method among nurserymen in New Zealand. Pittosporum cuttings can be taken and processed by many methods but these are not compared here. The following method is the one used at George Rainey Nursery

Source of Cuttings. A source of good material is essential for success. This may be stock plants or the nursery stock Many of the original stock plants, although still trimmed and shaped each spring, have served their purpose and are retained because they are decorative. A planting programme has been in progress for 5 years and is proving very beneficial. Autumn pruning of nursery stock provides us not only with most of our cuttings but also shapes the plants before winter-spring despatch and helps to make tube liners sturdier. A 10-15 cm cutting is taken and the terminal growth is removed to encourage branching at the outset.

Timing. As there are two main flushes of growth each year—September-October (spring) and March (autumn)—cuttings can be taken twice as this new growth hardens. Most propagation is done in late April-early May so as to fit into the bagging programme of the following summer. Average daily air temperature in November is 23°C and in April/May is 23-20°C.

The Rooting Environment. Cuttings are stuck in 100% pumice sand firmed into plastic propagation trays. They are placed in a propagation house consisting of a three-sided enclosure, open to the North and measuring 20 m long and 45 m wide. The side walls are 2.5 m high and there is no roof and no bottom heat. Misting is provided by 360 degree nozzles positioned throughout the structure and controlled by a timer set to 15 sec duration every 18-20 minutes. This varies depending on the weather.

Tubing. Because the cuttings have never been subjected to bottom heat nor fertiliser, they are relatively hardened off. The mist can be turned off once root initiation commences after 4-8 weeks and there is no need to move rooted cuttings to a hardening-off area. Rooted cuttings are tubed into 7 cm square pots in July-August (late winter-early spring) and shaded with portable shade covers for the first and last time for approximately 1 week. The plants are sheared in October-November (late spring-early summer) to encourage bushiness and for cuttings if they are needed

Propagation Notes for Some New and Novel Crops Introduced Into New Zealand

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INTRODUCTION

New Zealand's economy is largely based on its primary industries with this likely to continue into the foreseeable future In order to strengthen that base, many plants and animals not normally associated with New Zealand have and are being evaluated to determine their economic viability. Within the horticultural industry crops, such as, persimmons, nashi, autumn raspberries, chicory, babacos and pepinos have, with varying degrees of success, been grown for export.

One of the problems with the evaluation of new crops is that there is often little information available on propagation and production techniques because of language barriers and unfamiliar, traditional cropping practices also tending to confuse the issue.

This paper outlines some of the new and novel crops that have been evaluated at Ruakura along with the propagation techniques that we have found successful. These crops include florence fennel, ginseng, mitsuba, myoga, shungiku, stevia and wasabi.

PROPAGATION METHODS

Myoga. Myoga *(Zingiber mioga)* is a member of the ginger family and native to Japan. It is grown commercially for the young shoots and flower inflorescences or 'blooms' it produces in spring and autumn, respectively. Both are used in culinary dishes. Propagation is generally carried out through division of the underground rhizome (Follett, 1986a). To propagate, the rhizome is cut at an internode. There should be at least one and preferably two nodes present on each section of root. The root sections should then be cool stored, followed by planting out into the field or lining out into propagation trays in a glasshouse. For propagation, rhizomes are lifted in the late autumn or at the end of winter and cool stored. At Ruakura we have found that rhizomes lifted in autumn, divided and repotted into planter bags were more likely to emerge if they had been subjected to six or more weeks of cool storage at 4°C (Figure 1). The assessment, carried out after the myoga rhizomes had been left to grow in a glasshouse environment showed that over 90% of myoga rhizomes were likely to emerge within three months of being divided if they were subjected to cool storage for six weeks or longer. This can be compared with a 45% emergence for rhizomes with no cool storage.

The length of time the roots were in cool storage also affected the rate at which the shoots emerged when planted out Myoga rhizomes that were lifted in autumn were divided and potted into planter bags These rhizomes were then cool stored for either three or six weeks. Cool storage for six weeks compared with three weeks resulted in more plants growing with shoots emerging more quickly (Figure 2).

Seed propagation is unknown with the plant generally being regarded as sterile (Palmer, 1984). Japanese studies indicate that this may be due in part to the highly specific conditions required for pollen germination and pollen tube growth (Adaniya

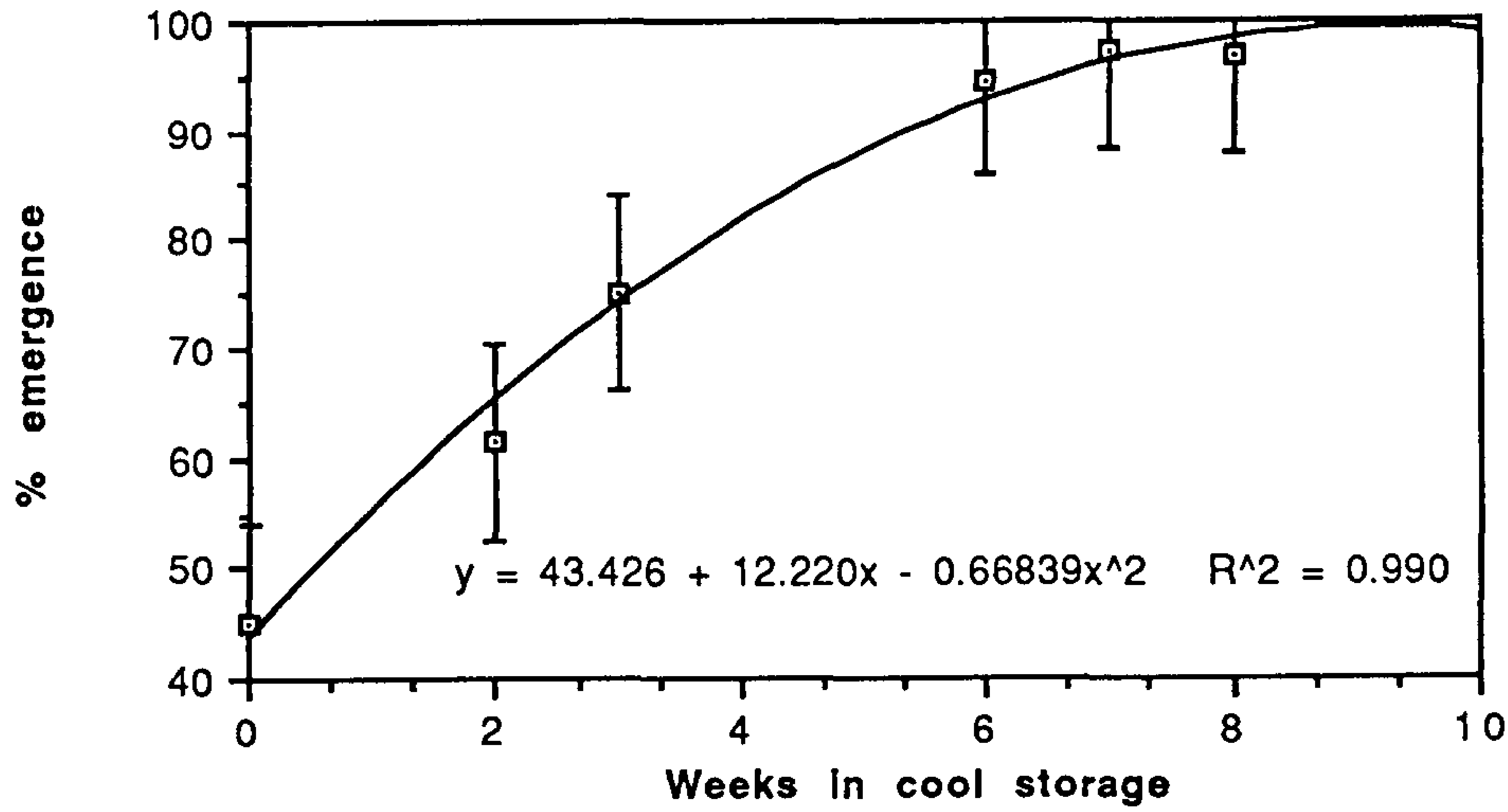

Figure 1. Effect of cool storage of rhizomes on myoga shoot emergence

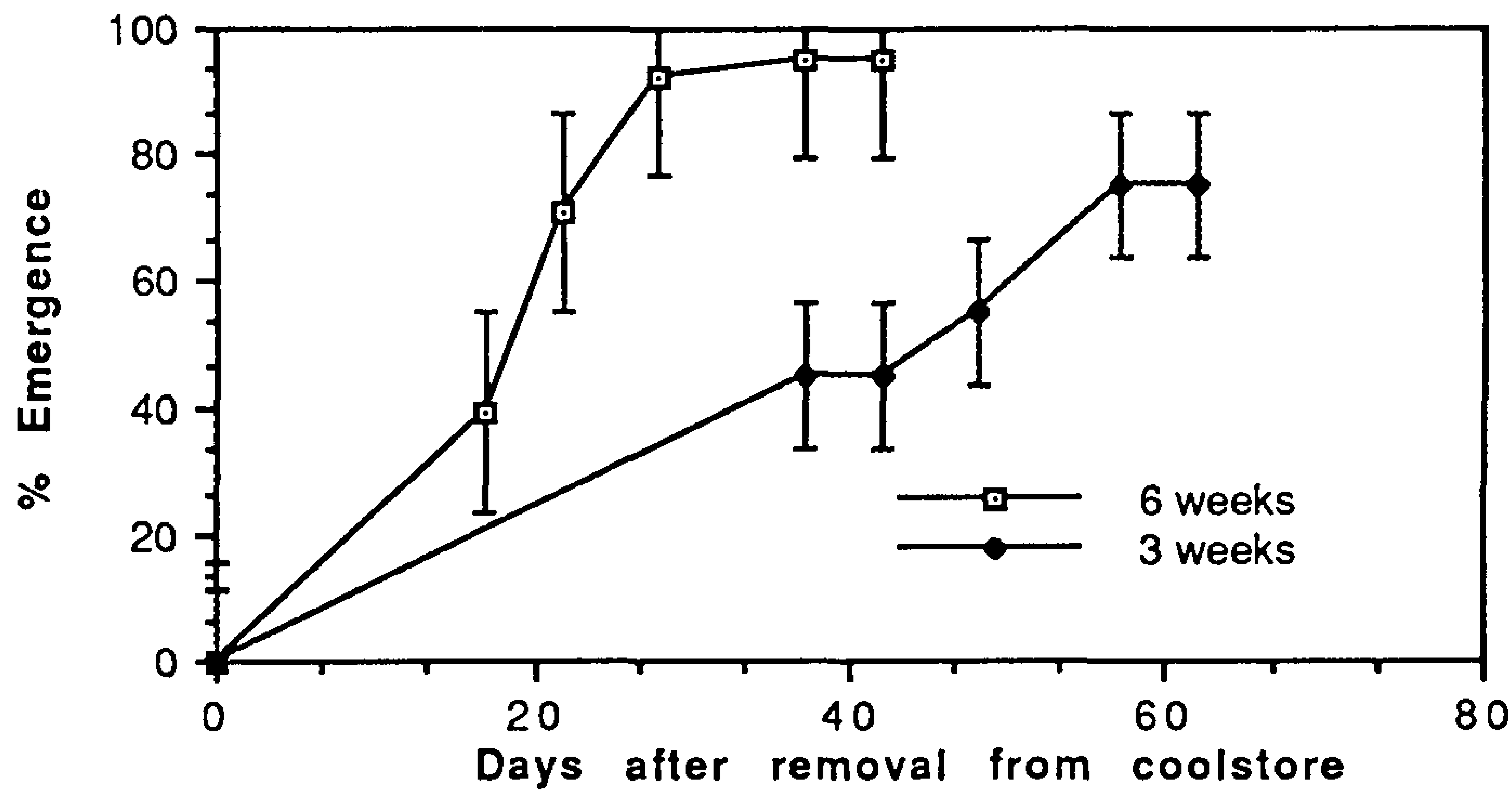

Figure 2. Effect of the length of time myoga rhizomes are in cool storage on the rate of stem emergence

and Higa, 1988). Myoga is also easily propagated by tissue culture .

Ginseng. Ginseng is an herbaceous perennial grown for its root which is highly prized in Asia for its medicinal qualities. The most important economic species are Korean ginseng (*Panax pseudoginseng*) and American ginseng (*P. quinquefolius*).

Propagation is generally by seed which is collected in late summer/autumn A curing period over a 6 to 18 month period is required to allow the seed embryo to mature and to overcome seed dormancy. At all stages the seed must remain moist. In Korea it is suggested that 100 days is required to fully cure the seed. The seed is mixed in sand in a 1:3 ratio then placed in large cement or wooden troughs between layers of sand and pebbles to ensure adequate drainage. In these troughs the seed is subjected to a period of stratification during the winter followed by storage over summer at 20° C or less which ensures that the embryo grows most rapidly (Stoltz and Garland, 1980). The seeds are regularly watered in excess to ensure they do not dry out. Frequency of watering depends on the time of the year The seeds are then lifted and sown in the autumn so that they can undergo a second period of cool storage prior to germinating in the following spring (Stoltz and Snyder, 1985) Seed coat splitting is an indication that the seed has been cured correctly and is ready to germinate and grow. Present indications are that fresh seed treated with gibberellic acid will split slightly faster and start to germinate after only one period of stratification (Table 1). Further work is required to determine the optimum concentrations of gibberellic acid, as well as optimum soaking and stratification times.

Table 1: Effect of gibberellic acid on ginseng seed ripening.

Treatment	Percent of seed			
	Not split	Split	Split and germinated	Split and rotten
Gibberellic acid	85	10	1	4
Control	99.5	0.25	0	0 25

Green unripened seed was either treated with gibberellic acid or left untreated then stratified for 54 days at 4°C followed by storage at ambient for 36 days before being assessed; 400 seeds were used per treatment

Seed treatment with fungicides is not recommended for *P. pseudoginseng* as it reduces seed viability (Proctor et al., 1990) however American research on *P. quinquifolius* has shown no deleterious effects for most fungicide treatments (Stoltz, 1986). Work at Ruakura has however shown a reduction in the rate of seedling emergence after seed had been soaked in a 1% benlate solution for five minutes prior to sowing for the control of fusarium (found on the seed). Again further work is required on disease control.

Seed is usually sown in situ using either hand pushed or tractor mounted seeders at a rate of 78 to 157 kg/ha (Hartman, 1979). At Ruakura we are sowing seed onto raised beds in rows 15 cm apart.

It is also possible to propagate ginseng by using tissue culture techniques (Choi, 1988).

Wasabi. Wasabi (*Wasabia japonica*) is a semi-aquatic plant native to the montane regions of Japan The plant is used as a condiment with mainly fish and buckwheat noodle dishes.

Propagation is possible by seed, offshoot cuttings, or tissue culture. In New Zealand wasabi flowers from early spring through to autumn. Seed germinates best when sown fresh with seed viability decreasing rapidly when the seeds are allowed to dry.

Optimum germinating temperature for wasabi seed is 5° C (Palmer, 1990). Generally seed is precision sown by hand into specially prepared nursery beds The Japanese seedling production cycle usually sees the seed collected in spring with seed being sown over summer. This ensures the seedlings are ready for planting in autumn. Seed is usually collected for propagation purposes when there is a need to eliminate virus build up and where it is not necessary to maintain a selected cultivar.

Generally wasabi is propagated using offshoot cuttings which are broken from the main wasabi plant at harvesting (Follett, 1986b). Offshoots can be either planted directly into prepared beds or lined out in propagation trays to allow roots to develop before final planting out. At Ruakura we have found that offshoot cuttings readily form roots when lined out in cool shady conditions with the application of propagation aids, such as rooting hormones, having no effect on the production of roots.

Florence Fennel. Florence fennel or finnochio (*Foeniculum vulgare* var. *azoricum*) is grown for the pseudobulb formed by the swollen bases of the stalks. Until recently florence fennel has been a major vegetable crop only around the Mediterranean. Increasing interest both in Europe and the rest of the world encouraged some New Zealand growers to plant small quantities.

Propagation is by seed with 1 gram producing about 120 plants. The optimum germination temperature is 20-22° C, with germination failures likely to occur from seed being sown direct into cold wet soils (Follett and Douglas, 1984). For early spring planting, plants are usually produced under cover in containers or in seed trays, but they should not be planted out too early as cold conditions can induce the plant to bolt and seed.

Sowing directly into containers is not generally recommended because of the uneven germination rate. Seed should be broadcast into seed trays at approximately 20 g/m^2 and the seedlings later pricked out into containers or, if they are vigorous enough, planted direct into the field after grading into similar height classes. In containers the young plants should be grown on at a temperature of 15-20° C. When the young seedlings have grown three to four true leaves they are considered good planting material. For late spring and summer plantings seed can be direct sown at 3 kg/ha to a depth of 1.5-2.0 cm in rows 40 cm apart and a spacing within the rows of 20-25 cm to give a plant density of 10/m^2. Wider spacing encourages plants to develop side shoots, which detract from bulb quality, while closer spacings tend to spoil the shape of the bulb.

Mitsuba. Mitsuba (*Cryptotaenia canadensis*) has long slender stems topped with three small leaves and is used extensively in Japan as a vegetable.

In Japan there are four production systems, all of which involve seed propagation (Follett, 1990). Production of kirimitsuba or cut mitsuba involves spring sowing seed in the field. The crowns that develop are lifted in early winter and these are then forced in specially constructed troughs to produce a product with green leaves and a blanched stem. Ne mitsuba and ito mitsuba are both seed sown field crops. Ne mitsuba produces a white stem as a result of mounding up the soil around the stem during the growing season while ito mitsuba is not mounded up resulting in a green stem. The fourth production method (ao mitsuba) involves growing the crop hydroponically in glasshouses. Seed is sown thickly onto foam pads placed in trays of water in growth cabinets. When the mitsuba germinates the foam is cut into $2cm^3$ blocks with each block containing several plants. The blocks are then fitted into holes in large polystyrene sheets that float in large troughs containing nutrient solution.

At Ruakura we have found no problems propagating mitsuba by seed.

Stevia. Stevia (*Stevia rebaudiana*) is a small herbaceous shrub grown for its leaves which contain sweet glucosides.

The plant can be propagated by cuttings, seed or tissue culture. Cuttings with a terminal bud collected from new growth produced after winter dieback produce strong healthy cuttings (Follett, 1985). Propagation by seed is more variable. Seed can be sown in situ. However, better results are obtained by germinating seed in a more controlled environment. Seeds can be collected in autumn, sown under cover during winter and be ready for transplanting in spring (Shock, 1982). Stevia can also be propagated from stem tips by tissue culture (Tamura et al., 1984).

Shungiku. Shungiku, garland or spring chrysanthemum (*Chrysanthemum coronarium*) is a popular green vegetable in Japan.

Propagation is by seed produced during the summer months. Seedlings are generally sown into seed beds with the seedlings being transplanted into formed beds when they are at the 4-5 leaf stage (Follett, 1990). The beds are usually 100-120 cm wide with 4 rows/bed and plants spaced 15-20 cm in the row.

At Ruakura we have found no problems propagating shungiku by seed.

CONCLUSIONS

One of the primary requirements of new crop investigations is to have sufficient plant material available for evaluation. Research on plant propagation at Ruakura has enabled sufficient plant material to be generated to allow agronomic research programmes to follow. We have found little difficulty in propagating and bulking up myoga, florence fennel, mitsuba, stevia and shungiku. Problems which require further research include virus buildup in vegetatively propagated wasabi, the loss of desirable characteristics in wasabi grown from seed, and the long curing time required before ginseng seed will germinate.

ACKNOWLEDGEMENTS

I would like to thank Mr J.A Douglas for his critical review of this paper

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Worsleya rayneri

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Worsleya rayneri was discovered in 1860 growing in the Organ Mountains of Brazil at an altitude of 1220 m. The huge leek-like bulbs with grey-green falcate leaves hang from acidic basalt cliffs, bathed in a constant mist from waterfalls. First described in 1863, it was many years before Arthington Worsley, following study of the plant in its natural habitat, succeeded in flowering *Worsleya* in his glasshouse in England. Also known as the blue amaryllis or empress of Brazil, *Worsleya* has remained rare in cultivation

I purchased three of the D-shaped seeds of *Worsleya* 20 years ago for five pounds. Germination took place after only 4 weeks at 22°C. Having little information on the culture—except that they disliked lime—I used a peat and pumice mix for the three small plants They were repotted every summer using long-term controlled-release fertilizers and given occasional applications of dried blood.

The evergreen growth slows in the cooler months and very little moisture is needed. As summer progresses they are watered copiously, growth being most rapid at the hottest time of the year.

After a number of years the plants had grown too large for buckets and were planted out into a protected bed of bark and pumice. Finally, in its ninth year, one bulb flowered. In January (mid-summer) a large bulge moved rapidly upwards from the base of the plant and after two weeks a soft green bud appeared. Within three days this had elongated 30 cm beyond the leaves and the flower buds opened over the next two days. The flowers were a beautiful lilac blue.

No seed was set from this first flower spike which was not surprising as *Worsleya* is believed to be self-sterile. However, the next year two plants flowered (4-9 flowers per stem) and seed was set following hand pollination. Three four-valved capsules set which took 15 weeks to ripen. In my group of mature plants I now have one which sets seed following self-pollination though a number of the resulting seedlings lack chlorophyll and die a few weeks after germination.

The only pests appear to be red spider mite and mealy bug, but these are minor problems. The greater bulb fly (*Merodon equestris)* can eat the growing centre of the bulb When this happens a number of small bulbs arise from the basal plate. These can readily be used for propagation of new plants.

Effect of Container Size and Media Volume on the Growth of Plantlets *in vitro*

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***Ficus lyrata* and a clone of an unnamed *Zantedeschia* were grown in four different sized plastic containers filled with 15, 30 or 60 ml of MS medium. Plant fresh weight accumulation was assessed at 2-week intervals for 14 weeks and the experiment terminated with dry weight determination. Maximum fresh weight of both species developed in the smallest containers with the largest volume of medium.**

INTRODUCTION

Many trials investigating plant growth *in vitro* have focused on the composition of the supporting medium These experiments have given us the basic media formulations, such as the Murashige and Skoog medium (MS) used in many tissue culture laboratories today (Murashige and Skoog, 1962).

Relatively few people have considered how the volume of the medium influences the potential of a culture system to grow and sustain plants. Fadia and Mehta (1975) demonstrated a direct relationship between the volume of the medium and plant growth.

Traditionally, glass culture vessels have been used, but these have been largely superseded by a wide range of disposable plastic containers. As with media volume, few people have considered that the culture vessel characteristics may influence the performance of an *in vitro* plant production system. Adams (1972) noted that strawberry cultures rooted only after transferring to a larger culture vessel. Monette (1983) showed that early growth (up to four weeks) of grape cultures was fastest in small containers, but after six weeks most shoot growth occurred in the largest containers.

A trial was planned to investigate the effect of media volume and container size on the *in vitro* growth of *Ficus lyrata* and a hybrid *Zantedeschia*.

Ficus and *Zantedeschia* were chosen because of their relatively fast growth rates coupled with their differences in culture appearance and shoot proliferation rates. *Zantedeschia* cultures tend to be more apically dominant and produce fewer shoots than *Ficus* cultures.

MATERIALS AND METHODS

Plants were grown on MS medium supplemented with (in mg l^{-1}) glycine, 2; myo-inositol, 100; thiamine-HCl, 0.1; nicotinic acid, 0.1; pyridoxine-HCl, 0.1; benzyl adenine, 3; plus sucrose, 30 g l^{-1} and agar, 8 g l^{-1}.

Four kinds of container were used (Table 1).

Table 1. Characteristics of the four types of experimental container

Container[1]	Height (mm)	Mean diameter (mm)	Volume (cm^3)	Surface area (SA) (cm^2)	SA/ volume (cm^{-1})
A	12.8	83 8	66 6	122 4	1 84
B	29 6	86 6	169 5	196 8	1 17
C	51 0	88.6	289.2	262 0	0 90
D	128 8	115 4	93 5	1076 0	0 55

[1]Container "A" was a disposable (polystyrene) plastic petri dish and the other containers were clear (K-resin) plastic food containers each with a close fitting lid.

For each species ten replicates of the four plastic containers were filled with 15, 30, or 60 ml sterile medium, (except for the 60 ml treatment and container "A" which was not considered practicable.)

Each dish was inoculated with either 10 pieces of *Zantedeschia* (average weight 120 mg) or 8 shoots of *Ficus* (average weight 30 mg) and incubated at 20°C under fluorescent lights (20 μmol m^{-2} s^{-1}) with a 16 h photoperiod.

The plant material in each replicate was weighed aseptically every 2 weeks over a 14-week period. At the same time the pH of the medium was also monitored.

RESULTS AND DISCUSSION

In all four containers the volume of medium had a direct influence on the rate of accumulation and total production of fresh weight by *Ficus* (Figure 1) and *Zantedeschia* (Figure 2). The initial growth rates in each treatment were similar until after the second week. By the fifth week it was apparent that some factor was limiting *Zantedeschia* growth. This coincided with a dramatic reduction in fresh weight accumulation and the first visual signs of culture deterioration. *Ficus* took approximately eight weeks to reach a similar fresh weight maximum. Significant deterioration of the cultures did not occur during the experiment. This suggested that *Ficus* is considerably more tolerant of nutrient depletion than *Zantedeschia*. The reduction in fresh weight of both species later in the experiment would have been due to desiccation

When the container size was compared with different volumes of medium it was clear that, irrespective of the plant material used, the largest fresh weight gain occurred in the smallest containers and the least growth in the largest container.

The data for both container and medium volume were combined to reveal the interrelationships between these parameters and plant growth (Figure 3). By week 4 in the *Zantedeschia* cultures differences could be seen between the treatments that took a further 8 weeks to develop in *Ficus*.

The rate of water loss from all the culture vessels was related directly to the surface area of the medium and was proportional to the surface area of the culture vessels. It was not influenced by the volume of medium or by opening during culture assessment. The greatest water loss occurred from the largest containers.

The pH of the media changed over time irrespective of the volume of medium or

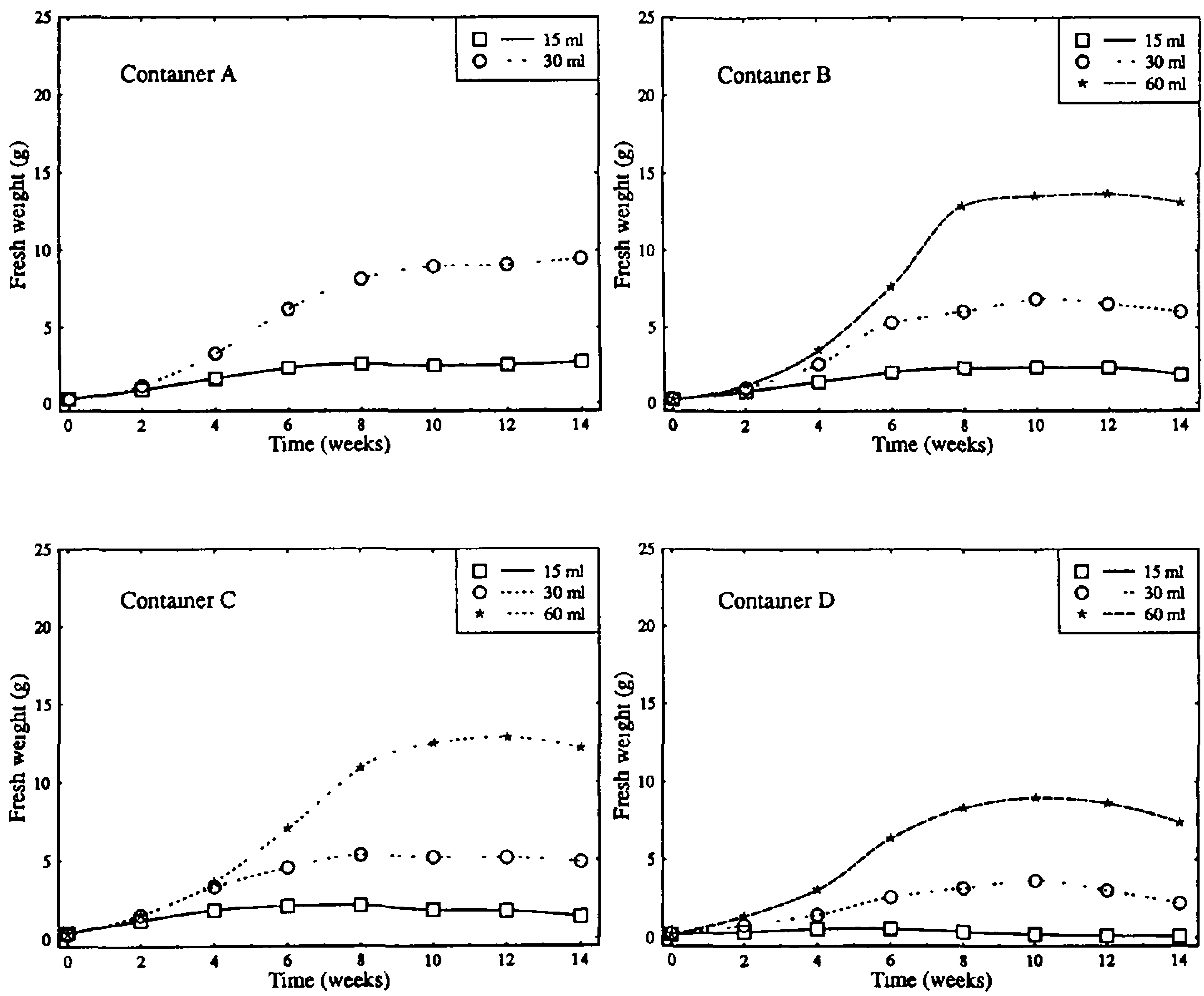

Figure 1. Time course of in vitro growth of *Ficus lyrata* as influenced by container and media volume

the type of container. In *Ficus* cultures the pH had decreased by 1.5 units after 4 weeks, but had increased by nearly 3 units after 12 weeks. In contrast, the *Zantedeschia* medium pH increased by 1 5 units after 6 weeks and then decreased by 0.5 units over the next 6 weeks. The different response by each species was probably a reflection of their preference for ammonium or nitrate nitrogen. It was somewhat surprising that the buffering capacity of the media did not improve when the volume of medium was increased.

CONCLUSIONS

Plant growth *in vitro* was dependent on both the volume of medium used and on the type of culture vessel Increasing the media volume consistently increased plant growth. Increasing the container size usually decreased plant growth. Reduction

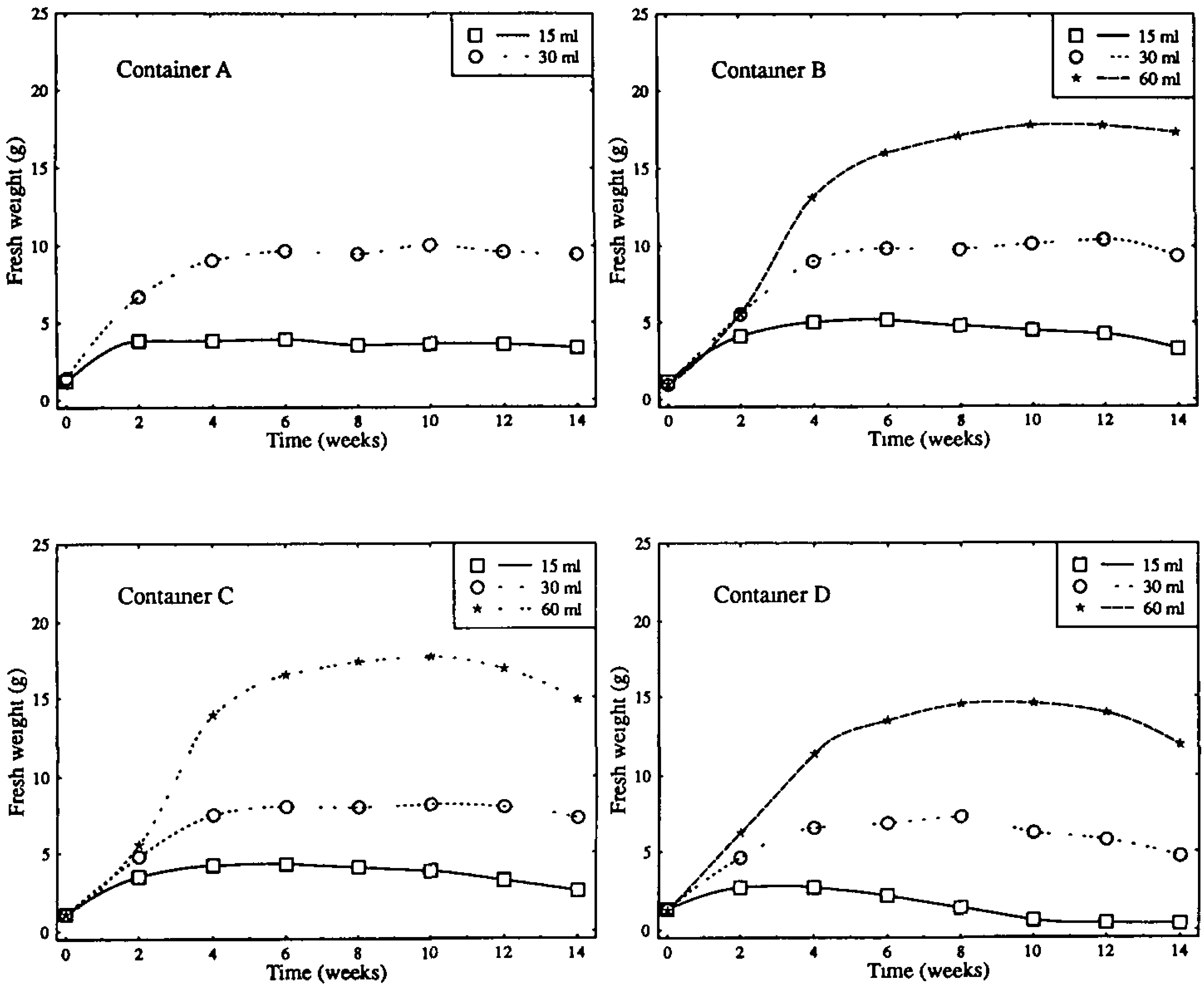

Figure 2. Time course of in vitro growth of *Zantedeschia* as influenced by container and media volume.

in plant growth over time was correlated with changes in media pH and was probably related to nutrient depletion. Maximum growth rates are likely to be achieved with frequent subculturing in small containers with a large volume of medium.

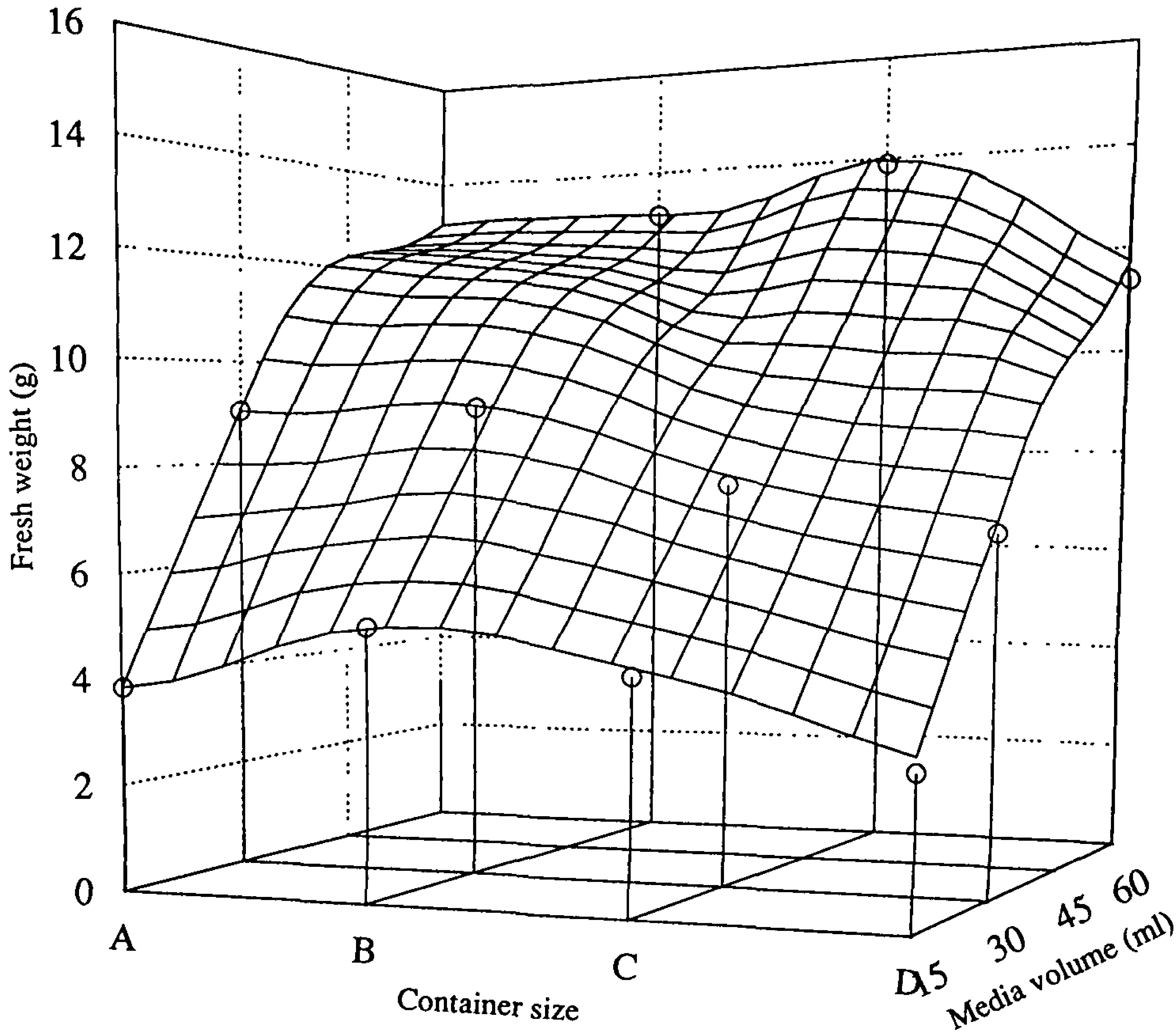

Figure 3. The effect of culture medıa volume and contaıner sıze on vegetatıve growth(shoot) of *Zantedeschıa ın vıtro* after 4 weeks

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Field Trial Results of *Acacia melanoxylon* from Tissue Culture

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INTRODUCTION

At the turn of the century, Australian blackwood (*Acacia melanoxylon*) was a very popular cabinet making timber, but supplies diminished and other timber took its place in the market Since the early 1980s, it has attracted interest in New Zealand as a special purpose plantation tree, an alternative to local native timbers which have become expensive and not widely available (Nicholas, 1982). *Acacia melanoxylon* grows on a wide variety of sites and it is possible to achieve the desired 6-m sawlog with a 30-40 year rotation.

Acacia melanoxylon often exhibits a poor form, usually as the result of insect damage to shoot tips causing loss of apical dominance. Within stands of *A. melanoxylon* good trees exhibiting rapid growth and improved form can be recognised. The Forest Research Institute (FRI) *Acacia melanoxylon* Programme includes silviculture, breeding and propagation research. Tissue culture was included in the propagation research as it had the potential to provide an early amplification of limited seed and cutting material which could then be multiplied further using less expensive cutting techniques. Furthermore, tissue culture could facilitate the import of desirable proven clones *in vitro* from Australia and South Africa where some selection work had already been done.

Early tissue culture research with *A. melanoxylon* at FRI has been reported (Jones, 1986; Jones and Smith, 1988). Results are presented from a preliminary field test of micropropagated *A. melanoxylon* one year after planting.

METHODS

Plant Material. *Acacia melanoxylon* seed (Jubilee Creek, South Africa seedlot number 8/0/84/10) was sterilized and germinated *in vitro* October 1986. Tissue culture techniques to produce plantlets have been described previously (Jones, 1986; Jones and Smith, 1988). These methods deal with the *in vitro* stages. In June 1988, rooted *A. melanoxylon* plantlets from 3 clones were removed from sterile culture, washed, root trimmed, and potted into 4 × 4 cm peat pots containing a peat:perlite:pumice mixture (2 1.1, v/v/v). Plantlets were placed inside a plastic frame in a glasshouse and misted each day. After three weeks, new foliage growth was visible on the tissue-cultured plants, which were then hardened off with increasing exposure to ambient conditions. Also in June, seeds from the same seedlot were sown in a hygiene tray and seedlings pricked out into root trainers (4 x 4 cm) after 14 days and grown in the same glasshouse as the tissue-cultured plantlets.

Plantlets and seedlings were lined out in a nursery bed at 8 × 8 cm spacing in November 1988 In June 1989, plants were conditioned by undercutting, wrenching and lateral root pruning. Due to unavoidable circumstances, a field trial was not established until November 1989, three months further into spring than considered optimal.

Site Preparation and Plot Design. The site was on the FRI Campus at Rotorua and was prepared by ripping to a depth of 50 cm at 2m centres. Plants were root trimmed and planted at 2 x 2m spacing. There were 4 plots each containing 68 trees giving a total of 272 trees in the field trial. Due to the late planting, tops were cut off all plant types to reduce water stress caused by lifting Therefore heights at planting were less than heights in the nursery bed Plants were measured in the nursery bed (June 1989), at planting (November 1989), and one year after planting (July 1990) for height and diameter.

In June 1989 at the time of conditioning in the nursery bed, two of the tissue-cultured clones (clones 2 and 4) exhibited plagiotropic growth. This growth orientation with the main stem lying horizontal rather than vertical, seriously affects both form and ability to compete with weeds following establishment.

All signs of plagiotropic growth had disappeared one year after planting. Heights were measured to the tip of the tallest branch and diameters were taken at the root collar at planting and after one year in the field.

Statistical Analysis. Plot 2 had a single tree random plot design including three tissue cultured clones and the seedling control. Data were analysed by one-way analysis of variance using Genstat 5. Means were compared using the LSD test at 5% level of confidence. Plots 1, 3, 4 were not analysed; they had one plant type per plot (P1=seedlings, P3=cl. 4 and P4=cl. 2.)

RESULTS

In the nursery bed, the heights of the 4 plant types were significantly different with Clone 3 being the tallest (Figure 1). At planting the seedlings and Clone 3 were significantly taller than Clones 2 and 4 despite topping. The same pattern remained one year after planting but the difference was no longer significant.

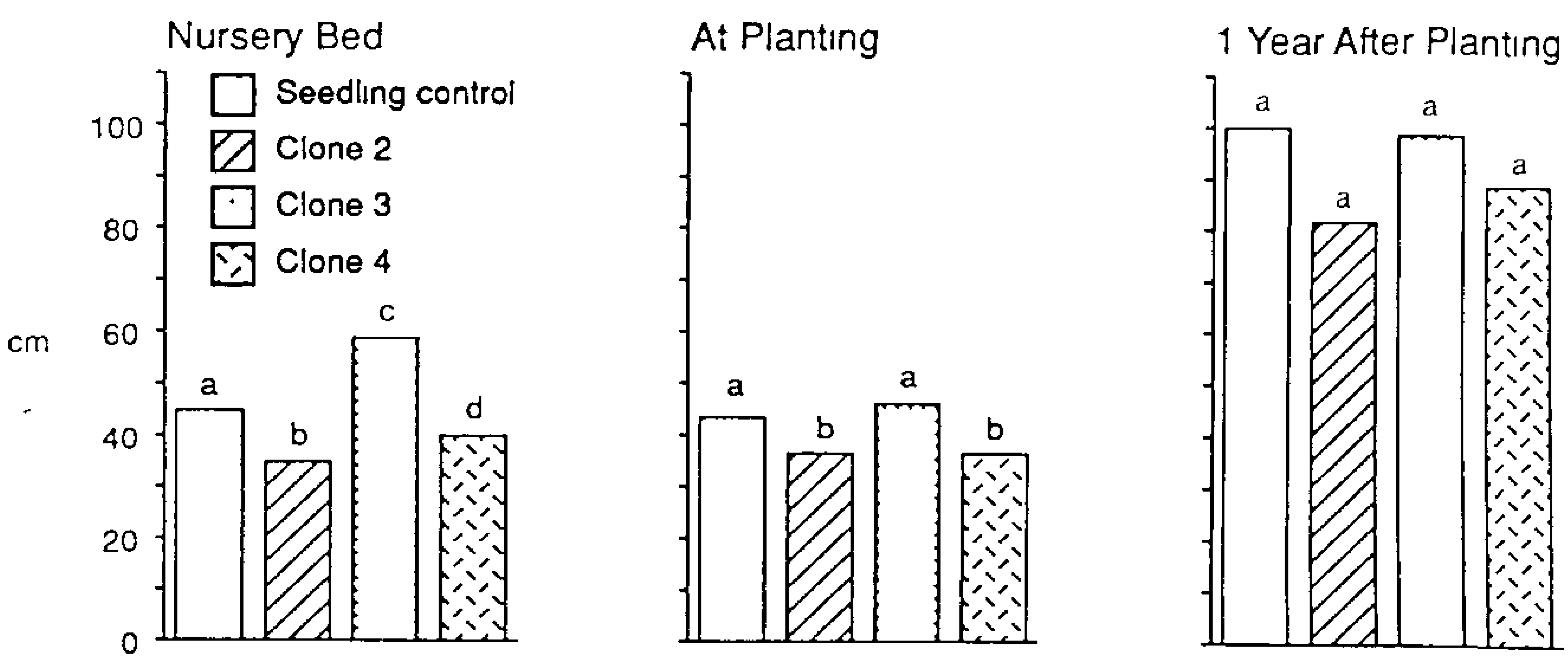

Figure 1. *Acacia* field trial heights.

Diameters at planting and one year after planting showed trends similar to those for height, with seedlings and Clone 3 significantly larger than Clones 2 and 4 (Figure 2) at planting. One year later, there was no significant difference between the diameter of the four plant types

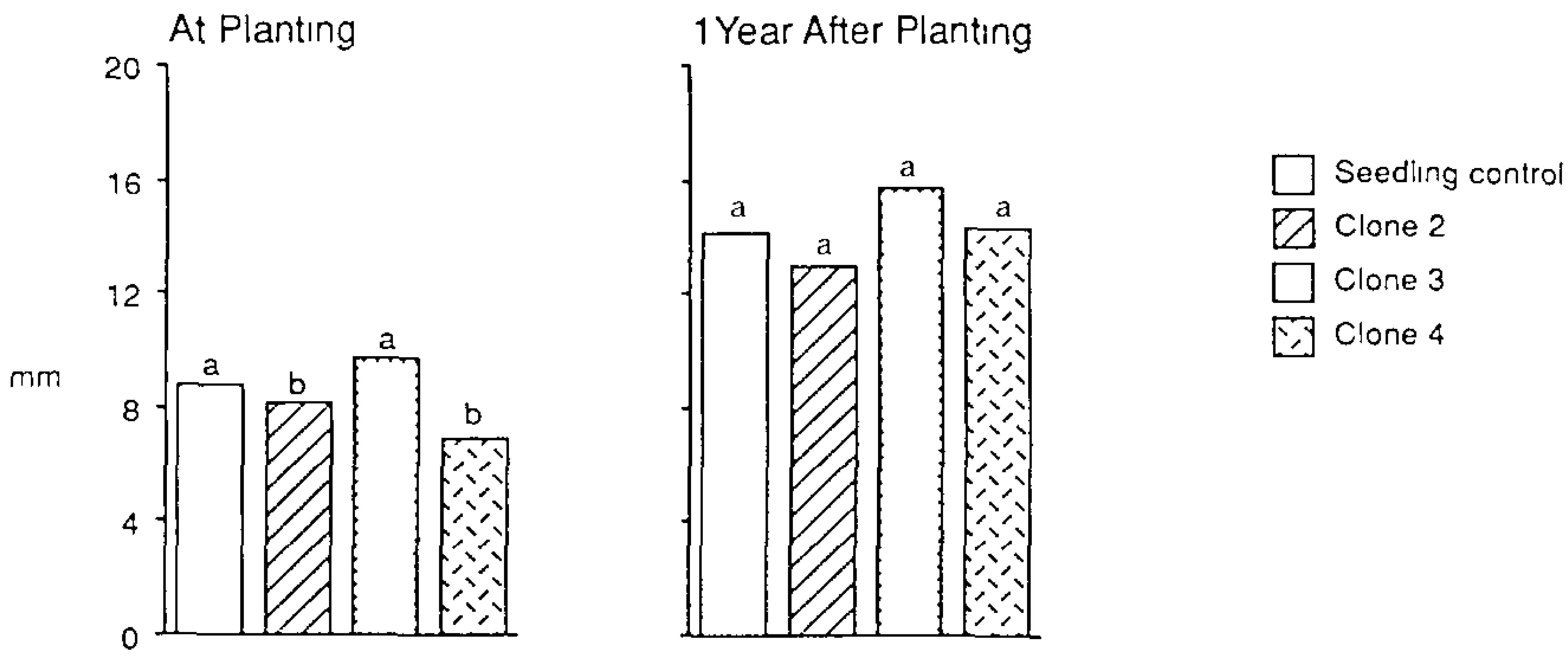

Figure 2 *Acacia* field trial diameters

There was no significant difference in height increment between the four plant types (Figure 3) Clone 2 tended to be shorter, but due to a wide range in heights 56-104 cm, this was not significant. However, diameter increment for Clone 4 was significantly greater than that for the other 3 plant types.

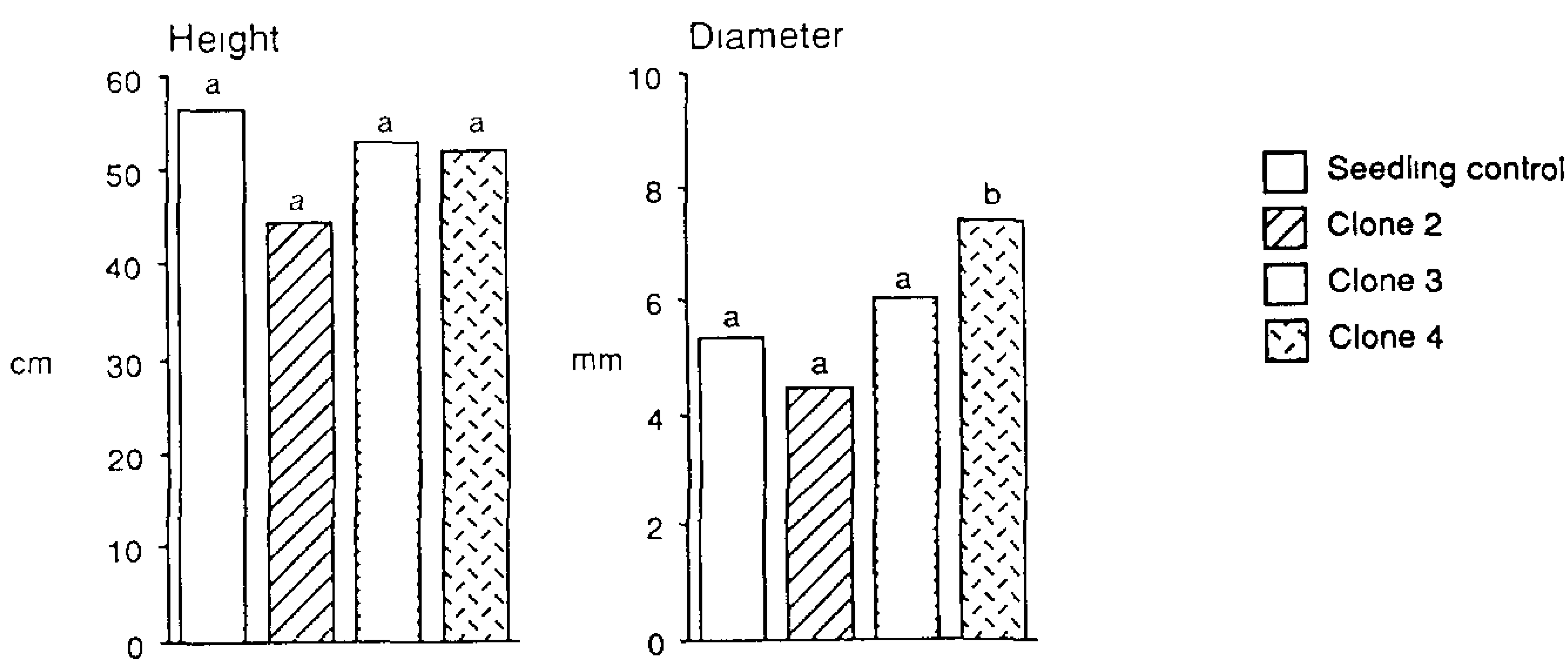

Figure 3. *Acacia* field trial height and diameter increment at 1 year

DISCUSSION AND CONCLUSIONS

Tissue culture has potential as a propagation method for early amplification of limited material (for some clones up to 1,000 in a 6 month period). The tissue-cultured planting stock used in this trial had a similar growth rate to seedlings. Although the tissue-cultured plants were not considered to have as good a root-shoot ratio as the seedlings at the time of lifting, this preliminary trial shows that three randomly selected clones were not inferior to seedlings in the critical first year following field planting. Subsequent field measurements are necessary to follow the growth of the *A melanoxylon* plantlets.

Conventional propagation research initiated at the same time as the tissue culture research has proved very effective, with many plants produced from root cuttings from young and old material. At this stage, tissue culture will not be used for amplification of select material within the FRI. However, the potential has been demonstrated by this study Should tissue-cultured plants become a preferred planting stock because of benefits such as high initial multiplication rates, further attention to nursery management techniques would be beneficial.

ACKNOWLEDGEMENTS

The authors wish to thank Trevor Faulds, Mike Dibley and Stephanie Bond for their helpful advice and assistance with the care of the material while it was in the nursery Michael Hong is also acknowledged for his help with design and analyses of field data

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Polyanthus, *Primula* x *polyantha,* Breeding

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My interest in polyanthus goes back to the heyday of the original Pacific Strain produced by the California firm of Vetterle & Reinelt (V & R). My brother and I grew these in the open ground and sold them wrapped. They were huge and took with them vast amounts of soil Our observation was that customers liked to select more than one colour and plants with unusual markings. As the viability of the seed we bought in was low on arrival and the cost high, we decided to separate a few of the more unusual selections and to start producing these ourselves.

After about five years our efforts were helped by the gift of a few packets of V & R seed from an old friend Alex Purdie of New Plymouth. Alex knew what we were trying to achieve and though it better that we had the "special seed to play around with".

Germination was patchy but we got a number of very unusual and, in some cases, strange plants. The best of these we selfed and repeated a second year. We matched colours and grouped them as V & R had done and have continued to do so ever since.

Our first objective was to establish a basic colour bank and then to produce as many cultivars as possible Exhibition heads with large strong stems were the ideal at the time. We also needed a balance of "pins" and "thrums" to give a high percentage of viable seed when crossed.

METHODS

Sowing. We sow the seed as soon as it is harvested which is usually November (early summer). Seed needs diffuse light and it should be uncovered, although we anchor it very lightly with fine vermiculite. When using plugs a plastic sheet is placed over each tray and these are stacked in a shed where it is cool Temperatures should not go above 16°C. Once germination starts there is a critical stage at which the seed should be covered completely and the trays moved to a cool house.

We grow 15,000-20,000 plants each year in 1/2 pint plastic bags. One batch consist of special crosses and the other our current year's seed crop. This has proved invaluable when growers have experienced problems with our seed, e g. poor germination, as we have been able to invite them to view our results and to take home some replacements to help them over their disaster

We are unable to produce seed of all strains by the beginning of October which is when most growers would like to sow it. We have found the seed can sometimes be stored for up to 10 years in the deep freeze and germination in some strains can be enhanced after a couple of years storage.

Selection. As the crop matures and flowers, we select as many as we can from the early-flowering plants. Later we may add others as choice plants are noticed. Colour groups are compiled and special groups structured where a new break is extended to other combinations. Pollination starts in July (mid-winter) and continues until late September. We have found when trying to isolate a characteristic that it is necessary to carry over summer desired parents and backcross.

Polyanthus has pins and thrums. Once the choice of combinations is made we emasculate a colour group of each type and the pollen is transferred from the anthers Although we try to hybridize only during good weather, weather conditions are not critical with polyanthus, and they will pollinate quite late in the day.

Once a cross is made the plant has to be checked daily until the stigma dries. The stigma is prone to *Botrytis* attack in early season crosses and pollinations made on high humidity days . Those that become infected must be removed.

Harvesting. This takes place normally from the end of October to the end of November, but sometimes as late as December Once the top of the seed head cracks and shrivels, it is harvested and placed on newspaper in seed trays. During the first two days the leafy calyces are removed to make cleaning easier In a warm, dry spot out of direct sunlight it takes only two to three days for the heads to firm and the seed to turn brown.

The husks are rubbed lightly over an Endecott sieve (2 8 mm) and the seed winnowed to remove the old husks The resultant trash and seed is then put through a series of finer sieves and we finish with a mixed grade of seed sizes with an average 1300 seeds per gram

CONCLUSION

Over the years we have had to change direction as demand has moved from the exhibition head to the more compact acaulis types. However we are continuing to aim for plants that are adapted to New Zealand conditions and which have:

1) flowers with good form, size, colour, distinctive ruffled and picoteed edges, and enhanced centres
2) increased disease resistance
3) flowers that are multiheaded and self-cleaning
4) uniform stem lengths.

Our latest effort has been towards the development of hybrids based on the Julians to be used as bedding plants that will withstand New Zealand spring and early summer weather.

It can be very complicated trying to improve an overall strain with infinite colour and maintain a commercial product at the same time. Plant breeding is time-consuming· one needs to start young, take an interest in your favourite plant and aim for goals. Preferably pick a plant that can be micropropagated and afforded plant variety rights.

Quality is the Key

Neil Huxtable[1]

KPMG Peat Marwick McLintock, Cardiff[2]

INTRODUCTION

In the 1950s there was more concentration on quantity than quality. From the 1960s consumer awareness led to increased inspection during the production process. The 1970s saw the oil crisis, and quality assurance came to the fore to conserve resources and reduce waste Quality through technical excellence was the key to Japanese pre-eminence in the 1980s and in the 1990s the combination of technical knowledge plus the effective use of people (the key to total quality management) is to the fore. In the future the issues at stake may well be quality of life and social cost quality

A quality driven organization concentrates on breaking down the barriers typical in old hierarchical organizations. Instead we aim for a structure in which external customers provide feedback which is passed through all levels of the organization so that they can work in harmony to meet the customers needs. The organization also passes feedback to its external suppliers so that they can correctly supply the organization.

Implementing Total Quality Management (TQM) must begin with a complete understanding and commitment by top management, followed by a company-wide awareness programme to tell everyone what is involved. Only then can you engage in planning and implementation. Finally, it is important to review progress regularly and improve continuously. It is vital to spend enough time on gaining a complete understanding of TQM, and getting commitment from the whole company before planning and implementation so everyone knows what is expected. This will ensure successful implementation.

One of the important features of TQM is to develop an open and totally fearless company culture. Very often people feel inhibited in stating their views, suggesting improvements or doing things differently, especially if they are constantly criticized by an over censorious management. Driving out fear is therefore an important feature exemplified in this concept of leadership. The role of management is to create the conditions to allow staff to reach their full potential.

THE COST OF QUALITY

The cost of quality is the total cost of everything that would not have been required, if everything else had been done right first time The cost of quality can be split into four categories·

- External failures (eg. returned faulty goods),
- Internal failures—(eg. things that go wrong during production);

[1]Keynote Address
[2]This company was involved as quality management consultant to Wyevale Nurseries.

- Appraisal costs (inspections during production);
- Prevention costs—the costs of activities which prevent problems in the first place, for example quality planning, training, quality improvement projects etc.

Investing in prevention activities reduces failure costs, so appraisal costs can also be reduced. In companies not practicing TQM, easily 20% of turnover can be taken up by quality costs, with 70% of this being due to the cost of internal and external failures. Typically only 1% would be spent on prevention. Lots of things go wrong, lots of money is spent putting them right, but hardly any is spent on prevention.

A company practicing TQM might double its prevention costs, from 1% to 2%, but it could expect failure costs to come down from 14% to just 2%. There would then be less need to check for failures, so appraisal costs might be reduced to just one per cent. This company is spending just 5% of turnover on quality, compared to the 20% without TQM.

WYEVALE NURSERIES

Wyevale Nurseries is a plant production nursery. It is part of Wyevale Holdings, which also includes the largest garden centre chain in the UK, and a specimen tree nursery. Wyevale nurseries supplies garden centres, local authorities, the landscape industry and other nurseries. Annual sales are some £5 million, with sites in the midlands, south-east, west country and France. It has around 200 employees.

The quality objectives it set itself were.

- To improve quality standards
- Minimize quality costs
- Increase market share
- Increase profit
- Reduce labour turnover
- Eventually to gain accreditation to quality standard BS5750.

Phase One. The first step was a director's planning workshop, followed by the formulation of a quality policy. The Comany's policy statement embodied many of the elements of TQM: "Wyevale Nurseries will provide the highest standard in customer service, including product quality and availability, value and timely delivery. To achieve this standard we will minimize errors and wastage throughout the Company by staff training and better systems."

There were then discussions with department heads, who attended the workshop, to obtain their views about what was needed and how it could be implemented. Departmental meetings, involving all employees, informed them of the Company's intentions.

Information gathering for the exercise included an external customer survey and calculations of the current costs of quality. External and internal failures accounted for 90% of the costs of quality, prevention costs only two per cent. The total quality cost was over 30% sales turnover, over £1 m at the Hereford site alone.

A quality manager was appointed to facilitate and co-ordinate the programme This is an important position and should be occupied by someone at senior management or director level. The role is coordinating and facilitating rather than responsibility for quality improvement—that function rests with the whole work force and it is important that it is seen to be so. In smaller companies the role of quality manager could well be combined with other activities.

Phase Two. The second part of the programme at Wyevale involved the following elements. Leadership training for directors and managers; "internal customer" survey to explore relationships between departments of the nursery which supply each other (eg sales and production), process flow charts to establish what goes on where; implementation of performance appraisal; setting quality objectives for each department; setting up a new internal communications strategy.

Phase Three. The third phase was to continue the education process with the work force in TQM: To address problem solving and problem analysis; to form corrective action teams; to monitor reduced quality costs; to produce quality manuals on issues such as planting, pruning, propagation etc; to produce a monthly quality bulletin sent to every member of staff to update them on progress throughout the organization. A staff attitude survey was conducted part way through the programme to determine reactions to the project and discover additional areas needing attention.

Achievements. Achievements to date include·
- Establishing clear departmental responsibilities;
- A confident quality conscious management and work force,
- An improved customer profile;
- Significant waste reduction (the Company reports savings in excess of £100,000 in the first year);
- Major reductions in cost of quality;
- Better communication and team-work;
- Improved methods and procedures

Hereford and Worcester Training and Enterprise Council have chosen Wyevale as one of its exemplary companies in its approach to quality and training.

Next Steps in the Continuation of the Quality Programme. The next steps will be the continuation of the quality programme to gain BS5750 and will include the appointment of a marketing director; the re-assessment of the marketing function; the implementation of TQM to outlying sites within the company; the implementation of a publicity programme; a quality improvement programme with suppliers; and gaining accreditation with the new Investors in People Standard, as a company which recognizes that its strength lies in the quality of its staff

Stockplant Manipulation for Better Rooting and Growth From Cuttings

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QUALITY RELATED TO EASE OF PROPAGATION

Attaining a plant of large saleable size as quickly as possible is the main objective of commercial nursery stock production, with due attention to shape in terms of branching and compactness, and the development of flower buds if appropriate for the variety. Batch uniformity should be high, and production methods must be cost-effective.

These objectives are undermined if a plant is difficult to propagate. Easy-to-root cuttings suffer least if the propagation environment is less than optimal, and well-rooted cuttings establish and harden with minimal difficulty, and grow-on to produce uniform batches of plants. On the other hand, cuttings of difficult-to-propagate plants may fail to survive, or may root only poorly. Subsequent weaning is difficult and the growth of those plants which reach the container will be variable, reflecting variation in root development. Initial propagation success is, therefore, an essential component of high quality production.

STOCKPLANTS

Cuttings are very sensitive to environmental conditions that affect transpiration (Harrison-Murray et al., 1988) and it is likely that most commercial facilities are in fact sub-optimal for many varieties of cutting. Furthermore, there is not always the opportunity to handle cuttings in the most effective way during peak propagation periods and so the advantages of wounding and auxin treatment are often lost, with the result that rooting is slower and possibly fewer cuttings root

It follows that cuttings should have the highest possible rooting potential when collected, so as to offset these deficiencies in handling and environments. The choice of cutting and the opportunity to manipulate rooting potential is much greater when specially grown and maintained stockplants are available than when cuttings are taken from young plants before they are sold.

Research has identified various ways in which stockplants can be made to produce cuttings with increased rooting potential, and a theme common to them all is that improved rooting is associated with the production of shoots with relatively thin stems.

STOCKPLANTS FROM MICROPROPAGATION

For some species, field- or container-grown stockplants raised from a micropropagated source produce cuttings which root faster and in greater numbers than those from conventional sources (Howard and Marks, 1989). Further studies with the dwarfing plum rootstock *Prunus insititia* 'Pixy' have shown that micropropagated stockplants produce a higher proportion of thin-stemmed hardwood cuttings than conventional stockplants (Howard and Ridout, 1991b). Comparisons between sources is enhanced by also taking account of shoot length, and it is cuttings prepared from the proximal parts of relatively long thin shoots that root better than those from relatively short thick shoots This relationship between shoot morphology and rooting is relatively weak when comparing different sources, partly because their ratios of shoot thickness to shoot length may differ, but it is much stronger when comparing shoots within a source, where the shoot diameter : length ratio is relatively constant.

WITHIN-PLANT DIFFERENCES

Shoots from hedged stockplants of *P insititia* 'Pixy' show a strong inverse correlation between stem thickness and rooting ability, whereby thin shoots root best (Table 1).

Table 1. Rooting of *Prunus insititia* 'Pixy' hardwood cuttings related to their basal diameter

	Diameter (mm)			
	< 6	6 - 8	8 -10	> 10
Rooting (%)[1]	58	44	30	13
Number of roots per rooted cutting	6 1	4 1	3 2	2 1

[1] For rooting (%) P<.001; root number P< 01

This relationship was only revealed by improving propagation conditions, because in overwet compost thin cuttings were particularly vulnerable to asphyxiation and rotting (Howard and Ridout, 1991a). In the same experiments (Howard and Ridout, 1991b) it was shown that the superior rooting of cuttings taken from the lower region of the stockplant compared to those from the crown was correlated with a lower stem diameter (mm) : length (m) ratio. An increase in ratio from 5.9 (relatively long thin shoots) to 7.4 (relatively short thick shoots) was associated with a reduction in rooting from 87% for lower cuttings to 47% for crown cuttings

The benefit of relatively long thin stems extends to other species. Cuttings of *Rhododendron* 'Dopey' and 'Hoppy' which rooted in dry fog had a 28% smaller stem diameter : length ratio than those which failed to root.

Preconditioning Stockplants in the Dark. So-called etiolation treatments, where stockplants are prevented from receiving light, or are exposed only to very low light intensities, often improve rooting of subsequent cuttings (Maynard and Bassuk, 1988). The enhanced rooting potential is present both in the stem which grew in the dark, and the more distal part that grew during the period that the stockplants were being weaned into full light before propagation. Recent experiments with softwood cuttings of *Syringa vulgaris* 'Madame Lemoine' (Howard and Ridout, 1992) show that shoots produced in the dark have relatively thinner stems and root more readily than light-grown shoots. In the case of these softwood cuttings, we have some insight into the reasons why rooting is improved in the thin stems.

At collection, cuttings from dark pre-treatments have a similar number and area of leaves to those from normal light-grown plants, so the relatively thinner stems of the former result in a greatly increased leaf area : stem ratio. This holds good when the stem is described in various ways, including diameter, dry weight and fresh weight.

During the period of about 10 days between sticking the cuttings and the emergence of the first roots, the dark-preconditioned cuttings with high leaf.stem ratio greatly increase in dry-matter content at the base of the stem where roots will emerge— the stems of light-grown shoots, often lose weight (Table 2).

Table 2. Changes in shoot morphology and dry matter accumulation related to rooting in *Syringa vulgaris* 'Madame Lemoine' softwood cuttings

	Normal light-grown	Dark preconditioned	Level of significant difference (p)
Proximal stem diameter (mm)	3 7	3 1	< 001
Stem dry weight (g)	0 43	0 21	< 01
Ratio of leaf area (cm^2) to stem dry weight (g)	205	442	< 01
Rooting (%)	16	74	< 001
Number of roots per rooted cutting	1 1	5 2	< 01
Length of longest root (cm)	0 5	2 1	< 001
Change in dry weight of proximal stem before rooting (%)	-11 4	+14 5	< 001

In unrooted cuttings, dry matter increase closely reflects the accumulation of carbohydrates, and the interpretation of these results is that carbohydrates surplus to the requirement for stem maintenance (which is likely to be relatively lower in the thin-stemmed cuttings) are available to drive the rooting process.

Implications for Nurserymen. Permanent stockplants provide the opportunity to increase rooting potential in shoots before they are collected as cuttings. Hard pruning gives rise to many shoots suitable for cuttings, but their high rooting potential is not due to their enhanced vigour, as has long been supposed, because these experiments show that weaker shoots root better than more vigorous ones.

The advantage of using relatively thin shoots for both hardwood and softwood cuttings only became obvious when the propagation environment was improved For hardwood cuttings sand beds were installed below the rooting medium to rapidly remove excess water after irrigation and so prevent basal rotting, to which thin cuttings were particularly susceptible When planting directly into the field, a compromise needs to be made between the thinner cuttings which root quickly and the thicker ones which survive longer in the poor conditions often present in soil during winter.

The advantage of thin stems to facilitate rooting in softwood cuttings can be obtained by temporarily growing stockplants in the dark, but it also extends beyond the use of dark preconditioning, because, as with hardwood cuttings, the smaller, thinner stemmed cuttings in any source rooted better than thicker ones Here also the environment was important because conditions had to be conducive to the accumulation of photosynthates. In these experiments this was achieved using 'wet fog', which allowed cuttings to receive approximately 20% available light without being stressed

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First Quality Plants - Can the Societies Play a Role?

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INTRODUCTION

This survey aims to specify which societies are possible sources of new or re-introduced plants for the trade, then define quality, and finally discuss how societies can achieve quality in plants, other than those which are already widely available

SOCIETIES

Specialist plant societies include those which deal with a wide range of plants, such as the Hardy Plant Society (HPS) or Alpine Garden Society; and those covering a narrower range—e.g. the British Fuchsia Society, Delphinium Society, and Royal National Rose Society, for example

Tender plants for outdoor use and woody plants are not well covered by specialist societies although they form a major part of commercial plant sales. Annuals are also poorly covered and development of new cultivars is led by parks departments' requirements for carpet bedding rather than general garden usefulness Many such annuals are so dwarf that they will scarcely peep above the rim of a window box or other container and will not mix in well with most bed or border planting.

There are also national societies whose interests cover the whole spectrum of garden plants, such as the Royal Horticultural Society (RHS), National Council for the Conservation of Plants and Gardens and National Trust.

The emphasis in this paper is on the amateur societies rather than professional bodies such as I.P.P.S., Institute of Horticulture or Horticultural Trades Association

QUALITY

Quality, as far as the specialist societies are concerned, is measured by merit as garden plants, whether wild-origin species (or forms thereof), cultivars (including hybrids) or clonal selections. Commercial considerations and marketability are not the primary role of amateur specialist societies

Plant health—freedom from virus, eelworm etc.—also affects quality and societies may be able to play a role in removal of pathogens by modern techniques

ACHIEVING BETTER PLANTS

Societies dealing with one genus, such as the Delphinium Society, have long been involved with selection and breeding of new plants but breeding of most genera has not been actively encouraged by societies with a wider remit in recent years. The Hardy Plant Society plant breeding subcommittee was recently started with the aim of encouraging members, amateur and professional, to try simple plant breeding or at least to select good forms from mixed ranges of plants or recognise valuable mutations and self-sown seedlings. The subcommittee hopes to "de-mystify" plant breeding and also to assist in the naming, registration and marketing of new plants on behalf of its members. Worldwide HPS membership helps in acquiring seed of possible parents. This is particularly valuable for genera such as *Phlox*, which have tremendous untapped potential as herbaceous plants, cut flowers and even pot plants, but for which many of the most promising species are not in cultivation in Europe or the British Isles.

The Hardy Plant Society Search List was originally started as a means of seeking out old plants of historic or conservation importance It seems a waste of effort to scour the world for a restricted range of plants, some of which must by now be superseded, and not to use the same list and importation system to import other plants of interest to HPS members including new cultivars, so plants other than those of conservation value have been added to the Search List. Establishing contacts for export/import is crucial and difficult. Bulking up and distribution of newly introduced plants is another important step: a distribution system which is seen to be equitable to all members, including nursery owners, is essential

Assessing quality and distinctness especially of new plants is aided by collections, including the National Collections scheme of the National Council for the Conservation of Plants and Gardens Trials, particularly those organised by the RHS, are also very helpful. However, the RHS trials have had their limitations in the past: they have only proved whether plants will perform well in the trials field at Wisley, in conditions that are not necessarily ideal for the particular plants; they do not show how the plants will perform in other parts of the country; there is a limit to the number of trials the RHS can run and it is difficult to acquire the full range of plants for each trial; once the trial is complete and the best sorts have been given awards, it is not necessarily easy for gardeners or nurseries to acquire stock.

The RHS is very actively trying to improve its trials system. Extending trials to Rosemoor and Pershore in the West and possibly Harlow Carr in the North would make it much more likely that plants can be grown in the climate that suits them best as well as telling us more about hardiness. Specialist societies might be able to help make plants from trials more widely available. Publication of information about good plants, new or old, including those from trials or National Collections is useful in making known which ones are most garden-worthy.

Clonal selection is unlikely to be within the interests or capabilities of individual society members but societies can identify a need for selection and encourage suitable bodies to take on the task, perhaps linked to National Collections or trials.

Improving plant health by meristem culture or heat treatment is an expensive process, beyond the means of most societies unless costs can be covered by the sale of healthy plants. The HPS project with double sweet rocket was an early venture and proved very successful; the society is considering which other plants should be cultured next.

The Plant Finder, published annually in association with the HPS, enables plant users to be much less approximate in their choice of plants and to select and buy the cultivar or species which is best for a particular purpose, not just the one that happens to be most easily available. Through the *Plant Finder*, quality plants will quickly come to the attention of a wide market, even if they are initially scarce and little known

CONCLUSION

Societies can certainly play a useful role in breeding, selection and introduction of quality plants. They may also be instrumental in improving plant health, at least for more popular and commercial types

Their success depends on vigorous and active membership, preferably with a good balance of amateurs and professionals, and good communications within the society—for larger societies, an effective group structure helps Societies with overseas membership are more able to achieve results. There is much scope for society involvement to improve the range of all sorts of garden plants, although there is comparatively little specialist society interest in trees, shrubs, tender plants and annuals. The specialist skills of I.P.P.S. members would enable them to do much within societies such as HPS and NCCPG to improve the quality as well as increasing the quantity of the finest garden plants.

Membership of HPS currently costs £8.50 single/£10.00 joint from the Membership Secretary, Mr S.M. Wills, The Manor House, Walton-in-Gordano, Clevedon, Avon BS21 7AN. Details of membership of NCCPG are available from the General Secretary, R.A.W. Lowe, NCCPG, Royal Horticultural Society's Garden, Wisley, Woking, Surrey, GU23 6QB.

The Development of a Market-led Propagation System

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INTRODUCTION

Propagation has more influence on the final quality of nursery stock than does any other stage of the production cycle. Both efficiency and effectiveness of production are controlled by the rate at which saleable plant size is achieved and this, too, depends to a large degree on the quality of the liner emerging from the propagation house.

Using modern technology to improve traditional cuttings propagation systems can come close to ensuring that each plant produced is of premium grade But they still have the drawback of being production-led rather than market-led. They fail to deliver high quality, fresh plants throughout the season. Instead they lead to maximum availability of plants in the autumn at a time when demand is below peak.

A MARKET-LED MULTIPLE SALES SYSTEM

The production system to be described in this paper develops plants to the point of sale in the same time as direct sticking but produces a more consistently high quality product. Delivery of plants can be scheduled to meet consumer demand throughout the normal growing season, and a smaller propagation facility is required It can produce a new batch of consistently high quality, uniform plants in each month of the growing season. This is a most important feature, since it allows plants to be produced in prime condition throughout the periods when consumer demand is at its highest.

The system is thus a truely market-led system. The producer can negotiate with the retail outlets the quantity of plants required at particular times during the sales season, and can adjust the growing programme accordingly to deliver fresh plants, in prime condition as required. In addition, by careful selection of plant type, it is possible to enhance the sales appeal of many species by producing plants in flower for delivery to garden centres throughout the season.

In this system, cuttings are rooted in cell trays in which the cell sizes are determined by the leaf area of the cutting. This greatly reduces the container size required at the propagation stage For example in the case of *Abelia* cuttings a cell size of only 37 × 37 mm is required, whereas if such cuttings are struck in the final pot, a container of 16 cm diameter is typically used.

Placing cuttings in small cells greatly reduces the rooting time. The roots are forced to grow downwards in the ribbed cells. The check to growth at potting-on which usually occurs when roots are allowed to spiral can thus be avoided and the particular advantages of direct sticking, in which checks to root growth and root disturbance are minimised, are retained

As the system uses the existing nursery infrastructure and does not demand investment in extra acreage it is ideally suited to small or medium size nurseries with limited capital and resources.

Different crops require different production programmes. The programme described in this paper is designed to produce, for the retail market, deciduous plants which normally require a 15 to 18 month production cycle.

METHOD FOR THE DEVELOPMENT OF THE MARKET-LED SYSTEM

The first step in developing the new system was a detailed analysis of the traditional Autumn Sales Production System (ASPS) which was then in use on the nursery. Its major shortcomings were identified as.

1) Cuttings for the year's plant production are taken at one time requiring large amounts of space in the propagation unit.

2) Large numbers of stock plants have to be grown to make available sufficient material at one time.

3) "Factory" mechanisation techniques rather than careful individual selection results in variable quality and high failure rates.

4) The utilisation of production facilities and systems is poor. Bottlenecks occur at crucial stages.

5) Major checks in growth occur at potting-on due to root disturbance or liners being pot bound

6) The throughput of the system is low with high handling costs.

7) Marketing strategy is constrained by the production process. Plants for spring sales are produced from July onwards and thus require additional space for overwintering.

8) The time to saleability is dictated by the liner pot size Thus there is a need for different sizes of liners to achieve sales at different times of the year. This inflexibility of the production process is one of the system's greatest shortcomings.

MAJOR PARAMETERS OF THE NEW SYSTEM

Consideration of the above shortcomings led to the identification of the following major parameters that would affect the design of the new system:

1) The actual growing season.

2) The earliest and the latest times of year the plant could be successfully rooted in economic numbers (i.e greater than 70%).

3) Cutting availability, rooting and weaning time.

4) Cutting to liner establishment time.

5) Liner to final pot establishment time.

6) The time to point of sale after establishment.

7) Indoor growing space available and whether the plant requires final potting indoors to aid establishment.

8) The earliest convenient indoor potting date

9) The amount of outdoor growing space available.

10) The earliest frost free outdoor potting date

11) The time of year stock requiring winter protection should be moved indoors.

12) The number of plants required each month by the retail outlets

13) The attributes of the plant that motivate sales (e.g foliage, flower, size, etc.

14) The species/cultivars to be grown

SYSTEM CRITERIA

The criteria the new production system should meet when established are as follows.

1) The system should provide a programmed production of a regular supply of different sizes of liner.

2) It should produce simultaneously a variety of market-fresh plants with a predetermined shelf life.

3) It should allow the production unit to work to contracts placed in advance.

4) Modern techniques and equipment should be used to release staff from mundane activities which are best left to automation This allows staff to concentrate on those activities which are not suitable for automation.

5) The propagation unit should be used exclusively for propagation. Weaning should be carried out elsewhere to ensure the maximum effective use of the facility.

6) Propagation misses should be minimised by rooting and pregrading cuttings before transferring them to liner pots.

7) The system should enable the production of the smallest fastest rooted unit of maximum flexibility that can be sown in the different sizes of liner pot.

8) Stock plants should be utilised to greatest effect by the provision of multiple batches of cuttings throughout the growing season. This is most effectively achieved by inserting the cuttings and potting the liners and final pots at staggered intervals during the season. This will also help to reduce overproduction.

9) The liner- pot stage of production should be retained to allow slow growing and difficult subjects to be adequately established.

10) The stock turn at every stage of production should be increased by optimising the use of indoor and outdoor facilities.

11) Optimum conditions should be provided to permit uninterrupted growing

12) Production time should be reduced without sacrificing quality

13) The number of final pots overwintered on the nursery should be minimised

DEVELOPMENT OF THE SYSTEM

In the analysis of the existing ASPS it was noted that subjects requiring final potting indoors to aid establishment, needed less production time than those that were final-potted outdoors, due to the faster growth rates achieved under protection.

To allow comparison with the existing system, two deciduous subjects were chosen for the pilot programme of the new system. One of these was normally final-potted indoors, the other outdoors, in the 15- to 18- month programme of the ASPS The two chosen subjects were:

Abelia x *grandiflora* 'Francis Mason' (Table 1),

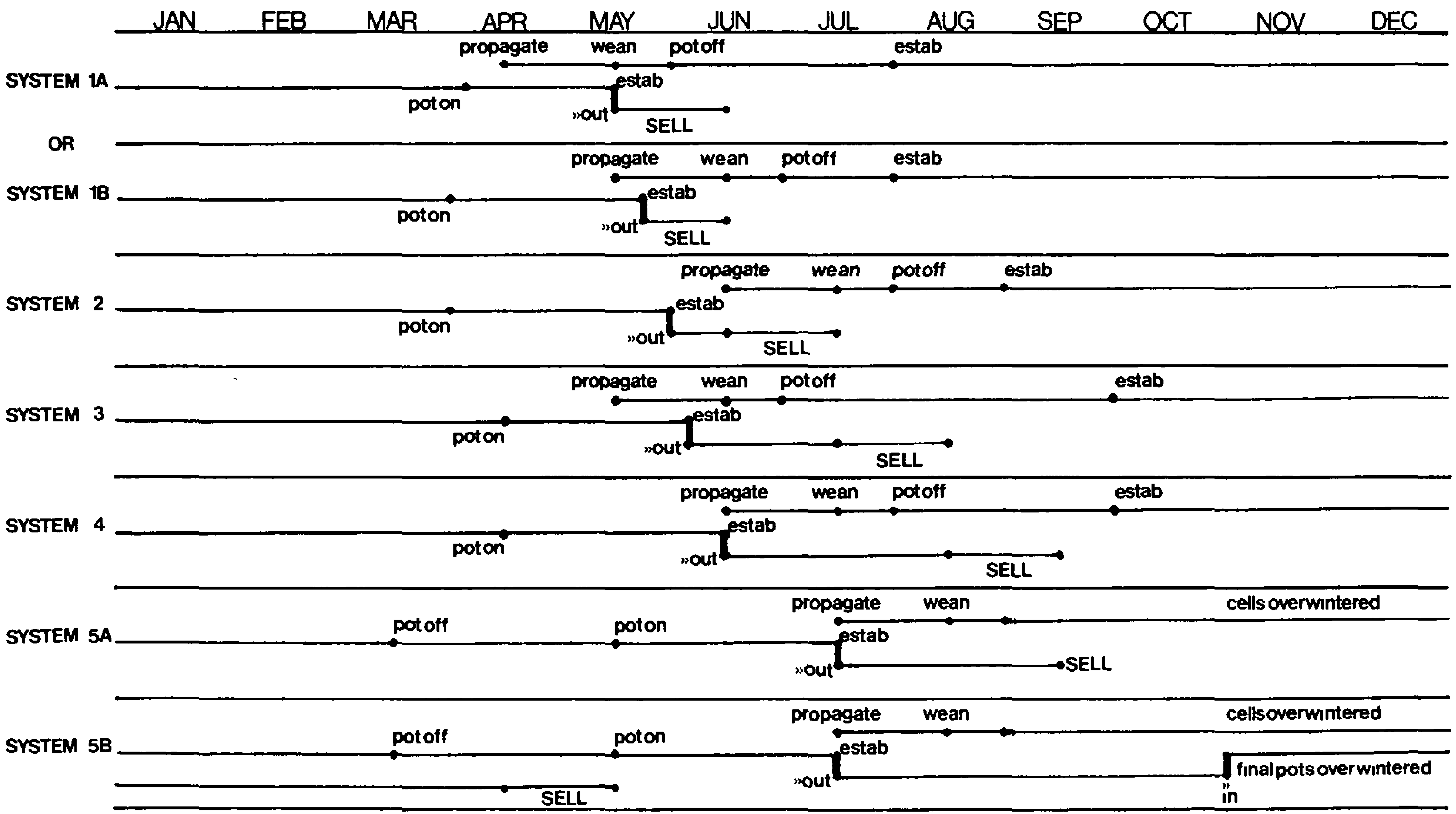
Spiraea japonica 'Gold Mound' (Table 2).

The first trial involved taking cuttings at 4 week intervals from April to September and potting a single rooted cutting into each different liner pot at 6 week intervals. From this, definite cut-off points for the propagation and potting-off times for each of the different liner pots, to achieve successful establishment and overwintering were identified The following observations were also made:

1) The latest an 11 cm, one-litre deep pot could be produced was from cuttings taken in April and potted-off not much later than June 1st

2) The latest an 11 cm, 0 75 litre pot-liner could be produced was from cuttings taken in May and potted off not much later than the end of June.

Table 1. Optimum systems for subjects final potted indoors to aid establishment. Test subject: *Abelia × grandiflora* 'Francis Mason'.



3) The latest a 9 cm, 0 5 litre pot liner could be produced was from cuttings taken in June and potted-off not much later than August 1st.

4) cuttings taken in April could achieve 50% of the final required plant size by the end of the growing season.

However, cuttings taken from mid-July onwards and potted-off from September onwards made no significant gain in size and were better overwintered in the cell trays. This required less overwintering room If the cuttings were left in the trays after March, they became difficult to manage and suffered severe checks to growth.

It was obvious that to produce final plants of the required size and grade in time for some of the sales months, particularly those in spring, would require the production of part grown final plants at different stages of development at the liner stage. However to avoid any checks in growth or deterioration of quality through reducing production time, it was imperative that the liners had reached an appropriate stage of development at the final potting dates established in the programme.

The next trials involved taking cuttings at four week intervals from mid-April to mid-July and potting off different numbers of cells in each liner pot at 6 week intervals (Table 3).

It was found that using multiple cell liners considerably hastened establishment time in the liner and final pots when compared with a single cell liner. Furthermore, substantial extra growth was achieved, producing a more uniform product which could be marketed earlier. In addition, by using multiple numbers of cells, larger liner pots could be established later in the season. However less growth was achieved because of the reduced potential for growth after the longest day has passed. Thus later propagation is best suited to liners for sales later in the season.

From further trials it was possible to fine tune and target a particular size of liner at a specific sales month by increasing or decreasing cell numbers which either accelerated or decelerated production time. However it was not possible to produce a liner which could be potted in the same season for mid-April sales and thus a quantity of the plants produced for September had to be overwintered. Also, because of the danger of frosts before May, those subjects that were normally final-potted outside had to follow the same liner systems developed for indoor final-potted subjects for May and June sales. This required a different set of liners for the other sales months.

While it was possible for different sizes of liner with larger numbers of cells to be produced later in the year for the same sales month, those selected-out were at their optimum point of growth, required the minimum number of cells and best met the criteria established for the new system

CONCLUSIONS

The pilot programme has been successfully employed for two popular species. The system is now ready for full operational production.

It is applicable to a wide range of subjects, but growers wishing to use it will need to carefully prepare production schedules to suit each variety

The system requires high quality propagation systems and facilities but in return offers the opportunity to produce plants of consistently high quality throughout the normal sales season.

While maintaining high output levels its main emphasis is on high quality throughout the production process The quality and marketability of the final product are enhanced and the viability of the production unit thus improved.

Table 2. Optimum systems for subjects final potted outdoors Test subject *Spıraea japonıca* 'Gold Mound'.

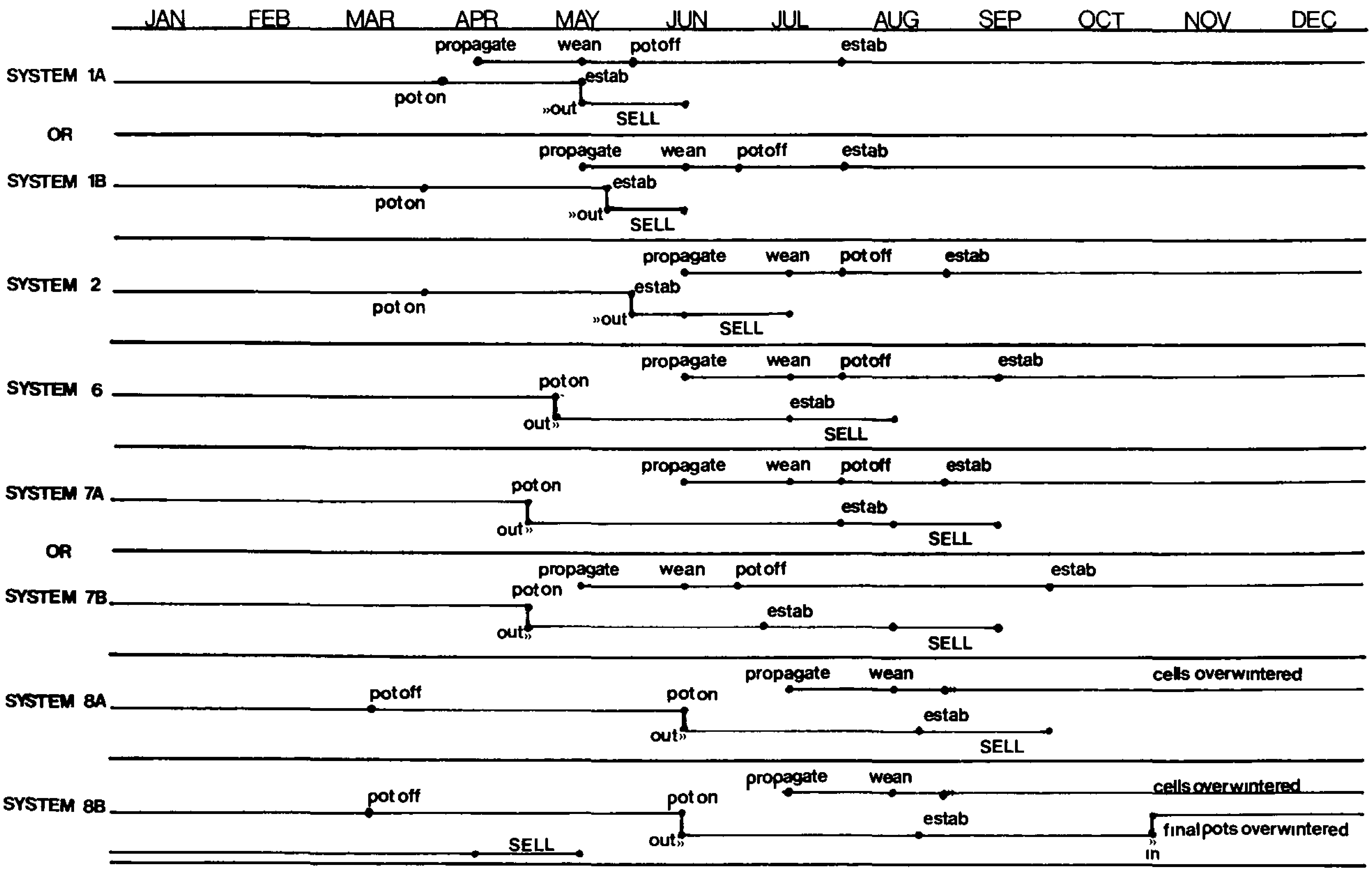


Table 3. Optimum liner systems for indoor and outdoor final potting

Liner system number	cell number and liner pot size (depth, vol.)	Propagation month	Potting off month	Establishment time in weeks of cells in liner pots	Potting on month
Optimum Liner Systems when potting commences 1st April for subjects final potted indoors to aid establishment					
1A	2 cell 11cm, 1L	April	Early June	8	Early April
OR 1B	2 cell 11cm, 0.75L	May	Early July	4	Early April
2	2 cell 9cm, 0.5L	June	Early August	4	Early April
3	1 cell 11cm, 0.75L	May	Early July	12	Early April
4	1 cell 9cm, 0.5L	June	Early August	8	Mid-April
5A	1 cell overwintered 9cm, 0.5L	July	Mid-March	8	Mid-May
(NOTE System 5B is an extended System 5A)					
5B	1 cell overwintered 9cm, 0.5L	July	Mid-March	8	Mid-May
Optimum Liner Systems when potting commences 1st May for subjects final potted outdoors.					
1A	2 cell 11cm, 1L	April	Early June	8	Early April
OR 1B	3 cell 11cm, 0.75L	May	Early July	4	Early April
2	2 cell 9cm, 0.5L	June	Early August	4	Early April
6	2 cell 11cm, 0.75L	June	Early August	6	Early May
7A	2 cell 9cm, 0.5L	June	Early August	4	Early May
OR 7B	1 cell 11cm, 0.75L	May	Early July	12	Early May
8A	1 cell overwintered 11cm, 0.75L	July	Mid-March	12	Early June
(NOTE System 8B is an extended System 8A)					
8B	1 cell overwintered 11cm, 0.75L	July	Mid-March	12	Mid-June

Notes 1) All liners grown and overwintered under protection
2) Systems 5A and 8A had to be extended to overwinter final pots to provide plants for the first sales month
3) Systems 1A, 1B and 2 are repeated due to insufficient outdoor growing time to develop liners to point of sale for mid May and mid June sales

Table 3 *continued*

Establishment time in weeks of liners in final pot	Month of moving final pots outside	Time in weeks to point of sale	Sales month	Total production time in months
5 5	Mid-May	0	Mid-May to mid-June	13
6 5	Late May	0	Late May to mid-June	12
8	End of May	2	Mid-June to mid-July	12
6 5	Early June	5 5	Mid-July to mid-August	12
8	Mid-June	8	Mid-August to mid-September	14
8	Mid-July	8	Mid-September onwards	14
8	Mid-July	8	Mid-April to mid-May	21
5 5	Mid-May	0	Mid-May to mid-June	13
6 5	Late May	0	Late May to mid-June	12
8	End of May	2	Mid-June to mid-July	12
9	n/app	0	Mid-July to mid-August	13
12	n/app	2	Mid-August to mid-September	14
9	n/app	5	Mid-August to mid-September	15
9	n/app	5	September onwards	14
9	n/app	5	Mid-April to mid-May	21

Parameters Growing season Mid-March to end of September / Rooting time 4 weeks/ Weaning time 2 weeks / Earliest convenient indoor potting date 1st April / Earliest frost free outdoor potting date 1st May / Time of year stock requiring winter protection moved in 1st November

Compost and Nutrition in Nursery Stock Production

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INTRODUCTION

The last 20 years has seen the steady development of peat dominated mixes for use in container nursery stock. The quantity of peat used by the nursery stock industry has now reached at least 220,000 m^3/annum, (Bragg, 1991).

The most notable developments in the use of peat based mixes have been:
1) The understanding of the physical nature of the materials being used,
2) Development of the use of controlled release fertilizers, (CRFs),
3) Managing the interaction of 1 and 2 above with the water requirements of the plants and the drainage away from the container.

The following sections of this paper will look at the three points above before looking at the future of peat use and at possible alternatives for nursery stock use.

PEAT BASED MIXES

Physical aspects. As the use of peat expanded in the 1970s so the method of harvesting it became more mechanized and there was a move away from the traditional sod-cut peat to surface milling and large scale factory handling of the raw material. This had two effects

1) The quality of peat from a surface milling operation is quite different from stripped down sod-cut peat, and considerable efforts have had to be put into the use of pine bark waste and other physical improvers.

2) Surface milling of bogs lays to waste vast tracts of land very quickly and can in no way be described as sensitive; fuelling the current debate on the use of peat.

The damage caused by the method of harvesting and the poor physical characteristics produced by factory processing was addressed by physically amending the peat. Pine bark waste along with other materials were examined by Scott (1984) and it was shown that waterlogging could be avoided using peat/bark mixes.

Bragg and Chambers (1988) proposed a simple Air-Filled Porosity (AFP) test as a method for growers to assess mixes for themselves Sand was shown to have no advantage in mixes, while barks, perlite and rockwool were shown to give measurable improvement. This then led to the peat suppliers looking with renewed vigour at screening and handling methods for peat and to the vast improvement in the quality of their products. New types of screening, particularly those now referred to as 'star' screens, handle the peat in such a way that the physical nature of the material is not destroyed. This allows a far greater degree of control of the end product and "designer" peats can be offered for specific uses.

The way the peat is handled on the nursery has also changed Growers can easily check the effect of ingredients on the mix, as well as the effects of the mixer and length of time of mixing so the requirements for the type of mixer had changed The fast-acting blade mixer has tended to be replaced by the slower turning drum type mixers.

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Fertilizer Aspects. The most important development in fertilizer practice in container composts was the introduction of controlled release fertilizers (CRF). These differed considerably in philosophy from previous attempts to produce 'control' over the rate of availability of fertilizer to the growing plant.

The two groups of CRF which are currently available in the U.K. are both based on the use of straight compound fertilizers which have been coated with a semi-permeable membrane. The difference in the two major sources is in the type of coating used. In the case of Ficote®the coating is an elastic type polymer which has micropores in it Osmocote®has a resin type coat which relies on its thickness and degree of cracking for the release of the nutrients. In both cases water has to travel into the granules to dissolve the fertilizer and then nutrients move outwards along the concentration gradient.

The longevity of products is currently given on the basis of laboratory determinations made at set temperatures. For Osmocote the temperature for the release period is given at 21°C, although in fairness to the manufacturers, Grace Sierra Europe they do have data for the release at temperatures between 5 and 30° C. Ficote®, which is marketed by Fiscons plc, is an imported product from Japan where the release data is obtained at 25°C.

When the products were first available in the U.K. there was a tendency to only suggest the use of single longevity products for particular uses However growers and the extension service began moving towards blends of longevities to achieve more even feeding patterns. This has led to the production of specific mixes such as the 'Spring' Formulation by Grace Sierra of their 12 to 14 month product and more recently to the introduction of their 'Midlands' mix. The latter is the result of 4 years of independent trials work between Bridgemere Nursery and ADAS (Agricultural Development and Advisory Source of Ministry of Agriculture) to achieve a specific blend for the criteria set down by the nursery and in relation to the nursery's climate. Grace Sierra then looked at the fertilizers used in the blend and gave a single mix of release patterns to achieve a similar end result. Undoubtedly this is the way forward with prescription mixes being produced for specific needs and specific regions.

Water in, Water out! With current overhead irrigation systems on gravel standing beds as little as 20% of the applied water may be used by the crop (Gilbert, 1991)! What does all that runoff take with it from the nursery?

Legislation in Holland prevents summer discharges of run-off containing more than 10 ppm of nitrate. Work in the west midlands by ADAS staff in association with major nurseries has shown that summer levels of nitrate discharge can be more than ten to fifteen times 10 ppm level. HRI Efford (Formerly Ministry of Agriculture Research Station, Efford, Lymington, Hants) is undertaking a major trial with ADAS on nitrate, phosphate, and pesticide losses. Obviously there is a relationship between the type of watering system, the compost used and the standing area and its drainage which needs to be established for the future.

The other area of water management which is more fully understood is the need for acidification Efford has been foremost in promoting the benefits of acidification to reduce lime scale on leaves, prevent pH rise in substrates, and to ensure availability of trace elements.

ALTERNATIVES TO PEAT

The Way Forward The use of peat in all horticultural sectors has been seriously questioned and there are specific areas where its use can be reduced. These include much of the retail use of peat as a garden soil amendment where it is totally wasted, and the final potting mix for much container-grown stock, particularly that which is intended to be planted into amenity/urban landscaping, (Bragg, 1991; Pryce, 1991).

There is a price to be paid for the conservation benefits of such a change in the use of peat. All the currently available alternatives are more expensive than peat as a raw material Therefore the end user must understand and make due allowance when budgeting It could also seriously be argued that peat has been undervalued for many years particularly as it is slow to regenerate but that as a material for growing plants in containers it is exceptional. For any material to be a serious contender for use in container growing of plants then certain criteria do have to be met·

1) Physically the material should be stable.

2) Chemically it should be inert or of low reactivity with low inherent nutrients particularly if it is intended to be stored for any length of time

3) It should be free from weed seeds and plant and animal pathogens

Materials. Of the materials which have emerged in the search for peat replacements the following raw materials look very promising:

Coir Coconut husk waste, which appears to have been first used in UK in the 1860s (Abbey, 1862; Toll, 1863).

Barks. The industry is already familiar with the use of pine bark from the work of Scott (1984). Mixed conifer barks do have a place as direct peat replacements. The mature bark mixes do offer good stand-alone materials, or can be mixed with woodfibre or coir to make very good container composts.

Woodfibre-waste. Processing seems to remove all the soluble carbohydrates and the end product, while looking like white wood, is really just lignin fibre.

Straw-based compost. Various novel treatment systems are emerging and if the stabilization of the residue can be obtained there is the possibility to use some of the waste which is being produced—and which is likely to increase with the ban on burning in the UK after the 1992 harvest.

Furnace / Boiler Slags. Many of the large fossil-fuel-burning power stations produce huge amounts of ash and in some cases near vitreous products Some of these are recoverable and can offer alternatives/dilutents for peat and grits or perlite.

Lignite Currently produced as a waste product of the china clay industry in Cornwall. It has been used in the past in mixes Bragg (1991) but renewed interest is developing in the use as a compost dilutent.

There are also materials which could be used as soil conditioners but are too rich or unstable for container mixes except as fertilizers. This includes many of the animal waste products and compost derived from sewage or refuse (Bragg, 1991).

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Developments in the Nursery Stock Industry of Eastern Europe

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INTRODUCTION

There have been vast changes since the fall of the Iron Curtain in Europe in 1989 Change continues at a fast rate so any attempt to describe the situation in Eastern Europe will be out of date by the time it is published This report is a result of information from numerous contacts and personal visits to nurseries in each of three former East Block countries and East Germany. Poland and Hungary were visited last in 1990 and Czechoslovokia in summer 1991. Eastern Germany was visited many times since 1989. Many Westerners do not realise that the situation in each of the former East Block countries was very different. For example more than 70% of Polish land was fully privately owned, whereas in Czechoslovakia nearly 100% of the land was owned by the State or was co-operatively worked— not so much as one private nursery survived collectivisation in that country. In East Germany a number of smaller private interprises survived 40 years in a communist state. The selling of trees and shrubs before the fall of the Iron Curtain was rarely a problem in any of the above named countries. As is usual in socialist systems there were always shortages and people could get neither the desired quantity or range of plants. Where there is no need to worry about sales, the pressure to cultivate to a high standard is lacking. However, the tradition of good nursery culture has by no means died out in the former East Block countries Indeed, very good quality plants—often cultivated under very difficult conditions and lacking many of the modern aids—have been exported over the years into western markets at very competitive prices. Poor quality plants sold easily at home. Intertrading between the different East Block countries has almost stopped hitting many nurseries hard Fortunately, export to hard currency countries has replaced the sluggish home and interstate trading in the East and many companies are doing well as long as the economic parameters don't change too dramatically

EASTERN GERMANY

Anyone owning more than 100 ha lost all this land in 1945. Nazis and war criminals lost all property. Refugees from former Eastern Prussia (now parts of Poland and the Soviet Union) were given this land. The first state farms were founded in 1946 and were to be models for later developments. From 1952 onwards the collectivisation of land was carried out and ended in 1960 with the so-called "Socialist Spring" The large state farms (Volkseigene Guter, VEG) which accounted for only 10% of the nurseries, already worked 37% of the land. Co-operatives (Landwirtschaftliche Genossenschaften - LPG) where the members "freely" joined up with their properties worked almost 40% of the land. Fifty-three percent of the remaining companies were operating privately and had control over 24% of the land By 1984 private nurseries were still very prominent in numbers but now had only effective control of 6% of the land—they were no longer of any significance. The most recent figures for East German nurseries are for 1988. The total area (without forest nurseries) was still practically unchanged at ca. 3,300 ha which included 1,100 ha fruit tree, 1000 ha shrubs, 400 ha roses and 300 ha. conifers (Maethe, 1990).

Two nurseries (Kmetsch KG, Hoyerswerdea and Kloss KG, Bad Liebenwerda) could not be integrated into the co-operatives, so the State took a controlling interest as a limited partner over the years The biggest state nursery group (VEG Dresden) had nurseries in Berlin, Dresden and Magdeburg was controlled from Dresden. In 1984 a so called Kombinat was created with seat in Quedlinburg. Not only all the state nurseries but also the state fruit and potato companies had now a central administration in that town It was run by agriculturists whose job it was to co-ordinate all nursery planning for the whole state. Plans were worked out with the nurseries as to what was to be produced, what profit they were to make, what increase in efficiency was to be reached and, amusingly, the amount of scrap metal they were to give up each year.

After the reunification of Germany all land taken from the rightful owners after 1949 is to be given back to them or their heirs But after 40 years of socialism this is easier said than done. The following points give an idea of the problems that have to be solved.

1) Most private land can no longer be identified by means of fences or other markings

2) On former private lands many buildings and roads have been built over the years. How can this "added value" be paid for by the land-owner?

3) Younger people have lost the normal relationship to land. A number of nurseries that survived as private interprises the last 40 years under very difficult positions, have not survived the introduction of West German currency. More and more people are out of work. Those with money (and many without) are buying cars, technical equipment, etc that were previously very difficult to get. Above all, plants of good quality and variety are being brought in from western Germany and the Netherlands so that poorer local plants have little chance of selling.

The Spath nursery in Berlin, once the largest and most famous nursery in central Europe, was a state farm. The state farms had enormous debts on the introduction of the DM and it could be speculated that land in Berlin is more valuable for building purposes than as a nursery. Therefore, the Spath nursery with its two hundred year old tradition is one of the sacrifices of change. It has ceased to exist. The state nurseries also had very large quantities of fruit trees grown on contract for the state fruit farms. In general, these farms have only taken a tiny proportion of these plants. They are busy ripping out orchards because it is now well nigh impossible to sell the huge quantities of 'Golden Delicious'. Nationalised nurseries or nurseries that had to join co-operatives are beginning to go back in to private ownership and responsibility. Some have been turned into limited companies and are trying very hard to adjust to the new situation. Wages and salaries are approximately 60% of the West German level (August 1991). When the economic upturn occurs in eastern Germany, then it is likely the western companies will profit greatly. Already Dutch exports to Germany are likely to increase by up to 20% in 1991.

HUNGARY

There were only state and co-operative nurseries in Hungary in the sixties. The economic growth led to a huge demand for plants so the nurseries expanded rapidly. In the seventies there was stagnation in state building programmes but private building increased to compensate for this. In the eighties many private nurseries were founded There are said to be more than 300 private nurseries now in Hungary (August 1991). Many larger towns have their own nurseries. One of the most interesting businesses that was quite successful under the old system, and still seems to be operating reasonably under the new, is to be seen in Szeged—a traditional nursery centre—near the Romanian border. Founded in 1968 with 40 members it now has ca. 3,400 members. Each family has between 1000 and 10,000 m^2. Each year 45 ha (108 acres) of rose rootstocks (more than 2 million) and shrubs (more than 500,000) are planted up. Good quality roses could be sold profitably at 0.70 DM=0.23 pounds sterling (August, 1990).

There is a very large nursery with about 330 ha (792 acres) of land with 140 workers in Siotok at Balaton Lake. They have a modern garden centre and export up to one third of their plants, mostly to western countries. They are looking forward to being free of state controls. Already deals are being done directly with foreign buyers. They could envisage a number of smaller private units rather than a big single unit doing quite well in their area. Many nursery workers are growing a few thousand roses or fruit trees privately.

Growers are now pleased to be able to pay better wages for good work; previously wages and salaries were set by the state. In common with nurseries throughout Europe they have difficulty in getting qualified staff

CZECHOSLOVAKIA

All nurseries were nationalised or forced into co-operatives during the communist era, so that no private nurseries survived before 1989. No one can say how many have been founded since 1989 because there is no nurserymen's association and the complete reorganisation of the state administration will take a number of years to complete. One can observe nursery stock being grown in private gardens near state nurseries. There are roughly 800 ha of nurseries in Czechoslovakia of which ca. 700 ha are to be found in Bohemia and Moravia, the remaining 100 ha in Slovakia. Approximately 10 million plants are grown in Bohemia and Moravia in 123 nurseries: 4 million shrubs, 1.4 million conifers, 1.6 million roses, 0.5 million trees, 0.3 million rhododendrons and other evergreens, 150,000 climbing plants and ca 3 million container plants. These figures do not take into account a relatively large number of young plants (grafted material) and forest seedlings that are also being sold. The nurseries often belong to towns or to different ministries: Forest, Science, Land and even the ministry responsible for state security! At the moment export is vital for the survival of most nurseries (August 1991) Internal sales are severely reduced because the communities have practically no funds. The cost of buying in plants from Eastern Germany has risen 10-fold since the introduction of the DM there, and their exports are only minimal to most former partners. Export to western countries has risen dramatically. Prices are based on the very low wages paid in that country: 60 to 180 DM (£20 to £60) per month. Individual buyers often place large orders. A French buyer bought 150,000 roses, probably for supermarket sales, and Italian growers are continuing to buy good grafted conifers in large numbers. The process of European economical integration is occurring, at least in this field, rapidly.

POLAND

Poland is beginning the change to a western type democracy with a number of advantages over the other neighbouring countries. The question of land ownership is not so complicated because over 70% is already in private hands. Most nurseries are privately run. Contacts between Poland and the outside world are better than in any other East Block country.

There are about 1500 nurseries working ca. 2000 ha of land producing ca. 15 million roses, 10 million shrubs, 0.8 million trees and 1 million evergreen bushes. In 1989 nearly 5 million plants, of which 4 million were roses, were exported. Furthermore there are approximately 3,400 ha of forest nurseries cultivating nearly a billion trees per year Small and excellent private nurseries have been able to do good business in the past and at the moment. They will no doubt continue to do so in the future. Many nurseries that were able to sell poor quality will only survive if their standard improves greatly. The previous tax system, based on the size of the production area rather than the value of the crop sold, meant it was more profitable to grow, for example, standard trees, very closely together even though it was no longer possible to cultivate them to a good quality Export was profitable up until a year or two ago but because the Zloty is now effectively aligned with the dollar it has become better to sell on the home market. However, the sales outlets are very poorly developed, as in other eastern European countries, so distribution of plants to the end buyers is an area for much development. Indeed many people are selling plants directly from vans and trucks, and shops are beginning to spring up everywhere. Producers of good quality plants are still having no great problem selling even though the picture of all plants being sold out in September is a thing of the past (August 1991). Already a number of Polish nurserymen are selling plants in France, Germany, Sweden, the U.K., etc.

CONCLUSIONS

Very few nurserymen want to go back to the old "secure" system. Now there is hope that things will improve even though many people in the 50 year age group know that the fruits of their present efforts are likely to be reaped by their heirs. There is a "fear of the unknown" in a free market situation by many people but capable businessmen are beginning to take over very rapidly. Young people are travelling, working and gaining experience in other countries. Therefore, given further good economic growth one can be optimistic about the future development of the nursery industry in eastern Europe.

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The Nursery Stock Industry in Greece

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INTRODUCTION

The nursery industry in Greece has flourished since before the age of Homer because of the vast range of climatic conditions favouring the cultivation of species ranging from tropical to hardy and alpine types During the last 20 years, the nursery industry has achieved significant progress which has established the acceptance of the Greek nurseryman and his propagation skills in many other countries There are many possibilities for further development, for example, the localization of extended geothermal fields and the use of solar energy will add a new dimension to the nursery technology

FRUIT SPECIES

Fruit production has a prominent role in the national economy. The range of fruit crops varies from the tropical (bananas and papayas) and sub-tropicals (such as feijoas, avocados, citrus and olives), to temperate deciduous fruit species.

Plant production nurseries are found throughout the country near farming areas. In the county of Imathia, which is one of the major fruit exporting centers in Europe, almost 90% of the deciduous fruit tree nursery stock is produced. Shield budding with or without backwood is the propagation method, except for walnuts propagated by patch or flute budding and kiwis propagated almost exclusively by leafy cuttings If budding is done in late May or early June with some species like peach, almond and apricot, trees develop to salable size in the same year.

The clonal rootstocks used for deciduous fruit species, such as peach × almond hybrids stocks and some *Prunus insititia* selections, are propagated by tissue culture. Clonal rootstocks for all the other deciduous species are imported It is costly to keep rootstock mother-plants and until tissue culture laboratories cover the whole range of clonal rootstocks for deciduous fruit species, Greek nurserymen will prefer to import them.

Nurseries for citrus species exist mainly in Peloponese and secondarily on the island of Crete. There are two types of nurseries. The first produces apomictic seedlings for supply to the second type, which propagates the commercial fruiting cultivars. Olive tree nurseries operate throughout the country near coastal areas. Olive trees are propagated mainly by leafy cuttings except a very few cultivars which are difficult-to-root Starting from cuttings olive trees can be saleable in one year. Grapes are the only machine grafted species. Grape propagation nurseries exist wherever viticulture—either for fresh consumption or for wine making—flourishes (i.e., Macedonia, Thessaly, Sterea, Hellas, Peloponese and Crete).

Nursery stock production of fruit species is supported by a national variety and virus certification scheme

POT PLANTS

Flowering and foliage pot plant nurseries are located near big cities, such as Athens and Thessaloniki, and along the national road connecting these two cities On the mount of Pelion, near the city of Volos, climatic conditions are ideal for growing azaleas, gardenias, hydrangeas and camellias. Propagation is by seeds, cuttings and, for the last five years, tissue culture Export to other European countries depends on innovations such as the compact gardenia at full bloom. Compact gardenia as a house plant has worked successfully and in spite of some problems in its production it is now exported to other European countries.

CUT FLOWER STOCKS

There are not many nurseries included in this trade but those which do exist include some of the best of all Greek nurseries. They are highly equipped and specialized in the production of carnation, rose and *Gerbera* nursery stock. Carnation stock production is carried out under controlled environmental conditions from start to finish Mother plantations are established on benches under cover. After tests for genetic stability, cuttings can be taken and sold as they are or rooted. Rose propagation is carried out in the field and in tissue culture laboratories. *Gerbera* cultivars are almost exclusively propagated by tissue culture. Carnation and rose are grown widely in Greece while *gerbera* cultivation is rapidly increasing. The production capacity of cut flower plant nurseries greatly exceeds the needs of the country. Exports of carnations and roses have been established and, in the last year, *Gerbera* has joined the list of exported species.

FIELD PRODUCTION

Field production includes large scale timber production nurseries and woody ornamental nurseries—both private and state owned. The ministry of agriculture has authorised local services in each county to establish nurseries for the production of seedlings used for reforestation purposes and landscaping public areas including national roads. Most of the seed is produced in seed orchards and only seed of a few species is imported. Most of these nurseries have been operating for longer than 60 years, producing millions of trees each year.

TISSUE CULTURE

There are six commercial tissue culture laboratories, four of them in northern Greece and the other two in Athens and Crete. Of those in northern Greece, two are specialising in the production of fruit tree rootstocks, mainly peach The third is operating in the area of ancient Pella and specialises in the production of roses The others are mainly involved in the production of foliage pot plants, gerberas and pot roses.

Since the Greek market is limited, tissue culture laboratories are trying first to expand the range of species produced and establish collaboration with nurserymen and growers abroad. They are already establishing the propagation of apple and pear rootstocks, bananas, grapes and orchids and two of them have already arranged the first exports of house plants

STRUCTURES

Pot plant and cut flower nurseries are equipped with modern fully automated glasshouses. Oil is used for heating glasshouses during winter while summer cooling is achieved by the use of fans, humidification and shading. Light intensity throughout the country is more than adequate even in the winter and during propagation it must be closely controlled.

Olive, citrus and kiwi nurserymen are favouring plastic houses of various types and construction, usually tunnels. These houses are mainly necessary for frost protection during winter and, depending on the area they may be slightly heated or not at all. Greenhouses based on solar and geothermal energy have been established in various parts of the country

Quality and Environmental Issues of Nutrition, Pest and Disease Control.

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INTRODUCTION

Quality on the nursery is like the red thread that runs through every inch of rope used by the Royal Navy. It should be addressed in every aspect of our work With consumer environmental awareness increasing, nursery stock growers cannot afford to lower quality standards. The day of the pest-damaged plant being acceptable because it was in a biological control regime is over. In the Eric Gardener Memorial Lecture at BGLA (British Growers Look Ahead exhibition run by National Farmers Union) this year Jonathan Porritt (former director, Friends of the Earth) made the following statement: "Consumer demand for higher quality produce in terms of safety and the phenomenon of green consumerism with its emphasis on higher environmental quality are by no means the negative factors some growers see them as. The key to the future is to be found in adding value." The value added element is primarily a marketing tool but at the production level we must embrace the techniques available—both old and new—and be proud to say so.

GROWING MEDIA

The use of growing media other than peat requires a lot of skill and understanding to maintain quality We should be trying out the new media to gain experience in the different management techniques necessary to maintain plant quality with them Pressure by Friends of the Earth to place a levy on peat use should be shown to be unnecessary by our willingness to accept sensible and practical alternatives. Growers have always been innovators and will always rise to an occasion The pressures won't go away and may increase if we do nothing

Before using a new mix, find out what is in it and how it behaves. This is fundamental to a quality crop. Learn to live with different products and look for local alternatives, do not just accept national trends.

CHECK LIST FOR GROWING MEDIUM ALTERNATIVES:

- Establish if it needs different nutrient levels. Some products release nutrients over a period of time and interfere with controlled release fertiliser levels.
- Find out what the AFP is of the mix and adjust the watering levels accordingly.
- Will it support capillary watering systems well and does it have sufficient matrix suction for tall pots?
- If you export plants, does the compost have clearance for exporting in containers?
- For edibles like herbs, is the mix free from harmful bacteria and does it need regular testing to prove it?
- Does it shrink over a long period of growing?
- Does it give off unwanted smells when placed in a domestic environment?
- Some mixes include heavy metals; that is not all bad. Copper in low doses will reduce moss and liverwort.

- Does its use require a COSHH health and safety assessment because of possible contaminants, or health risk from dust particles?

NUTRITION

Farmers are one of the biggest polluters of rivers, from badly sited slurry lagoons or silage pits. Horticulture seems to be one of the "good boys" in this respect but cannot be complacent and does have several potential problem areas. Britian's new National Rivers Authority will become more aware of water pollution, and drainage water from container beds must be carefully controlled even in a CRF regime. Already, maps of nitrate sensitive areas are drawn up and nursery stock growing will not be immune from controls.

EEC legislation currently under debate suggests that nitrogen levels in some areas of this country could be limited to 250 kg/ha with no one application to exceed 120 kg/ha. If we consider that nitrogen levels of our present compost may have over 500 kg/ha we need to begin to think hard about what we grow and how we grow it. We currently put sufficient nutrient into a pot to last over 12 months but legislation may make that practice illegal unless we can show that our practices are safe. In principle they are, as the nutrient release is gradual and in fact may be less than a corresponding agricultural application. Belgium will introduce fertiliser legislation in January 1992 that limits N to 400 kg/ha and Germany is looking at "concept measures" or only applying what they can prove will not leach into ground water supplies. This may effectively discriminate against larger plants because of the amount of nutrient added!

With overhead liquid feeding on gravel and 3-litre pots spaced at 18 pots/m^2 and a Rotoframe sprinkler applying 150 gal/hour/m^2 only 16% will go directly into the pot, the remaining water going into the gravel. The run off of liquid feed from container beds is an issue yet to be faced but one that brings with it the challenge of recycling irrigation water.

WATER

Ground water levels are falling through increased domestic, industrial and agricultural demand, making it increasingly difficult to obtain new ground water abstraction licenses. So we must look to economise on the quantity consumed. As we turn to previously unused sources we must not allow our quality of product to suffer—which means the control of water borne fungal disease and nematodes.

- Using less water and putting plants under stress can result in pesticide damage previously not seen
- Splitting a water application into two and applying two periods of 15 min separated by one to two hours can often be as effective on containers as one continuous application of one hour.
- Irrigate at night where possible, it uses off peak electricity, ensures minimal evaporation from sprinkler jets and generally there is less wind distortion of sprinkler patterns.
- Collecting rainwater and supplementing abstraction is worthwhile.
- Check the conductivity of bore hole water regularly as salt water ingress is becoming more frequent, even inland.
- Winter storage for summer consumption should now be considered a normal part of any nursery development.

- Water collected from rivers, streams or ponds should always be sterilised with UV light or chlorine before being used in mist and fogging systems.
- Consider ways in which water can be recycled or stored for reuse.

Drainage water too is now under the scrutiny of the legislators. Dirty water from some farm activities is now no longer suitable for discharging straight into a ditch or water way. We must consider whether the quality of water from our container beds or glasshouse is of reasonable quality to be put into natural water courses. Those companies doing export plant washing or washing down the propagating shed floor into a stream may have to prove it is safe to do so With the use of recycled water, collecting rainwater and re-scheduling of irrigation, quality need not suffer. We should be aware of current practices that may put us in conflict with ever changing legislation.

PESTICIDES

The biggest issue here is the loss of many very effective and widely used products. What is needed is a harder look at prevention rather than cure. Pesticide applications have been curative rather than preventative by nature. To maintain quality and reduce a dependence on pesticides is not easy Most countries in the EEC subscribe to the theory of this statement but little is being done by way of any major research. Successes in the industry mainly come from within it and we must continue to experiment, refine and review our practice so that the pressures that will only increase are already overcome by the time they arrive.

Weed Control.

- Chop down weeds on uncropped land to reduce seed pressure on cropped areas.
- Trim seed heads before they mature if you cannot get round to hand weed After a seed head is removed many of the ephemerals will die and not return
- Increase the use of mechanical cultivations on field grown crops. Growth and land will improve as a result Make sure the job is done on time or things can get out of hand quickly.

Insect and Disease Control.

- Persevere with the use of biological control. It does work well. Get used to the patterns predator and pest naturally create. Understand life cycles and breeding habits. If the predator hatches from eggs make sure that its larvae coincide with the pest.
- Watch temperatures in tunnels and glasshouses High temperatures and humidity caused by a tunnel not opened up at the weekend can be the cause of pests and diseases emerging that may otherwise be dormant.
- Be more aware of vent control. Botrytis can be controlled by increasing ventilation or by spacing plants a little wider in one direction just as effectively as by spraying.
- Get to understand weather conditions and the type of pests and diseases that are encouraged. Hot and dry for two weeks? Watch out for red spider, rusts and leather jackets. Warm and humid conditions will bring in aphids, powdery mildews and bacteria. Heavy rainfall on outside beds will bring many soil borne pests out of the sand or gravel and into the pot where it may be drier.

- Watch out for your crops that may resist a particular disease. If certain plants regularly are free from mildew, propagate from them and build up your own resistant clone.

Residues. Legislation may reduce acceptable pesticide residues on plant material, particularly herbs and similar edibles. Using harvest intervals may not be sufficient to guarantee minimum levels and routine residue tests might become necessary on edible crops. As far as I am aware no routine tests are carried out on container grown herbs but many are on vegetables and the linking of herbs to lettuce in respect of off-label recommendation may mean it is only a matter of time before residue levels follow. Check that products sprayed onto herbs have completed their harvest interval before dispatch

Disposal of Excess Pesticide. The current process of disposing of excess pesticides onto suitable low value waste land may not be allowed for ever. Again the NRA is nervous about the practice and have the power to stop you doing it. Some authorities are promoting the use of a pesticide disposal scheme where waste is collected by a contractor who then takes on the obligation of disposal. Alternatively you can buy a system such as the Allman Sentinel which contains a carbon filter to remove pesticides from tank washings and pot, bulb and cutting dipping solutions. A recent government draft document on water goes into great detail on sheep dip disposal but the disposal of materials used for sterilising pots and dipping bulbs, whilst not mentioned, will no doubt be included in the future. These processes as we know them are under threat unless we ensure we dispose of the end product legally. Get used to mixing the right amount of pesticide for the job. It not only avoids waste, it saves time and money.

Plant Health and the Single European Market

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In 1985 the European Community Governments agreed to establish a single market, which meant abolishing restrictions on trade between the member states. This went far beyond the removal of certain customs duties and non-tariff barriers to trade which resulted when the common market was first created. The idea was that in future there would be no greater restraint on trade between the UK and France than between Kent and Sussex (for example). The term normally used to describe this idea is free circulation.

The consequences of this decision, now on the way to implementation, are that by 31 December 1992 (the date set in the Single Market Act) there will be a slackening of frontier controls at any border between two member states. The Customs Entry form, a document which has always represented the focus of control and monitoring of goods entering the UK will disappear completely for imports—and this of course includes plants and plant propagating material—from other member states. However as far as plant health controls are concerned it may be necessary for there to be interim arrangements until the new system of production measures is in place. Imports from countries outside the EC will continue to be subject to the present system of control, ie. the requirement for most plant material to be accompanied by a fully authenticated phytosanitary (health) certificate issued in the country of origin. But for trade within the EC, a whole range of functions for which the Customs Entry provided a basis including the checking of phytosanitary certificates accompanying planting material will disappear in 1993 or soon after

The main basis of the Commission's new system for plant health is a community-wide scheme for certifying production of all plant propagating material and certain other plant products for distribution either within or between member states.

If places of production, ie. nurseries, meet Community plant health standards then a "plant passport" will be issued to allow free movement anywhere in the Community. This is in effect a system of plant health control at places of production of propagating material, ie. propagating nurseries and certain other production premises. Once the "plant passport" has been issued the material will cross community country boundaries without further checking or inspection of the material at points of entry into those countries. Currently, of course, community countries have the powers, through their individual plant health services, to stop consignments of planting material at points of entry such as ports and airports to check phytosanitary certificates and, if necessary, inspect the plants for freedom from quarantine pests and diseases

There will also be, after 1 January 1993, provision for the designation of "isolated zones" within the Community which are free of harmful organisms present elsewhere in the Community. However there will also be provision for the designation of "ecological regions" which for underlying reasons such as climate or cropping have plant health concerns which do not affect the rest of the Community — for example citrus production in Spain and other Southern European countries.

Material entering these zones or regions would have to have a passport which indicates that it meets the unique plant health status of the region of zone. For example we may wish that, as the UK is free of Colorado beetle and is therefore an "isolated zone" as far as this pest is concerned the plant passports should confirm that all imported plant material and certain produce is free of this pest.

With this system in place all phytosanitary certificates and related controls between member states will be abolished. Third country trade, ie. plant material from non-EEC countries, will continue to be subject to the present controls and be inspected at entry to the Community. Third country material in those categories requiring a passport would be given one when it was cleared for entry into the Community.

The Commission strategy also provides for the introduction of a Community Plant Health Inspectorate which would monitor the activities of all national inspectorates such as our own plant health service. To date a Chief Inspector, Mr. Gennatas, has been appointed and will be recruiting a small team of community inspectors. Their remit will be, amongst others, to ensure each community country is applying the rules fairly and correctly. They will, for example visit the UK to monitor and discuss our own methods of inspection and production checks. They will also have a pre-clearance role in certain 3rd countries for certain commodities.

For the new system of place of production control to operate effectively it will be necessary for all producers of plant material and certain traders and agents to be registered under the Community rules and their premises will have to be inspected. These inspections will cover only quarantine pests; it will not cover quality pests, varietal purity or other quality conditions. There are however three marketing schemes proposed; a scheme for young vegetable plants, a scheme for fruit plants and finally, a scheme for ornamental plants. If and when such schemes are introduced then in addition to the prime importance of ensuring production premises are free of quarantine pest and disease, quality pests, varietal purity etc. could form part of the new system. These schemes have interesting, and in some cases controversial features, which are being examined. There will clearly be an overlap between passport/quarantine requirements and the other requirements of any marketing scheme, ie. health standards. All our efforts must be devoted firstly to getting the new system, based on the passport agreed and in place. Marketing schemes such as those I have mentioned may have to wait.

As I have said, all producers of plant material, traders and agents will have to be registered with MAFF and will be visited by plant health officials on a regular basis.

This brings me finally to the question of responsibility for issuing the plant passports. It is quite clear that plant passports should only be issued when an officer of the responsible plant health authority is satisfied that the plant material is free of quarantine organisms and that the nursery or place of production is also free. However the physical process of labelling the material must be the responsibility of the producer under such official supervision as may be considered necessary dependent upon the perceived quarantine risks.

Training—A Key to Quality

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INTRODUCTION

The whole emphasis of producing, selling and distributing nursery stock today is on quality. Unfortunately, quality does not come cheap It normally implies more input, more attention to detail, more knowledge of what to do, more uniformity of materials and procedures, more organisation, more communication, more commitment, more participation—in short more skill and professionalism. The implication of all this is that more training is required, which in turn requires careful planning. The steps necessary are:

1) Set quality goals.
2) Identify and devise methods for meeting these goals and draw up a plan.
3) Implement the methods.
4) Monitor performance against the plan.

1) Setting Quality Goals. Normally this takes the form of an appraisal of what you are currently doing and how it can be improved; often a reaction to customer criticisms, past problems and failures.

A recent and highly significant development in setting quality standards is the British Standard B S 5750 Quality Assurance. This standard will become increasingly important in the years ahead. It will almost certainly have E.E.C. connotations Already some of the supermarket chains and Local Authorities are insisting that their suppliers have B.S. 5750. It will not be too long before landscape contractors, garden centre operators and an increasing number of nurserymen adopt a similar approach. Adoption of B.S. 5750 by any company implies the need to consider quality in all its aspects, and in all aspects of the business It is likely to lead to a far more radical approach towards quality than the traditional methods.

2) Identify and devise Methods, and Draw Up Plan. In practice a method or procedure is often identified first (e.g. the use of "intermediate" pots to increase the size and branch structure of a container plant). This will then need careful planning into the whole operation so that it integrates well.

3) Implementation of Methods, Procedures and Plan. This stage is where the real work of training and retraining will take place. It is vital that this phase is set in context with the others if it is to be really effective.

4) Monitoring of Performance. This is always essential, not only to ensure the whole operation works as it should but also to throw up unforeseen problems and difficulties which result in the need for appropriate reaction-replanning, retraining, etc.

OVERALL STAFF TRAINING PROGRAMME

As will be obvious, individuals' requirements will vary according to their position and role within the organisation Notcutts' approach to this is set out in the table below (Table 1). We regard this as the blueprint for our staff development training programme as detailed in Table 2.

Table 1. Categories in staff development plan

Career position	Staff for develop	Training	Probable duration	Experience	Qualification	Aspiring to
New entrant	School leaver returner		1-3 yrs	Full range work areas	NVQ Level I/II	Nursery person
Nursery person	Reach job competence	SEE STAFF DEVELOPMENT TRAINING PROGRAMME	2-3 yrs	Full range to specialise	NVQ Level II III?	Leading-hand
Leading-hand	Skilled experienced		2-3 yrs	General supervisory specialized	NVQ Level III crops	Charge-hand
Charge-hand	Experienced Leading-hand		3 yrs +	Supervisory Planning work based projects	NVQ Level III IV?	Assistant Manager
Asst Manager	Asst Man showing extra ability		3 yrs +	General management within department	NVQ III or IV	Manager
Manager	Highly competent with ambition		5 yrs +	As above + external training	NVQ IV or V External qualif	Senior Management

Table 2. Staff development training programme

NEW ENTRANT	
Induction including quality awareness	- in house
Notcutts craft skills	- in house
College training	- college
Other skills training, e g first aid, safety awareness, F E P A	- in house/L A T B [1]
NVQ Level I (II)	
City and Guilds 1 (2)	
(some proficiency tests)	
NURSERY PERSON (ENTRANT)	
Continued skills training	- in house/L A T B
College training	- college
Showing people how (Instructional techniques)	- L A T B
Quality awareness	- in house
Introduction to supervision	- in house
NVQ Level II F E P A	
Craftsperson	
LEADING HAND	
Effective supervision 'A'	- L A T B
Health and safety at work	- L A T B
Extra skills training	- in house/L A T B
Quality assurance	- in house (external)
(Coaching/counselling)	- in house
('S' Series)	- M T C [2]
First aid	- St Johns or similar
NVQ Level III ?	
Craftsperson	
F E P A	
CHARGE HAND	
Effective supervision 'B'	- M T C
Work planning	- L A T B
Quality supervision	- M T C
Instructional techniques	- L A T B
('S' Series)	- M T C
Extra skills training	- in house/others
Coaching/counselling	- in house
Assertiveness- M T C /L A T B	
ASSISTANT MANAGER	
Effective manager 'A'	- M T C
('S' Series)	- M T C
Manager support skills	
- assertiveness	- M T C /
- managing stress	- L A T B /
- negotiation etc	- other external training
Quality management	- M T C
Counselling/coaching/mentoring	- in house
Extra skills training	- in house/others
NVQ Level III IV?	
MANAGER	
Effective manager 'B'	- M T C
Quality management/control	- in house/others
Selection interviewing	- L A T B
Staff development/appraisal	- L A T B / others
Staff coaching/counselling	- L A T B / others
Mentoring	- in house
Extra skills training	- external
NVQ Level IV V ?	

[1] L A T B = Local Agricultural Training Board
[2] M T C = Management Training Centre (A T B)
[3] At the time of writing NVQ levels III and IV had not been fixed - hence ?

The objectives of this programme are to produce a knowledgeable, skillful individual who is able to cope adequately and without excessive stress into his or her appointed role.

MANAGEMENT TRAINING

The training programme by management is reasonably uniform across departments. As is usual, most managers of departments have tended to specialise for a varying period in the particular crops in their charge and have acquired considerable experience of the special needs of the crop. Despite this most managers could switch from one crop to another and after a settling in period would perform equally as well.

TRAINING REQUIREMENTS WITHIN DEPARTMENTS

At departmental level the particular skills required to carry out the work of the department come into focus It is advisable, if not essential, to carry out a skills analysis of the department. This is normally done by listing the operations which take place and considering the various aspects of each operation and whether a training schedule is required for it to be carried out efficiently. After consultation with the staff, set procedures are drawn up for each task and these form the basis of the training schedules. Staff can then be assessed individually for their competence in the various activities and any shortcomings be picked up in a training session, either "on" or "off" the workplace.

APPRENTICES

In the main, apprentices are the first stage in an on-going procedure to staff the nursery with a high proportion of thoroughly and broadly based well trained and skilled staff, upon which our future depends The most able apprentices provide the management of the future, but many provide skilled craftsmen and supervisors vital to the effective operation of the departments. Notcutts' apprenticeship lasts three years and incorporates a blend of: working in all the nursery departments on a planned programme of work experience, informal on-job training; formal training on the nursery, and formal training off the nursery (e g. knapsack spraying, tractor driving etc) and college training. At the completion of the apprenticeship the objective is that each apprentice will hold five proficiency test passes—carrying a craftspersons qualification and N.V.Q to at least level two Each trainee begins with a comprehensive 3-day induction course to introduce them to the industry and to Notcutts.

TRAINING AND QUALITY

Implementation of an integrated training programme properly planned should ensure high levels of skill, uniformity of working procedures, flexibility of approach, with the ability to quickly take on new procedures. All these attributes in the workforce mean any changes decided upon as a result of adopting B.S. 5750 or similar, and carrying out the procedures previously discussed, should be quickly assimilated by the whole staff.

The Next Generation—Stimulating an Interest

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How many times have we all heard—where have all the good staff gone? Or, I can't get good people to work for me. This is a situation that we started to address in Blakedown Nurseries in the mid 1980's by upgrading our recruitment One step was to increase our links with local schools through career talks to classes and hosting visits. Two years ago, after a visit from a local school's Rural Studies Class, a chance idea emerged in conversation with the teacher Since the students were so keen about growing plants, and as they grew a few at school already, why not grow some on a semi-commercial basis for Blakedown Nurseries? The teacher and the class all seemed to be very enthusiastic about the idea so we decided to give it a try.

The initial meeting between myself and the pupils was to decide which crops the pupils were going to grow and work out a rough format for prices, etc At this planning stage a number of problems became apparent to the students, because they had no pots, no compost, limited facilities and very little technical skills. Their business acumen was also limited although this soon changed. To provide interest and a challenge I decided that as little as possible would be handed on a plate to them They would have to purchase or hire materials needed for this project and we would conduct a proper business relationship. By the end of the second meeting, after much serious negotiating, we had agreed to hire them pots, sell them compost for a nominal sum and provide technical skill free of charge so that they could produce a saleable crop to the standards we had agreed upon. By this stage enthusiasm among the students was high, and they had decided on the name of their nursery, which was to be Carolian Plants. They had also designed a logo, produced headed notepaper for their use with us, and had sorted out a management structure among themselves; so when negotiations were occurring they would have nominated people to represent them on various topics.

This was happening in school term time so the scaling of the operation and the crops to be produced had to fit in with the school system. Herbs in 0.5-litre pots were chosen since they are a relatively quick crop, they can also be produced from seed which means there is no need for stock plants, and the end product would be saleable at a much earlier stage than normal hardy nursery stock.

It was now November and everything was set Carolian Plants, as they are now known, had purchased and sown their seeds and were getting their nursery up and running. Other problems started to emerge—weekend watering, and monitoring temperature and humidity conditions in the small school glasshouse. These problems they overcame exceptionally well. The students formed a voluntary rota system to come in at weekends and the Christmas holidays to tend the plants as necessary.

The first batch of 500 plants was due to be delivered in March—this objective was achieved. From an initial expenditure budget of £35 they had realised a return of £125 in 6 months. This is a sure way to stimulate an interest! This year we have repeated the project and in addition hardwood cuttings were inserted during the winter. This extra crop has been introduced so that next year's students will have a crop already in the pipeline when they inherit the Carolian Plants project.

An added bonus this year has been the allocation of funds from the school governors for the purchase and construction of a 40-ft poly-tunnel to help expand the container production at the school.

During the growing period, the students were making visits to our nursery to study our techniques. This close contact strengthened our relationship with pupils and staff. During the spring we were getting some requests from students as to whether we had any weekend work available. Enthusiasm was growing! We were able to employ some of them for Saturday morning work, during which we would always make sure they had a supervisor available to give them the necessary help.

By this stage the net result of the exercise was:

- We had introduced a number of young people to hardy nursery stock production
- We had developed a link with the school which has since become very strong and is continuing.
- We had also initiated some potential recruits to our company.

Coupled with this project, we had decided to continue on traditional recruitment avenues—newspaper advertisements and careers evenings. With newspaper advertisements there is very little flexibility, but with the careers evenings we decided to examine what we were doing, make some changes and do some experimenting. We felt these evenings had degenerated, to us sitting behind a table and doing the run of the mill things—like showing videos and handing out pamphlets, and only occasionally getting to speak with potential recruits. We were not achieving our objectives.

The first change we decided on was that I personally would not go to any more careers evenings as I am now too old! Students generally regard anyone over the age of 25 as being ancient, or like their parents. They often relate better with younger people. Now I have a right hand man on recruitment who is 20 years old. He, and our 1st and 2nd year apprentices, with my guidance, now prepare and attend careers evenings and there has been an increase in people who have applied for positions with us as a result. Our apprentices and staff are now a lot more aware of the work needed to recruit the next generation of nurserymen, and the need for careful thought and refinement in recruitment. They also have a lot of fun in planning and executing the careers evenings, which is a great morale booster. Those who are actually chosen to attend the careers evenings look upon it as quite an honour and a perk even though they often have to do it in the evenings.

Now we have reached the stage where we have Saturday people, and applicants from the Careers evenings and newspaper advertisements who are interested in joining our company.

The next stage for recruitment of staff is the interview. The interview at Blakedown is a two stage procedure. Firstly, the applicant comes to visit us at the nursery with their parents or guardians. This is important as we look towards parental support for all of our younger people. During the first meeting I tell them about Blakedown Nurseries and also about the nursery stock industry, our training system and career opportunities. They are then given a guided tour of the nursery by my younger colleague At the end of the nursery tour I again meet the applicant and his parents and ask if they are interested in a career with Blakedown nurseries. If the answer is no, then obviously everything finishes there. If yes, we agree to take them on for one week's work trial. At this stage no offer is made of any financial remuneration for the trial week I only offer them the opportunity to come and work for a week and see what it is like in real life and also to meet the other staf—especially the existing apprentices. We don't want recruits just because our company looks good on the surface. We want to feel that they know a little bit more about the job and the industry so that they can make a valued decision about joining us or not.

When the applicant starts their week's trial they again get a brief look around the nursery to refresh their memory, as it may have been some time since our initial meeting They are also given an induction form which briefs them on working hours, health and safety topics etc. They are given a programme so that they know exactly what department they are going to be working in each day, and the name of the supervisor. In actual fact it can be quite a challenging week as the applicant will be in a different department each day However, we feel it is more important that they get variation in their work and see what is going on on the nursery. The final document that they are given is an appraisal form. At the end of each day the person who is supervising the applicant fills it in and also discusses it with them. As each day goes by they know what we think of them. This daily debrief is also an opportunity for us to get feedback from the applicant.

At mid-day on Friday I get the finished appraisal with the comments of the 5 supervisors. Equipped with this information a decision is then made as to whether we want to take the candidate on or not. We then meet with the candidate at 4 p.m. and debrief them—the good points of the week, the bad points—what they liked and didn't like. We then invite them to tell us whether they would like a full time position with us as an apprentice or whether it is not the life they hoped it would be. If at this stage they are interested in continuing their career with us and we have decided we want them—then we would offer a full time job If they decide that they don't want to stay then we part company on good terms. If they decide they want to stay, but the majority of my supervisors have not found that person is right for the company then we regretfully inform them we will not be able to offer a position. Irrespective of the outcome of their interview we now pay the applicant for their week's work, even though they have not expected this.

Though this may sound a long-winded process we have found that this system has resulted in us achieving very good quality and committed recruits. It also ensures the total involvement not only of my senior staff, but also all of our junior management, since they are involved in the recruitment and final decision making process. This year, out of our five new apprentices, three are from the Carolian Plants project, one from a careers evening and one from an advertisement. Over the past 3 years, out of a total of 23 apprentices being recruited by this system we still have 20 in our employment, and they have proved to be very good apprentices.

Quality Management—The Impact on Production

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Many businesses have been frightened by the concept of quality This is totally unnecessary There is nothing mystical, only the need for understanding, commitment and a common sense approach. The common sense and understanding comes from the acceptance that for quality management to be successful, every part of the company work together. It is especially important that sales/marketing and production work in harmony and with a commitment towards meeting the needs of the customer

Far too many of the companies I encounter are production-led, thus finding it difficult to establish a sound basis in the current competitive market place Equally there are many companies who are approaching the future on the basis of sales-led promotions thinking that this is marketing. Such approaches create compartmentalized companies with a narrow-minded approach to quality management.

Quality Management is about·

a) Knowing what the customer wants
b) Getting the best performance throughout the company.
c) Doing things simply but effectively
d) Reducing errors, waste
e) Developing a competitive approach, there is nothing wrong in being best
f) Teamwork
g) Good communications
h) Recognizing good work
i) Aiming for continual improvement (KAIZEN)

KAIZEN is the Japanese concept of improvement, continual improvement in every aspect of life. In the work place, continual improvement involves everyone —managers and workers alike. KAIZEN is a way of life in Japan. It is the key to Japan's competitive success, and whilst in our industry we are unlikely to be threatened by the Japanese, we are vulnerable to the threat of many other competitors, any one of whom may just adopt the philosophy of continual improvement leading to the all important competitive edge being gained.

It must be accepted that errors do occur, errors in one part of the business create problems elsewhere. Errors multiply, errors are costly. Everyone at every stage must work to reduce and eliminate errors In production, errors may take different lengths of time to appear. In propagation, wrongly handled or prepared cuttings will soon be showing signs of not rooting. It could however be an evergreen cutting which may sit for many weeks or months before it finally fails. Propagators often put the failure down to a quirk of the plant, it could of course be poor quality management. Why not set your self the task of improving your percentage take by x % and using a quality management approach to initiate the improvement?

Badly collected or stored budwood will inevitably lead to lower bud takes. There may be one team preparing budwood one team budding and yet another tieing, each one interacting with the other and yet each can seriously affect the end result

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It is clearly evident that each team should interact with the other to set their requirements and establish the all-important customer/supplier relationship

At the end of any chain is the external customer. You must meet their needs in terms of quality, which of course means more than just delivering a good or bad plant. It also means getting it to them when they want it at a price they are prepared to pay—and you are prepared to accept—in the condition they expect. Failing on any of these means you have a dissatisfied customer who might easily place the next order elsewhere

The other point to remember is, who usually "gets it in the neck" if a bad quality product has been delivered. Maybe the lorry driver, who had nothing to do with assembling the order. It often also gets to the point of an irate call to the salesman who again probably didn't lift the order. Everyone absolves themselves of responsibility Quality management means that everyone accepts responsibility and works hard to ensure these errors don't occur in the first place

As a consultant, I very often ask staff who are working on a crop which customer will be taking delivery of the plants. Of course this is very unfair because unless it is contract grown the customer may be unknown. But I would expect them to know what market sector the crop is aimed at. But the response I often get is a vague, blank, don't know, don't care I'm just told to weed/prune/space etc. Again the shedding of responsibility. Quality management must encourage the acceptance of responsibility but to be strongly assisted by supportive tiers of management communications. The work force must know what is expected of them. They more importantly must know what the customer expects. Senior staff must train and educate the work force into knowing what is good enough to go out of the gate and perhaps more importantly what can't go out.

In the real world after having set standards, all too often I have encountered situations where staff are put under pressure to send plants out which do not conform to them. Sales staff oversell, or are struggling to achieve budgets, they don't like to say no. You have all, I am sure, met these situations but by developing sound communications the element of destroying workers confidence can be overcome. I was recently at a nursery where a team were caning and tieing a crop. It was also very weedy. The message from the manager was to complete the caning and tieing by a set time The workers knew that while they were working through the crop they should pull out weeds. However, they found that the weeding was slowing the job down dramatically. As they thought the key job was caning and tieing they started to weed less thoroughly and pick up speed. It was clear though that the crop again would need to be gone through in about 10 days to be weeded. Quite clearly the workers were unhappy because they felt they were only doing half the job and management were concerned that they weren't getting through the crop quickly enough. A case of poor communications from both parties because both were unaware of the others concerns. But a classic case for improving for the future

Documented work procedures would help to eliminate such discrepancies that often occur Such procedures also have to be audited to ensure the tasks are being done in accordance with the documented system. It may be possible to improve it at this stage.

Teamwork is essential for problem solving and improving for the future. It develops greater satisfaction, a more enlightened approach, lateral thinking, better understanding between departments and a greater enthusiasm to implement new approaches.

Many companies are affected by Total Quality Paralysis. Not knowing where to begin, they never get started It must be approached form the top down and the base up. Understanding and commitment are vital pre-requisites. You must then implement gradually, carefully, constantly building, measuring and improving.

Quality Management has a profound impact on production! Why keep on the treadmill of doing more and more to maintain the same position. Use quality management to do the same and achieve more (or less to achieve the same.) But for all you competitive animals I'm sure you want to go forward My advice is do it the best way do it the quality way.

Specialization—Is This the Future?

Peter Catt
Liss Forest Nursery Limited, Petersfield Road, Greatham, Hampshire

When I first started Liss Forest Nursery I thought that my future lay in specialization and I had to convince my business partner that I was right My partner was the finance and I was the production This was way back in 1970 and my chosen subject was rhododendrons. My intention was to grow species, hybrids and the dwarfs together with the Japanese azaleas Liss Forest Nursery had not long been in existence before I realized that my ideas were not right for me. There were two reasons for this. Firstly I like growing most plants and secondly came the problem of the economics of distribution. Had I not changed my mind, then a third reason would have been cash-flow. Therefore I changed my idea of specialization in rhododendrons to one of growing mainly ericacious plants. This gave me the opportunity to grow the forms of *Erica* and *Calluna, Pernettya* and *Gaultheria* etc., of which I was very fond. I soon widened the range still further when offered cuttings of *Camellia, Eucryphia, Magnolia, Stewartia* etc. Now I was happy. My partner was less happy, saying that one's first ideas are usually the best

All of this happened within a five year period. The partnership then ended (amicably) and I was on my own. Being on my own meant an empty field, though my partner did give me two polythene tunnels and I took over all the stock which had built up, half of which was mine. The range of plants changed still further now because I had lost much of my source of material. Rhododendrons were no longer the main crop. This was partly because I had lost a free supply of grafting stocks but also more rhododendrons were being produced by cuttings within the trade. We were by now producing large numbers of camellias which occupied our limited propagation facilities. I had a good customer base and knew better what was required. The numbers of most lines were gradually increased, as was the range Little by little some lines were discontinued and others added, and this continues to the present day. Currently we offer about 1,000 species and hybrids.

You will see then, from my point of view, true specialization is not the future. What I have done in the past I intend to continue into the future. As I see things, distribution is the problem of specialization. One needs large quantities of a popular plant to be able to deliver economically and over a fairly long selling season.

What is specialization? I suspect that specialization means different things to different people. Growing for the garden centre market is specialization Growing for the landscape sector is specialization. Growing conifers or standard trees or alpines or bedding plants are all forms of specialization. I.P.P.S. members are specialists in plant propagation and our future is in the propagation of both new and old varieties and cultivars. Some members are liner specialists and as such help growers like me to offer a more complete range to our customers

Where a business employs just one or two people then the limited number of plants that can be produced must be much sought after. Where a large firm is involved then the sales team must advise the propagation management of demand, both in quantity and variety

Publicity on television or articles written in the papers will greatly influence what the buying public will be asking for and the first feel of demand will be felt by the salesman. This information should be fed to the propagator as soon as possible and management must obtain material at the earliest opportunity in order to meet expected demand If the firm itself is doing a promotion then everything should have been done to make sure that stock is up to the right levels beforehand

It is of course possible to specialize within a given field, by selecting certain lines within that field. For instance although many wholesale nurseries might list *Corylopsis pauciflora*, I widened my offerings to *C. glabrescens*, *C gotoana*, *C. veitchiana* and *C. willmottiae* 'Spring Purple' I could have added a few more. Dedication to a specific species is only possible in a few instances and our past president, Raymond Evison, with his Clematis bears testimony to this But this is an exception and his numbers are mind-blowing.

So, to sum up, I do not really see myself as a specialist, although I grow for the garden centre trade, and I do not see the future creating lots of specialists producing to supply bigger concerns that then distribute the products to the garden centres, although I do see groups of growers (as is already happening) doing some joint marketing.

For myself, I see my future looking for interesting old plants and discovering or raising new ones to add to our existing list and improving the publicity by joint promotions.

Plant Promotion—What is its Value and Role?

Michael L. Dunnett
Blakedown Nurseries, Ltd , Kidderminster, Worcestershire

WHY WE SHOULD PROMOTE GARDENING

When we talk about promotion, we are actually talking about promotion of the pastime of gardening, because it is within this pastime that our products (plants) are used So how do we go about this? We must support every aspect of gardening at all opportunities and on every occasion. We must offer encouragement and advice wherever possible The following are some examples of how we as professionals can support and promote the pastime of gardening.

1) Encourage good amenity planting. People who are exposed to plants in their public places start to expect them as a part of everyday life. Britain in Bloom is a good example of one of the reasons why bedding plants have become popular in the last decade.

2) We must sponsor and provide information for the media whether this be local newspapers, national magazines or television. As we all know, television is incredible as a promotion medium. We are fortunate that there are so many programmes on the television, any average week will see 3 to 4 hours devoted to gardening. The following of major gardening programmes is also substantial with the BBC *Gardeners World* regularly having nearly 4 million viewers.

3) We must, as an industry, participate in events which promote gardening in the widest sense—for example garden festivals.

4) We should always encourage amateurs who belong to local flower clubs, gardening societies or even womens institutes!

5) We should promote gardening as healthy exercise and one which reduces stress.

6) Gardens are relaxing and fun for all ages

7) Gardens can be used for all sorts of enjoyable pastimes.

All of us who are professional horticulturists must be seen to be "Environment Improvers". The product that we grow and sell is of incredible benefit to the community and the environment. It is documented that a person inhales 23,000 times each day and this absorbs 35 lb of oxygen, all of which is produced by plants. Plants act as mops—catching much of the 12 million tons of pollutants released into the atmosphere each year by industry and motor vehicles. All these attributes are promotable, and will help to sell more plants.

We are also fortunate that we have such a beautiful and desirable product. We have plants that have: big or majestic flowers; delicate scent; masses of colour such as summer bedding plants; bold and exciting foliage; autumn or winter interest; fruit; and fascinating features such as cacti and carnivorous plants.

All these plants are used in gardens and gardening Not only is gardening the country's second most popular hobby, after watching T.V , but also the most interesting and exciting. So the first rule for us all is to be excited—then you will excite others. Excitement leads to enthusiasm, and enthusiasm is the best possible form of promotion for the pastime and the plants which we all grow to support it.

GENERIC PLANT PROMOTION

Generic plant promotion should be looked upon as an umbrella—possibly provided by Trade Associations and operated on a national basis. Two examples of recent promotions are "Autumn, Natures Time for Planting" and "Gardening for Beginners."

SPECIFIC PLANT PROMOTION

If you are to have any form of impact on the market you must be able to answer yes to the following questions:

1) Can I distribute my product on a national basis?

2) Am I capable of producing at least 40,000 and preferably 100,000 plants of the same variety at a time when the customer wants them?

3) Have I got the time and resources to handle a promotion?

4) Have I got the personality to promote a product?

So, how do we go about it? Firstly, you will need a plant—ideally it needs to be a new plant or at the very least a plant which is currently grown in very small quantities. It needs to be able to be propagated relatively easily and in large quantities. It needs to be able to be grown easily within your nursery production system.

If your plant comes up to these criteria then you will have to put your mind to other matters. If it is a new plant it will need a name. Everything depends on a name that is simple and easily remembered. You will need good photographs of the plant. You may need market research You will need an advertising and PR agency, a designer and a good printer

All these are required because you now have to get your plant known both to the garden centre retailers and the ultimate consumer, the amateur gardener You will need to produce leaflets, talk to journalists, talk to your customers, exhibit at trade shows Support your product at the retail outlet with point of sale material by means of labels, display boards, leaflets etc. An expensive and very time consuming occupation, believe me. You as a person will need fortitude, persistence, commitment and above all vision.

How can we tell the value of marketing? Ballerina trees have sold 245,000 trees in two years *Scabiosa* 'Butterfly Blue' has sold nearly one million plants since its introduction in 1986. Both are heavily promoted plants. There are in the order of 2.7 million motor cars sold in the U K. each year, a heavily promoted product.

In the U.K. we eat 750,000 tons of sweets and chocolates each year—29 lb for each man, woman and child. The top selling chocolate bar, Kit Kat, has sales of £170 million per year. The total wholesale nursery stock industry is valued at between £175 and £200 million per annum. Chocolate is heavily promoted. Its consumption is increasing by up to 16% per annum despite the health warnings!

So what is the 'bottom line'? I believe that we can clearly see both within our own industry and in other non- related industries that promotion will sell more product. It is not necessary for every nursery company in the U.K. to be promoting **individual** plants, in fact it is desirable that they don't otherwise everything will be promoted. It is, however, essential that we wholeheartedly and consistently support every aspect of gardening. Above all enthusiasm for the product which we all produce is absolutely vital.

Propagation at Monrovia Nursery

Sean Sweeney[1]
Drumsillagh, Butlersbridge Co , Cavan, Ireland

INTRODUCTION

Monrovia has had an excellent history of producing the best quality containerized nursery stock in the United States and has an exciting future ahead of it. There are now three company locations.

The site in Azusa is 500 acres, of which 400 are used in production This site is in a Zone 10 area on the U.S.D.A. hardiness map, so all of the tropical plants are grown here. The Oregon site was purchased in 1984 and is at present 510 acres This site is used to grow the hardier plants. The nursery has recently purchased a third property in Visalia, in central California, which is approximately 1,500 acres in size. One thousand-two hundred of the acres have a slope of less than five percent which is usable for nursery stock. By 1995, all the production in Azusa will have been moved to Visalia, and in December 1995, a total of 900 acres is planned to have been developed. In 1995, the nursery plans to have 1,660 acres in production in comparison to 425 acres in 1984. This is an increase of 267% in 12 years.

Monrovia currently produces 42-million plants annually and offers over 1,200 plant taxa to the trade. It has developed and introduced over 150 new plant cultivars, and has been granted over 100 plant patents and trademarks on special introductions. The company has its own research department and, to assure quality and improve growing methods of container stock, 30,000 soil and tissue tests are run each year. Much of the success of the company is due to its ability to attract and retain quality employees. Over 25 percent of its 1,000 plus employee's have worked for the company more than 10 years.

In the late 1970s, a water recycling and treatment plant was built to preserve that precious resource. The plant is capable of processing 3 5 million gallons of irrigation runoff per day. The treated water is blended with an equal amount of fresh water before it is injected with fertilizer and reused. Incorporated into the plant is a sophisticated fertilizer injection system. The system assures that every plant on the nursery is fertilized with each irrigation. It is completely automatic utilizing electronic proportioners, and monitors itself 24 hours a day. In addition to the nutrients supplied through the irrigation water, slow release fertilizers are added to the soil. The compost contains redwood and fir sawdust and stable manure and this is combined with native top soil to make up some of the nine different soil mixes used at the nursery.

The nursery has a sales staff of 60 which help sell the $60 million worth of plants sold annually out of the Azusa location alone.

CUTTING PROPAGATION

The propagation department occupies almost 30 acres and has 3.5 acres of greenhouses. It is the most labour intensive area of the nursery, employing between 200 and 250 workers depending on the season.

[1] Mary Helliar Travel Scholarship Award recipient, 1990/91

Propagation by cuttings accounts for 80% of the propagation at the nursery. Depending on the time of year, between 25 and 100 people work in the cutting shed. Producing cuttings is a year round operation. The cutting shed is supplied with propagation material by a specialized crew and by the pruning crews which do the required pruning on the containerized plants in production for this reason.

All pruning on the nursery must be coordinated with the needs of the propagation department Material for propagation is stored in refrigerated storage units kept between 40 and 45°F. Cutting material is generally stored for no longer than three days. Some plants are cut and flatted immediately. Clippers and knives used to prepare cuttings are dipped in Consan disinfectant at 200 ppm. All prepared cuttings are washed in chlorinated (15 ppm chlorine) water

IBA is the principal rooting hormone, mainly at concentrations of 1,000 and 3,000 ppm. The different solutions are coloured with dyes for identification purposes Rooting hormone solutions contain 55% methanol and 45% water. Methanol is used to dissolve the IBA and NAA, to preserve the solution and to assist in disease prevention.

The general propagation mix contains 90% coarse perlite and 10% peat moss A mix containing 70% fine perlite and 30% peat moss is used for azaleas and other fine-rooted plants. All propagation media and flats are pasteurized at 145°F for 45 minutes.

Sixteen million cuttings are produced annually with *Juniperus* being the biggest group of plants propagated. Each person makes 2,500 to 3,500 cuttings per day. Cuttings are rooted under intermittent mist in greenhouses or in the outdoor mist beds. Greenhouses and mist beds are heated by hot water supplied by two 250 hp boilers. Bottom heat is maintained at an average of 68°F. The intermittent mist systems are turned on one hour after sunrise and off one hour before sunset by 24 hours master clocks. The mist is not used at night unless it is windy. Pairs of six-minute clocks allow for a variable mist frequency of once every hour to once every two minutes. The duration of each misting is normally six seconds.

Between 20 and 45 people work in the potting shed depending on the time of year. The general potting mix contains three parts bark, two parts peat, one part sand and one part perlite Four other mixes are also used for various crops with special soil needs. All potting mix is fumigated prior to use. New potting is hand-misted for 3 to 4 weeks to reduce transplant shock.

OTHER PROPAGATION METHODS

Other methods of propagation at the nursery are by seed, grafting and tissue culture. Seed represents 15% of propagation and the others combined total 5%. The seed flat media consists of four parts peat moss, one part sand and one part perlite Flats with media are pasteurized prior to sowing. Flats are topped with a thin layer of silica sand to provide good surface aeration and drainage. Tropical and subtropical species are germinated indoors, while most hardy species are sown outdoors in a shade house.

Ferns are produced from spores or vegetatively (i.e. by division or rooting plantlets) Fern spores are sown in new flats containing shredded sphagnum moss. The flats and sphagnum moss are sterilized at a minimum temperature of 180° F for three hours. Spores germinate in 3 to 6 months producing the prothallus. Once the prothallus goes through the sexual stage, plantlets (sporophytes) are produced. After an additional 3 to 6 months, they are planted into pots. A 3 in. pot requires 18 months to 2 years to produce from the sowing date.

Grafting is a very important propagation method at Monrovia. I spent most of my time working in this department. Approximately 350,000 grafts are made each year and the most important plants grafted are *Acer palmatum* cultivars and evergreen magnolia Most grafting is done during winter although some grafting takes place year round. Grafts are made in liners or in 1- and 5-gallon cans There are also patio tree items which are grafted, with weeping mulberry and weeping juniperus being examples

All the *Mahonia aquifolium* 'Compacta' are air-layered.

The tissue culture department is used to bulk up new and hard to propagate items. The main plants propagated here are neriums and syringas.

CONCLUSION

Of the 18 million liners produced annually by the propagation department, about one-third are sold to customers. The remaining liners are used for the nursery's own production. Monrovia Nursery Company is the largest and most successful containerized nursery in the United States of America. And I can without doubt say that I thoroughly enjoyed my stay with the company. I would like to take this opportunity to thank the I.P.P S and everybody responsible with the Mary Helliar Travel Scholarship for their help in making my trip to Monrovia possible.

Eucalyptus Trees in India

Angella Evans[1]
Wye College, Kent

The genus *Eucalyptus* was introduced into Indian silvicultural systems in the 1960s via the "Fast Growing Species Scheme". It was first planted in Karnataka, Southern India on degraded lands and now covers a vast acreage throughout the country. The genus produces much biomass because of efficient use of water and nutrients It has been the centre of world-wide debate as scientists claim the eucalypt can help solve the fuelwood crisis. On the other hand environmentalists claim that the eucalypt is causing environmental and socio-economic collapse among the rural poor communities.

The eucalypt is a member of the family Myrtaceae with a natural range extending from 7°N to 43°S in Australasia. The eucalypt owes it's dominance in Australia, in part, to its ability to colonise bare ground, and the growth of lignotubers, indefinite shoots, naked buds and epicormic shoots that enable rapid growth When planted outside Australia in localities that do not have insects that defoliate them their productivity is remarkable. In favourable conditions eucalypts such as *E grandis* can grow 10 m in the space of 2 years. Yields per ha per yr can reach 10 m^3 on severe sites and up to 40 - 50 m^3 in very favourable conditions.

Due to the production of epicormic shoots the eucalypt is mainly grown on short rotational coppice systems, ranging from 6 to 8 years. As a forestry tree the eucalypt is used for paper, pulp, charcoal and in the rayon industry Its use for fuelwood is somewhat debatable. The controversy that surrounds the extensive monoculture include claims by scientists that the eucalypt can replace indigenous forests to produce fuelwood for the benefit of the poor and bridge the gap between demand and supply. Environmentalists believe that the eucalypt, planted extensively, is degrading land, leading to desertification and destruction of farming practices. The main areas of controversy include:

1) Eucalyptus consumes too much water disturbing the hydrological balance.
2) Impoverishment of the soil due to efficient use of nutrients.
3) Eucalyptus farming is robbing good agricultural land of food production.
4) Fewer agricultural crops are produced due to incentives from the government to grow eucalyptus.
5) Rich farmers become richer and the small farmers are being squeezed out.
6) Large plantations are disturbing the ecological balance of the country.
7) Extensive plantations leads to socio-economic collapse among the rural poor.
8) Eucalyptus intercropping adversely effects agricultural production.
9) Eucalyptus discourages ground flora and wildlife.

The Indian government appears to be very keen to afforest India with large plantations of eucalyptus often replacing indigenous lands, with no current proposals to replant with native species. Much research has been undertaken to prove the positive attributes of eucalyptus but the wider issues have been largely left out. This may be due to the fact that over 90% of research grants emanate

[1] Mary Heillar Travel Award Recipient

directly from government institutions. It seems unlikely that scientists will undertake experiments that will prove the species to be detrimental, especially for a country that is trying to become self reliant. The eucalypt may hold the key to increasing the country's finances, as eucalyptus products fetch high prices, which bring about economic benefits.

However, most scientific papers reviewed seem to be of the opinion that the eucalypt does not degrade the soil of water and nutrients and can compare well with another forestry tree, *Shorea robusta* of the family Dipterocarpaceae. It must be mentioned at this stage that most experiments undertaken by the Forestry Research Institutes (F R I.) have been very short, ranging from 2 to 6 years The results gained from these experiments cannot be long enough to gain an accurate assessment of the situation

To conclude, the view that eucalyptus monocultures drain the soil of water and nutrients, is in my view true. However, the same could be said for any "efficient" crop especially agricultural crops.

I think what must be understood is that eucalyptus monocultures are perceived to some as a substitute for forest cover, replacing indigenous forests In fact they are a crop producing biomass in a short period of time and as in any crop this depends on many factors site, age of plantation, fertilizer application, plantation spacing and geometry. The plantations therefore must be perceived as a "long term crop". An introduced exotic cannot replace native forest or be as rich in flora and fauna The eucalypt is being exploited to bulk up India's economy and feed the huge industries that will pay a high price for the wood and other byproducts. The planting of eucalyptus on private and government land has enough justification provided that it does not prove harmful to surrounding village economies

To the forester it is good because it produces quick biomass at low prices To the farmer it is good because it produces high biomass with low investments. It is therefore necessary to have the right approach backed by balanced studies and research to understand the site, species and silvicultural systems used.

The major points raised by environmentalists against the plantations of eucalyptus are socio-economically based. It is thought that western advisors from governments, World Bank and the FAO have played an aggressive role by framing development programmes for forests, often with little thought to their long term effects or on the social impact of the schemes. On forest management these bodies are thought to be, scientifically ill-equipped to understand the management of the tropical forests.

A positive approach is required by government officials, as clear-felling should not be allowed to continue More co-operation between rural people and government bodies is required to sustain the people who depend on native lands for their survival. It must be understood that a tribal people's well being cannot be assured by monoculture plantations. The existing eucalypt plantations must be managed more efficiently by improving existing silvicultural practices, in order to meet the demand of the industry rather than extending clearfelling practices. In reaction to the loss of indigenous lands rural communities view eucalyptus as detrimental/ because they are losing out and in some cases becoming poorer Much more research is needed in this area before reckless expansion of any exotic is taken up on a large scale. Recognition that rural communities need basic essentials of fuelwood for cooking and, in some areas of the Himalayas, to burn for warmth must be understood. Removal of natural forests disrupts these people's lives, usually resulting in the ill health of the women and children. They spend longer time looking for fuelwood and sometimes travel greater distances to gather small wood products and scavenge for material to burn. The continued burning of dung in these areas also disrupts the recycling of nutrients to the land. Rural people still make up a vast majority of India's population, but with the depletion of natural resources more and more people flee to the cities and expect to find a better life. This causes even more social problems and ill health.

India is an extremely large country with many states that all vary enormously in climate, topography and communities of people. Individual areas should be thoroughly examined for the correct use of species and silvicultural systems used. More of the 600 or so species within the genus *Eucalyptus* require closer examination especially for reclamation practices. Improving existing silvicultural systems require further research. Economic well being of rural communities balanced against commercial forest plantations is essential. Ecological balance and economic uplift must be weighed up before large expanses of monoculture are established.

The collecting of firewood is an important factor that contributes to forest degradation. This could be avoided if fuel was made available at reasonably cheaper rates. To save forests from depletion it is necessary to meet fuelwood demands, so that local people are not forced to go into forests for clandestine collection.

The needs of the industry as well as that of the rural poor must be met in a balanced manner, so that requirements of one section are not deprived to benefit the other. This involves socio-economic considerations necessitating political decisions.

G.B&I. Region Seminar Series

Two concurrent discussion groups considered the topics of: (1) Propagation, and (2) Training. These seminars aimed to pool current knowledge on the topic. The session on "Propagation" revolved around the concept of Total Quality Management The aim of the "Training" session focussed on the most appropriate types of training, and the amount of time and effort to put in.

The significant conclusions developed by these groups are given in the papers that follow.

Propagation

Maurice Barletta, Reporter
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Propagation and Quality

Discussion began with the concept of Total Quality Management (TQM), and how the propagation unit of a nursery could fit in with this. The point was made that propagation was the starting point for quality production in all the subsequent stages on the nursery.

This was considered a difficult ideal to achieve if the nursery was not large enough to support a full time propagator On small nurseries, propagation itself is just one aspect of the propagator's job. Activities further down the production process, such as potting up liners for sale to generate cash flow, tend to push propagation down the priority list

Propagation and Marketing

The development of more active marketing in the nursery trade can also lead to conflict, as the sales departments may demand particular plants at a time that does not fit in well with propagation Outside this time, the propagator is faced with taking more cuttings to cover losses and fill the salesman's requirements.

It was generally agreed that the demands from the marketing men did not take account of the lag time between propagation and saleable plants. The biggest problem facing the propagator is not how to propagate, but what to root and when. A comment, based on experience in the large numbers business of micropropagation, suggested that the key to success was good planning and control. Weekly production is scheduled more than 12 months in advance.

It was suggested that a better understanding of propagation by the sales team would save costs, reduce propagator stress and avoid customer disappointment. Propagators welcomed the fact that propagation is more market orientated because they felt a more valued part of the nursery team, less isolated from the business as a whole. One idea was to redefine the propagator's job, from "one who puts roots on plants" to "one who produces young plants"—this would give greater satisfaction and a greater appreciation of the propagator's role in overall plant quality

Irish nursery stock producers reported that the trend was away from on-nursery propagation towards buying-in liners for growing-on. But this has limited the container trade to producing only what is available from liner growers and has lead to little differentiation between the ranges offered by nurseries. Nurseries are beginning to take on the propagation role once again so that they can each offer their own unique lines. Liner growers, it was suggested, should develop much closer links with their immediate customers and with end buyers.

Information and Education

Lack of information on developments in propagation techniques was identified as a problem now that a free flow of information from Government advisors and experimental stations had stopped. Personal contacts, trade press and, of course I P.P.S. meetings were chief sources of information. It was pointed out that more use could be made of the UK supply trade, as well as looking at the activities of other sectors of horticulture.

Even so there was considered to be a skills gap in basic propagation techniques such as budding and grafting. It was suggested that the education service could steer students with a natural awareness of plants towards nursery stock, although the point was made that too heavy a hand on the steering wheel could result in a rejection of the sector by those being steered.

Training

Spence Gunn, Reporter

I P P S GB&I Regional Editor

The group decided early on that training was a vital element of nursery management. Discussion focussed on the most appropriate types of training, and the amount of time and effort to put in.

Smaller nurseries in particular found that while they identified a need for training, it was difficult to allocate sufficient time. Training often conflicted with the demands of production and for this reason it was considered that, ideally, one person should be given responsibility for training, fulfilling the role of training or personnel officer—although it was recognised this person may have other duties too.

Induction training, when people first join a nursery, was seen as vital. To give sufficient attention to induction training, nurseries should avoid taking on new staff during busy periods. Working longer hours with existing staff was thought to be preferable Recruitment should be planned so that new staff were taken on when there was sufficient time for induction training

It is also important to plan training and staff development so that each person on the nursery had a training programme relevant to their needs and the needs of the employer.

Some of the problems can be overcome by forming, or joining, local training groups. These can help substitute for the management layers missing from small nurseries.

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Some of the problems can be overcome by forming, or joining, local training groups. These can help substitute for the management layers missing from small nurseries.

The cost of Training

The comment was made that some nurseries put a lot of resources into training staff who then leave. The group drew the distinction between those who leave for other horticultural jobs and those who leave the industry completely. In the former instance, training was still considered worthwhile, because the trained person was a net gain to the industry. The individual nursery was equally likely to benefit by recruiting someone else's trained person Movement within the industry was considered generally beneficial because it increased the experience of the workforce

Effort should be put into preventing trained people leaving horticulture. ATB (Agricultural Training Board) forklift training courses were a particular problem because trainees could obtain a certificate then leave for higher paid jobs in other industries where they could use their skills. Ideally this should be avoided by greater attention to initial recruitment. Employers could also consider contracts which specified a minimum period of employment following such training.

Training Groups

The problem of finding resources (time, money, the right staff) for training are greatest for small nurseries.

Some nurserymen expressed the fear that poor quality college training was leading to a shortage of skilled people for the industry. It was all very well for colleges to further a student's education, but should it be the industry's role to provide all the training in practical skills?

Widening Experience

Managers expressed a need for greater help, perhaps from training groups, on how to train. Looking at practices in other industries was considered a good idea. It was suggested that perhaps the next I.P.P.S. regional conference could include a visit to an airport or factory with a view to learning from their manager's experiences.

Understanding the Market

Edward Back MHort (RHS) MIHort
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INTRODUCTION

Marketing is often viewed by horticulturalists as something apart from production and even further from propagation, but of course it isn't. In commercial horticulture, it is only marketing that makes production and propagation possible, without a market there would be no point in either.

Conversely of course there is no point in employing the most sophisticated marketing techniques to define a market, quantify the potential demand and specify the product needed to satisfy that demand if you don't have the ability to produce it profitably.

Marketing is not something practised by others, spending large sums of money in city offices, running massive businesses. Anywhere a demand meets a supply whether for money, for barter or for free, a market exists and we are all part of it.

How the Market Works

The economists' idealised conception of a market is one where large numbers of independent producers of one identical product meet large numbers of independent buyers of the same product and all present have an accurate knowledge of the overall supply and demand. In this situation the market settles at a price such that all buyers willing to pay that price have bought and all sellers willing to sell at that price have sold. Buyers unwilling to pay that price remain unsatisfied and sellers unwilling to sell at that price remain with product on their hands. Only if one side or the other foregoes its right to determine its price will the market sell out for certain, for example an auction with no reserve price.

It is a regrettable fact that only in agriculture and horticulture do approximations to this model still exist, every other industry has moved away from the supply of identical products into product differentiation, added value and consequently more controlled marketing.

Who Controls the Market?

In the concept just discussed, no one buyer or seller can control the market or even affect the final concensus price to any significant degree. But markets with an imbalance of either buyers or sellers can be controlled to some extent. If one large buyer faces many small sellers that buyer can exert considerable control over the market and so can a large supplier facing many small buyers Even in these situations, the market is not totally controlled because whilst the single large seller or buyer can control either the price or the quantity sold or bought, neither can determine in advance what quantity will be available for any given price or what price will be required to purchase any given quantity.

Real life is much more complicated, markets are influenced by substitution buying and selling and both buyers and sellers ideas of the supply/demand position may be very imperfect There can be a glut of rhododendrons in Yorkshire and a shortage in Kent but unless sellers and buyers know this and move supplies from north to south there will be large differences in the regional price of rhododendrons

Modern Marketing

Modern marketing began with the development of industrial production and the ability to make products rather than accept what occurred naturally. This product differentiation could be used as a marketing tool and the parallel development of long distance distribution systems and new methods of communication enabled manufacturers to tap markets further and further from the centres of production to create demand as well as satisfy inate needs.

Is selling nursery stock greatly different from selling motor cars or washing powder? As a product for marketing there are significant differences.

Firstly, the production rate of industrial goods can be varied considerably by adding new machines, working additional shifts and by closely controlling environmental conditions Conversely, within every plant there is a biological clock which controls the development of the plant and once started cannot be stopped or substantially controlled.

Secondly, nursery stock products cannot be stored like nuts and bolts. Conversely, Ford Escorts do not grow into Ford Granadas—however long you leave them in the showroom!

The industrialists' ability to vary production in the very short term is in sharp contrast to the long production cycle of most nursery stock, and in total contrast to its seasonality of production and its finite stock number in each production year. For this reason, some theories and practices of modern marketing of industrial products should be treated with caution when applied to nursery stock. In particular the theory of equating market demand at different price levels with the unit cost of production at different output levels (demand elasticity equated with economies of scale). The nurseryman's dilemma in a finite stock situation is deciding whether to sell for a lower price in the autumn and improve the cash flow or hang on for an anticipated higher spring price and improve the margin. If he does hang on and the spring market collapses he is in a very invidious position indeed, a fact which is responsible for much of the "short termism" evident in nursery stock selling.

What is Marketing?

Marketing is essentially a strategic operation as opposed to selling which is a tactical one Selling is important but it should be the final tactic that completes the strategy, not the only weapon in the armoury. Many companies don't have anything between production and selling; their marketing is non-existent. Marketing is the specifying and initiating of future production to meet an anticipated future demand profitably. This requires a knowledge of what the market will want or more importantly, can be persuaded to buy.

Market Surveys and Business Appraisal

Professional market surveys are very expensive and need to be accurately targeted to be effective. This implies knowing what you want to do and accurately and honestly appraising your business strengths and weaknesses. Once the business appraisal is complete it will point to certain sectors of the market and eliminate others and the object of the market survey is to narrow down these possible sectors into a "best fit" of business strengths and market requirements with a defined distribution system. If you don't have a business at present you have the chance to define market deficiencies and set up a business to service them. Either approach is equally valid; in any case fitting a business to the market is not a once only job but a continual adjustment to changing circumstances and emerging opportunities

For those who can't afford a full blown market survey there is a halfway house. Get a market research company to design you a survey you can use yourself and do your own foot slogging, it's the salaries of all the people they pay to ask the questions that costs the money. Alternatively find a small out-of-town agency and get them to carry out a telephone survey for you. Properly done it is broadly effective and much cheaper than personal visits.

Existing businesses already have large amounts of valuable information if they will only take the time and trouble to quantify and analyse it. They also have customers who properly approached can be very enlightening on the business' successes and shortcomings and on the strengths and weaknesses of competitors

Making the Business Relevant

If you are not producing what your customers want (or can be persuaded that they want) it doesn't matter how well you grow it, they won't buy your product if it is not relevant to their needs. In this position there are two options, change your product or change your customers and in nursery stock it may be quicker to change customers. In reality you will need to do a bit of both but it's better to have researched the market first and fitted most of your production to its needs. Most of it but not all, otherwise you simply end up supplying what the market already knows it wants and your role is solely reactive. Use your knowledge, look around a bit, find some lines with sales appeal and go out and sell them actively to customers, be pro-active. That's what a lot of industrial marketing consists of, a mixture of supplying what is wanted by the existing market and also creating a market for products that your business can produce and most others don't

Product Differentiation—What Can We Do?

Let us look at the soap powder industry, all marketing very similar detergent products which do the same basic job—washing clothes. The differences in performance between similar products is minute when compared with the common good they all achieve which is getting clothes clean. Their marketing, however, concentrates almost entirely on these small, real or implied, differences and only peripherally on simply washing clothes. The objective is to distinguish one product from another and sell you its real or perceived benefits rather than its unexciting actuality.

In the nursery stock industry we have identical plants produced by many nurseries; *Berberis darwinii* is *Berberis darwinii*, no matter from which nursery out of several hundred suppliers it comes. As wholesale producers we have a problem if we seek to follow the washing powder industry and try and differentiate all the lines we grow There could well be several thousand on a large nursery and most of them produced in relatively small numbers. For short runs, customised labels are uneconomic so we will end up using industry standard labels for most of our products anyway.

A more practical approach to differentiation is to project the nursery image as a whole in terms of quality, professional ability, overall presentation, prompt delivery, personal service, product range and value for money. These factors influence all customers, not only those in the retail market but landscapers and local authority buyers as well It is more cost effective but it does depend heavily on good staff who do a thorough and consistent job and understand the value of good customer relations.

SUMMARY

Analyse your own strengths and weaknesses and those of your business. Build on the strengths. Define your market. Whatever you decide to do, set targets, write them down in a business plan and keep referring to it Modify the plan as you amass more knowledge and experience, fitting a business into a market is a continuous process. Finally, don't be overawed by professional marketing people, *it is not an exact science and they don't get it right all the time either No matter* how bulky the report, how glossy the paper, how impressive the graphs it is just a sophisticated approximation. Above all don't be afraid of this mysterious business called marketing. The market after all is only millions of people, just like you, looking for something to spend their money on!

Marketing—Planning for Profit

D.P. Elliott
Johnsons of Whixley, York

In a free competitive market-place responsibility for marketing must ultimately lie within the individual firm As many of the constraints on production disappear the need to maintain profitability is more dependent on marketing. Successful firms will increasingly be those for whom marketing takes the lead

Marketing is most concisely defined as getting the right product in the right place at the right time. This leaves too many loose ends for me and I prefer its definition as the process of balancing the company's need for profit against the benefit required by consumers, so as to maximise long term earnings per share (or return on capital). It is this need to maintain long term profitability, and thus the survival and development of a business, that places the emphasis on strategy and planning to develop the marketing ethos.

There is a conflict between the consumers' need for benefits and the firm's need for efficiency and profitability. There are marginally profitable plants or groups of plants that one would prefer not to sell but which one feels obliged to carry in order to satisfy customers. Finding an acceptable balance between the difficult to predict needs of the consumer and the difficult to estimate requirements of the firm is not easy.

It is important to select market opportunities which can be satisfied by the resources available in your business This is equally true for the established as well as the new firm and can be ascertained by asking the following three questions.

1) Is there a genuine need which is not fulfilled at present?
2) Are we equipped as a company to fulfill it effectively?
3) Does it look profitable?

Assimilating and appraising this information is fundamental to developing the marketing strategy. To do this requires a thorough knowledge of the market on the one hand and an objective understanding of the strengths and weaknesses of your company and its competitors on the other In addition, gathering the information to develop a strategy involves some predictions about changes in the commercial environment which can influence development over the period. These may include operational factors such as research, demographics, information technology and environmental considerations, and marketing factors such as the single market and quality assurance.

Having chosen the products and services it is important to consider the other inputs to the marketing mix.

Product and packaging development must be underwritten by the need for product appeal. This is most often translated into product quality and to take full advantage of the other inputs to the marketing mix this should have the highest priority. Picking any one plant and comparing it through a random sample of nurseries will clearly demonstrate that there is considerable room for improvement. Continuing investigation of the inputs at the production end (call it research and development if you like) should enable us to change this mix to increase product appeal to the consumer at marginal extra or even reduced cost, although cost reduction should never be undertaken at the expense of product quality.

With our largely commodity style products there is little opportunity or indeed reward for packaging and presentation development. It is however important to incorporate state of the art labelling developments as the technology becomes increasingly available.

Especially noticeable in the autumn, pricing is one of the most visible aspects of the products image, after quality or performance. 'Cost plus' and demand pricing are the two approaches normally taken to set the price. Almost without exception, demand pricing—where competition and availability sets the general price level—is the rule for our industry. Variations from the general level can be achieved by superior quality, distribution, selling, advertising etc. Because we are a low margin industry, very small drops in price can have huge effects on profitability with little effect on volume sales. But the effect of small price increases can be dramatic in terms of profitability. This has important implications for the choice of product range.

Sales promotion involves incentives to purchase and can involve a wide range of techniques from price variations, to bonus offers of extra plants, to free deliveries etc. Its purpose should be to achieve new or additional purchases either by increasing sales or widening distribution It may be linked to advertising and branding but should be carefully used as part of the overall strategy to ensure increased long term profitability. Careful planning to achieve clear objectives is essential along with monitoring to measure success.

Advertising is probably one of the most difficult areas of investment in small companies. We should use it to create favourable attitudes to the company and its brands and be aware that it is investment wasted without being followed up by superior product and service performance It must be well planned and carefully budgeted and like product quality, good quality advertising costs the same as poor. Keeping the message simple and putting across ideas to maintain continuity will assist success

It has been interesting over the past few years to see individual brands being promoted in a market-orientated way. This type of high risk marketing has been limited in the past to protected varieties while the majority of the industry has limited brand development to the overall company image. It is important to recognise the factors which constitute your company brand and to build on these strengths These may encompass high quality, service, cheap prices, specialised products, wide range etc. Method of distribution can vary in efficiency and complexity and it is important to have a trade-channel strategy which will have significant effects on the structure of your business. Decide whether you wish to distribute to retailers, wholesalers, contractors, distributors, mail orders companies, etc. This will have significant effects on the marketing strategy and the overall management of the business

Finally, it is important to recognise that the marketing strategy, which can be used to develop plans for a 3 to 5 year period in the life of a business, should be reviewed annually to incorporate changes in the business environment It should not be written in tablets of stone In addition to directing the business towards its corporate objectives, it provides a yardstick for constructive and measured change

Technical Sessions

VICE-PRESIDENT VERL HOLDEN: It is with great pleasure that I welcome you to the 32nd Annual Meeting of the I P.P.S Western Region. We have over 300 persons registered, the largest for any I.P.P.S. meeting in Oregon We are here in Beaverton, which got its name in the early days from the thousands of beavers which inhabited this area along the tributaries of the Tualatin River

We are in nursery country here—all around us There are about 4,000 licensed nurseries in Oregon. Many large wholesale nurseries, that have nation-wide shipment of plants, are in the immediate vicinity.

We have a wonderful poster display this year, probably the best the Western Region has ever had.

I want to thank all the people on our meeting committee this year for a job well done, in particular I want to thank our program committee chairman, Richard Regan from Oregon State University Extension Service at Aurora, Oregon, who has assembled a great bunch of highly qualified speakers for this meeting.

Curtis J. Alley Award of Merit

Bruce Macdonald, Director, University of British Columbia Botanical Garden was 14th recipient of Western Region's Curtis J. Alley Award of Merit. The presentation was made at the Region's annual meeting banquet at Beaverton, Oregon, September 5, 1992.

A position at the UBC Botanic Garden lured Macdonald from his native England to British Columbia in 1980. He became involved in Western Region activities soon after transferring from Region of Great Britain and Ireland that same year.

He has initiated a number of Western Region innovations. The Region's first area meeting was organized by Macdonald in 1988. He was instrumental in developing the Region's publicity and promotion program. He authored the Region's first information brochure, and also its recent revision. His idea of a travel scholarship is just now being initiated. The Region Executive Committee has just approved his suggestion to sponsor the I P.P.S. membership of a Chinese horticulturist

Macdonald was Western Region President in 1988-89, after serving as Vice President from 1985 to 1988 He was the Region's Alternate Director on International Board in 1988-89, and its International Director in 1989-90.

He has served on a number of committees, chairing several of them He now chairs the Grants Committee after earlier being a member of it. He has chaired the Long Range Planning-Nominating and Honors Committees after previously serving on them. Macdonald has also been a member of the Publicity and Promotion, Newsletter, and Annual Meeting Committees.

Macdonald's involvement in I P.P.S was not new with his Western Region membership. It began as a member of the G.B & I. Region, which granted him Honorary Membership in I.P.P.S in 1980 for his many contributions to the Region. He was Secretary of G.B. & I. Region until moving to Canada.

Macdonald is a horticulturist of world renown. He became involved in the UBC Botanical Garden's innovative Plant Introduction Scheme (P.I.S.B.G.) early in its development and became the program's leader. His book on plant propagation, *Practical Woody Plant Propagation for Nursery Growers*, has become a worldwide standard. Macdonald is in demand as a speaker on horticultural and trade programs. He has been a speaker on annual meeting programs of five of the six I.P.P.S. regions.

How to be Market-Driven

Jheri Ketcham
Clackamas Community College, Small Business Development Center, 7616 SE Harmony Road, Milwaukie, Oregon 97222

Marketing is in the news. We read about it, hear about it—everywhere we turn we're told about the virtues of marketing: How marketing can be the key to our business' success; that the nursery industry will continue to thrive if we all get down to the business of marketing; That without marketing there would be no market; And a product without a market is like an airplane without wings—it won't fly.

I don't disagree, the logic is sound, but what we fail to hear or understand, is how? What does marketing consist of? Where do you begin? How can you practically implement marketing without spending a fortune. What can you, as nursery owners and managers, do to assure a market is ready and willing when you're ready to sell.

You do this by becoming market-driven. By letting the market be your guide, your road map to your business decisions. By setting your antenna on your market and letting them shape your business. This does not mean printing a bigger and better catalog or hiring another sales representative. Convincing your market to buy is important but its only the final step to a process that begins before you make that first graft, or plant that first plant. It's a process that penetrates every aspect of your business. It's realizing that you're in business, not only because you enjoy growing plants, but because you're serving your customers' needs.

To explain how a company can become market-driven I will use examples of **how not to be market-driven.** Each illustrates a fundamental flaw in marketing strategy. Some you may be able to relate to, since they are often heard in the industry. I will also use each example to explain a major step to becoming market-driven. Steps that are essential in assuring your business has a market—and a future.

HOW NOT TO BE MARKET-DRIVEN: I.

When Making a Business Decision, Only Listen to Your Neighbor, Spouse, or Fellow Grower. Getting assistance from friends and family is fine—if you're planning a family reunion, but they should not be relied on to direct your business. Only your market, your current and future customers, can give you the information you need to succeed. It's your market that will give you the best indication of what to grow, to what size, and what services to offer. I'm not saying to ignore the advice of neighbors and other growers but to temper it with what the market is demanding. Just because you can grow exactly what the neighbor does is no guarantee a market will appear when you're ready to sell.

So, the first step to becoming market-driven is listening to your market It's

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So, the first step to becoming market-driven is listening to your market It's listening to your customers, former and future, before making any decision about your business. It's asking yourself, before you install a new inventory system, or purchase a new piece of equipment—is this good for the customer Is this what the customer wants?

Listening to your market does not mean taking everything they say as gospel or trying to incorporate each of their whims indiscriminately. To be market-driven means determining what is *most important* to your customer and then letting that information guide your decisions It's taking a customer's perspective—putting their shoes on when looking at your own business. In the customer's eyes you're selling more than just a plant. A customer will be appraising your product and your business in its ability to fulfill his needs—in most cases this goes beyond just obtaining a 1-gal rhododendron or a grafted maple.

For an example, let's say you grow grafted conifers. Each of your potential customers will be viewing your conifers in terms of what is most important to them. To a new grower who plans to grow your conifers on, your expertise and guidance can be just as important as the plant. To a garden center, your ability to deliver on time, and to a collector, your reputation. Each looks beyond your plant to see if you can satisfy their particular needs

The first step in marketing—or to be market driven, is to listen to your market when thinking and planning for your business It's understanding that your product is fulfilling their wants—not yours. It's listening to what is most important to them.

HOW NOT TO BE MARKET-DRIVEN: II.

Consider Anyone and Everyone to be Your Primary Market. The second example of how not to be market-driven is having only a vague notion of who your customers are. It's having little idea who buys your product and what they do with it once it leaves your nursery It's trying to be everything to everybody.

Unfortunately, trying to appeal to everybody usually leads to not appealing to anybody The nursery market is not homogeneous A landscape contractor has different needs than a garden center. Each is looking for a different mix of plants and services so each in turn can serve their own customers Each is turning to a grower for not just plants but an entire list of criteria that is important to them.

Consider the toothpaste market. A fairly generic product—one toothpaste is very similar to any other, but then why over 20 brands? It's because the industry has been very successful in designing each toothpaste brand to appeal to a certain group of customers. They've realized that each group considers toothpaste important for different reasons. Whether its fresh breath or whiter teeth, each toothpaste is answering the needs of a particular group

To be market-driven requires you to target your efforts. To look at your market as a collection of very distinctive groups, each with a distinctive list of criteria in judging your product. It's selecting whom you want to serve, and then honing your products and services to most appeal to your target. It's realizing that each group turns to you for different reasons It's saying to yourself that you're in business to serve the local garden center market or the East-coast landscaper.

It's OK to target more than one group You just need to realize that each is turning to you for a different set of reasons. That each group has different wants and perceives you and your business in slightly different ways. What is important to your landscape customer might be irrelevant to a garden center.

Keeping in mind who your market is and what is important to them will make your decisions easier Right from the beginning you'll have a much better idea of what to plant, to what size and what else to offer. Knowing your audience will help you design your catalog or write an ad that speaks directly to your customer.

HOW NOT TO BE MARKET-DRIVEN: III.

Become a Victim and not a Player of the Market. Becoming a victim of the market occurs when you let the market attack you, instead of you attacking the market. It's having little idea of whether or not what you grow will sell. It's taking the first price offered because you have no idea if another customer will appear. Victims of the market believe they have no control and spend their time in fear wondering if a market will appear.

To be market-driven means doing your homework. It's taking control of your business by keeping an eye on the market and understanding how it will affect your actions It means finding out that the current price of primroses would never cover your expenses—before you plant—not when you're ready to sell.

Proper marketing requires knowledge. You don't have to conduct fancy market research. You just need to keep your eyes open. It means talking to your customers to find out how their business is doing. It's spending the time to find out what happens to your plants—after they leave your nursery. It's asking your garden center customers what sold and if not sold, why? It's asking your landscape customer what type of projects they're working on and what they expect in the future.

Taking control also means doing your homework before you get started It's getting on the phone before you plant and finding out whether or not there's a market for the plant you love to grow And if there is, who else is supplying it, at what time of year, in what quantities and for how much.

And finally taking control means studying your competition. It's becoming a catalog collector and studying what they have to offer that you're not offering. It's understanding why customers are buying from them instead of you.

A market-driven company acquires knowledge—knowledge of the market, of their customers and their competitors.

HOW NOT TO BE MARKET DRIVEN: IV.

Use Price as Your Best Weapon to Attract and Keep Customers. There's nothing wrong with wielding price as an incentive to attract and keep a customer—if, you happen to be a commodity. If you believe you're selling wheat and that your wheat kernel is very much like everybody else's wheat kernel then you have no *other choice but to compete on price. And being a commodity can be profitable* **if** you know you're the lowest cost producer. But for the majority of nursery growers this doesn't apply—not everybody can make money by competing on price alone.

Fortunately, in the nursery industry you are not bound by the restrictions of selling a commodity. You have the ability to put together a mix of products and services that sets you apart from other growers—to design a unique "value-package" that avoids the headaches of competing on just price.

The fourth step a market-driven company takes is, therefore, designing this value-package. It's finding a mix of product and services that removes your product from the commodity mode by offering your customers more than just a plant.

You do this by making best use of your strengths and your competitors' weaknesses—to find a mix that appeals to a given market. For example, a small wholesale greenhouse grower I know, knew he couldn't compete with the bigger nurseries in town. So he decided to use his strengths in location (center of town), selection and service (they have a retail site at the same location) to target local charity groups that sell plants to raise money. By supplying the right mix of plants and services he created a captured market for his plants—at his stated price, not theirs.

When considering your value-package don't be fooled by customers who claim they only care about price A major buyer of a discount chain told me that the lowest price doesn't guarantee that he can turn around and sell that plant. What's important to the buyer is a plant that performs for the customers—that will sell, even given the notoriously poor conditions at the store. If a grower can provide a plant and services that assures the retailer he can sell that plant then he's willing to pay more. Price does not make the sale

Another danger about competing on price alone, is that it won't build customer loyalty. A buyer who says he's only looking for price has no allegiance to your nursery if he believes he's only buying a commodity.

To be successful, a market-driven company must take the time to design a value package that raises the value of their product. To avoid competing on price alone requires realizing that you're selling more than just plants.

HOW NOT TO BE MARKET DRIVEN, FOLLOW EMERSON'S ADVICE: V.

If a man can write a better book, preach a better sermon, or make a better mousetrap than his neighbor, though he builds his house in the woods, the world will make a beaten path to his door.

-Ralph Waldo Emerson, 1869

Even if you can write a better book or grow a better plant, there is no guarantee your business will succeed. Emerson was a great poet but not a great business strategist. In today's world, where products (and growers) proliferate, the market will not tromp to you door, even if you think you have the best Great authors go unpublished each day while sensationalized and lurid novels become best sellers. The key to business success is not only knowing what the market demands but making sure you let them know that you can provide it. It's not sitting home quietly hoping success will knock.

As you probably have guessed, this final step to a market-driven company is promotion. It's letting the market and customer know what you have to offer. It's letting the world know you're in business and telling them why you're good.

Promoting your business does not mean making big bold statements that have no substance or placing a screaming pink cover on your catalog. Like the icing on the cake, it does no good if the cake tastes bitter. To get them to come back for a second bite you have to clearly explain what your value-package is and why it's important to a potential buyer.

A good promotion informs. You keep a customer's interest by telling them clearly and concisely what you have to offer and why you're good. It explains how your package of products and services, addresses their needs. It goes beyond just proclaiming in an ad, "Bare-root Seedlings For Sale" A good promotion will also explain why these seedlings are important to the customer It points out what the customer needs to hear: **"excellent future survival, largest selection, best form!".**

Promotion also does not end with a catalog or a trade show It's a process that occurs year-round. Whenever you speak to a customer, fill an order, or talk to another grower you are promoting your business This occurs, because every action you take reflects back on your business. Every action shapes an image in your customer's mind of what kind of business you are. Not returning a phone call, or being late on filling an order, all reflect on your ability to provide your value package. You can print a spiffy catalog that totes your customer service, but as soon as you ignore a customer's request, you've lost the benefits of your catalog.

HOW TO BE MARKET DRIVEN

In conclusion, to be market-driven means simply using the market as a guide, a road map to building your business. The steps don't require a great infusion of money or a great deal of your time. It just requires following these simple steps:

I. Place your market first by listening to what is most important to your market, not what is most important to you.

II Target your efforts to specific customer groups. Avoid trying to be everything to everyone.

III. Do your homework. Don't become a victim of obvious market trends or events.

IV. Build a mix of products and services to avoid having to compete on price alone

V. Promote! Tell them why you're good.

The Target Seedling Concept: Potential Marketing Tool

Robin Rose[1]
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Speak with any grower of plants who is in the wholesale or retail business and it isn't very likely you will run into one who says they sell poor quality stock More than likely you will hear about past problems that have been overcome I know of no one in the propagation business who hasn't had some problem some time and who isn't currently working on this year's crop of problems. If growing plants were easy, there would be no need for all of the societies founded around plant propagation, soils, fertilizers, and genetics.

This paper is about the **Target Seedling Concept** (Rose et al., 1990) and its use as a marketing tool First, what is the definition of the target seedling concept? In a forestry context it means to target specific physiological and morphological seedling characteristics that can be quantitatively linked with reforestation success. The idea is that for whatever purpose the plants are intended, it is important that they are physiologically and morphologically prepared to grow well in their destination environment. The key word in the definition is "quantitative," as opposed to "qualitative." It is vital that there be quantitative *criteria* by which the seedlings are measured.

How can the **Target Seedling Concept** be used as a marketing tool? In most cases marketing a product includes telling the customer what makes this product better than some other. Criteria are set, standards are put in place, and the definition of a good product emerges As customer needs change, so do the criteria for a successful product. Targeting characteristics for success is one way of letting customers know you have standards and criteria for success. They can expect to get a good product.

For years in the forestry business tree improvement and genetics have been used as marketing tools Seedling bags and refrigerated trucks have had company symbols and slogans like "Seedlings from Superior Trees" put on them in large block letters to let buyers know that they are getting "superior" seedlings Customers expect these seedlings to grow faster, be more disease resistant, have good form, higher density wood and be ready to harvest earlier than woods-run seed. Granted, the customers expectations may not always be correct, the assumptions about the seedlings unproven, but tree improvement does work very well as a marketing tool. It certainly is true that genetically improved seed is better than woods-run seed so there is a sound basis for marketing seedlings this way.

SEEDLING TRAITS TO CONSIDER

It needs to be made clear that a key element in the **Target Seedling Concept** is that many seedling traits operate together to produce the desired field response. Thus, each of these traits affects many others It is a matter of getting all of the best traits to overlap (Figure 1).

[1]Project Leader

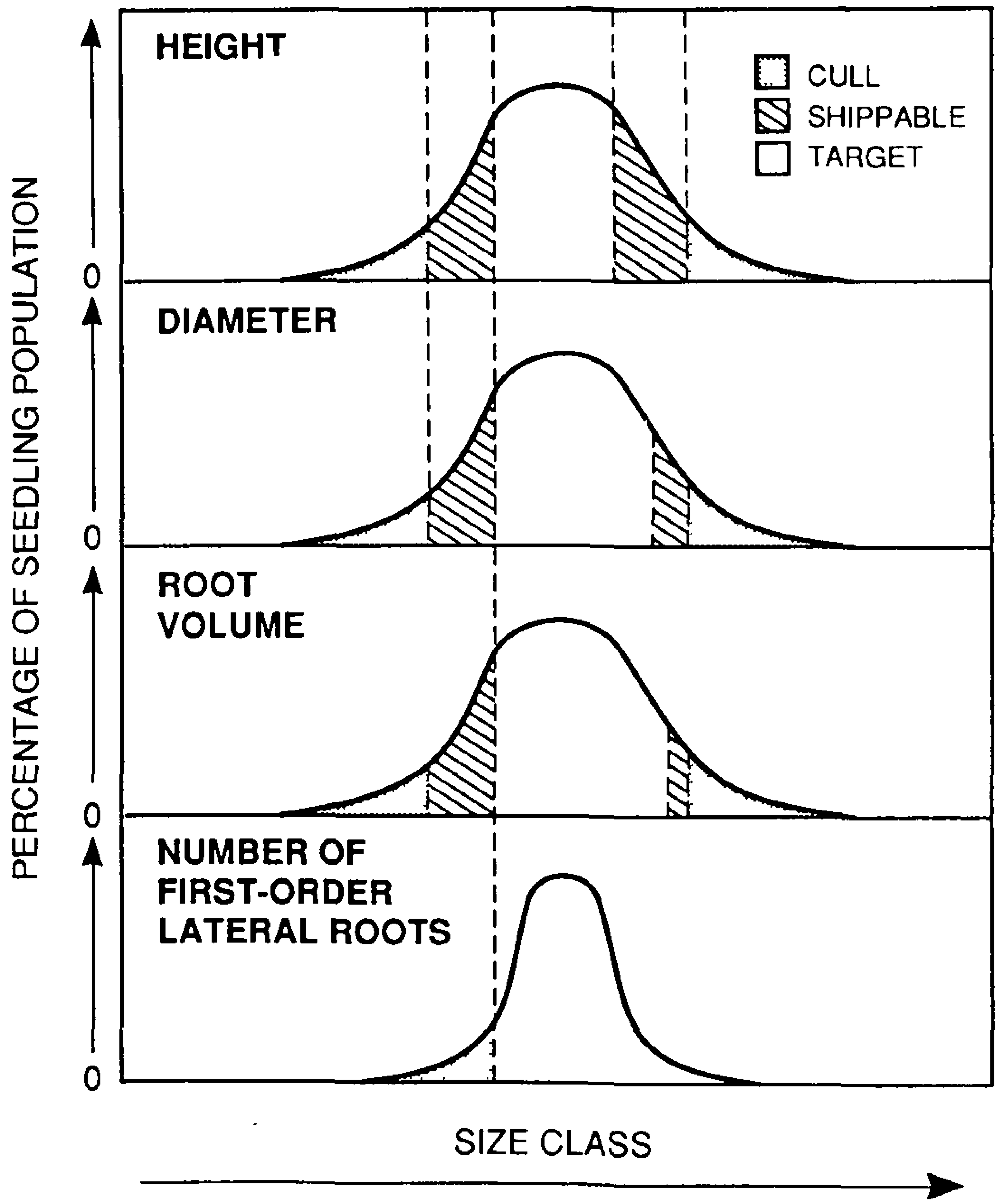

Figure 1. Schematıc of dıfferent seedlıng parameter dıstrıbutıons wıth cull factors

Height. The greater the heıght of a seedlıng, the greater the leaf area available for photosynthesıs and transpiratıon and the greater the seedlıng's weıght and bulk. Greater weight and bulk, of course, decrease the number of seedlıngs that can be carried by a person during planting. Height affects the shoot/root ratio of seedlings The limitıng factor in setting a practıcal height is actually the amount of root that can be planted properly.

Diameter. Diameter is closely related to seedling vıgor, partly because average diameter of a seedling population at any one tıme ıs correlated with the average size of its root system Furthermore, stems wıth larger dıameters tend to have larger buds (unless they have been top-pruned). Such buds contain larger numbers of pre-formed leaf primordıa that wıll elongate to become the first flush of growth after planting. Seedlıngs with larger dıameters also have larger xylem cross-sectional areas for water transport, although durıng establishment the size of the root system ıs the limiting factor for the process (Carlson, 1986).

Size of the Root System. In additıon to increasıng the potential for water uptake, larger root systems wıthin a single genetic source also have a higher root growth potential. The size of a root system can also affect the rate of transpiration and gas exchange. Small-rooted seedlings are water-stressed because not enough water is absorbed by the roots to balance transpiration losses from the needles. If this condition is chronic, then currently available photosynthate can become the limiting factor for root growth High root volume has been shown to improve growth after planting (Rose et al , 1990).

Cold Hardiness. Nursery managers have long known that a seedling's dormancy status and cold hardiness affect the time it should be lifted and handled (Lavender, 1984) Changes in such phenological traits as date of bud set, bud size, needle color, and degree of root suberization, are now being used to estimate the dormancy status of seedlings prior to lifting them in the fall and spring for transplanting or outplanting. Unlike morphological measures, however, dormancy and cold hardiness have not often been considered as operationally useful target characteristics. By putting seedlings through a pre-set freezing cycle, one can quantify their LT_{50} (the lethal temperature at which 50 percent of them sustain some sort of bud, cambium, or needle damage).

Mitotic Index. Mitotic Index or MI (number of dividing cells/total number of cells) is used by researchers to investigate bud dormancy (Carlson et al., 1980). It has also been used successfully on roots (Dunsworth et al , 1982) A squash mount of a bud or root observed through a microscope at 400X magnification allows the number of dividing cells to be counted MI tends to decrease rapidly in the fall in some species.

Days to Bud-Break. Terminal and lateral buds of seedlings are now viewed as potentially useful indicators of whether a seedling has had its chilling requirement met. Seedlings require chilling to break dormancy in the spring. The number of days before terminal and lateral buds break is being used successfully to target the best time to life seedlings (Ritchie, 1983)

Plant Moisture Stress. Plant moisture stress is used as a target characteristic. As moisture stress in a seedling increases, there is a corresponding degradation of the photosynthesis mechanism and an impairment of future growth. Most nurseries try to lift their seedlings when the water potential of stems, branches, or needles is below -10 bars. It is equally important to plant seedlings when stress levels are low.

Variable Chlorophyll Fluorescence. This very new technology is still in its infancy, yet it holds great promise as a target parameter. The hope of this tool is that it will tell us if seedlings are fully dormant. It also has promise to tell us if seedlings are only marginally alive after severe frost Time will tell.

Who Sets the Target? Different targets are established for different reasons—as a public service, for profit through the sale of seedlings, or for profit at final harvest. Various cultural practices are applied to achieve the desired target. As these practices can result in a wide range of seedling morphologies and physiological conditions, nurseries must decide what practices to employ to achieve their goal. Ideally, no matter what goal, every nursery should be growing seedlings that survive and grow well after outplanting. The proper place to rate the quality of cultured seedlings is in the forest plantation.

CONCLUSION

The **Target Seedling Concept** has potential as a marketing tool in the same way that tree improvement and genetics are being used currently Emphasizing targeted criteria to meet a customer's needs would seem to have much more impact than current statements about growing quality plants Stating that the plants have been hardened-off to an LT_{50} of -18° C would seem to carry more weight with a customer than making the blanket statement that the plants are dormant or cold hardy. Adhering to a target system of criteria would appear to: 1) tighten the quality controls used to grow plants, 2) give both grower and customer more confidence in plant performance, and 3) lead to the best marketing advantage a business can have—a good reputation.

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Unique Methods for Marketing New Plants

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Mitsch Nursery is a wholesale liner propagation nursery. Our product gives us both a responsibility and an advantage concerning new plant introductions.

It is our responsibility to introduce new plants in such a way as to create a market for these new introductions and to have sufficient stock to supply this created market.

We have an advantage that allows us to make many more introductions than most nurseries. When we find a plant with definite merit for the home owner and the grower, we can have that plant in our catalog in just a few years. If we discover a new plant, we can first produce it in small quantities for evaluation purposes, thus saving considerable capital investment, and still shift into heavy production for immediate release in only one additional year.

Let me first mention a few facts about why we are able to introduce many new plants before I explain how we introduce and market them.

One particular plant that we recently introduced through Mitsch Nursery was *Pinus virginiana* 'Wate's Golden'. This plant is quite rare and hard to find, even in the collections of avid conifer enthusiasts. 'Wate's Golden' is light green in the summer but turns a bright gold in the winter. Fast-growing and hardy, it has wide climatic and soil tolerances. When we moved to Oregon in 1986, I brought a three foot tall plant plus ten new grafts with me. By grafting any available wood each year and by keeping most of the propagations, in four years we had sufficient stock to do over three hundred grafts of this cultivar Since we were not selling mature plants, we were able to offer it to our customers immediately.

When I discover a mature plant with merit in an arboretum and if I can obtain about 25 scions, we can usually offer that plant in four years or less. For example, I discovered an outstanding specimen of *Picea abies* 'Inversa' growing in an eastern arboretum. For some reason this striking plant was not readily available in the trade. I obtained scions from this tree over a three year period and offered it on a wholesale basis the fourth year.

Having the ability and the desire to offer new selections, this presented us with the problem of creating a market for these relatively unknown plants.

The most obvious starting point was with the Mitsch Nursery catalog since it best represented our product, including new introductions. A full color front cover and a half-color back cover were utilized to attract attention, and one of the photos is usually a new introduction.

Inside the catalog we have always used brief descriptions of all of our offerings to give a general idea of how each plant grows, its color, and its hardiness To make this catalog an attractive production that would encourage a customer to page through it, we use two colors of ink for highlighting important items on a page, and we have commissioned a local artist to do pen and ink sketches of plants found on the nursery. These sketches are reproduced on high quality paper and are suitable for framing.

We also offer a line of reference books for sale through our catalog Not only does this increase interest in our catalog, but it also gives our customers a fine source of reference books that cover our products.

Another means of education is the nursery trade show. We started with a local trade show and decided to do one other show each year in another part of the country. At each trade show we have a selection of new plants that we are offering, or that we will be listing in the next year or two.

The new plants do attract the attention of attendees, but we also utilize other features to draw people to our booth so that they will see our material. At the local trade show large pieces of ceramic art created by an artist friend and intended for utilization in the garden enhance the display We felt that merely cramming plants into the booth area worked against our goals. Playing a video of our plant offerings also attracts the attention of passersby.

A good newsletter is an invaluable tool for educating our customers. The biggest challenge with a newsletter is enticing people to read it. In general, newsletters are treated as "junk mail", especially when they deliver a hard sales pitch. We produce an informative newsletter that has been well received and has proven to be profitable.

Our newsletter, *Mitsch-Coenosium Notes*, is produced in-house on the nursery's computer with myself as the sole author and my wife, a former high school English teacher, as proof-reader. The writing is done on Wordperfect, a word processor, and the layout is accomplished with Ventura, a desktop publishing program, both of which are also used to do our catalog

The heart of the newsletter is always an attention-getting article. Just a few of the articles written include *Plants For Bonsai, Weeping Hemlocks, Golden Conifers, How To Graft,* and several devoted to gardens and arboreta of the United States and Europe.

A soft-sell sales approach is utilized throughout each newsletter. A book special is featured in each issue with a generous discount given off the retail price. A section of plant specials always occupies the last page. The plant specials and book special have never failed to generate substantial income for the nursery.

The autumn edition of the newsletter is mailed a few weeks before our catalog. This edition features new plants being introduced for the first time. Plants are listed with their descriptions, thus giving the customer advance notice of new introductions.

Landscaped gardens are a feature of Mitsch Nursery that have attracted considerable attention and generated additional sales. Over 1800 assorted conifer cultivars are in the Mitsch Nursery collection. Many of these cultivars are planted in the gardens and most are not known to our customers. Visitors at the nursery see our new offerings in landscaped situations and will often add some of these plants to their orders.

Our new cultivars attract many visitors to the nursery. The gardens also have quite a few grafted oddities and a variety of ceramic art forms scattered throughout the plantings which elicit considerable comment. Visitors touring the gardens often encourage others to visit the nursery and see the collections, thus giving us potential new customers

We also generate a market for our new introductions by creating a demand for new plants among retail customers. We use a number of different techniques to generate this interest.

I aggressively seek speaking engagements for meetings of various plant societies. In my presentations I use slides of unique plants being offered for sale through Mitsch Nursery.

Periodically I will write an article for a horticultural publication that encourages the use of special plants that are available from Mitsch Nursery The magazine is either one published for the general public or one associated with a particular plant society

Plant donations to arboreta or other public gardens go very far in generating public demand for finer plants. Mitsch Nursery donates plants to arboretum auctions, such as the annual auction by the Arnold Arboretum We make outright gifts of plants to a number of arboreta, especially new cultivars we are promoting.

Although we do not give plants to just any arboretum, we do allow any arboretum or public garden to purchase less than wholesale quantities at wholesale prices.

Getting new cultivars into locations where they may be seen by the general public is an excellent way to generate a demand for these plants. There is some risk of propagation material being stolen from any plant in a public location, but that risk is far outweighed by the benefits of public exposure to the plant.

I am certain that many others have utilized one or more of the marketing techniques described up to this point. The last two marketing techniques are my most unique ones.

In the past year I have made two high quality video tapes that have proven to be very successful. The first was a video catalog of Mitsch Nursery grafted conifers showing all 172 of the conifers we produce by grafting with scenes of mature plants, close-ups of foliage, and detailed descriptions of their growth and landscape uses. This video has increased sales for the nursery, both directly from customers and indirectly from consumers, both of whom have seen it.

The second is an instructional video on how to graft, and it is also selling quite well. As a former educator I was able to draw upon my classroom experiences in its production. It has not had a direct influence on sales, but it has added to the reputation of the nursery.

A video tape is an excellent selling tool. Its major drawback is cost. Each of my tapes is approximately two hours long and should have cost anywhere from $10,000 to as much as $30,000 to complete I have done each tape for only a fraction of those figures. Hiring a camera crew is very expensive. Instead I purchased a high quality video camera and did all of my own filming on high quality tape. Studio time for editing costs a minimum of $50 00 per hour, and ordinarily several hours of time is used for each minute of finished tape I greatly reduced my edit time by assisting in the studio and being well prepared so the production cost of the 3/4" edit master tape was very reasonable.

Coenosium Gardens is a retail business that sells rare and unusual plants to retail customers and collectors. It is my personal business, and it purchases its plants from Mitsch nursery for resale only. Most of the plants are sold mail order, but I do have a small area on Mitsch Nursery where a limited number of plants are displayed for immediate purchase. Coenosium Gardens will only sell plants that are up to three years old.

Coenosium Gardens allows me to sell a limited number of new plants before I am able to offer them on a wholesale basis through Mitsch Nursery Releasing a few plants into collections has created interest in those plants. It has also given the nursery a good reputation as a place where special plants can be obtained. Both wholesale and retail customers are able to purchase a propagation of almost any plant seen in the gardens during a visit. It is an advantage for us to be able to satisfy customer desires in this manner.

Mitsch Nursery is a unique nursery producing many unique plants. Marketing unknown plants has proven to be a challenge, a challenge that we have met with a combination of proven methods and new methods that we have developed in our own special way.

Using the Computer for Customer Service

Michael Poynter
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The I.P.P S organization is involved with sharing information primarily about specific techniques in plant propagation. It is, however, important to take a close look at the other aspects of commercial plant propagation as they relate to propagation as a business Record keeping has always been an important job of the propagator and when the number of plants and orders involved in the organization increases we now have the computer as an affordable and readily available tool to the business.

Up until about 8 years ago computers for use in business were pretty well confined to larger multi-user mini or main frame machines that were exceedingly expensive. With the advent of personal computers even the horticulture industry saw several companies offer software to growers that would help them run their businesses. Although the dealers claimed that they would do quite a wide variety of things they were best used for handling accounting functions.

With the advent of the spreadsheet programs, starting with Visicalc, the grower could do some of the same things on the computer that he was used to doing on paper and found that much of the tedium was taken out of doing "what-if" calculations to determine profitability of different crops

When the personal computer became available we saw companies introduce software targeted at horticulture businesses None of these early attempts were successful in the long term. The problem is in dealing with our inventory. Off the shelf programs are not designed to handle a growing, changing, and sometimes dying inventory where multiple start dates of the same item can overlap in their availability. Many of the production situations can be handled on a spreadsheet when the production is primarily intended for use by yourself. But when dealing with custom orders that can be altered in quantity or ship date and are mixed in with other custom orders or production for yourself, it is best to use a database program that handles orders more like an accounting system. The big difference here is having the numbers of items to be propagated or shipped tied directly to specific orders versus just in one lump figure that includes many orders and maybe your own production also.

Skagit Gardens is a wholesale grower of bedding plants and herbaceous perennials. With our finished plant material we do business almost exclusively with independent garden centers and not chain stores. This choice has forced us into computerization of the business to handle the detail involved with customers that demand exact cultivars on each order and not just assortments.

Bedding plant growers commonly produce up to 20% extra seedlings for production, which are often dumped. We began selling a few extra seedlings and rooted cuttings from our propagation and now for the majority of our business in the off-season, our propagated material is sold through brokers and shipped to other growers.

This little sideline got out of hand and we are now dealing annually with 12 million plants in 4500 orders selling for a quarter million dollars and going to nearly every state and province in the U.S. and Canada. The prefinished program now comprises one fourth of our total sales and is handled as follows:

We offer our plants to other greenhouses through horticultural brokers. The price is the same for the customer regardless of who he books the order with. We either custom-grow the item for the customer or we ship out of production that we have speculated on for this purpose, or we sell extras from our own production at the last minute while they are still useable.

The plants are shipped to the customer by common carrier with a packing list and the broker is billed for the plants less a broker's percentage. The broker pays us, the customer pays the freight, and the broker takes the risk of getting paid on time or at all.

At any given time at Skagit Gardens we might be propagating the same plant for ourselves for any of several pot sizes, or for other growers as custom orders, or as speculation for the growers that need something at the last minute. In order to keep track of all these possibilities we have developed a complex system of color tags and summaries on computer printouts. There are numerous ways to make mistakes but the business is there for the grower that can handle this level of complexity with the fewest errors. These choices in the market place have forced us into a high degree of computerization

The best service that you can give a customer is to get them what they ordered, get it to them on time, and in good condition. This sounds obvious but it is a rarity anywhere in our country. The emphasis needs to be on timing and on correct shipping. There are far more growers that can produce a high quality plant than there are growers that can get it delivered on time and in good shape. A grower could have any business he wanted by simply being extremely reliable.

SOME SPECIFIC USES OF THE COMPUTER AS IT RELATES TO CUSTOMER SERVICE

Accounts Receivable Aging Reports. By carefully monitoring the customers' account you can help the customer stay out of trouble We have a 2 percent discount for those that pay cash for their order and when someone gets late with their payment they can qualify for our permanent 2 percent discount by going on COD.

Order Pulling and Delivery. By having cutoff times for specific delivery dates and entering all of the orders into the computer before pulling you can gain in efficiency. By using master pulling lists you can more efficiently pull the material for the days' orders and you can use the computer to route trucks during the order entry process thus showing where you can work on certain delivery areas to get the trucks as full as possible. This requires training customers to order by your rules. If the customer perceives the grower as reliable, and the system works, then customers are trainable.

Customer Sales Histories. Computers are very good at providing customers with sales histories of what their purchases were and you can often provide a customer with information that they don't have themselves. This is useful in planning future orders.

One of the toughest areas of our business is in determining availability of saleable product. With all of our sophisticated computerization we still rely on physical counts of what's ready on a weekly basis We have found that we can fax this information to customers weekly and they can fax back orders to us that need very little altering to be ready to ship. To do this a fax machine with memory is required to broadcast one set of information to multiple locations automatically. Mail is the way to go when timing is not so critical; the computer has long been used to produce mailing labels and can be used to select the type of group to receive the mailing if it isn't appropriate for the whole customer base.

Cost Accounting. Computers are very well adapted to computations such as cost accounting. This is an important aspect of customer service but not often viewed as such The grower has to know his costs in order to stay profitable and stay in business to serve the customer in the future. The grower also needs to know when to drop a crop because the perceived value in the market place won't cover the costs of producing it. Likewise, a crop may be relatively inexpensive to grow but could command a higher price if one only asked for it. The higher margin available should be taken to offset the numerous crops that we grow that have too narrow a margin. These are important decisions that require good cost accounting *information to make. Good decisions here benefit the customer* by helping the grower stay in business and insuring supply but also to grow in capacity and diversity which is also to the customers advantage allowing them to do the same.

Crop Scheduling. The area of crop scheduling is the area that most sets our business apart form others from a software respect Many of the above listed uses of the computer, with the possible exception of cost accounting, can be handled wholly or partially with generic software But crop scheduling isn't one. Customer service here is provided by doing the crop scheduling based on ready dates or ship dates versus using start dates for an initial reference

Crop scheduling, especially as far north as Mt Vernon, Washington, requires that the grower take into account the time of year in determining start dates to reach a particular ready date Production times for a pansy plug, for instance, can vary from 5 to 9 weeks depending on the time of year. By adequately defining how a crop needs to be grown at different times of the year, the computer can be used to schedule any order for any date and additionally handle changes in quantities and ship dates that result in changes to production numbers and dates. As the numbers increase, it quickly becomes impractical to schedule activities manually. If you grow too many you are unprofitable and if you grow too few or on the wrong date you are perceived as unreliable. Since we are in the business of propagating for custom orders we have found it necessary to write our own software to handle these orders. If you don't have to do this then don't. It is very expensive. The single aspect of our software that sets it apart from what is available from software vendors is our ability to specify whether individual items on an order are to be produced as custom items and thus have all of the activities scheduled for them or whether they are to come out of existing production.

You can get a system that can handle orders quite well and you can get a system or develop one on a spreadsheet that can schedule the activities it takes to produce what you have determined are your goals for the coming season but I don't know of another system that allows you to enter orders for the customer that will be a mixture of custom and existing or extra items. The trick, of course, is to know what in the world needs to be done in a given week

The grower that can make the fewest mistakes can come out ahead in the market place Let's face it, there are a lot of ways to kill a plant. We have built much of our propagation business on making fewer mistakes and thus being perceived as a more reliable source The word perceived is significant here for a grower can and will make mistakes. The computer can be used to provide information to handle problems and the results of this handling can be quite different from the customers point of view.

If a grower experiences loss or delay in production of pre-sold crops the computer can provide lists of who ordered, when they ordered, etc Timeliness is what's important. Letting a customer or broker know of upcoming crop problems early enough for them to make alternate arrangements is critical in customer service Many growers will delay this process in the hopes that the crop will grow out of the problem or that he can locate some substitute material elsewhere. It is the unpleasant surprises that a customer gets on the ship date that can ruin business.

If you take care of your customers and you take care of your employees then profits will take care of themselves.

Grass Seed Production in the Willamette Valley, Oregon

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Oregon is the national leader in the production of cool-season grass seed crops and is known as the "Grass Seed Capitol of the World." In 1990 Oregon harvested 500 million pounds of seed from about 400,000 acres of grass The harvest provided a farm gate value of $195 million. Grass seed is the fifth most valuable agricultural crop produced in Oregon Over 90% of grass production is in the Willamette Valley. Cool season grasses grown in the state include:

Agrostis sp , bentgrass
Dactylis glomerata, orchardgrass
Festuca rubra, fine fescue
Festuca arundinacea, tall fescue
Lolium sp., ryegrass
Poa sp., bluegrass

The state produces both forage and turf cultivars Oregon's rise to world-wide prominence in grass seed production did not happen over night. Growing began nearly 100 years ago.

HISTORY

Oregon's grass seed industry started in the late 1800s The earliest harvests were from native grass stands found on the flat open prairies of the southern Willamette Valley. Velvetgrass, *Holcus* sp was harvested and barged down the Willamette River to Portland before the turn of the century.

By early 1900, ryegrass seed was being cleaned from cereal crops grown on the ridges in the south valley where soil drainage was adequate to support wheat and oats. Ryegrass was a weed in many of these fields. Growers cleaned it from their grain after harvest and marketed it through local seed dealers.

The year 1921 marked the first commercial planting of ryegrass specifically for seed production. Early plantings consisted of native or unnamed cultivars found locally or imported by local seedsmen.

The first attempt, in 1931, to grow certified perennial ryegrass in the south Willamette Valley was unsuccessful. The field, planted with seed from New Zealand, froze out. In 1932 more certified seed was imported. A second attempt was successful and the 10 acre field produced Oregon's first certified ryegrass. Ryegrass seed acreage gradually increased and by 1938 an estimated 44,000 acres were planted.

As grass seed acres increased, so did two disease organisms that caused significant yield and quality problems. The problem fungi were ergot, *Claviceps purpurea* and blind seed disease, *Gloeotinia temulenta* By 1945 growers and USDA plant pathologists at Oregon State College in Corvallis had discovered that open field burning of the straw residues after harvest controlled the diseases. In addition, burning reduced weed problems and controlled various insect pests.

Open burning became the accepted practice throughout the Willamette Valley. It has helped lead the way for Oregon's grass seed industry to become the world leader in the production of high quality grass seed.

PRODUCTION

Several factors contribute to the Willamette Valley's prominence in grass seed production.

Climate and Soils. The Willamette Valley has an ideal climate for quality grass seed production. Average annual rainfall ranges from 35 to 50 in. with 90% falling between October and May. This supplies enough moisture for good fall plant establishment, winter vegetative growth and spring seed filling. Harvest months, *July and August, are typically dry, allowing for maturation and harvest under* ideal conditions. Artificial drying is not necessary.

Winter temperatures are low enough to provide vernalization and stimulate seed production yet mild enough for winter growth without crop damage. Average December through February temperature on the central valley floor is 40° F. This period has an average daily minimum temperature of 35°F. In the south Willamette Valley, fields are flat with heavy, poorly-drained clay soils. The high winter rainfall and heavy soils make it unsuitable for other crops. Ryegrass and tall fescue seed crops are well adapted to these soil conditions and have become the primary agricultural commodity

The foothills along the east side of the valley are also good for seed production. Early grain production on the steep, shallow soils caused serious soil erosion problems. In addition, rocks in many of the fields made annual cultivation difficult and costly. The establishment of fine fescue and bentgrass crops in this area provided the long term perennial crop cover needed to solve the erosion problem

As the economics of growing grass seed improved and production of turf-type cultivars increased, production expanded to better soils in the northern end of the valley Land traditionally used for raising wheat, legumes, and vegetable crops were converted to grass seed production.

Industry Infrastructure. As the seed industry grew, many farmers began specializing. They eliminated some of their other crops and livestock enterprises Barns were converted to seed cleaning facilities. Over 280 approved seed cleaning plants currently operate in the valley. They range in cleaning capacity from less than 100,000 to over 20 million pounds annually. Many of the facilities are grower-owned but commercial operations also provide seed cleaning services to area farmers. The abundance of seed cleaners provides for processing and shipment of seed on a timely basis as the market demands.

The development and acceptance of innovative production techniques give growers the ability to produce high quality seeds. USDA Weed Scientist, Dr. Orvid Lee, pioneered the planting technique of "charcoal band" seeding of perennial ryegrass A slurry of activated charcoal, water, and fertilizer is sprayed directly over the seed row during planting. The herbicide diuron (Karmex) is then broadcast over the field controlling grass and broadleaf weeds between the rows. The charcoal band de-activates the herbicide and allows the newly-seeded ryegrass to emerge without injury. Weed-free seed is produced the first production year using this technique. Most turf-type perennial ryegrass and fall-seeded, turf-type tall-fescue fields are planted using this technique.

Research and Quality Assurance. New cultivar development work is being conducted by the private seed company plant breeders. Research efforts by OSU and USDA scientists focus on improved weed and disease control programs and improved agronomic and crop management practices. Recently, efforts to find alternatives to open field burning have occupied much of the private and public research work.

OSU's seed certification program plays an important role in the development of the seed industry. Field history requirements, seed field inspections, and production of seed meeting high purity and germination standards assure quality seed reaches the consumer. Since its organization in 1916 the certification program has become widely recognized for its size and emphasis on quality. There are over 700 certified seed cultivars grown in the state. Over half of the grass-seed acres is in certified cultivars. The program is an active participant in an international certification program sponsored by the Organization for Economic Cooperation and Development (OECD). This assists the seed industry by facilitating seed movement into international markets. Willamette Valley grass seed is sold to every state and exported to 60 foreign countries.

THE FUTURE

The seed industry faces several important issues. Oversupply and increasing restrictions on open field burning top the concerns.

Acreage increased by nearly 100,000 from 1985 to 1990. Drought conditions in the U.S. southwest and reduced housing starts in the eastern U.S. resulted in a large carryover of perennial ryegrass and tall fescue seed. As production is curtailed, growers face lower prices and reduction by as much as 30% of their contracted acres.

Open field burning continues to be restricted by legislative and regulatory actions. By 1998 open field burning will be reduced to under 40,000 acres and all propane burning will require strict emissions requirements. Increased fees will be charged for all burning.

Oregon State University, in cooperation with the Oregon Department of Agriculture, Department of Environmental Quality, and the Oregon Seed Council is searching for field management methods without burning and for expansion of straw markets. With an estimated 1 million tons available annually, this will continue to be a challenge.

The dairy industry in Japan uses about 150,000 tons of perennial ryegrass and tall fescue straw annually. However, the low nutritional value and other feeding problems limits this use.

On-farm composting of the straw is another option being studied Use of the compost as a soil amendment on the farm, or marketed commercially as a soil conditioner or potting medium, holds some promise

The industry remains committed to quality seed production. It believes that grass seed production has a beneficial environmental and economic impact on the area. The industry intends to retain the distinction of being the "Grass Seed Capitol of the World."

Producing Virus-Indexed Liner Plants for Small Fruit Production

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The production of liners for small fruit production has reached a state of sophistication beyond what anyone could have thought of at the beginning of this century Modern propagation is a meld of ancient horticultural techniques developed over the centuries and the very latest in horticultural science and technology. The modern plant propagator is an artist at applying all these elements in the successful propagation of small fruit liners

One could probably state without rebuke that the strawberry plant has been a key factor in the evolution of modern horticultural science and technology. Genetic "fingerprinting" to maintain the identity of cultivars was pioneered mostly using strawberry plants; it is also an aid to plant patent holders (Smith) A lot of what we know about tissue culture today was pioneered using the strawberry. Strawberry plants have always been popular in plant research because of their growth habit and small size Much of the very best and valuable nutrient deficiency studies was done by the late Dr. F.D. Johanson (Johanson, 1980) utilizing hydroponics

Research with strawberries has wide application in the world of horticulture. Modern disease-free and most notably "virus-free" plant propagation techniques were developed for the strawberry plant and this led directly to the development of virus certification programs for a wide variety of plant materials including other small fruits and tree fruits (Maas, 1984).

Plant breeding is the beginning of modern expansion of cultivars Some selecting from the wild still occurs but plant breeders are the real contributing factor in developing new cultivars today. Once a desirable cultivar is made available it becomes the responsibility of the plant propagator to increase numbers of disease-free plants to satisfy public demand. While this demand is being met a lot of feedback between the propagator and grower must take place.

It is common in the small fruits—most notably grapes—for certain clones to produce better quality and/or quantity of fruits than others. The grower is in the best position to note this fact and let the propagator concentrate on producing the best clones based on the needs of the grower. This makes the whole area of propagating small fruit liners exciting because there is room for large production propagators and equally there is room for the small custom propagator Because of the diversity of the total industry, many commercial growers do their own custom propagation as do many hobbyists. Hobbyists and commercial growers differ greatly. The same philosophy behind the old adage that there is nothing better than a "home grown tomato" applies equally to the small fruits

Because a specific small fruit cultivar must be propagated free of disease and be true-to-name, a series of steps are involved to achieve large quantities—all of equal quality. In this overview strawberries will be used as the example and reference to other small fruit species will be made as the discussion progresses.

Plants grown in the open environment are susceptible to a wide range of pests and diseases, so some physical and cultural barriers have to be placed between the plant being propagated and its disease vectors. Safeguards to assure the end product is true-to-name are also needed for a specific cultivar Certification is normally directed as freedom from known viruses and, in most states in the U.S., nurseries are licensed and inspected by their respective states for freedom from pest and disease.

Some states provide fully staffed and funded certification programs whereas other states have no such programs in effect (Stadelbacher, 1980). Some state programs are regarded more highly than others; on the U.S. West Coast, the States of Washington and California are the main strawberry plant producers and their respective certification programs are state of the art and regarded highly world-wide.

To propagate “disease-free”, true-to-name plants, one must obtain stock that has been index-tested Such plants can be found by contacting the USDA. Common sources of indexed plants are from UC Davis screenhouses in California; OSU screenhouses in Corvallis, Oregon; USDA; other state programs and from certain private laboratories. One of the very best sources is the National Clonal Germplasm Repository, 33447 Peoria Rd., Corvallis, Oregon. 97333. (Phone (503) 757-4448. Dr. Kim Hummer, Curator; Vonda Peters, Plant Propagator; Donna Gerten, Information Manager)

Indexed strawberry plants from these sources are called nuclear stock and one is lucky to obtain more than a mere handful of stockplants. To protect the nuclear meristem stock from pest and disease problems it must be maintained in an approved screenhouse using wire or plastic cloth no larger than 20×20 mesh The idea is to make the structure aphid-proof and it must have a double entry system to gain access and exit from the screenhouse. There are no specific recommendations for construction other than the minimum mesh screen size The screenhouse constructed for the growing of a foundation block is subject to approval prior to the planting of the nuclear stock inside the house (Department of Food and Agriculture, state of California).

Once the foundation block is established, it can be used for the traditional runner propagation program. Runner propagation is not as rapid as tissue culture and, due to the limited number of nuclear meristem plants available, tissue culture is often used as a direct method of plant propagation This includes material for raspberries and blackberries as well as for strawberries

Virtually every virus-indexed strawberry, blackberry, and raspberry plant grown in the U S. will have come, at some time, from tissue culture (TC). This is because TC has been used to clean-up plant cultivars from known viruses. Increased plant vigor, crown branching, and profuse runnering are additional temporary beneficial growth habits resulting from TC. These altered growth habits are the result of hormones added to the cultural medium which last three to four months after the plants are taken out of the TC. The extra runnering increases the productivity of the increase block (nursery row). A three-fold increase in runner plants is often enjoyed in the increase block (The Grower, 1986). In the case of strawberry plants TC is 3 to 10 times more expensive than runner production—so runner production is still the preferred means of propagation. Tissue culture is being used extensively with blackberry plants because tip layering propagation is much slower than runner production of strawberry plants Whether the goal is to produce certified strawberry plants or some other small fruit, such as blackberries, raspberries, grapes, or blueberries, the principles are much the same.

While the principles in producing virus-indexed planting stock are similar, procedural differences are present due to the difference in genus, species, etc. of the small fruits. The certification program in Oregon for grapevines uses heat treatment instead of TC for developing virus-free nuclear stock (Registration and Certification of Grape Nursery Stock, Oregon Administration Rules, 1971). A hot water bath, hot enough to kill the virus but not the grape stock, is used; non heat-treated samples of the same clone are maintained to insure the heat treated vines stay true-to-type. These plants are also indexed for viruses to help establish the freedom from virus of the original imported cutting.

In regard to virus certification, commercial growers insist on such stock for all strawberry plantings. Red raspberry and blackberry growers also see the value of virus certification and they are enjoying enhanced yields and longevity of the plantation as a direct result. Recently a virus certification program has been set up for the blueberry industry. The knowledge and expertise gained from all this is branching out to benefit the entire horticultural community as well.

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Propagation of Filberts by Stem Cuttings

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INTRODUCTION

Presently, the filbert (hazel nut) (*Corylus avellana*) is propagated primarily by layerage, because of difficulties inherent in other methods of propagation (Bergougnoux et al., 1976). Either of two factors may limit propagation of filbert by stem cuttings: poor root initiation (Bergougnoux et al., 1976; Falaschi and Loreti, 1969), or abscission of the vegetative buds on otherwise well-rooted cuttings (Lagerstedt, 1970; Lagerstedt, 1982). Bud abscission is the major problem we encounter. Rooting of terminal stem cuttings varies by cultivar but is generally excellent. Unfortunately, the percentage of these cuttings that retain buds is generally low, so the propagation rate (the percentage of cuttings with both roots and one or more vegetative buds) is low as well. Bud retention of 0 to 10% is typical of terminal cuttings of filbert cultivars.

There is interest in propagation by stem cuttings for at least three reasons: 1) With identification of Eastern filbert blight in the Willamette Valley, Oregon, rapid propagation of new, resistant cultivars is needed. 2) Non-suckering rootstocks have been introduced which, presumably, will not develop productive layerage beds. 3) There may be efficiencies in cutting propagation for production of filbert planting stock. Therefore, the purpose of this report is to describe progress made in propagating stem cuttings of filbert, and to suggest ways in which propagators and growers can use and improve these methods.

METHODS

We tested the relationship of rooting potential and bud retention to the position of the cutting on the shoot (Fig. 1). The terminal cutting consisted of the apical end of the cutting—the apical bud, one or more expanding leaves and an expanded leaf.

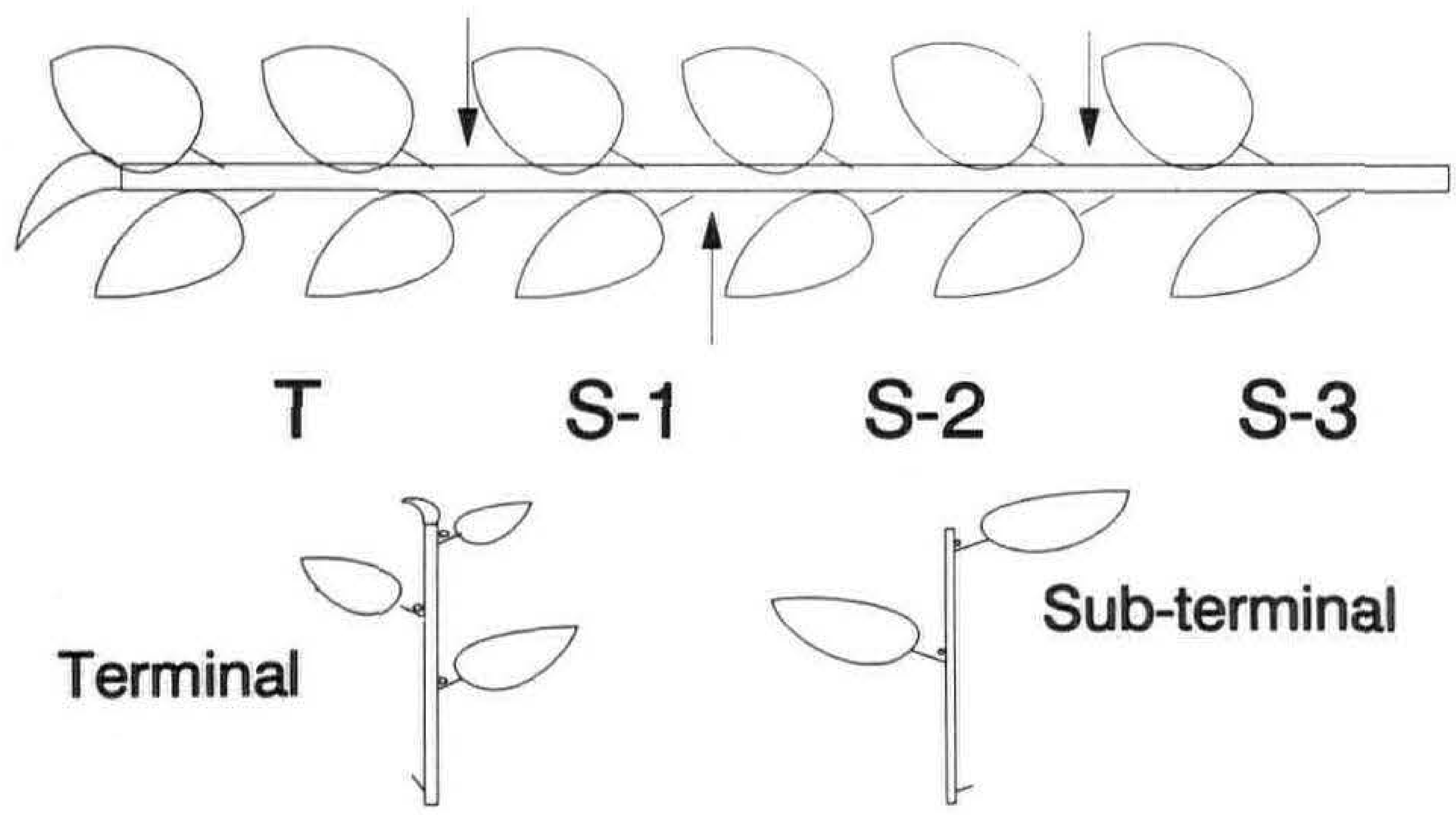

Figure 1. Identification of terminal and sub-terminal cuttings from vegetative shoots of filbert.

Cuttings below the terminal we designated sub-terminal. In the work described here, sub-terminal cuttings arbitrarily included two nodes with leaves retained and a node at the base of the cutting.

Unless otherwise stated, we applied 1000 ppm IBA to the base of the cuttings as recommended by Lagerstedt (1982). The rooting medium was composed of perlite:peat (2:1, v/v) in 8 in. deep beds at about 75°F. Intermittent mist was used to maintain water content of the cuttings. We used a timer programmed to apply mist less frequently early and late in the day and progressively more frequently, 10 sec mist at 8 min intervals, during the warmer parts of the day. Ventilation and about 50% shade were used to control air temperature.

After about 12 weeks, cuttings were evaluated for the presence of adventitious roots and axillary buds, and whether both roots and buds (R+B) were present on cuttings.

RESULTS AND DISCUSSION

Among the four cultivars tested, rooting generally declined from terminal to base of the shoot (Fig. 2). Conversely, bud retention generally improved from terminal to base. Thus, bud retention was the factor limiting propagation of terminal cuttings, whereas rooting limited propagation of sub-terminal cuttings. As a result, the percentage of cuttings with both roots and buds was highest on the first sub-terminal cutting, S-1. This percentage ranged from about 65% for 'Ennis' to over 90% for 'Butler' and 'Barcelona'. The percentage of terminal cuttings with both roots and buds ranged from 0 to 70%. 'Ennis' was the cultivar most prone to bud abscission. Propagation (R+B) of terminal, S-2 and S-3 cuttings of 'Ennis' was < 25%.

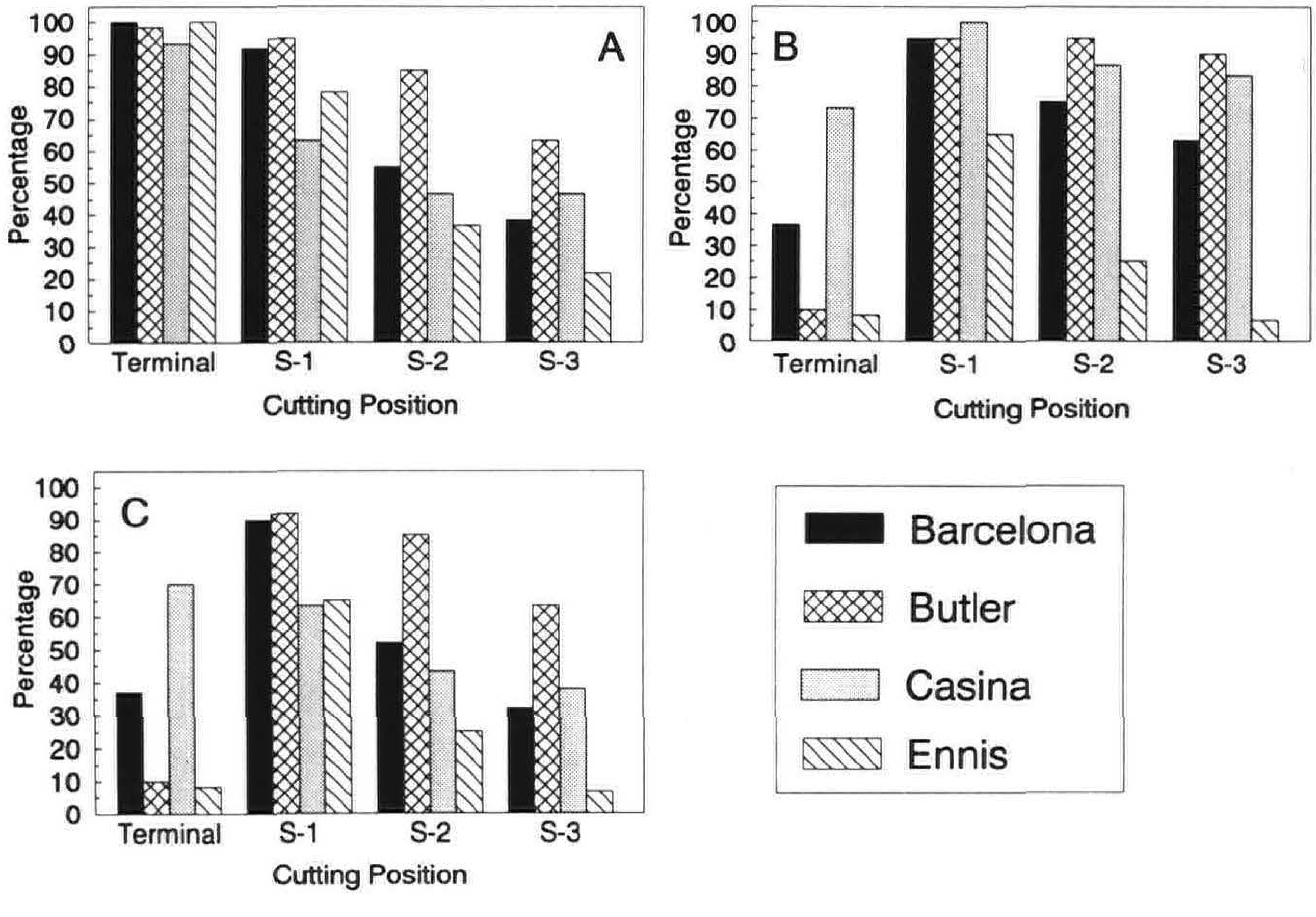

Figure 2. Effect of cutting position on the percentage of stem cuttings with (A) roots, (B) buds, and (C) both roots and buds in four filbert cultivars.

The optimal period for propagating sub-terminal cuttings was from late June to late July (Fig. 3). We used 'Casina' for this experiment and it was evident afterward that terminal cuttings of this cultivar had unusually high bud retention. As a result, the contrast between terminal and sub-terminal cuttings was blurred. However, throughout this period the inverse response of rooting and bud retention on terminal and sub-terminal cuttings was evident (Fig. 3A,B). Terminal cuttings rooted better than sub-terminal cuttings, and there appeared to be a marked decline in rooting of sub-terminal cuttings in August (Fig. 3A). In contrast, bud retention on the sub-terminal cuttings improved significantly as the shoots matured, even though bud abscission was similar during early to mid-June (Fig. 3B). The net result of this experiment, therefore, was that the performance of terminal and sub-terminal cuttings from mid-June through early August was comparable (Fig. 3C), and, thus, unique among the cultivars studied.

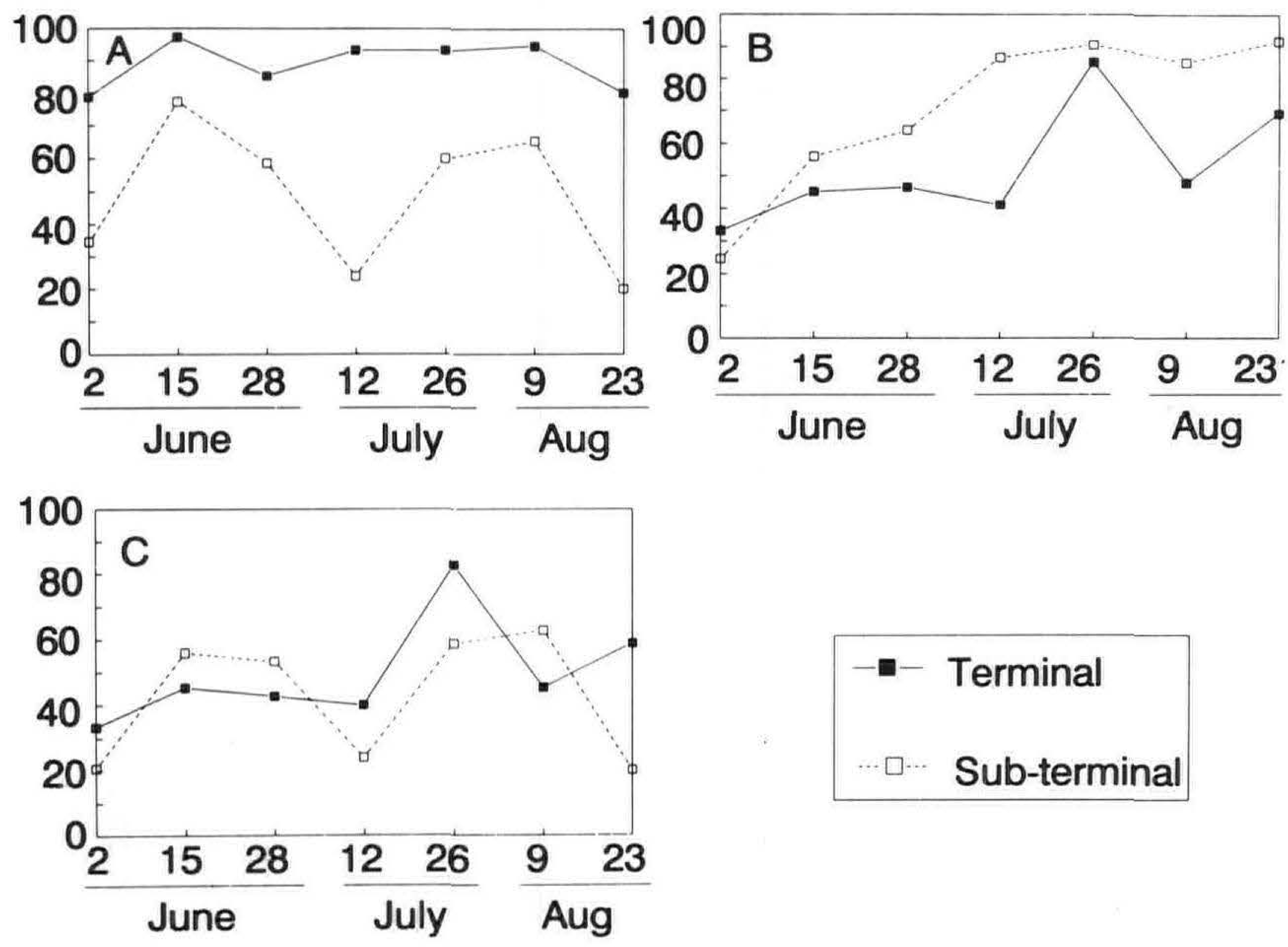

Figure 3. Effect of collection date on (A) rooting, (B) bud retention, and (C) the percentage of cuttings with both roots and buds on stem cuttings of 'Casina' filbert.

Cuttings from juvenile stock plants rooted and retained buds much better than cuttings from mature stock plants. Nearly 80% of the sub-terminal cuttings of 'Casina' from juvenile stock plants had roots and buds (Fig. 4A). On the other hand, rooting potential of sub-terminal cuttings from mature stock plants was much lower, even though bud retention was >90%, resulting in R+B < 50% (Fig. 4B).

The response of 'Casina' cuttings to IBA concentration varied with cutting position. The optimal concentration for rooting of terminal cuttings was 1000 ppm (Fig. 5). At higher IBA concentrations, bud loss on terminal cuttings increased significantly. The optimal concentration for rooting of sub-terminal cuttings was 6000 ppm IBA and the buds on these cuttings were much less sensitive to auxin.

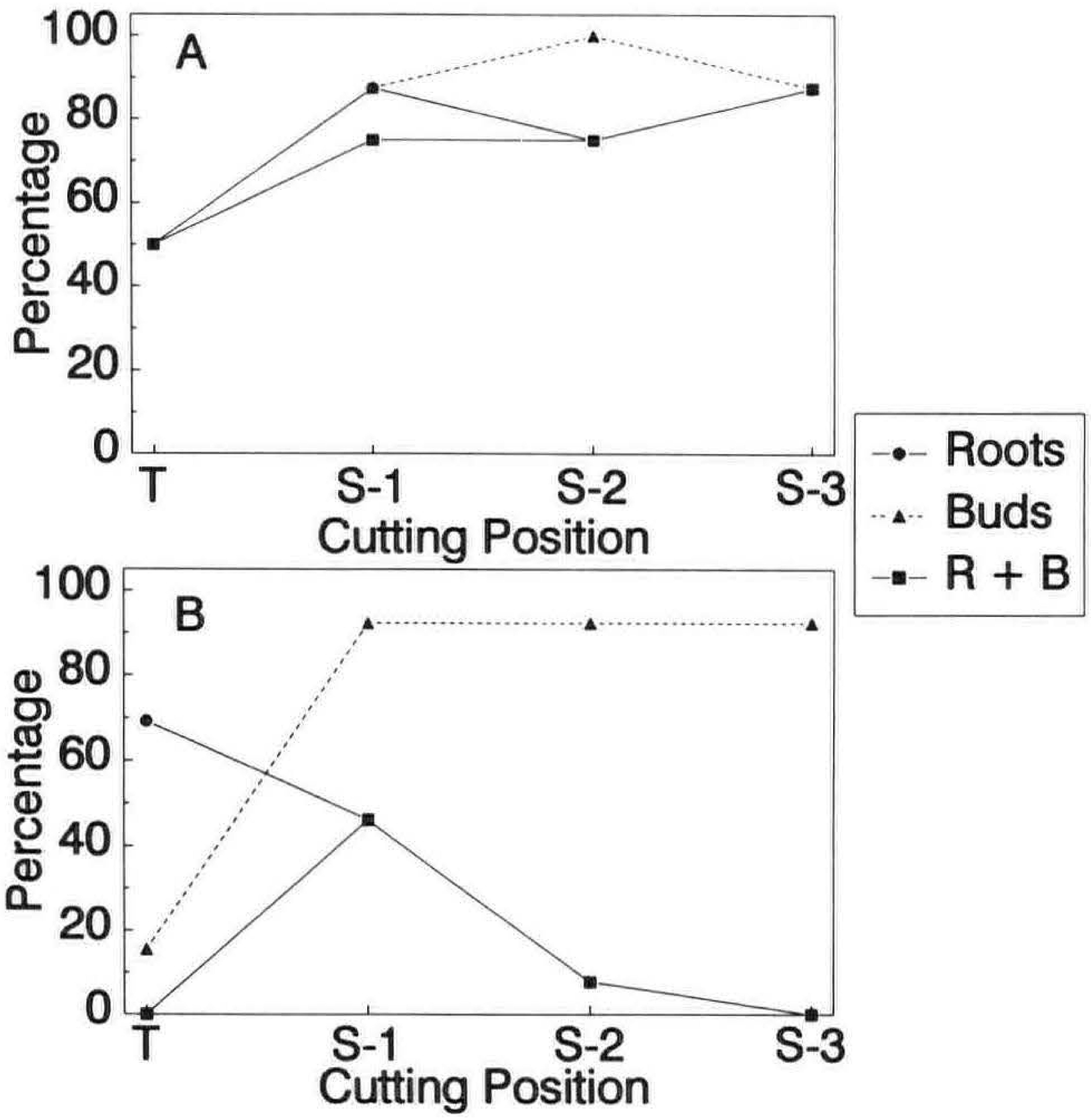

Figure 4. Rooting and bud retention of stem cuttings of 'Casina' filbert collected from (A) juvenile, or (B) mature stock plants.

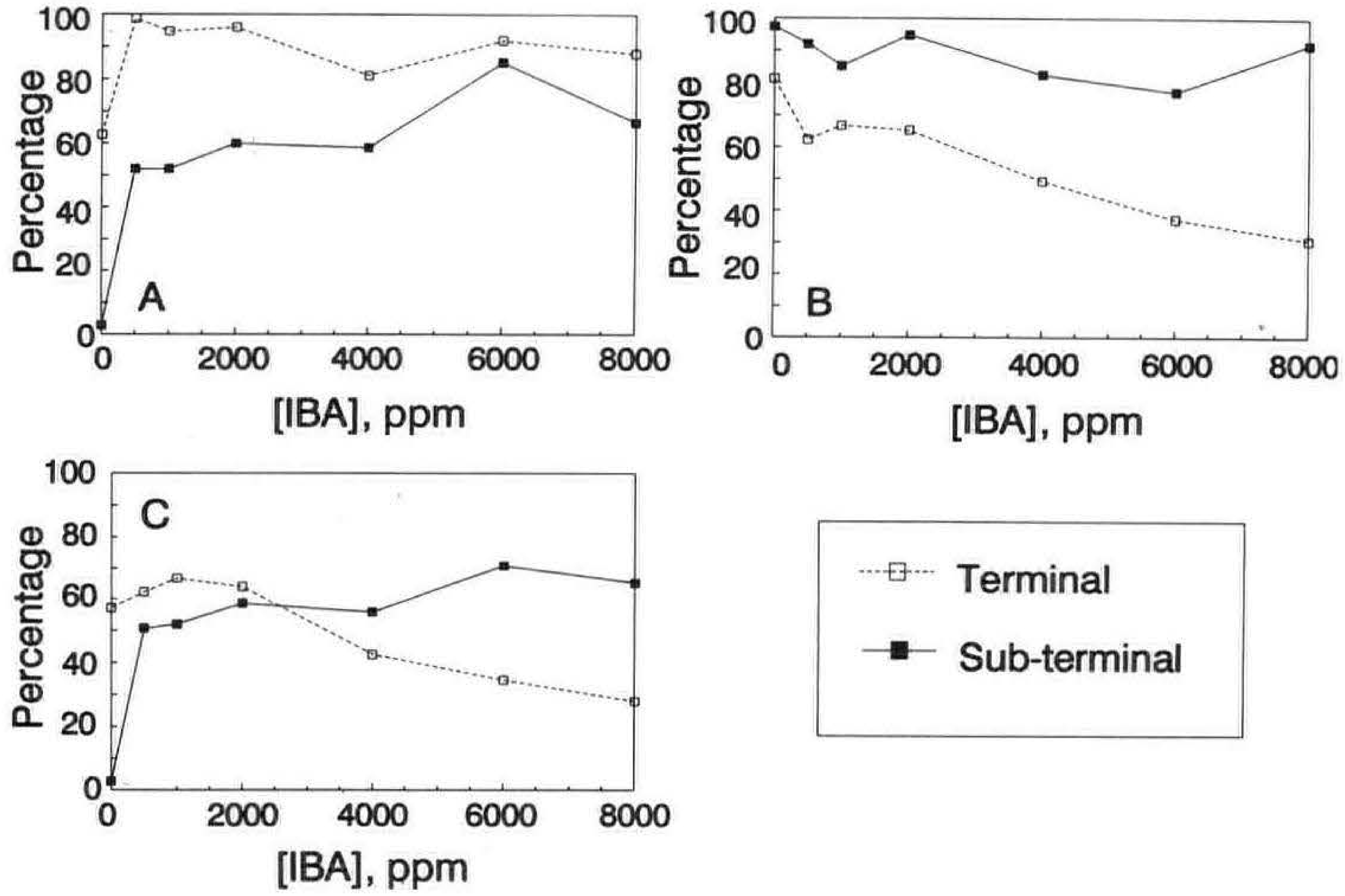

Figure 5. IBA Dose-response of stem cuttings of 'Casina' filbert. (A) rooting, (B) bud retention, and (C) the percentage of cuttings with both roots and buds.

In summary, sub-terminal cuttings of filbert had good to excellent rooting potential and significantly better bud retention than terminal cuttings, despite the unusual performance of 'Casina'. The most reliable sub-terminal cutting was S-1, though further work may improve the performance of the other sub-terminal cuttings. On S-1 cuttings, phase of the stock plant, stage of shoot development, and auxin dose have been identified as key factors in propagation of sub-terminal stem cuttings of filbert.

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VOICE: Why were the studies on *Agrobacterium* for root initiation not continued?

WM. PROEBSTING: We have been continuing this work. It seems to be a very effective rooting agent but I do not see an immediate practical use for it. Most propagators do not have the culturing facilities for it in their nurseries

VOICE: How do your own-rooted filbert plants compare in the nursery and afterwards with those started by layering?

WM. PROEBSTING: They overwinter very well. There have not been any particular problems with the cutting-grown plants but our comparative trials have not gone on very long

VOICE: How do you apply the *Agrobacterium* to the cuttings?

WM. PROEBSTING: The bacteria must be in a water suspension. We apply auxin in alcohol first, let the cuttings dry for 10 or 15 min. and then dip the base of the cuttings in the *Agrobacterium* suspension only briefly so as to not leach out the auxin

Mechanization in Bareroot Shade and Fruit Tree Production

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There are numerous methods of improving production efficiency in a nursery operation. Some areas for consideration are: job training, employee motivation, quality control, production scheduling, improved working conditions, and mechanization of labor intensive activities. At Carlton Plants, mechanization has been an important factor in keeping up with the demands of a rapidly expanding production schedule

Motivation for a program of mechanization comes in the form of savings through: 1) a reduction in the labor required to do an activity, 2) reduced exposure of employees to potential injury, 3) better utilization of existing equipment, 4) fuel conservation, and 5) lower payroll costs. Even with these incentives, mechanization must become a priority to the nursery person in order for the program to be successful. This is to say that one must be conscious of the opportunity for improving by changing methods through mechanization.

The process starts by challenging activities and asking: is there a better, faster, easier, and safer way that they can be performed? Analyze the situation to determine if an already existing piece of equipment can be expanded or improved upon. Key personnel, such as production supervisors, equipment operators, and the shop workers are very important to this process Determine the advantages of mechanizing a process and what the gains will be Then calculate the costs and probability of success of the project. Many good ideas are just not practical or cost effective—know when to say stop!

Don't get caught up in thinking that all ideas must be original. There are many creative people in the field of agriculture that have already developed machinery that can be adapted to your particular situation with some modification.

Sources for ideas can come from visits to competitors, horticulture and agricultural trade journals and machinery shows, such as the Northwest Ag. Show in Oregon and Tulare Ag. Show in California.

Over the years our employees have worked hard to improve production techniques through a variety of innovations. The following list will indicate the equipment, the job and what was accomplished by mechanization.

Four Row Multi-Row Disc. Used to loosen soil in spring after subsoiling of budded tree liners and second year shrubs—does four rows at a time, replacing single row rototillers on small tractors.

Four Row Cultivator. Used to cultivate soil during spring and summer for weed and moisture control—one operator and tractor replaces four one row units on tree and shrub liners.

Befco Four Row Fertilizer Applicator. Applies supplemental fertilizer to tree and shrub liners—replaces J D 650 tractor and John Blue one-row applicator.

Helicopter Fertilizer Application. A helicopter is utilized on a contract service basis to apply fertilizer to tree and shrub fields when the fields are too soft for equipment to operate. Three hundred acres can be done in one day.

Hagie Multi-Row Sprayer. A custom sprayer which can be utilized to treat all sizes of trees and shrubs, accomplishing up to eight rows at a time This sprayer replaces a variety of other sprayers and can go into areas that other types of sprayer equipment cannot.

Cat Two-Row Digger. Used to harvest trees and shrubs two rows at a time Reduces travel by people and equipment and speeds up harvest.

Racked Planting Trailer. These trailers are used to transport potted tree and shrub liners to the field for planting. Reduces the number of trips to the field by 50%.

Corn Chopper for Rootstocks. Used to chop and grind the tops of dormant rootstocks into chips—eliminates hand work of removing and disposing of unwanted brush.

Pneumatic Air Pruners. These pruners are used to cut off the stub of the rootstock at the bud. Operation is very rapid and easy on the hand of the operator.

Gas-Powered Hedge Pruners. These shears replace regular hedge shears to speed up the pruning of soft, dense foliage on field-grown shrubs.

Subsoiler with Anchor Chain Drag. The anchor chain drags behind the subsoiler to break down clods and smooth out the field to make it easier on the person plowing.

Bobcat Tractor with Snowblower. We use this unit to trench the saw-dust so trees can be heeled in for storage after harvest. This replaces a plow unit and lots of shoveling.

Racking. Portable racks are used to store trees and shrubs in coolers. They replace pallets and are much more efficient in the use of storage space.

Honda Four-Trax with Trailer. This set up is used to haul bulky, hardwood cuttings from the fields. This operation takes place in winter when fields are wet. One unit can replace 6 to 8 people and reduces chance for injury to workers.

These are just a few examples of how ideas can be converted into practical applications. One must be persistent in the approach to mechanization and each project, as there will be many failures along the way. The payoff, however, can be profitable and rewarding.

Mechanization is not just limited to large projects, many small applications are just as productive in their own way. However, mechanization has its costs. Machinery, parts and fabrication work can be very expensive, not to mention management time.

Propagation: Necessity is the Mother of Invention

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I was recently asked, "What is your nursery?" I stumbled in my thinking and then said the normal answer; "We propagate and grow many types of broadleaf evergreens, deciduous shrubs and conifers". I can remember walking away from this answer with a question in my mind as to what kind of nursery my husband and I had and how did it get to where it is today.

The necessity in the beginning, 13 years ago, was money. Lots of children bound for college, two jobs that wouldn't provide that kind of income, and a two-acre home in the country.

We were going to raise berries but Jack Bigeji, a nurseryman friend, suggested that we go into the nursery business. Not knowing anything about the nursery business, we felt it was necessary to educate ourselves. We selected a propagation night course at our local community college and away we went in the fall.

Four weeks into the course we rooted a plant It seemed easy and I could see dollar signs all over the place. Just cut a stem from a plant, put some hormone on it, stick it in a flat on some heat and watch it make money for you This is so easy, why didn't I know about this sooner?

After our community college class, we recognized that maybe there were some other things we should know about propagation. I went to work for Ed Shultz "for free" if he would teach me how to operate a nursery. It was a great experience! Ed taught me a number of useful things: how to ball and burlap a broom stick, how to weed, work in the rain, and how to propagate quality nursery stock. At the same time, his family taught us that the nursery business was a wonderful way of life.

One day Ed came to me and told me I was fired! He said the work was enjoyable but the object was to make a profit. It was time to start our own nursery. It was good he did, otherwise I would have stayed forever!

On our own with enthusiasm but no money, necessity made us be inventive We needed a propagation house to work in, so we built a quonset type house with water pipe, bending it ourselves with a borrowed bender We used electric cables for bottom heat and room fans for ventilation. For flats we used bulb flats that were 2 ft. × 3 ft. × 9 in. deep which were free from a local bulb farmer. We filled these with pumice and stuck cuttings on the kitchen table at night. The flats weighed about 95 lb a piece! We hauled them to the propagation house with an old door laid across a wheelbarrow. Soon they rooted but we needed to sell them, so we invented a market for ourselves. We sold them to other propagators in the area who were short for their orders.

Finding true-to-name cutting stock became a necessity. Nurserymen in our area would allow us to come onto their fields and take cuttings for credit on propagation material. Places of business in town would allow us cutting rights if we would prune all their plants for them. The State of Oregon would issue us permits along freeways and state roads for certain plants if we would give them credit on plants that they might need in the future.

One late evening, we were taking cuttings around an office building. It was cold and very late so we decided to take a break and get a cup of coffee. We pulled into the parking lot of a nearby restaurant. We started to get out of our car and were surrounded by a group of armed policemen that had decided that we might be the persons who had been burglarizing local businesses. The necessity at this point was to stay out of jail! I can't tell you how glad I was that we had a written permission letter from the owner to take cuttings, as it provided our alibi.

We started sticking conifer cuttings in early March because bottom heat cost money. The easier growing junipers were treated with Hormex #8 and put into pumice flats The harder-to-root cuttings, such as *Juniperus chinensis* 'Robusta Green', were treated with Hormex #45. They were watered periodically during the day and left with 45% shade over them through the summer. In the winter the house was covered with poly and no bottom heat used. They rooted very well with very little expense. We also took our *Photina* x *fraseri* cuttings in a similar fashion. When the *Photinia* leaf was completely green on the new growth and the stem was still red, we stuck the bottom of a 4- to 5- in cutting into straight Woods Rooting Compound and put it into pumice flats. Rooting was fast and they were a good money maker for us.

In December we take our *Arctostaphylos uva-ursi* 'Massachusetts' cuttings, treat with #3 Hormodin and stick them into flats of peat and perlite. These cuttings are then put onto heated beds with temperatures kept at 66 to 70° F. The rooting percentages are very high for us and our turnover is quick. We felt we had invented a few ways to increase profit.

As the demand for propagation material grew, so did we. Most of the money we received from the plant material went back into building the nursery. We knew we needed certain equipment to be able to increase our production, so we started touring other nurseries to see what was needed and what could be invented to save costs. Well, it was easy to see that we just *couldn't* get along without having a million dollar propagation house that had all sorts of really neat fog systems, steam bottom heat, mist booms, and lots of employees The problem was that none of the local banks would give us a million dollars free!

A new propagation house was built using professionally made components assembled according to our own needs—bigger and arranged efficiently. Heat beds were made from scratch using dense building insulation on the ground. Next a handmade grid of P.V.C. pipe was laid down over the insulation and covered with pea gravel We learned that a regular household water heater would produce enough hot water to heat the beds. We experimented with a small, cheap pump to move the hot water through our pipes. A common thermostat turned the pump on and off automatically to get the heat level we desired in the propagation bed.

For summer propagation, cooling was a necessity. Water mist that would not soak the cuttings in the flat was most desirable. We found that by boosting the water pressure to about 125 psi with an in-line pump through normal mist nozzles, we had made wet fog. This system was cycled on-off with a standard time clock to get the needed cooling and water.

As the value of fog grew more obvious for some rooting processes, we looked at the expensive commercial systems and decided to try inventing something more within our budget. Being a mother, I had long before learned all about room vaporizers and humidifiers for sick kids You guessed it, several of the new electronic room fogging humidifiers will create fog in a greenhouse and they are very inexpensive.

As the numbers of plants and hours increased in the nursery, we found that we needed help We enlisted our children until they went on to college to pursue law, science, medicine, or anything that would keep their hands reasonably clean. The hiring of employees became a necessity. Other than some mechanization in planting, we have found that there is no invention around to take the place of good employees.

The necessity for good business practices became immediately clear when a big customer didn't pay his bill. We then invented policies and practices to safeguard ourselves. Marketing, advertising, and educating ourselves by going to different nursery chapter meetings became an asset to our business right away. The association and education that the I.P.P.S. organization has given us is invaluable. Going to different trade shows has not only been fun but also profitable for contacts and orders.

Growing nurseries need lots of room. The two acre country home was sold for the 12 acre new nursery site. The necessity for more room has brought us to building a new, neat, clean nursery and a new home What fun!

Now if asked what is my nursery, I would reply; "Our nursery is profitable and Ed Schultz and family were right, it is a wonderful way of life"

The goals that were ours in the past, are still the goals of today. Necessity and invention become the way we achieve our goals. Let's hope that the necessity of preserving our industry and our planet will make us all be inventive so that those coming after us can also have a wonderful way of life in the future.

Ideas for Efficient Production of Container-Grown Plants

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The last 10 years have brought with them a wealth of new technologies, production practices, and types of equipment to enable us to grow our varied crops more efficiently with higher quality. As we begin using these new "high tech" methods of plant production, we may overlook those other techniques that we can develop within ourselves that are vitally important to success in our business. I am speaking of our skills as managers of people, working to meet production schedules, producing a quality product at a competitive cost, resulting in a reasonable profit for our companies.

There are many costs associated with operating a nursery business. Tractors, greenhouses, canning machines, computers, and other production equipment all cost money to operate and maintain. Better efficiencies in these areas will certainly result in a stronger bottom line. There is one major area in our businesses that if properly managed will yield the most at year end. That area is labor.

At Monrovia Nursery Company, labor makes up roughly 33% of the operating budget each year. With such a large percentage of total cost going to this one area, any improvement in efficiency can greatly affect overall profitability. With this in mind, we are constantly looking for new and better ways to do things. We are also looking at our work habits to see if they, too, need improvement.

Today, I am going to be speaking about those "other" things that we may not often think about when we consider how we produce our nursery products for a price-conscious consumer.

First and foremost, as nursery owners or managers, we must challenge ourselves to be creative We must be able to think farther out than the simple tools available to us to do our jobs each day. Often, the solution to a productivity problem involves much more than the work habits or the speed of the crew in the field. It may involve the overall attitude of the workers toward their jobs. It may also involve the system of supervision being used by the company. As managers, we must be keen to look at all these possibilities to gain greater efficiency in our businesses

At the Oregon location of Monrovia Nursery Company, we were fortunate to be able to build a nursery operation from the ground up, and, from the very beginning, train the first workers hired in what we feel are proper work habits. I happened to be the very first worker hired and someone then mentioned to me how much easier it is to build a business based on good work habits than it is to try to change the work habits later of many people who were not trained properly. I have never forgotten that message.

We, in the United States, have read much lately about the great success of many Japanese companies due in part to their management philosophy of "Team Building". Teams are very important in the nursery business also. Our employees want to know that they are part of the company, that their work is important, and that their efforts are appreciated. They want to be a part of our "Team". At Monrovia Nursery Company—Oregon, we often call our workers "players". In the shop and maintenance areas, we have what we call the "Blue Team". This team is called out when there is a major breakdown and repair is needed The Blue Team works as hard as they can and stays until the job is done In the management area, we have the "Eagles". The Eagles are the problem solvers of the nursery and their primary goals is to find positive solutions to problems that affect successful operation of the business. The Eagles try to come up with ways to inspire our employees to succeed in growing and shipping our crops efficiently. Over the past few years, we find ourselves spending more and more time on these team building activities

We began setting goals at Monrovia Nursery Company several years ago. We now routinely make goal setting a part of our business in all departments. Setting goals is a cooperative effort within each department as to the priorities for a given time period. Once the goal is set, everyone works to bring the goal to fruition. Last year we took goal-setting a step further. We were concerned that while we do a good job in producing plants for reasonable cost, it takes much too long to load a semitrailer and we felt that we had no control over the outcome. We tried goal-setting. When the truck arrived in the morning, we gathered the crew and looked over the load We decided together how many hours it should take to load the truck. We then marked the side of the truck with a marker showing where the crew should be each hour in order to finish the truck on time. If the crew stayed on schedule, they knew when they would be going home that afternoon. It worked! We now set goals for every semitrailer that we load and we have just about eliminated overtime on the loading docks. This, as a result of simply giving the loading crew the tools they needed to feel like they had control over their progress.

Employee pride is a very important part of production efficiency in the nursery business When employees take pride in their work, they also take interest in and are more accepting of new ideas that are aimed at increasing productivity. We, as managers, need to constantly work at building employee pride in our companies, facilities, and products. We can build employee pride by letting employees be a part of the solutions to new problems or challenges around the nursery. Often the best solution comes from those working most closely with the processes involved.

In order to increase production efficiency around the nursery, we must make a regular habit of looking at all activities for possible improvements. We must develop our ability to question first if an activity is really necessary, and second, if there is a better way to carry out the activity in question. In short, we need to be able to question the many activities that occur in our businesses each day and try to either eliminate or improve them.

Planning is perhaps the most basic component of managing production activities for higher efficiency. We all need to start with a plan. The plan should envision the entire activity, beginning to end, and all the other factors that might effect it in some way. Tools, equipment, manpower, and process are all included in the plan. The plan can always be changed, but it is important to have some sort of idea how the work should proceed and what to expect when the work is completed. Unplanned work is seldom efficient.

Our supervisory skills themselves are extremely important. We should try to lead by example. Efficient workers are inspired and lead—not threatened or intimidated. The "gentle but firm" approach is usually the best. We should be very short and clear in our instructions to workers Examples should be set out ahead of the crew if possible At Monrovia Nursery Company, the pruning supervisor walks the roads with the crew leaders and prunes samples and sets them out prior to the arrival at a division of the rest of the pruning crews.

Once the work has begun, it is very important that the supervisor stays with the crew for a time to watch the work in progress and monitor both speed and quality. Any corrective action should be taken at this time If the crew is working to the satisfaction of the supervisor, they should be told so and then the supervisor may leave for a short time. As the work progresses, the supervisor needs to continue checking back at lengthening time intervals through to completion If the workers are doing a good job, they should be told so It can be a humiliating experience for both the supervisor and employees to go back and do a job over again because it wasn't properly explained or checked on.

At Monrovia Nursery Company—Oregon, we have a concept that we call "Working In Circles". Working In Circles describes a smooth work flow, where a crew knows what work there is to do, how the work is to be done, and what additional work there is to do when the job at hand is completed. In the planting or canning department, there should be tractors bringing in liners to be planted, tractors hauling newly planted #1 pots to the field, people unloading from trailers these newly planted pots, and tractors hauling empty trailers back to the canning machines for more product This all happens in a "circular" motion—hence "Working In Circles".

Employees can be rewarded in many ways. Money is at times a strong motivator and many companies have adopted piece work programs as an incentive to higher production At Monrovia Nursery Company, we have been reluctant to pay on piece work for several reasons, but mainly because we have a hard time defining where and where not to use it. We have a concern that some employees may feel that they are not being treated fairly because their department is not paid on a piece work basis while other departments are

We have had success at motivating employees in other ways. Several years ago, we were concerned at what we felt was low production of our cutting crews in the Propagation Department. We were looking for ways to increase the daily production of the department. Piece work was discussed, but we decided to try something different. We first explained to the workers in the cutting department what the daily standard was to be. We then prepared a chart showing all the names of the employees in the department followed by the days of the week On the same chart we posted the daily standard required Each day, we posted each individual's production on the chart Those employees who made the standard were acknowledged and those who did not were worked with. Daily production did increase with this new system. People began to show interest in how they were doing in relation to the others in the department One day the crew leader had a new idea. He went down to the stationery store and bought a small packet of those gold stick-on stars that our teachers used on our papers in elementary school. That evening, he placed that star behind the name of the employee with the highest production This simple recognition of the efforts of an individual results in additional production increases. Rewards do not have to be monetary to be effective

Managers and supervisors need to look at their supply of tools and how that supply can greatly affect worker efficiency. Tools should be available in ample quantity and be in good repair. Shovels need to be the proper type Pruners need to be sharp. A good pair of shears is expensive, but the cost of those shears pales in comparison to the cost of lost time and reduced productivity that results when they are dull and do not cut well. At our nursery, we encourage employees to take proper care of their pruners, but we gladly issue them another when they become even slightly dulled. A good tying machine also is such a labor saver that it should be replaced when the workers begin having trouble with it It is not worth the down time to keep struggling to repair it

Support personnel play a key role at times in the efficiency of the work of a large crew. At Monrovia Nursery Company—Oregon, mechanics start work in the early morning hours to fuel tractors, repair or maintain canning machines, or prepare equipment for the crews who arrive hours later. If crews had to temporarily stop work as the shop performed these activities, much work time would be lost and efficiency would be very low indeed. Maintenance and other functions need to be scheduled around the production activities, not the other way around.

Whenever possible, jobs should be combined or unnecessary ones eliminated. Many times at the nursery, I have seen the spacing crews space a large block of can tight plants only to be picked back up and sent to canning the very same week. If the supervisors had done a good job of communicating, those plants would have been sent directly to canning and the cost of "double handling" the plants saved. Plants that need to be pruned should be pruned before spacing or canning where the pruning debris can be cleaned up for less cost Fast growing cultivars should be spaced right off the canning machine rather than 2 weeks later after they have been set can tight There are many opportunities to cut out or combine jobs. This greatly increases efficiency and lowers production costs.

Uniformity is a very important part of the production process that can affect both sales success and the costs of production for a wholesale nursery. Most companies appreciate that uniformity is an important part of quality, but many may not be aware of how it can affect efficiency also. Plants can be canned, staked, or pruned in a uniform manner for the same cost as for an irregular, crooked, or random one. Poor production practices produce irregular, uneven plants of poor quality that take a tremendous amount of time to assemble and groom in the field by crews trying to select quality plants of even sizes. Crews spend unnecessary time combing an entire bed of plants for a few of the same size to fill an order. As these crews struggle to assemble the order, the truck sits unloaded and may not finish being loaded until late in the evening. For a large scale nursery, this has the effect of creating a tremendous backlog of unfinished trucks during the shipping season. Overtime hours are increased and mistakes are made by tired workers. Production costs are increased when the plants in the field are endlessly consolidated as they are not all saleable When the plants are uniform, they can be assembled "row run" much more quickly with little or no consolidated required. Mowers, pruning machines, direct sticking, vacuum seeders, and other mechanization can all contribute to a more uniform product, but ultimately, uniformity comes through excellent supervision.

Agriculture is changing. The nursery business is now competing for workers with restaurants, manufacturing, and construction interests We cannot afford to keep turning over employees and retraining others. Skilled, efficient workers are valuable workers and we need to recognize that when we think of wage and benefit programs. The labor pool is growing smaller and we as owners and operators need to plan for this.

Lastly, we must be extremely vigilant in our approach to managing our businesses for greater efficiency Crews need constant supervision and we ourselves need to ask the question each day, “am I doing all that I can do to control costs by operating efficiently?”

BRUCE BRIGGS: In studying “the best of ideas”, you mentioned you like to see your workers question everything everyday. How can you do that and maintain motivation, and also keep respect for the person criticizing and the person giving advice?

MARK BUCHHOLZ: What I mean is to challenge ourselves to really see if those things we are doing are necessary, to see if the solution we are offering to the problem is the right one We think of it in terms of the training of a team—to never feel that we have “arrived”—that we are always learning

Crop Water Requirements of Container-Grown Plants

Richard P. Regan
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Irrigation is a necessary practice for producing container-grown woody landscape plants. Overhead sprinkler irrigation is the most common and practical system used. With overhead irrigation large quantities of water are required to compensate for low water-application efficiency (Beeson and Knox, 1991). Water-application efficiency is the amount of water stored in the root zone compared to the total amount of water used for irrigation (Israelsen, 1962)

When to irrigate and how much water to apply is best determined by the crop water requirements, the capacity of the root-zone medium to store water, the water application uniformity, the leaching requirements, and the availability of irrigation water. The most common methods used to determine when to irrigate container plants are the visual crop appearance and the relative weight loss judged by lifting the container. Plants with similar crop water requirements should be grouped together, and irrigation scheduled accordingly.

Crop water requirements (ET_{crop}) are the amount (depth) of water needed to replace water lost from evapotranspiration of a healthy crop achieving full production potential under a given growing environment (Doorenbos and Pruitt, 1977). Evapotranspiration (ET) is the sum of water loss in vapor form to the atmosphere by transpiration from leaves, plus evaporation from soil (medium) and leaf surfaces. Evaporation of water from the medium surface is greatest for newly planted crops due to increased exposure to sunlight. As the crop develops, the foliage canopy shades the medium surface reducing water evaporation. Transpiration water loss increases as the plants grow larger and root systems fill the container.

Crop water requirements are affected by: 1) climate, 2) crop characteristics, and 3) production practices This report will briefly discuss these factors and how they relate to container-grown plants.

CLIMATE

Climate has a major influence on crop water requirements. Daily temperature, wind, relative humidity, amount of sunshine, and day length are contributing factors Crop water requirements are greatest on sunny, dry, windy days compared to days that are cloudy, humid, and calm To show this relationship between climate and crop water requirements the evapotranspiration of a standard *reference crop* (ET_0) *is used The reference crop is defined as a clipped expanse of* green grass and the amount of evapotranspiration expressed in mm (millimeters) or inches of water per day.

Local meteorological data are used to calculate reference crop evapotranspiration Several procedures are available and all are beyond the scope of this report to describe. In Florida, the Thornthwaite procedure is often used to study crop water requirements. Potential evapotranspiration calculated by the Thornthwaite procedure closely predicted the actual transpiration water requirements of container-grown ornamentals (Fitzpatrick, 1983; Roberts and Schnipke, 1987). However, the Thornthwaite procedure works best in humid regions and is not reliable in more arid regions (Cuenca, 1990). The FAO Blaney-Criddle method is very satisfactory for calculating reference crop evapotranspiration in the western United States (Allen and Brockway, 1983). At the North Willamette Research and Extension Center, Aurora, Oregon, crop water requirements for container-grown plants are estimated using the FAO Blaney-Criddle method modified for a 24-hour period

CROP CHARACTERISTICS

There is great variation in the crop water requirements of plants produced outdoors in containers (Burger et al , 1987). Woody landscape plants can be grouped into three major categories 1) high (*Potentilla fruticosa* 'Mount Everest'), 2) moderate (*Juniperus sabina* 'Tamariscifolia'), 3) low (*Tsuga canadensis*). These differences are primarily caused by crop characteristics.

Crop characteristics that affect crop water requirements are plant species or cultivars, stage of development, and planting date. Crop coefficients (k_c) are used as an index to show the difference between crops and the changes that occur during the production rotation ($ET_{crop} = k_c \times ET_o$) Crop coefficients have not been determined for most woody landscape plants.

The rate of crop growth and development is an important crop characteristic Transpiration water requirements of container-grown *Acer* species were found to be significantly less for slower growing trees (*A. saccharum*, *A. platanoides*) when compared to faster growing trees (*A. rubrum*, *A saccharinum*, *A. negundo* (Roberts and Schnipke, 1987) Growth rate is not always a good indicator of crop water requirements. Fitzpatrick (1983) found that certain slow, moderate, or fast growing plants had similar transpiration water requirements.

PRODUCTION PRACTICES

Several production practices will change the crop coefficient of container-grown plants These practices include. 1) container spacing, 2) pruning, 3) container and bed surface color, 4) size of beds, 5) and irrigation frequency. Although these factors are studied extensively for food and fiber crops, few have been investigated for container-grown woody plants.

Wide container spacing is a major factor that affects crop coefficients. Burger (1987) found that crop coefficients for plants spaced at container-width were as much as 50 percent greater compared to crop coefficients for the same plants at container-tight spacing At wide spacings more sunlight can penetrate the foliage canopy increasing the energy load of the plant and medium resulting in higher evapotranspiration. Preventing excessively high container medium temperatures during the summer should help reduce crop water requirements. Medium temperatures are reduced by irrigating a few hours (2 to 4) before maximum air temperature occurs or by using reflective container colors (white) and/or dark bed surfaces (Keever and Cobb, 1985; Keever and Cobb, 1984). Narrow beds have more outside row containers exposed to sunlight and higher temperatures

Overhead irrigation water is held by dense canopy foliage reducing the amount of water that is captured in the root zone (Beeson, 1991). Water on the foliage will evaporate and transpiration is reduced accordingly (Israelsen, 1962). Therefore, with frequent overhead irrigation, water held by plant foliage is a part of the crop water requirements.

Plants with damaged or weak root systems have lower crop water requirements than plants with healthy root systems According to Welsh (1991), over-watering container-grown *Photinia* x *fraseri* decreased medium aeration resulting in poor root development, reducing transpiration water requirements. Winter injury to roots of container-grown plants can also result in reduced crop water requirements the following spring.

Pruning reduces the plant's leaf area and allows more sunlight to penetrate the foliage canopy. Summer pruning is likely to cause a change in a crop's water requirements and requires further investigation. After extensive topiary pruning *Juniperus* species will decline in vigor and/or die if irrigation is not reduced. Dormant shoot pruning of hybrid crape myrtle (*Lagerstroemia* 'Tuscarora')[1] before planting in containers did not affect transpiration water requirements or change the leaf area (Zajicek et al , 1991)

Nursery crop producers have an obligation to use irrigation water efficiently Competition for available water and emphasis on beneficial use will continue to escalate in North America Irrigation management based on a crop's water requirements will conserve water, reduce leaching, and improve product quality.

([1]Bot Ed Note—The cv Tuscarora is a selection from hybridization utilizing *Lagerstroemia fauriei* and *L. indica*)

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Micro-Sprinklers

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The term *micro-sprinklers* is a general one including misters, mini- and low-volume sprinklers. Low-volume sprinklers have been in use at our nursery for approximately five years. The following discussion is limited to low-volume sprinklers which are generally also low-angle design and operate on low pressure.

Originally, the problem of irrigation of containers in shadehouses with covers at or below 10 ft led us to the low angle design of the NAAN Turbo Hammer model (Figure 1). At a separate propagation facility the problem of elevation changes of 80 ft in 600 ft of line distance and limited water availability demanded some unusual solutions. To compound the problem, growing space on a small hilly acreage looks more like grandma's crazy quilt than an efficient, high tech nursery facility. Level space for container beds and shade houses does not come in regular shapes and sizes. Small sprinkler patterns were needed to avoid waste. The NAAN 7102 has been most useful in production of 2- and 4-in. liners, and for some 1 gal stock in these unconventional areas (Figure 2).

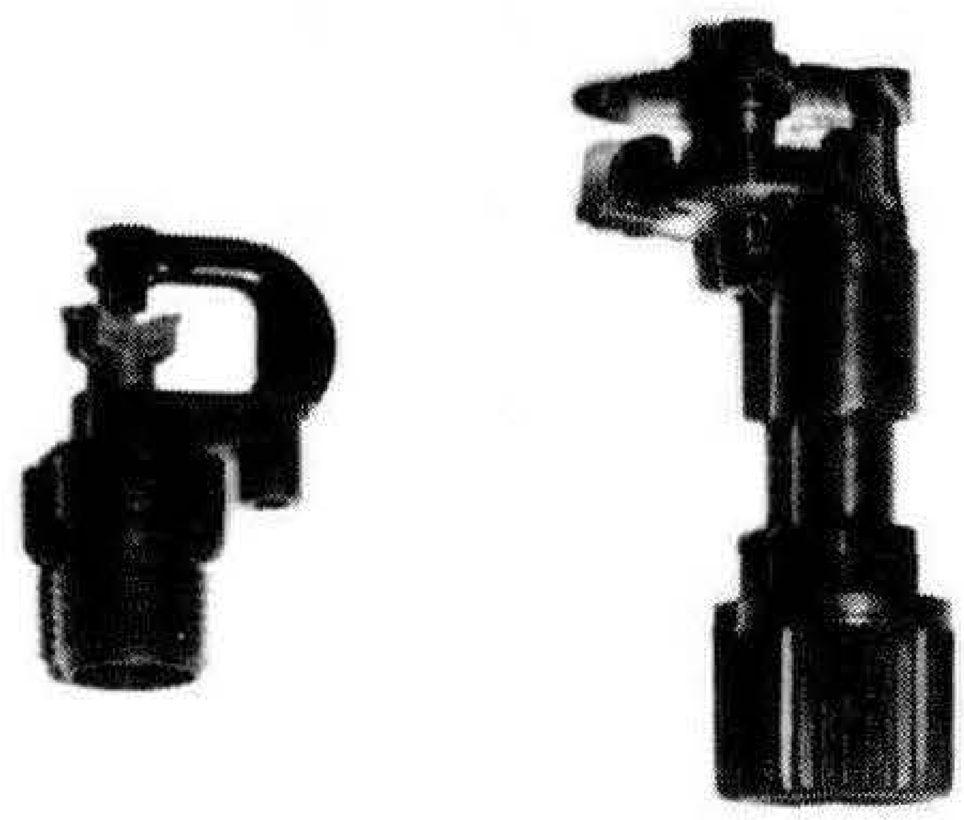

Figure 1. Two types of low volume sprinklers:
Left. NAAN 7102 Spinner— low Volume, very low angle, 0.57 gpm at 15 psi. *Right.* NAAN 501 Turbo Hammer— low volume, low angle. 9.7 gpm at 15 psi.

The nursery produces flowering shrubs, primarily rhododendrons and azaleas for landscape use. The facilities have evolved over the past decade, therefore most changes have included adapting the old systems as much as possible to minimize the expense of improvements. The two sprinklers mentioned above are designed to be installed on PVC with standard threaded couplings. Standard electrical control systems are effective with these units.

Figure 2. NAAN 501 Turbo Hammer sprinklers in use during the summer.

Advantages

Using the familiar brass impact sprinkler for comparison, Table 1 shows some of advantages of the micro-sprinklers.

Other advantages of the low-volume sprinklers:

- The low operating pressures mean longer equipment life.
- Parts can be hand-tightened without wrenches or special tools.
- Replaceable parts reduce the expense of maintenance.
- Low rate of application allows the grower to closely match the discharge rate to the absorption rate of the container mix and soil.
- Small diameter coverage pattern minimizes waste outside the growing area.
- Visual monitoring of uniformity is simplified because the rotation speed of a sprinkler varies with the volume of water ejected from it. A damaged or partially plugged sprinkler will rotate slower than others in that line.
- Though I have no quantitative evidence, it seems that droplet size or velocity produces a gentler spray. I have noticed reduction of soil compaction and splashing which can carry disease organisms and dislodge fertilizer beads.

Table 1. Comparisons between brass impact and micro-sprinklers

	Brass impact	NAAN 501	NAAN 7102	Comments
Minimum pressure	psi 20	15	15	The brass impact sprinkler is not uniform at low psi
Maximum pressure	psi 70	45	45	Pressure regulator may be needed for low-volume units
Peak of water stream above nozzle	ft 7	1 to 2 5	0 5	
Discharge at minimum pressure	gpm 2 0	0 15	0 09	
Discharge at maximum pressure	gpm 3 9	1 73	1 02	
Diameter coverage	ft 72 82	26 53	17 4 35 1	Brass impact needle setting moves during operation Low-vol adjustment parts installed— stay set

Disadvantages

- In unsheltered areas wind can distort intended distribution. Shade covering on walls of growing houses minimizes this problem.
- The Turbo Hammer model is an impact sprayer The hammer does split after several seasons of use
- The Turbo Hammer model seems to have a dry zone between 2 and 4 ft from the sprinkler. Uniform application on pot sizes 1 gal and smaller can be a problem.
- Pressure differences must be calculated to assure that each sprinkler on the line matches all others. Elevation differences and friction losses significantly affect the output.
- Minimum water application on plants in containers with fertilizer can develop excessive amounts of dissolved fertilizer Frequent monitoring is necessary and appropriate flushing routines must be observed.

CONCLUSIONS

Irregularities of water distribution in the installations at our nursery are in general related to the use of sprinklers in container beds. These low-volume sprinklers are primarily designed to be used in field growing and orchard situations where water can move laterally to moisten the entire root zone. Also the nature of the crop we grow does not allow the low placement of the sprinklers—above ground but below foliage, where they would be less affected by wind.

Water management in the future will be important to the entire industry. Many alternatives are available to meet the many growing situations and variety of crop needs. Good design, good maintenance and good management of any system are the keys to efficiency. "A properly designed, maintained, and managed low-volume sprinkler system can deliver water with an application efficiency greater than 90 percent."

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Wheel Line Irrigation Systems

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In 1985 Carlton expanded its tree production and also planted shrubs as a part of the production schedule. This increased the acreage that needed to be irrigated and maintained. We needed a more efficient method of irrigating in order to cope with the new demands. At this time we pressed into service two "Wade Rain" wheel lines and movers we had received with the purchase of some property.

The advantage of this system is that the pipe does not have to be disconnected, moved by hand, and reconnected. One person can irrigate many acres by just starting up the power unit and rolling the lines to the next position. It is fast, easy and safe. The system we utilize has 64 in. diameter wheels, 4 in x 40 ft pipe sections and Rainbird 30 sprinklers.

Cost for 1200 ft of wheel line and one power mover runs between $6,500 and $7,250 This is about four to five times the cost of a regular hand line. However, costs are recovered through labor savings, as one person can irrigate several hundred acres when using wheel lines. This type of system can be utilized on rootstocks and shrubs during their first growing seson. The wheels, pipe sections, and power unit dismantle easily for movement to another field the next spring

Drip Irrigation in Containers

Mike Scott
Fairway Nursery, Clackamas, Oregon 97015

Traditionally high dollar crops such as grafted Japanese maples, *Stewartia*, and *Parrotia* are difficult to propagate and slow to grow. Their growth response in polyhouses under uniform conditions, however, is the opposite. Fairway Nursery, in looking for an efficient, uniform delivery system for water and fertilizer, opted for a drip irrigation system.

The system is very simple and consists of a polyethylene feeder pipe into which a multi-outlet dripper is plumbed Each dripper feeds eight regulating sticks that are placed in the pots. The drippers operate under low pressure, 35 psi and deliver 0.25 gph per stick at a 97% uniformity. The most important component of any drip system is filtration. A 140-mesh, 2-in. Arkal disc filter along with Netafim's design of a turbulent flow path in the regulating sticks prevent clogging from particulate matter in the water

We are able to irrigate 1800, 5-gal containers on 2700 sq ft Water useage is approximately 900 gal per day as opposed to 1780 gal with traditional overhead irrigation. The multi-outlet dripper costs $1.14 per unit and polyethylene feeder tubing 17¢ per foot. Dependable uniform watering allows for accurate feeding. We use an Amiad displacement injector to apply 50 ppm of 10.1:6 fertilizer during the growing season.

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Rainguns as an Irrigation Option

Lowen Pankey
Redwood Lane Nursery, 30754 Peach Cove Rd , West Linn, Oregon 97068

The raingun is a large capacity impact sprinkler, mounted on a sled, recoiled by a mechanically driven drum.

TYPES OF RAINGUN SPRINKLERS - TYPES OF DRIVING DEVICES

Gas and Diesel Powered— *Driven by a gasoline or diesel powered engine.*

Advantage:

1) Low initial cost

Disadvantages:

1) There is a great deal of mechanical equipment to maintain
2) One must be a mechanic to make certain it runs correctly.
3) Gasoline can be a hazard.
4) Need an experienced crew to operate (pouring gasoline into a hot engine is hazardous)

Diaphragm— This raingun uses a rubber diaphragm as a drive unit

Advantage:

1) Inexpensive to operate.

Disadvantage:

1) With all valve portings and valve assemblies, the maintenance can be high.

Turbine Driven— Driven by water from the irrigation system

Advantages:

1) Very portable.
2) No mechanical operation.
3) One person operation.
4) Works best, with fewer problems.

Disadvantage:

1) After three years of use, we have had no repairs and no complaints.

APPLICATIONS

Rainguns have a gpm (gallons per minute) range of approximately 100 to 500 gal under correct pressure. We are operating 120 lb at the gun. The water atomizes well enough so that the raingun could be used over small transplants. There is some splashing effect, but it is minimal.

Pulling across the field, we are applying approximately one inch of water and have the ability of covering around six acres a day with the T65 Bauer raingun that we own The Bauer T65 gun covers a path 200 ft wide and approximately 800 to 900 ft long.

SETTING UP THE NURSERY FOR A RAINGUN

1) We have a 10 ft row every 200 ft at standpipe.
2) Our rows run 600 to 700 ft long.
3) We run 100 gpm at 120 lb pressure.

Water Supply. Adjustments may have to be made on an old and/or existing system. At our nursery, we have buried 4 in. mains which require about 150 to 160 lb at the source of the water, and the pipe we have is 125 lb operating pressure. During the initial setup, we experienced pipe splitting and eruptions.

If you do not have a water source of this capacity, there are tractor driven booster pumps that can be put at the gun. This method works, but it takes more time and energy to set up.

Time and Money. Setting water everyday, using aluminum pipe, took a crew of four men, approximately four hours a day. Using the raingun, setting water each day, now takes one man, one hour a day to set the gun twice a day The amount of time we save is enough to offset the cost of the raingun if one amortizes it over the next five or six years. It will pay for itself, not even considering the relief from setting aluminum pipe.

CONCLUSIONS

Most likely we will never again use aluminum pipe on field stock. The raingun has been a great investment and has served our water needs well This in no way means it will have the same value to every nursery situation. I don't think it applies to container stock as it would have to be physically set up to operate and the water force may knock over small container stock. If you are considering a change in your irrigation practices, you should at least consider the raingun.

Drip Irrigation on Slopes

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At Whitman Farms we grow unusual trees in root-control bags, tree seedlings, and cuttings of *Ribes* and other species Each enterprise demands it's own irrigation system, but by far the most difficult to manage is the root-control bag. Root-control bags have always been a challenge to the irrigator, so some guidelines have been developed The most important is that the bag should be filled with the soil removed from the hole in which the bag is placed If an amended soil, or heaven-forbid, potting medium is used in the bag, the much finer clay particles of the natural soil outside the bag will draw the moisture from the bag. I know this is true because I use potting medium in my bags I also use 10 in. root-control bags in which I can grow a tree up to 2 in. caliper The final result is a healthy, excellently rooted plant that I can lift easily.

However, it has taken ten years to develop a suitable irrigation system. Since we have very limited water, drip was the only option, but there are myriad wrong ways to deliver the drop. With bags only 10 in wide, it didn't take long to realize that the standard in-line emission systems with their 12 in. or more spacings could miss the bag entirely and usually did. My rows are 400 ft long with some on an 8% grade, so a pressure compensating system would be optimal I have not been able to find such a set-up that is cost effective. I have finally settled on a product called Ro-drip with holes at an 8 in spacing It is fairly inexpensive, is only 5 mils thick, and can handle no more than 8 lb of pressure or it will explode like a balloon. It is supposed to deliver 40 gal of water per 100 ft of tubing and is designed to be used only one year.

Needless to say it does not begin to put out an even supply of water on uneven ground, and I use the tubing for more than one year Hence, for insurance, I run two tubes down each row If I run 18 rows (thus 36 lines) for 8 hours a day, I can maintain about 8 lb of pressure and I can get around the field in 4 days.

With these two rows of delicate tubing, we want to keep hoeing to a minimum. We can't use preemergent herbicides because if a plant dies before maturity which, due to the nature of the species I have chosen to grow, happens frequently, we replant into the same bag and so can't have a residual herbicide So the first year a bag row is put in, we mulch heavily with wood chips which we can usually get free. This helps with weed suppression and water retention and the chips usually last a couple of years It is preferable to mulch all the bags every year with mushroom compost, but the price of compost has soared, and the resistance from the field workers who were charged with the task of spreading the highly redolent material was high to start with.

The other two enterprises at Whitman farms are simple. The seeds are watered overhead and the cuttings are stuck four across, between two lines of Ro-drip—one cutting on each outside and two in the middle.

My system is working adequately for the time being, but there is one major drawback to Ro-drip, and that is disposal of the used plastic tubing. I have miles of it in my shed still looking for a recycling center.

Drip-Tape

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A McGill & Son Nursery, P O Box 70, Fairview, Oregon 97024

The availability of water and conservation of water is and will be a very important topic for the 1990s.

McGill Nursery does not have an abundance of water available. We don't have any wells and our only water supply comes from a small spring-fed pond. If we start pumping out of that pond for big overhead sprinkler lines, it will not take long to empty. So, McGill Nursery was forced to conserve water years ago.

Our solution came in the form of a DRIP-TAPE system. DRIP-TAPE is manufactured by T-Tape Systems, San Diego, California The water is pumped from the pond to the "DRIPHUT". In the driphut are the filters and regulators. From there, the water flows into a network of plastic pipes. In the plastic pipes are hook-up tubes every 44 in. (44 in. is our row spacing). When we start planting, we hook the drip-tape to the hook-up tubes and we are ready to go.

After the initial investment of pump, filters and regulators, the system is relatively inexpensive Our drip-tape comes in 7500 ft reels at a cost of about $150 which means it adds only 2 cents to the cost of a tree. The tape stays with the tree 2 to 3 years. We, at McGill's, use the medium (8 mil) drip-tape with hole-spacing at 12 in. The operating pressure is relatively low at only 12 psi.

The rolls of drip-tape are mounted on our Michigan 2 row mechanical planter and a guide-tube makes sure that the tape gets situated a few inches under the plants.

For tree growers it is advisable to put the tape a few inches on either the left or the right of the little tree, so you don't have any problems when you have to stake the tree later.

When the tractor moves, the tape starts unrolling; and besides all this, the water is following the planter. When the planter is on the end of the rows, which are between 1200 and 1300 ft long, the water is not far behind This gives us the opportunity to plant all summer long.

Advantages of drip-irrigation include the following·

1) Water savings—60% over sprinkler-irrigation. We can irrigate 20 acres at one time against 3½ acres with overhead-sprinklers
2) Energy cost reduction.
3) Labor savings (one person can open and close the valves).
4) Field operations can continue, because furrows remain dry.
5) Less soil compaction
6) Moves destructive salts away from crop.
7) Better yield and quality.
8) Plant protection from disease—no wet leaves.
9) Can be automated
10) Fertilizer injection.

Every year we grow our tissue culture plants on Drip-Tape and have more than one million plants on the system.

The digger digs the tape, together with the trees, and the crew disposes of the old tape. It is advisable to chlorinate the tape twice a year to keep it clean of algae, or use phosphoric acid if you have an iron problem.

Integrated Pest Management in Forest Nurseries of the USDA Forest Service

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There are twelve USDA Forest Service nurseries in the United States; all grow tree seedlings for reforestation or revegetation/rehabilitation projects. Many have been in existence since the early 1900s, the Wind River Nursery on the Gifford Pinchot National Forest in Washington State was set up in 1909 to grow seedlings to reforest the Yacolt burn, a huge area in southwest Washington destroyed by forest fire. The youngest nursery is the J. Herbert Stone Nursery in southwest Oregon, which produced its first seedling in 1978

PEST CONTROL AND PESTICIDES

Over the years, many pest control tactics, ranging from manual weeding by crews of housewives living near the nursery to mechanized fumigation of nursery fields, have been used in Forest Service nurseries. Each method had a reason for being used. Often one method was used because it was the only method that was available or effective. In the 1950s and 60s, a multitude of new pesticides were introduced to the agricultural community and their killing power and low cost allowed the nurseries to produce large quantities of cheap seedlings.

The world has changed. Pesticides are being detected in water sources, including groundwater. Nurseries have begun to be surrounded by houses as the population of the United States grows. Activist groups have been formed whose primary objective is to reduce or eliminate pesticide use. Pesticide residues on food are a growing concern. Ironically, while the use of pesticides on crops in the United States has increased 33-fold since 1945, the percentage of crops lost to pests has not shown a concurrent decrease; losses have actually increased (Pimentel, et al , 1991).

NATIONAL ENVIRONMENTAL POLICY ACT AND ENVIRONMENTAL IMPACT STATEMENTS

In response to these concerns, Forest Service nurseries are beginning to develop ways to reduce their use of pesticides. The first step has been to prepare an environmental impact statement (EIS) on nursery pest management for each nursery. An EIS is a document required by the National Environmental Policy Act (NEPA) of 1969 whenever an action by a federal agency might have a significant impact on the environment and the people within that environment A nursery's pest EIS outlines a workable integrated pest management (IPM) program for each nursery.

INTEGRATED PEST MANAGEMENT

IPM in the Forest Service is not new; in fact, it has been Forest Service policy to practice IPM in all their pest management activities since 1982. IPM is not new to forest nurseries either; many nurseries have been using an IPM program, or parts of one, for many years. It is only now, however, that a formal legal commitment to IPM in Forest Service nurseries has been made. The definition of IPM that is being used for the Forest Service nurseries stresses the consideration of values other than economics in selecting treatment timing and method

> "Integrated nursery pest management is the maintenance of seedling pests at tolerable levels by the planned use of a variety of preventive, suppressive, or regulatory methods (including no action) that are consistent with nursery management goals. It is implicit that the actions taken are the end-result of a decision-making process where pest populations and their impact on hosts are considered and control methods are analyzed for their effectiveness as well as their impacts on economics, human health, and the environment." (USDA Forest Service, 1989)

IPM IS A DECISION-MAKING PROCESS

At the heart of this IPM definition is the decision-making process: **how** the nursery should go about deciding if a pest is a problem, when to treat, and what method to use. The decision-making process is diagrammed in (Figure 1):

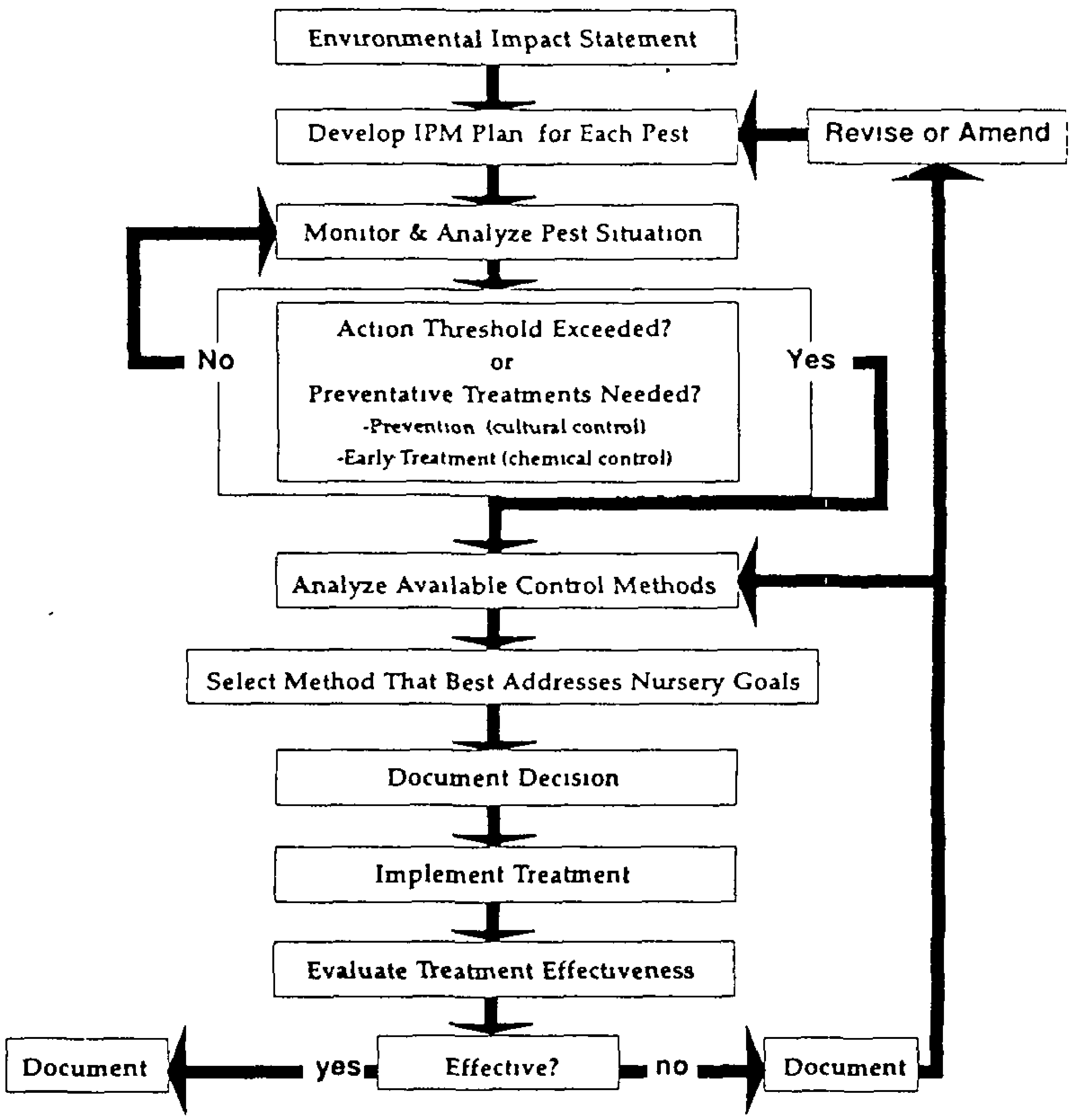

Figure 1. The decision-making process used by USDA Forest Service nurseries for their IPM programs

Most of the steps are self-explanatory. However, explanations of the "IPM Plans" step and the "Monitor Pest Population or Damage" step may be helpful.

IPM Plans. An IPM plan is necessary for each pest that occurs at the nursery. At a minimum, the plan should include

1) ***Information on pest biology and impact, including damage thresholds if known.***

2) ***Monitoring procedure.*** A brief description of how the pest or its damage will be tracked and assessed is included in the procedure. Items such as frequency of monitoring, where to look for the pest or its damage, damage or pest assessment methodology, species, and age of target crops, and monitoring data sheets are useful.

3)***List of treatment alternatives.*** All biological, cultural, and chemical treatment methods (or combinations thereof) (including no action) should be included if effective and feasible

4) ***Pesticide information.*** Product labels, material safety data sheets (MSDSs), health effects, environmental impacts should be included or their location at the nursery referenced.

5) ***Comparison of treatment alternatives.*** Treatment alternatives should always be compared to one another with regard to effectiveness, impact on environment, impact on human health, and cost. A simple comparison matrix for control of cranberry girdler moth (*Chrysoteuchia topiaria*) is shown here (Table 1).

Table 1. A comparison of control alternatives for the cranberry girdler moth at the J Herbert Stone Nursery

Treatment option	Human health risk	Risk to environment	How effective	Cost to treat	Preference rank
1. No action	None	None	None	None	Low
2. Weeding and mowing	Negligible	Negligible	Low to moderate	High	High
3. Use of Bug Vacuum	Negligible	Negligible	Moderate	Moderate to high	Moderate to high
4. Spraying of Pydrin	Moderate	High	Moderate to high	Moderate	Moderate to high
5. Combination of B and D	Moderate	High	High	Moderate to high	High

6) ***Annual decision and decision rationale.*** The selected treatment or combination of treatments is documented and the reasons for selecting it are described. This decision should be reviewed each year and modified if necessary.

Monitor Pest Population or Damage. For some pests, it makes sense to monitor their population or the damage they cause and begin control measures when a threshold level is reached. Threshold levels may be quite sophisticated, such as a certain number of insects per trap, or quite simple, such as the presence or absence of the pest on the seedlings. Monitoring works well in forest nurseries for insects, foliage pathogens, and weeds.

For other pests, such as soil-borne fungal pathogens, preventive activities or treatments must be made long before the seed is even sown in the soil in order to prevent significant losses. In these cases, monitoring is not as useful and the decision to treat or not must be based on historical occurrence of the pest or climatic, soil, or seedling conditions that may pre-dispose the seedlings to attack or infection.

HIGHLIGHTS FROM ONE NURSERY'S IPM EFFORT

In 1990, the J. Herbert Stone Nursery, a USDA Forest Service nursery near Medford, Oregon, began a pest management program following the guidelines we have outlined here. Among many achievements, they have begun a water monitoring program, tested innovating non-chemical pest control methods, improved public relations, and reduced their use of pesticides.

The Bug Vacuum. A vaccum machine was purchased in 1990 to remove lygus bug and cranberry girdler moths from seedling beds. It attaches to the front of a tractor and removes insects and other light debris from the crop by a hydraulically powered vacuum. The nursery plans to use the vacuum when lygus damage is seen on seedling shoots or when threshold levels of cranberry girdler moths are caught in girdler pheromone traps. Tests still need to be run to compare vacuuming with insecticide treatments.

Water Testing. The nursery has written and begun using a water monitoring plan. Both surface water and subsurface water are sampled and tested for pesticides and nitrates. Lysimeters (monitoring devices that sample water in the unsaturated zone above the water table) are used to sample subsurface water. The goal of the nursery is to be able to detect off-site movement of pesticides and nitrates via leaching or surface runoff.

Broccoli and Mustard. A cooperative research project continues at the nursery to look at the effects of different soil amendments on populations of soil-borne pests. Incorporation of sawdust, bare fallowing, and use of *Brassica* species, such as broccoli and mustard, as cover crops/soil amendments shows great promise in reducing populations of *Fusarium* spp, a fungus capable of causing widespread damping-off and root rot.

Currently the nursery uses chemical fumigants to control fungi, insects, and weed seeds in the soil; fumigant accounts for over 90% of total pesticide used (pounds of active ingredient per year) in most forest nurseries, including the J. Herbert Stone Nursery. Due to the high risks associated with the application of fumigants and the quantities used (350 lb per acre), non-chemical alternatives such as cover crops are being tested.

Good Neighbors. A public meeting is held at the nursery each spring; neighbors and any interested individuals and groups are invited. At the meeting, the nursery staff describes the pest management activities that are planned for the up-coming growing season and invites comments and suggestions. Nursery staff also notify each neighbor bordering on the nursery property prior to the application of fumigants.

Handweeding or Herbicides? In 1984, the Forest Service in Oregon and Washington was enjoined (prohibited by law) from using herbicides on all of its lands until a worst-case assessment of risks was prepared. The Forest Service nurseries were included in this ban. Weed control following the ban was by mechanical or manual means. In 1990, the ban was lifted and herbicides were again allowed on Forest Service lands The J. Herbert Stone Nursery, however, has continued to use hand-weeding in all seedling bed areas. Herbicides are used only along fencelines and other perimeter areas This has reduced the risk of herbicide exposure to employees working in seedling beds as well as injury to seedlings from herbicides

IPM in Motion. Figure 2 shows pesticide use (excluding fumigants) over the past 10 years at the J. Herbert Stone Nursery. Use of insecticides, herbicides, and fungicides has decreased from 10 to 15 lb/(a.i.) per acre in the early 1980s to less than 2 lb per acre in the last 2 years. The overall trend towards less is due to the loss of herbicides available for use between 1984 and 1990 and the current reduced herbicide program. It is also due to improved monitoring for diseases and insects resulting in less frequent and less extensive fungicide and insecticide treatments.

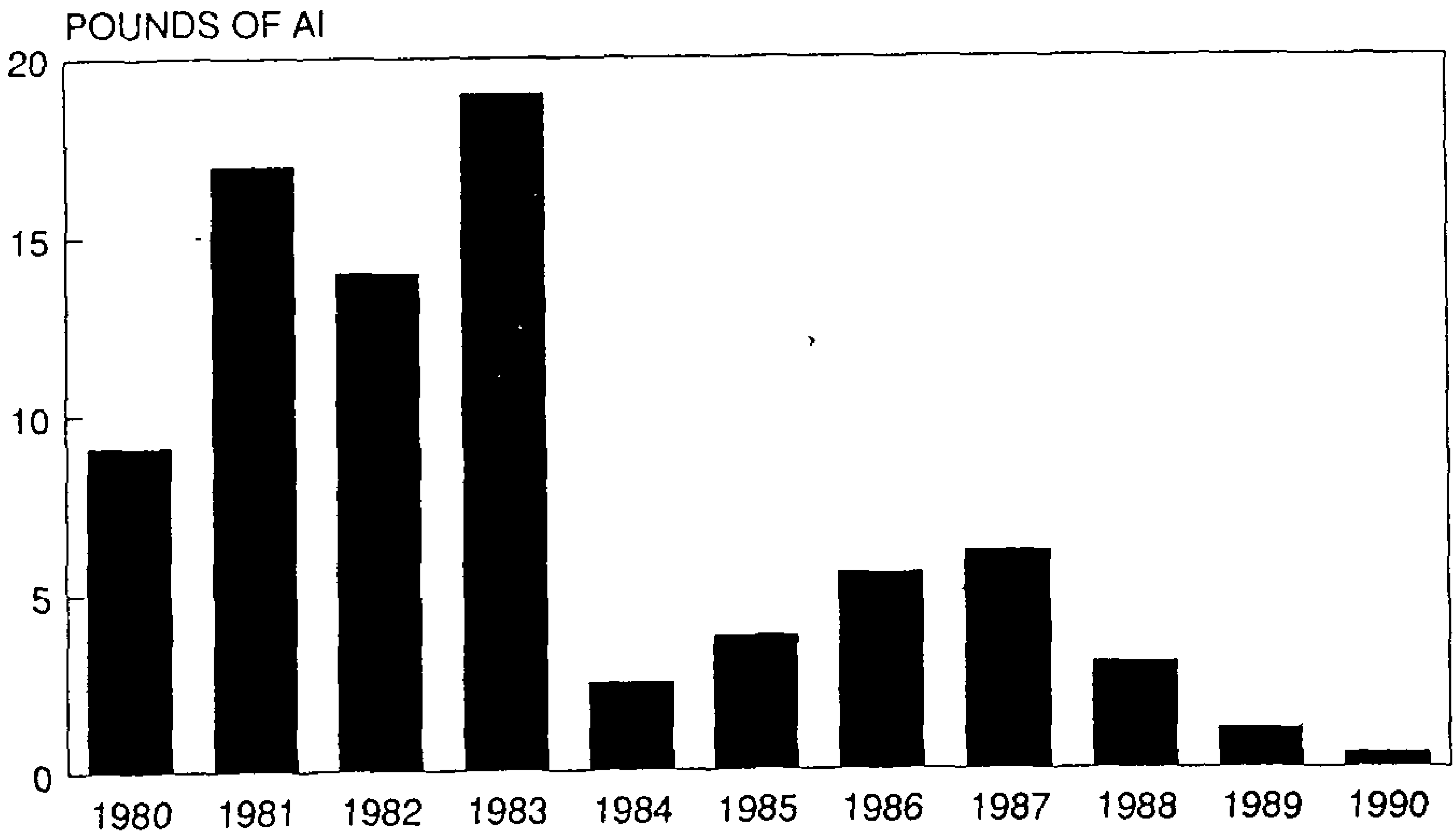

Figure 2. Pesticide use at the J Herbert Stone Nursery between 1980 and 1990 Fumigant use is not included A.I = Active Ingredient of Pesticide

The major challenge for the future for all Forest Service nurseries remains finding effective alternatives to fumigation as well as continuing to test and use non-chemical or less-toxic alternatives to insecticides, fungicides, and herbicides.

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IPM Monitoring Systems for Nursery Production

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Integrated Pest Management (IPM) is an approach to pest control developed during the past 30 years. It can be defined as use of all available techniques to maintain pest populations below economic injury levels (Pfadt, 1978) Pest control has shifted toward IPM because pesticides failed to provide permanent suppression of pests and because of concerns for the environmental and safety risks of pesticides. Adoption of IPM has been credited with reducing insecticide use in agriculture during the 1980s (Zilberman et al., 1991). IPM can provide these benefits to nurseries without sacrificing productivity or quality, if it is applied properly.

The three elements of an IPM program are. economic thresholds, control methods, and monitoring techniques. Monitoring binds thresholds and controls together into a workable IPM program It measures pest populations against the economic threshold to ensure that controls are timed correctly and are used only when necessary. Intensive monitoring systems were the key element of IPM programs developed for apples (Prokopy et al., 1980). They are essential for nursery IPM as well.

We have developed and operated an IPM monitoring system for tree nurseries during the past twelve years. It illustrates monitoring techniques used in nurseries and the benefits of IPM. It also illustrates two principles essential to development of an effective IPM program. First, sampling data must be accurately recorded and maintained. Second, the biology of insect pests must be understood.

In our monitoring system a weekly report is prepared for each field. It details the location and cultivars where samples were collected; and also records the species of insects found, the numbers present, and the amount of injury. Our monitoring program focuses on two primary pests. The leafrollers that destroy terminal buds in spring as well as spider mites that defoliate trees in late summer. We sample 400 to 1200 trees per field and examine the terminals closely for leafroller larva We also collect 80 to 240 leaves per field and count spider mites with the aid of a hand lens.

Initially, monitoring reports provided data that nurseries required to apply pesticides based on their own thresholds. They still serve this basic function of making treatment decisions based on an economic threshold The reports also form a data base that has increased our understanding of insect biology. This information helps us refine economic thresholds, pest control practices, and the monitoring system itself.

The first biological information that we obtained from monitoring data was the identity of the principal leafrollers attacking nursery stock. These were winter moth, *Operophthera* ssp, eyespotted bud moth, *Spilonota ocellana,* omnivorous leaf-tier, *Cnephasia longana;* and obliquebanded leafroller, *Choristoneura rosaceana*. Larva of all four species feed on leaves and buds during the spring. The oblique-banded leafroller is the only species that has a second generation during the summer We supplement field sampling with pheromone traps to predict emergence of second generation obliquebanded leafroller, but in the spring we must rely on intensive field sampling for all leafroller species. Monitoring showed that the omnivorous leaf-tier was the most damaging species. Other leafrollers feed on any leaf they encounter, but omnivorous leaf-tier concentrate their feeding on meristem tissue in the apical buds. A single larva may move along the tree row and destroy several buds in succession. Infestations of this species develop quickly because larva spin silk threads and are blown in from overwintering sites outside the nursery. Our records of leafroller feeding injury showed us that field monitoring may not detect infestations of omnivorous leaf-tier before economic damage occurs. Therefore, we used the sampling data to develop a degree-day model to predict emergence of this species. Pesticide applications can be timed more accurately by combining monitoring and the degree-day model This minimizes damage by omnivorous leaf-tier without resorting to a costly calendar spray schedule.

Monitoring data for spider mites also identified our principal mite pest, the two-spotted spider mite *Tetranychus urticae*. This species overwinters in the soil and does not colonize nursery stock until late spring or summer We rarely find European red mite *Panonychus ulmi*, which overwinters as an egg on the plants. This information allowed apple nurseries to eliminate the dormant oil spray commonly applied in apple orchards to kill eggs of the European red mite.

Our records also documented the host preferences of the two-spotted spider mite. In shade tree nurseries, honeylocust, *Gleditsia triacanthos*, and European mountain ash, *Sorbus aucuparia*, have damaging populations nearly every year. Green ash, *Fraxinus pennsylvanica*, and Norway maple, *Acer platanoides*, are rarely affected. Spider mites even have preferences among cultivars of the same species. The apple *Malus pumila* [syn. *M domestica*] rootstock cultivar 'EMLA 7', is usually much more heavily infested than 'EMLA 26' Host preference information for spider mites permits us to concentrate sampling in susceptible cultivars This reduces the cost of monitoring It has also enabled nurseries to reduce the cost of spider mite control by limiting miticide applications to susceptible cultivars

Our monitoring records of pest injury and chemical use document the benefits of a nursery IPM program. Figure 1 shows spring bud loss due to omnivorous leaf-tier and other leafrollers.

During 12 years of IPM monitoring, damage caused by leafrollers has declined by approximately 90%. During this period pesticide use was reduced by 50% (Figure 2) Pest control at this nursery was improved by timing pesticide applications more accurately, eliminating unnecessary treatments, selecting more effective pesticides, and improving application equipment. The monitoring system was directly responsible for the first two changes. It contributed to the others by evaluating chemicals and by demonstrating the need for improved equipment.

Table 1 shows the record of spider mite infestations and miticide use in an apple rootstock production bed during nine years of IPM monitoring. Infestations by spider mites have fluctuated widely due to climatic variation. Monitoring has not had a noticeable impact on spider mite populations Miticide use was reduced, however, by shifting from full cover sprays of the entire field to spot treatment of infested cultivars IPM monitoring has been an important factor responsible for this reduction in pest control costs

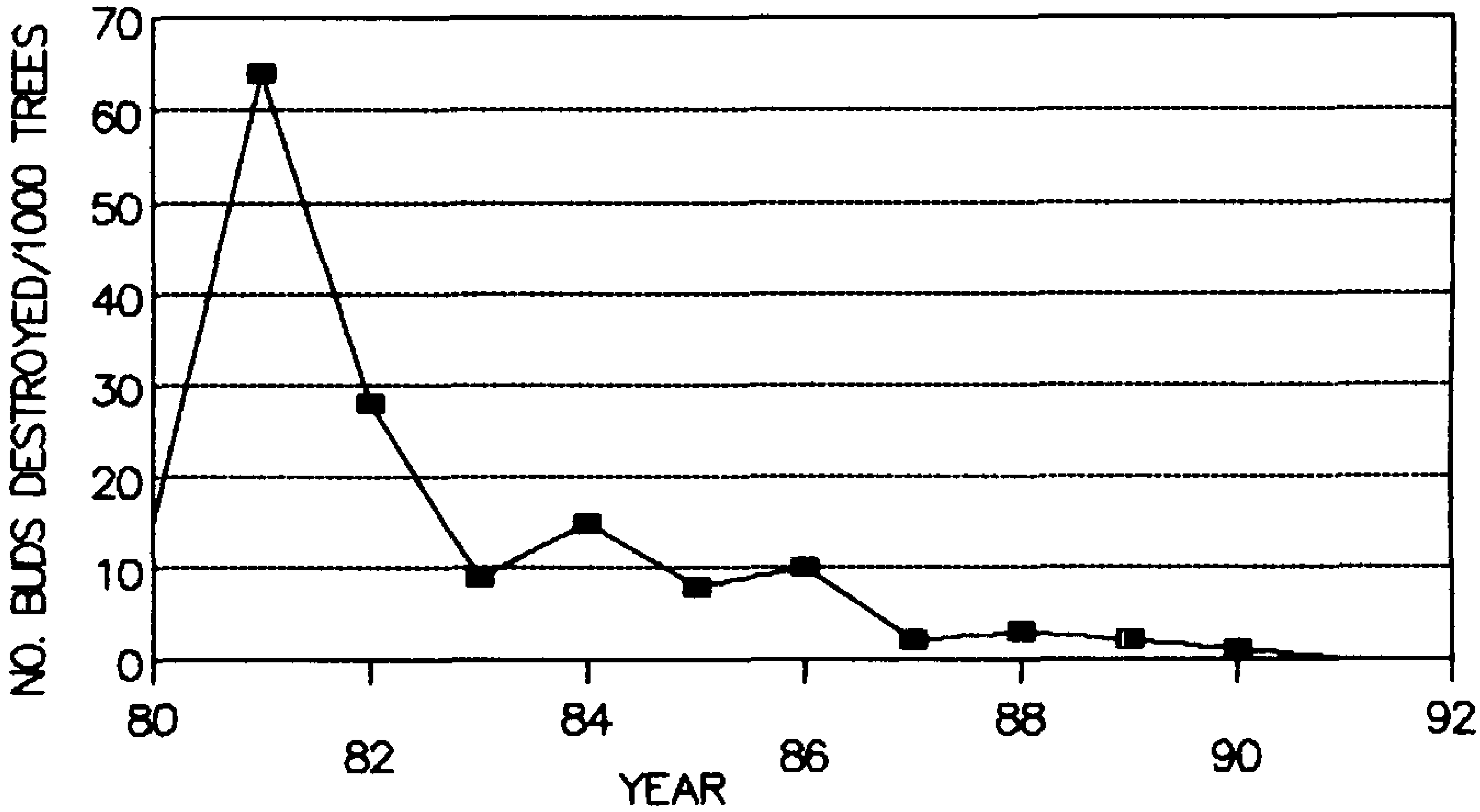

Figure 1: Leafroller damage in 1-yr budded trees. Nursery Treco, Inc

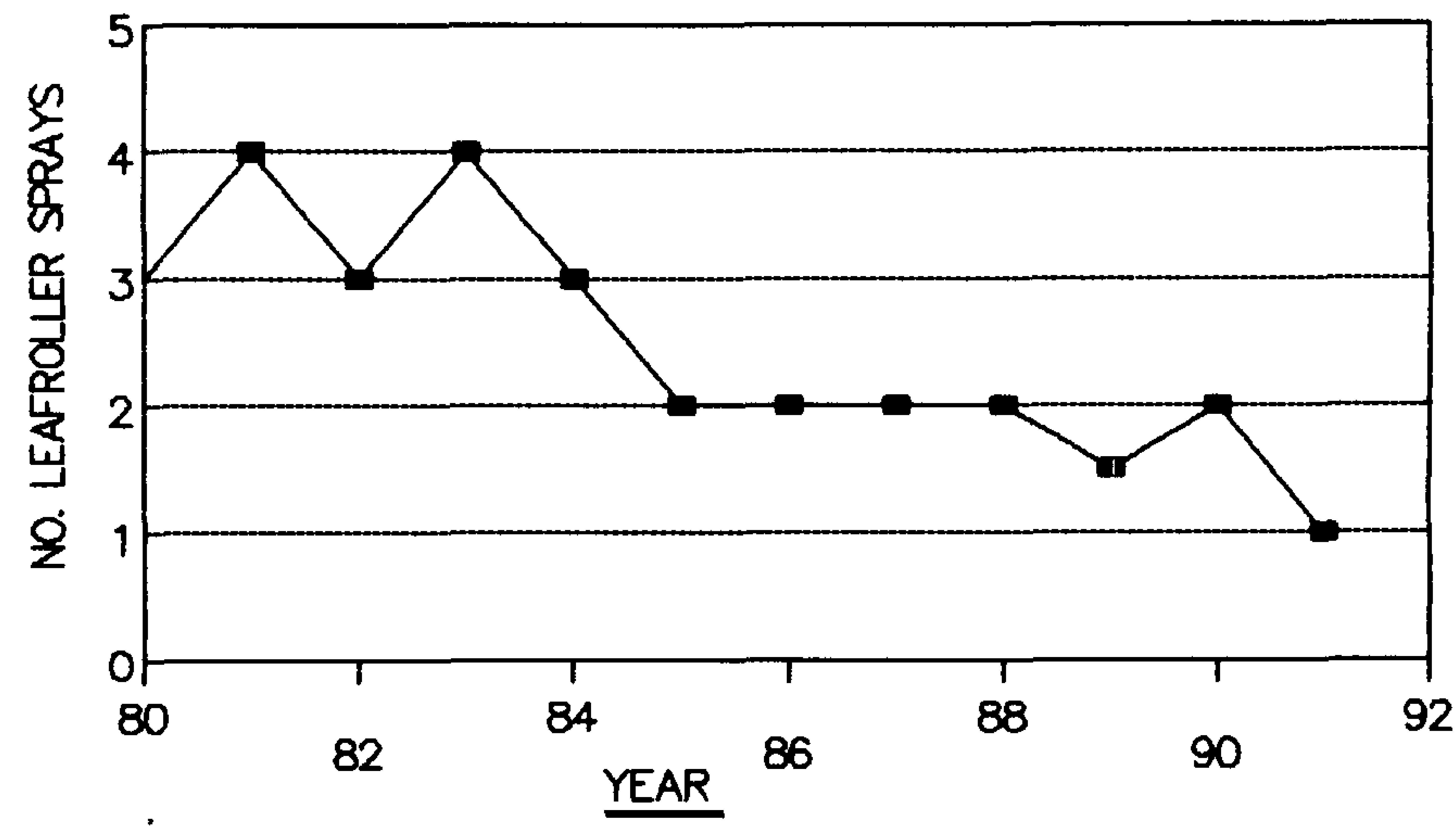

Figure 2: Pesticide applications for leafrollers. Nursery Treco, Inc

This nursery IPM program reduced use of pesticides to control leafrollers and mites and it also reduced injury by leafrollers. Other nurseries that use IPM monitoring have reported similar benefits:

1) Fewer pesticide application, lower costs for chemicals and labor.
2) Reduced labor costs to repair damaged plants.
3) Increased percentage of undamaged, saleable trees.

Integrated Pest Management is an effective tool for nursery production. It requires rational economic thresholds, effective pest controls, and good monitoring techniques. The monitoring component of a nursery IPM program must be based on thorough sampling, accurate recordkeeping, and a detailed knowledge of insect biology.

Table 1. Spider mite infestations and miticide applications in apple rootstock. Nursery: Treco, Inc

Year	Maximum density of mites (no /leaf)	No of full treatments	No. of spot treatments
1982	7 3	3	1
1983	10 3	2	3
1984	8 6	2	1
1985	10 0	2	3
1986	1.2	2	2
1987	22 3	1	2
1988	2 8	1	2
1989	5 1	0	3
1990	14 3	1	1

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Entomopathogenic Nematode use in Nurseries and Greenhouses

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Entomopathogenic nematodes in the genus *Steinernema* and *Heterorhabditis* and their associated bacteria (*Xenorhabdus* spp) have shown great potential as biological control agents for a variety of insect pests including several curculionid species, or so-called "root weevils" and sciarid flies, such as fungus gnats The nematodes are able to kill hosts rapidly, are easy to apply, and are exempted from federal and state registration requirements in most countries because of their safety to mammals and plants Difficulties in production, storage, formulation, quality control, and application technology had limited their success for market introductions in the past. Recent public pressure to limit environmental contamination associated with chemical insecticide use has resulted in a dramatic increase in research conducted by scientists in government, universities, and industry to overcome some of these technological difficulties Industry has now seen the development of three major biotechnology companies which have been successful in introducing nematode-based products into some commercial markets.

Production. Since their discovery as biological control agents, nematodes have been produced *in vivo,* in which an insect host serves as the medium for nematode-bacterial growth and production. This method has limitations because it requires a constant source of healthy insects, is sensitive to biological variation, and costs of production are high in terms of equipment and man-hours More efficient methods of production using *in vitro* methods have been and are being developed.

Currently, both heterorhabditid and steinernematid nematodes are produced in monoxenic solid phase systems. However, there are economic limitations to this approach such as labor costs, consistency of production, and sensitivity to contamination. *Steinernema* spp. are now commercially produced in monoxenic liquid culture systems which utilize fermentation tank technology. This approach is the most economical of all known methods. Nematode production is taking place in tanks of up to 80,000 liters in volume, which has lowered costs considerably, allowing successful introductions into markets requiring large numbers of nematodes, or markets of low cash crop value

Formulation. The successful market introduction of an entomopathogenic nematode product requires a reliable and stable formulation. This has been a difficult task because most larger markets are demanding a product with a minimum shelf-life of 6 months when stored at room temperatures (20-25° C) Nematode products contain living animals which have certain temperature, oxygen, and moisture requirements necessary for their survival and effectiveness as control agents. While no nematode formulation has been completely successful in reaching these goals, some have been developed in certain market segments. A few commercial products use moist substrates such as sponge, vermiculite and peat. These materials require refrigeration because warm temperatures increase nematode metabolic activity thus reducing pathogenicity and virulence. Other materials such as alginate gels, clays, activated charcoal, and polyacrylamide gels immobilize or partially desiccate the nematodes. This reduces their metabolism and improves their tolerance to temperature extremes. Commercial products using alginate materials can now provide a viable product for 5 months at temperatures as high as 25°C

Application Technology. Strategies must also be developed which insure the successful delivery of the nematode to the target site and target insect, thereby increasing the probability of nematode-insect interaction. One strategy is the selection of proper equipment for application. Entomopathogenic nematodes can be applied through most common agricultural liquid application equipment including irrigation systems (via chemigation which is preferred for certain crops) They can withstand pressures of up to 300 lb/in^2 and can be applied through most common nozzles with openings as small as 50 microns. Another consideration is proper spray volume and sufficient irrigation. This can vary tremendously depending on soil type, crop, relative humidity and rainfall. Most nematode applications are targeted against life stages found in the soil environment and sufficient spray volume must be used to insure adequate coverage and movement of the nematode into the target area. Adequate irrigation is also crucial to insure nematode movement, survival, and persistence in the soil. Target pest populations and behavior play a role in timing and location of application. Different insect species may require different field dosage rates and optimum entomopathogenic nematode species need to be assessed.

Compatibility with a wide range of agrochemicals has been demonstrated which has allowed nematodes to be introduced successfully into many existing Integrated Pest Management programs With certain root weevil species, high population pressures have been effectively controlled with a combined approach of using nematodes against the immature stages and insecticides against the adults stages

In North America two entomopathogenic nematode species have been introduced commercially for control of certain insect pests associated with nursery and/or greenhouse production These are *Steinernema (=Neoaplectana) carpocapsae* (Weiser, 1955) and *Heterorhabditis bacteriophora (=heliothidis)* (Poinar, 1976). By far the most successful large scale introductions have been with *S. carpocapsae* because of improved production and formulation technologies Insect pests listed on current labels are. 1) black vine weevil (*Otiorhynchus sulcatus)*, 2) strawberry root weevil (*O. ovatus*) and 3) fungus gnats (*Bradysia* spp.). Future market possibilities are 1) sugarcane rootstalk borer (*Diaprepes abbreviatus*), 2) blue green weevil (*Pachneus litus*), 3) shore fly (*Scatella stagnalis*), 4) leafminers (*Liriomyza* spp.) and 4) western flower thrips (*Frankliniella occidentalis*).

Diagnosis of *Phytophthora* Using ELISA Test Kits

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New ELISA test kits specific to the genus *Phytophthora* were evaluated in the Plant Disease Clinic at Oregon State University. All pure cultures of *Phytophthora* spp. tested produced a positive kit result. However, some *Pythium* sp. and *Peronospora* sp. also produced a positive kit result. Other common root-rotting fungi such as *Rhizoctonia* sp., *Armillaria* sp. and *Cylindrocladium* sp. resulted in negative kit reactions. The type and location of tissue sampled was critical for correct kit results and interpretation. Approximately 50% of the samples sent to the Plant Disease Clinic tested positive for *Phytophthora* and were diagnosed as having a *Phytophthora*-related disease.

OBJECTIVE

Recent advances in serology have resulted in new ELISA test kits for fungal and bacterial diseases (Kim, 1988; Miller, 1988). An ELISA test kit specific for the genus *Phytophthora* was recently released for commercial use (Peterson et al., 1990). The objectives of this research were 1) To evaluate the specificity of *Phytophthora* kits to various fungal genera, species, and isolates of *Phytophthora;* and 2) To determine the usefulness of these kits in the diagnosis of plants suspected as having a *Phytophthora* disease.

MATERIAL AND METHODS

A total of 17 species of *Phytophthora* including 18 isolates each of *P. cinnamomi* and *P cactorum* collected from throughout the world were evaluated for reaction to a *Phytophthora*-specific immunoassay (Test kit E, Agri-Diagnostics Associates, Cinnaminson, NJ). Isolates were grown on a glucose yeast peptone agar, ground in sterile sand with extract solution, and boiled for 10 min prior to using the test kit. At least two tests in each of two different experiments for each isolate were compared to sterile sand controls. Pure cultures of several *Pythium* sp., *Fusarium* sp , *Rhizoctonia* sp., and *Cylindrocladium* sp. were also evaluated using the new test kit

The test kits were used to aid in the diagnosis of plant samples sent to the Oregon State University Plant Disease Clinic over a two-year period. The following data were collected for each plant sample suspected by the grower, county agent, field representative, or specialist of having a *Phytophthora* disease· field history, plant symptoms, significant fungi observed microscopically or isolated on selective media and *Phytophthora* test kit results.

Diseased plant tissue was prepared by grinding pieces of root, crown, or leaf tissue between two small sheets of abrasive paper, called extract pads, provided in each kit. For small samples such as seedlings, the entire root system was rubbed against the extract pad rather than grinding subsamples An extract pad was rubbed directly against discolored or cankered areas of large samples such as woody ornamentals All subsequent steps were followed as outlined in kit directions.

Several large trees of *Chamaecyparis lawsoniana* infected with *P. lateralis* were sampled to determine where a positive color reaction was strongest. Extract pads were rubbed against the discolored area of the cambium, the zone between healthy and discolored cambium, and above the discolored area on healthy appearing cambium. The outer phloem, cambium, and inner xylem of core samples were also tested using the kits.

RESULTS AND DISCUSSION

All pure cultures of *Phytophthora* spp. used in this study reacted positively with the new test kits (Table l); however, there were differences between and within species. For example, *P cinnamomi* gave the lowest color reaction when compared against all other species (Table 1). Color reactions were also quite variable among the 17 isolates of *P. cinnamomi*, but among isolates of *P. cactorum*, kit reactions were not variable.

Table 1. Absorbance of different *Phytophthora* species[a]

Species	Absorbance[b]	S E.[c]
Phytophthora boehmeriae	2.95	0.024
P cambivora	2.32	0.025
P cinnamomi	0.20	0.027
P. cinnamomi	0.40	0.037
P citricola	2.82	0.075
P cryptogea	2.91	0.024
P drechsleri	> 3	
P erythroseptica	2.62	0.034
P fragariae	> 3	
P gonapodyides	2.72	0.007
P ilicis	2.97	0.023
P lateralis	2.87	0.024
P megasperma	1.04	0.105
P megasperma	2.88	0.033
P megasperma	2.77	0.187
P megasperma	2.89	0.008
P. palmivora	2.17	0.010
P pseudotsugae	2.86	0.018
P vignae	2.99	0.006
P wyringae	2.97	0.014

[a]An equivalent of 1 ug dry wt mycelium was tested on Agri-Diagnostics Phytophthora Kit E

[b]Absorbance at a wavelenght of 405 nm This was a 0-3 scale where 0.3 was considered as the positive-negative threshold

[c]S E. = Standard Error based on at least 2 wells in each of 2 different experiments

Cross reactivity occurred only with some (not all) *Pythium* sp. and several *Peronospora* species. *Pythium middletonii*, isolated from rotted juniper roots, and other *Pythium* species reacted with the *Phytophthora* kit E but negatively to a similar kit specific for the genus *Pythium*. Were the junipers infected by *Phytophthora*, which could not be isolated, or was the disease caused by *Pythium*? Blackberry and raspberry crowns can be infected by either *Phytophthora fragariae* or *Peronospora rubi*. The cross reactivity exemplified by these cases makes positive kit interpretation difficult.

The test kit was a useful aid in the diagnosis of plant problems sent to the Plant Disease Clinic Over 200 samples representing 46 plant genera were tested Many of these plants (88%) were suspected by someone as having a *Phytophthora* disease but only half of these reacted positively to the test kit. Some representative data for a few plant species are contained in Table 2. Kits were particularly useful in mid-summer when *Phytophthora* routinely failed to be cultured from dried, infected plants.

Table 2. Expected and actual kit[1] results from plants suspected as having a *Phytophthora* disease

Plant Genus	Number of samples where diagnosis suspected as *Phytophthora*	Number of samples yielding *Phytophtora* culture	Number of samples tested positive with kits
Abies	8	4	7
Juniperus	7	0	4
Pieris	4	1	2
Pinus	10	0	5
Rhododendron	36	6	9

[1] Kit E, Agri-Diagnostics Associates

A positive result only occurred for an infected plant when discolored or rotted portions of a plant sample were tested. Strongest color reactions were obtained from *Chamaecyparis lawsoniana* when cambial tissue at or below the line between healthy and discolored tissue was tested. Negative color reactions were obtained from samples taken above the discolored tissue or within the xylem toward the center of the trees. Other studies have shown that greater than 1% infected tissue must be present to obtain a positive reaction (Benson, 1991; MacDonald et al., 1990) Therefore, the type and location of tissue sampled is critical to obtain an accurate test kit result.

Use of these kits does not preclude the need to obtain a wide variety of information to diagnose root and crown rot problems. Many of the samples that tested negative did not have field histories, topography, or symptoms consistent with a *Phytophthora* disease. Alternatively, even though all the evidence indicated a *Phytophthora* diagnosis, it may not be the major underlying problem since *Phytophthora* infected plants were found in situations where the major problem was due to winter injury, excessive fertility, or nematode control failure.

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Use of Pheromones in Pest Management[1]

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Insects have a highly developed chemical communication system. They use chemical signals more than any other animal group to communicate among themselves and with the outside world All messenger substances which regulate behavior between individuals of the same species are called *pheromones* The pheromone communication system is most advanced in social insects Pheromones can have many different functions. For example, sex pheromones help bring males and females together for mating and reproduction. Alarm pheromones are commonly found in ants, bees, and wasps to alert the colony about imminent danger from an intruder Ants can also produce a trail pheromone which guides members of the colony to a recently discovered food source. Aggregation pheromones are used by bark beetles (Scolytidae) during mass attacks to attract mates and increase the number of beetles attacking a tree. Of all the behavioral chemicals which are involved in within-species communication, sex pheromones have found the widest application in pest management. They are the focus of this review. Readers who seek additional information about pheromones and their application are referred to the recently published book, *Behavior—Modifying Chemicals in Insect Management* (Ridgway et al., 1990).

SEX PHEROMONES

The idea that insects use odors to attract the opposite sex for mating was proposed more than 150 years ago. Since then the presence of sexual attractants for the purpose of mate finding was demonstrated in many insect species, particularly in Lepidoptera The first chemical identification of a sex pheromone was that of the famous silk worm, *Bombyx mori*, in 1959. A German biochemist, Adolf Butenandt, extracted the abdomens of 250,000 female silkworm moths to obtain 12 mg of the sex attractant which he called Bombycol He identified the compound as a straight chain alcohol with 16 carbon atoms. Identifications of many other sex pheromones followed, primarily of species of economic importance. Rapid advances in analytical techniques, particularly in gas chromatography and mass spectrography, made these identifications possible and less cumbersome. Analytical methods have become so sensitive that the chemical composition of pheromone components can now be determined from single insects.

Pheromone Production, Release, and Perception. In Lepidoptera (moths and butterflies) the sex pheromone is produced in glands located in the tip of the abdomen During "calling" the pheromone is released. The female raises the tip of the abdomen and exposes the pheromone glands to release the sex scent to the atmosphere. The pheromone diffuses and is then carried downwind. The male moth detects the female scent with his antennae at extremely low concentrations. The antennae are equipped with thousands of sensory hairs. These olfactory hairs

[1] Technical Publication 9710 of the Oregon State University Agricultural Experiment Station, Corvallis, Oregon

are tuned to the sex pheromone and tell the male to move upwind towards the "calling" female. In some large moths, males can detect "calling" females over long distances.

Sex Pheromone Chemistry. The chemical structure of sex pheromones of many lepidopterous and other insect species are now known. Generally, they are straight carbon chain molecules which contain between 12 and 17 carbon atoms. Some consist of mixtures of alcohols, acetates, and aldehydes; others are mixtures of various isomers. The sex pheromones of many species consist of blends of several components. Related species often use the same components but in different ratios.

Controlled-Release Technology. To make use of pheromones in the field they must be released slowly into the atmosphere. The objective is to achieve constant release over a long period of time. Rubber and polyethylene plastic were some of the earliest slow-release substrates and they are still used today as baits in traps. The synthetic pheromone is dissolved in an organic solvent and applied to the substrate. It becomes embedded in the matrix of the substrate and is slowly released. Another release method is hollow fibers (small plastic tubes) which are filled with the attractant. The fibers are welded shut on one end and the pheromone evaporates through the open lumen of each fiber The rate of release is controlled by the size of the opening and the number of fibers. Another dispenser system releases the pheromone through a plastic membrane. The diameter and thickness of the membrane control the rate of pheromone release. For monitoring, it is desirable to adjust the rate of pheromone release in order to maximize the response of males to the bait.

For mating disruption, dispensers are often constructed in such a way as to release large amounts of pheromone at a constant rate. Slow-release systems which are being developed for mating disruption include hollow fibers, plastic membranes, plastic laminates, polyethylene tubes and silicon polymers. Some of these mating disruption dispensers are applied manually within the crop canopy (e.g. polyethylene tubes), others require specialized application equipment (e.g. hollow-fibers). There is also considerable interest in sprayable slow-release pheromone formulations which can be applied with conventional spray equipment.

APPLICATION OF PHEROMONES

Use of Pheromone Traps for Detection and Monitoring. Disposable adhesive-coated cardboard traps are available from several commercial suppliers for use with pheromone baits. The number of individuals caught depends not only on the effectiveness of the pheromone bait, but also on the design features of a trap such as shape, size, and opening. Pheromone traps have several advantages over previous trapping methods. They are species-specific (trap only one species), sensitive at low population density, easy to maintain, and inexpensive. There are also disadvantages Pheromone traps do not perform well under poor weather conditions. Their drawing range is not well defined. Also, they catch only males. This can be a disadvantage since control decisions are often based on female activity (egg laying) rather than male flight. In spite of these shortcomings, pheromone traps have become valuable tools for detection and monitoring of pest species.

Pheromone traps are employed by Federal and State agencies in various survey programs to detect the presence of exotic pest species. These activities are carried out as part of a quarantine effort to prevent the establishment of new pests in the United States Pheromone traps are also used to monitor the spread of already established pest species. One example for such a program is the gypsy moth survey which is being conducted in many states.

Pheromone traps can provide valuable information on the seasonal activity of pest species. This information is used in pest management programs for the timing of control treatments. For instance, insecticide sprays against codling moth, *Cydia pomonella*, are timed using estimates of adult emergence (provided by the pheromone trap) and degree-day forecasts of egg and larval development (Riedl et al., 1986). Similar methods of spray timing are available for the European pine shoot moth, *Rhyacionia buoliana*, and other pests.

Pheromone traps are also used, but to a lesser extent, to evaluate whether a pest population is high enough to warrant control For instance, empirical treatment thresholds are available for the codling moth, a widely distributed pest of apples and other deciduous fruits. If codling moth catches exceed 1 or 2 moths for 2 consecutive weeks, a control treatment is necessary. Another example is the spruce budworm, *Choristoneura fumiferana*, a pest of eastern coniferous forests. Pheromone trap catches are correlated with infestation levels and traps can be used as an early-warning system to predict tree mortality.

A special and more recent application is the use of pheromone traps for resistance monitoring (Haynes et al., 1987; Riedl et al., 1986). Insecticide resistance has become a growing problem in recent years. It is important to detect resistance before it becomes widespread and leads to control failures and economic loss. Pheromone traps are used to collect and test insects for resistance. Insects captured on the adhesive-coated trap bottom are treated topically with a small droplet of insecticide in a solvent carrier or they are exposed to insecticide incorporated in the trap adhesive. By comparing the concentration-mortality response with a susceptible population it is possible to determine whether resistance has developed. Both pheromone trap assay methods have been used in recent resistance surveys for several tree fruit pests including codling moth, several leafroller species, and leafminers

Use of Pheromones for Control: Mass Trapping, Mating Disruption, and "Attract and Kill". The idea of using sex pheromones directly for control of insect pests is not new. Long before synthetic pheromones became available, it was proposed to use virgin female-baited traps and remove all male individuals in a population. The hope was that by removing all males, female insects would not be able to mate and reproduce. The practicality of this idea was not tested until synthetic pheromones became commercially available Mass trapping experiments with pheromone traps have been conducted with many pest species but results have generally been discouraging In mass trapping experiments pheromone traps are used in a similar manner as for monitoring except that trap densities are much higher.

Experiments conducted in California with codling moth indicated that even with very high trap densities such as 70 per acre it was not possible to remove enough males to prevent mating and achieve acceptable control Even if mass trapping was effective it may not be an economical control method because of the high material costs.

A more promising approach is the use of pheromones to disrupt the communication between sexes and thus prevent mating and reproduction. This control method has come to be known as the mating disruption or male confusion method Mating is disrupted by releasing large amounts of sex pheromone from many point sources into the atmosphere. Males are apparently unable to find "calling" females against this background of high concentrations of sex pheromone. It is not exactly clear how mating disruption works. Three hypotheses have been proposed. The "false trail" hypothesis suggests that males are more likely to follow the artificial sex pheromone signals which are emitted from many points in a field Another suggestion is that the pheromone trails of wild females become "camouflaged" by the large amounts of synthetic pheromone in the atmosphere A third hypothesis proposes that males become "habituated" in the presence of high concentrations of pheromone, decreasing their level of responsiveness to calling females

It was first demonstrated with the pink bollworm, *Pectinophera gossypiella*, that mating disruption might become a viable control tactic for some insect pests. Several slow-release formulations are now registered for pheromonal control of this cotton pest. Among tree fruit pests, the most successful example of control with the mating disruption method is the Oriental fruit moth on peaches. The pheromone is released from closed plastic tubes which are attached to tree branches at a density of 200 to 400 per acre This slow-release formulation is now registered for control of Oriental fruit moth and is used on 6,000 acres of peach orchards in California where populations have developed resistance to organophosphate insecticides.

Registrations of pheromones for mating disruption have been granted for about one dozen pest species in the United States. The majority of the registrations are for control of fruit insects, including Oriental fruit moth, codling moth, peach tree borers, and grape berry moth. Registrations for forest insects include Gypsy moth and western pine shoot borer Vegetable and field crop pests for which mating disruption is a registered control method are the pink bollworm, artichoke plume moth, and tomato pin worm. The growing concern about pesticide residues on food commodities has renewed the interest in alternative control methods such as mating disruption with pheromones However, there are also certain problems with this new control method First, success of mating disruption with pheromones has been limited to situations where pest density is low. Under high density conditions control with this method has not been satisfactory. Another problem is that it is often difficult to properly demonstrate the effectiveness of control by mating disruption since large test plots are required and a suitable untreated check area is often not available for comparison

Pheromone traps can be used to monitor the effectiveness of pheromone treatments. The lack of male response to traps is taken as an indication that pheromone concentrations are still high enough to disrupt male-female communication However, one should rely not only on pheromone traps but also on frequent field inspections to monitor the effectiveness of pheromone treatments since traps are not always reliable indicators. Development of damage in a pheromone-treated area means that some mating has occurred or that fertilized females have immigrated from untreated areas nearby.

A third control application of pheromones is their use in combination with insecticides. The pheromone acts as an attractant and improves the performance of a conventional insecticide Special formulations of insecticide-laced hollow fiber dispensers are available for control of several pest species.

COMMERCIALIZATION OF PHEROMONES

Before artificial pheromone lures became available some use was made of the natural pheromone released by virgin female insects to bait traps. As more and more pheromones of economically important pest species were identified and synthesized, commercial companies became involved who began to produce and supply pheromone dispensers and traps. There are now at least eight companies in the United States and more than 50 worldwide who are developing pheromone products for pest management applications. A partial list of pheromone companies in the United States and products they provide is given in Table 1. The involvement of private companies has benefitted the development of standard

Table 1. Commercial companies in the United States developing pheromone products

Company and location	Traps	Pheromone controlled-release systems for	
		Monitoring	Mating disruption
Trece Salinas, CA	X	rubber cap, polyethylene cap	
Scentry Buckeye, AZ	X	hollow-fiber, rubber cap	hollow-fiber
Hercon South Plainfield, NJ	X	plastic laminate	plastic laminate
BioControl Davis, CA			polyethylene tube
AgriSense Fresno, CA			silicone polymer
Consep Bend, OR	X	plastic membrane	plastic membrane

pheromone products. Registration of pheromones by the Environmental Protection Agency is required if they are used for mating disruption and in combination with insecticides but not if they are used as baits in traps

SUMMARY

Sex pheromones have found wide application in pest management programs in agriculture, forestry, and stored products Their principal use is as baits in traps. Pheromone traps are used in insect surveys for detection of exotic pest species and for monitoring the spread of established pests. They also provide valuable information on the seasonal activity and on the need for control of many pest species of economic importance. Monitoring with pheromone traps has become an essential part of many pest management programs, has helped make insecticide applications more effective, and has contributed to a reduction in overall pesticide use Pheromone traps have also found application for monitoring the development and spread of insecticide resistance. The most promising control application of sex pheromones is the mating disruption technique. This selective control method is now registered against more than 12 pest species in the United States. Mating disruption with sex pheromones is a particularly useful control method in situations where resistance has developed and insecticide use is very high.

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VOICE: Question for Kirk Smith What manner of movement do you expect with the beneficial nematodes in the soil and how does their reproduction take place?

KIRK SMITH: Nematode movement in the soil is pretty complicated. It depends upon soil type, soil moisture, soil temperature, etc. They only move 3 or 4 in. in depth with a surface application. To get around this limitation, immediately following a nematode application we recommend a ¼ to ½ in. irrigation Nematodes will follow the water movement down through the soil strata. They do not tend to move much in the soil horizontally. In nursery situations with 1 to 3 or 5 gal pots one shot is enough to get the nematodes down into the root zone. Application techniques is one area we are studying now.

The nematodes reproduce in the insect hosts. We believe that the beneficial nematodes are best thought of as a biological insecticide. You make the application at the time the insect problem is present in the larval stage. The nematodes will persist for only about 3 or 4 weeks after application and will not kill the insects in the adult stage.

Propagation of Oregon's Rare and Endangered Plants

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The Need to Conserve Native Species. Of the estimated 250,000 different kinds of plants on earth—species, subspecies, and varieties—over one in every ten is threatened with extinction in their wild habitats. Approximately 25,000 of these rare and endangered plants are in the continental United States, Hawaii, and Puerto Rico. The Pacific Northwest has 250 to 300 of them.

In 1984, a national organization called the Center for Plant Conservation (CPC) was formed to use the resources of botanical gardens and arboreta to help conserve rare and endangered native plant species. The Berry Botanic Garden was one of the charter participating institutions for the CPC, and is responsible for the plants of our region, including Oregon, Washington, and northern California. We are joined by 19 other botanic gardens, including the Missouri Botanical Garden, New York Botanical Garden, the University of California at Berkeley Botanical Garden, and the Rancho Santa Ana Botanical Garden in Claremont, California. The mission of the CPC is to use resources of botanic gardens, such as institutional contacts and the knowledge of plant taxonomy and propagation, to conserve plants at risk of extinction in the United States.

At The Berry Botanic Garden, we maintain a Seed Bank for Rare and Endangered Plants of the Pacific Northwest, which was set up in 1983 by a grant from the Meyer Memorial Trust In 1991, we had over 1100 accessions of approximately 250 taxa of rare plants, and well over a million seeds in cold storage. These seeds are meticulously cleaned, counted, dried, and labelled before being stored at 5° F. These standard procedures help conserve them for long periods, perhaps centuries.

Our job, however, just begins with seed storage. If we do not know how to propagate these plants, seed storage itself is an empty exercise. Consequently, much of our effort is aimed towards propagation of rare species. The seeds are stored against the time when they might be needed for re-establishment in the wild. Other possible needs might be research, including horticultural breeding

The Horticultural Merit of Oregon's Rare Plants. Rare species are also of interest to propagators since many of them have horticultural value which a comparison of plants listed as rare or endangered in Oregon and *Hortus Third* shows us. The number of taxa listed in any category of rarity in Oregon includes 572 taxa (species, subspecies or varieties) (Oregon Natural Heritage Program, 1991). Many of these (125) are also candidates for listing under the U.S. Endangered Species Act, or are already listed as "Threatened" or "Endangered." These rare plants of Oregon are in 208 different genera. When compared against *Hortus Third*, I found 109 taxa in both lists, meaning that 19% are of direct horticultural significance. These included 17 endangered or threatened throughout their range, 48 that are rare in Oregon but more common elsewhere, 15 thought to be rare, and 29 on the equivalent of a "Watch List" Of the 208 genera on the total list, 187 or 90% are listed in *Hortus Third*. Another 51 plants listed by subspecies or varieties in the Oregon list were listed to the species level in *Hortus Third*.

The significance is that nearly one fifth of Oregon's rare plants are of horticultural interest on their own merit; most of the rest are related to horticultural species Some of these species are scarce everywhere in nature, and others only at the edge of their ranges here in Oregon. However, all of these have horticultural significance, since rare plants are often found in special habitats, such as alpine areas, making them especially suitable for horticulture Also, plants at the edge of their ranges have characteristics slightly different than the "main population", making them extremely valuable for horticultural breeding and selection of forms that grow under varying soil types and climates. Rare plants are a horticultural resource that we cannot afford to loose

The list includes native members of horticultural genera such as *Allium, Erythronium, Fritillaria, Gentiana, Lewisia, Lilium, Penstemon, Polemonium,* and *Sedum*. Plants of the genus *Lewisia* are perhaps the best known natives, grown by alpine enthusiasts and rock gardeners around the world. They propagate easily from seed, making them a natural for the nursery trade. They are available from many nurseries. Five different kinds of *Lewisia* are listed as rare or endangered in Oregon.

Propagation of Endangered Species at the Berry Garden. We at the Berry Garden propagate plants out of a basic love of plants, and out of our obligation to help conserve the botanic diversity of our entire region To us, it is the biological features of rarity that are important. For example, we are interested in learning to grow some plants to re-establish plants once found in the state of Oregon, but which no longer occur here. *Clintonia andrewsiana* is a native of California and southwest Oregon with bright blue berries each August and September It has been wiped out from the redwood forests in Oregon, and there is some interest in returning the plant as an Oregon native. Also, the very rare golden paintbrush, *Castilleja levisecta,* was once found in Oregon. There has also been interest expressed in re-establishment of this plant now known only from the state of Washington Propagation information is essential if these future projects are to be successful.

We have carried out extensive work already on two species. One is *Stephanomeria malheurensis*, the rarest plant in Oregon. It occurs on land owned by the Bureau of Land Management a few miles south of Burns. It is an annual plant and very near extinction due to a complex set of factors occurring at its single known site. In the first few attempts to germinate seeds of this species, the staff of the Berry Garden had very little success Upon inquiry, we learned that the researcher who had described the plant botanically had also learned its germination requirements (Gottlieb, 1973). It germinates in only a very narrow temperature range of 12 to 20° C in the dark, again pointing the need to know propagation requirements for rare species to carry out conservation work. Under these particular conditions, 85% of seeds germinated in less than 48 hours.

Another species we have worked with is Barrett's penstemon, *Penstemon barrettiae*, known from about 15 sites on rock outcrops in the Columbia River Gorge and tributaries of the Columbia River. One site was at the Bonneville Dam located directly in the path of a planned new navigational lock. Working with the U.S. Corps of Engineers, staff of the Berry Garden took cuttings of every plant that could be reached with a "cherry picker" to establish genetic lines at the Garden Woody penstemons were known to root from cuttings, so it was felt this approach would work Cuttings were chosen because they would generate the exact same population characteristics as the plants already at the site This was important since botanists had already observed large variations in the plants from each population, and we felt it was important to maintain this genetic diversity. Unfortunately, differences in ease of propagation also were observed among individual plants, and the offspring from cuttings of some of the plants were lost because they proved to be resistant to establishment; others are surviving quite nicely awaiting the time when they will be re-established close to their original sites Several small populations are already being re-established on an experimental basis.

Propagating endangered plants is, for the most part, not any more difficult than propagating any wild plants, but it is certainly different than propagating most plants in horticulture or agriculture. Wild plants typically have built-in germination controls to help them survive in nature (Phillips, 1985; Young and Young, 1984; Thompson, 1967). Typical germination controls are thick, impermeable seed coats, which require repeated freezing and thawing or abrasion to crack in nature. Other seeds have chemical germination inhibitors in the seed coats or endosperm; in nature these degrade over time, are leached out by water, or require cold temperatures to break down. Some seeds have delayed maturity of the embryos which only time will cure. Suggested treatments include scarification of the seed coat, acid or heat treatment, stratification (cold, moist storage for varying times), and, in some cases, embryo excision

When looking to methods to germinate seeds or rare and endangered native plants, we turn first to the literature on propagating native plants in general. Several overall references are available, including Young and Young (1986) and Phillips (1985) Other sources are specific literature from scientific research.

Seeds of many rare and endangered plants germinate quite easily, and grow in garden settings very well. It is not necessarily the species reproductive system that limits its distribution in nature, but rather its reliance on certain habitats. Seeds of *Plagiobothys hirtus,* known from only one extended population in southern Oregon, germinate readily and grows to profusion in cultivation. Seeds of another species, *Oenothera wolfii,* known from about seven sites in coastal areas of northern California and southern Oregon, germinate without any treatment under standard greenhouse conditions. The silvery phacelia, *Phacelia argentea,* also known from the same coastal region, roots well from cuttings, and sows itself freely in our cold frames. The silvery phacelia is a pioneer on inner coastal sand dunes, binding the sand very well It is threatened in nature by off-road vehicles, grazing, and beach stabilization efforts where it cannot compete.

However, even as there are puzzles for more common native plants, there are problems in germinating seeds of some of the rare and endangered ones A few examples will suffice. Let's return first to the golden paint-brush, *Castilleja levisecta* (St Hilaire, 1987, St. Hilaire, 1988) This beautiful paint-brush shares the characteristic of many other paint-brushes in being a hemi-parasite It relies on a parasitic association with a host plant during at least part of its life cycle in order to survive and grow In the case of the golden paint-brush, we can germinate the seeds An intern at the Berry Garden found that seeds required a minimum of 6 weeks stratification in a refrigerator, resulting in 80 to 87% germination. However, getting the seedlings established is another thing, and we have been unsuccessful to date, even though they have been planted with seeds of possible hosts from its native habitat. We have learned of a native plant enthusiast in Washington State who has maintained a population of this species in her garden for over ten years. The host plants she used were several species native to Australia, certainly not its host in the wild in the Pacific Northwest However, this information may be the key to learning how to propagate this plant for possible reintroduction efforts when we are able to pursue these in the future.

Another puzzle to us in *Howellia aquatilis*, a plant once found in Oregon. Its biology is described by Lesica (1990) in a special report to the U S. Forest Service This species spends its entire life cycle under water, and even blooms and self-pollinates with under-water flowers. It occurs sporadically in very small and isolated populations across the Pacific Northwest states, as far east as Montana. Seeds germinate in September, overwinter in ponds, produce flowers the following spring, and seeds by June. By September, 90% of the seeds from the year's seed crop have germinated. Only 10% are estimated to winter over to the next year. Germination of this species is fairly easy, but seed storage for conservation purposes is not so easy. For a plant that germinates so quickly, there may be little or no dormancy requirements. If there is no dormancy mechanism, we were not sure whether seeds could withstand drying and freezing necessary for seed storage conditions of our seed bank. We are currently testing these in experiments at the Garden in cooperation with the U.S. Fish and Wildlife Service.

A rare species of Washington State, *Hackelia venusta*, is extremely difficult to propagate, the seedlings being highly susceptible to fungal infection. Seed germination was finally obtained by clipping off the end of hard seed coats, treating the seeds and all equipment with a 10% bleach solution, and excising the embryos after they had imbibed water. These were procedures worked out through correspondence with specialists in the genus *Hackelia*. Seedlings died none-the-less shortly after germination. Some limited success was then obtained by using all procedures but not excising the embryos as had worked for other members of the genus.

Fritillaria gentneri had another problem. No seed germination was observed in early trials. This recently described species (Gilkey, 1951) has only a few populations in the wild, the largest being about 250 plants. Upon further examination of seeds, it was found that all examined lacked embryos, which presents some interesting question for its biology and propagation in the wild.

Here, I have attempted to show some of the problems we have encountered, which may (or may not) resemble many of the problems you encounter in your own work. My main point is that rare and endangered plants are, for the most part, like any native plants in their germination and propagation requirements. If we were doing this exercise for horticulture alone, we might not choose to work on the difficult species However, since our work is for conservation purposes to help conserve the botanic diversity of the Pacific Northwest, we work on the biology and reproduction of even the most difficult and obscure species

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Implications of Propagation Techniques on Landscape Performance

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According to its Constitution, the I.P P.S. is made up of people "actively engaged in plant propagation". Many of us could be called plant producers as well as plant propagators But few, if any of us are landscape architects, landscape contractors, or urban foresters. We are concerned with propagating and producing plants, and not with using and maintaining them. Plant propagation, not plant performance, is our interest But the way we propagate a plant can have a long term effect on its ultimate performance in the landscape.

The fact that understock choice affects landscape performance in trees has long been known Budding *Acer rubrum* cultivars onto *A rubrum* seedling understock produces trees which exhibit a 30 to 40% frequency of delayed incompatibility. These incompatible trees snap off cleanly at the bud point, but often not until they reach 3- or 4- inch stem diameter. This problem has been almost eliminated from the nursery trade by propagating *A. rubrum* cultivars on their own roots by cuttings or micropropagation.

Flowering crabapples have been traditionally propagated by budding onto domestic apple seedlings (*Malus pumila* [syn *M. sylvestris*]). In the landscape, unsightly understock suckering is the usual result. We have tested a number of clonal understocks and found that EMLA 111 and EMLA 106 almost completely eliminate the suckering problem These understocks produce a tree of slightly smaller mature size and may induce the tree to fruit more heavily at an earlier age. The early fruiting may cause a slight reduction in caliper growth in the nursery.

Recently, some nurseries have begun producing crabapples on their own roots from softwood cuttings. These plants tend to produce fewer suckers as well, but the long term anchorage, soil adaptability, and disease resistance of these root systems is unknown. Recently, *Malus* 'Red Jewel' has been found to be *Phytophthora* susceptible on its own root, while budded plants have not shown this problem.

Pyrus calleryana cultivars are grown by budding onto a variety of understocks. *Pyrus calleryana* seedlings, *P. ussuriensis* seedlings, 'Bartlett' seedlings and Old Home x Farmingdale clonal rootstocks have been used. Trees budded onto 'Bartlett' seedlings have developed a reputation of being short-lived on the U.S. east coast, but are successful in the Northwest. It is suspected that on the east coast, where fireblight is relatively common, the disease moves into the rootstock and kills it. Old Home x Farmingdale rootstocks are fireblight resistant and generally successful, but we have observed incompatibility of certain combinations when grown under stressful conditions We are still evaluating these for long term landscape success Both *P calleryana* and *P ussuriensis* have been quite successful *Pyrus ussuriensis* is hardier and *P calleryana* has the best proven tolerance of drought, flood and urban conditions. At this point, we choose to use *P. calleryana* seedlings, but continue to evaluate the others.

Amelanchier cultivars are grown by cuttings, micropropagation, and budding onto a number of understocks. I recently examined failing *Amelanchier* sent to us from a customer The *Amelanchier* were purchased from another nursery, which had budded them onto *Sorbus aucuparia*. We have tested this combination and found that the trees are compatible at first, then die within a year or two. Most *Amelanchier* cultivars appear compatible and do well on *Crataegus phaenopyrum*, but each cultivar should be evaluated. Our production is from micropropagation. Although slower growing in the nursery, these plants are successful. Most *Amelanchier* are grown as multi-stem in the landscape Own-root plants have the advantage that their suckers are identical to the desired cultivar.

Flowering cherries can be propagated by softwood cuttings, by budding, or by grafting onto *Prunus avium*. Some cherry cultivars do not root well, but for those that do, own root plants seem to be superior They produce faster growth with a reduced incidence of root rot, although this will probably vary by cultivar.

Some of the most puzzling problems of deciduous landscape plants are due to adult-juvenile phase changes. Most tree cultivars are propagated in the adult phase. Traditional budding and grafting techniques generally perpetuate the phase of the stock plant. The process of micropropagation causes a change toward the juvenile phase In some plants this causes no problem, in some it is beneficial, but in others it creates problems for landscape use

The first instance we documented was in "thornless" cultivars of *Gleditsa triancanthos* propagated by the traditional T-budding technique Although there is certainly a degree of genetic control over thorn production, the phase of the plant is most directly in control. Thorniness is a juvenile condition. Adult growth (branches high on a mature tree) are generally thornless. Heavy pruning and the resulting lush growth can initiate a change toward the juvenile phase. We have found that repeated heavy pruning of scion orchard trees can change these stock trees to the juvenile phase After a number of repeated shearings, trees budded from older scion orchards will begin to produce thorny plants. Like a living oxymoron, as the trees become older they become more juvenile. Table 1 shows the results of scion source on thorniness of 'Skyline' honeylocust whips in two production locations.

Table 1. The effect of shearing and age on thorniness of 'Skyline' honeylocust whips from two production locations

Age scion block (years)	Sunset Farm Whips with thorns (%)
2 (field-grown trees)	10
8	23
10	33
14	41

Age scion block (years)	Independence Farm Whips with thorns (%)
2	0
8	19
10	23
14	26

The most frequent source of phase changes in plants is in those that have been micropropagated. Several years ago, we began trials with micropropagated flowering crabapple cultivars. We had better transplant survival and growth with these than we had experienced with softwood cuttings. We were very happy with them until the trees branched and we took a close look at them. We found a significant percentage of these crabapples were thorny, a condition we had never seen in budded plants (Table 2). At that time, the plants were 4 to 5 years out of culture Thorniness is a juvenile condition in *Malus*. It had been brought on by propagation technique, and it had not gone away. It is unknown how long these plants would maintain the juvenile, thorny state after planting in the landscape.

Table 2. Thorns produced by micropropagated flowering crabapples, 4 to 5 years after leaving the micropropagation lab.

Cultivar	Thorns present (%)	Heavily thorned (%)
Zumi Calocarpa	100	22
Royalty	100	15
Snowdrift	96	10
Radiant	89	9
Spring Snow	34	2
Centurion	20	2

To follow up on this juvenile phase change, I tried an experiment budding *Malus* 'Royalty' from traditional and micropropagated sources onto the same understock (EMLA 111). The one year trees from the two sources are quite different, with the comparison shown in Table 3. Thorns are generally expressed on the branching that occurs the second year after budding. I will evaluate for this next year.

Table 3. Comparison of one year budded *Malus* 'Royalty' from traditional and micropropagated sources on the same understock

Feature	Budded trees	Micropropagated
Height	5 ft	6 ft
Branches	3	9
Branch angle	60°	90°
Branch orientation	45° upward	90° horizontal
Largest leaves	4 in.	3½ in
Spurs	no	yes
Color	purple	less purple
Leaf gloss	glossy	less glossy

The final example of propagation technique influencing landscape performance is in *Betula pendula*. *Betula pendula* 'Youngii' is a weeping plant. If not staked up, a budded plant would grow flat on the ground. It produces a plant with an extremely slender stem that will not support itself until two to three years old.

Micropropagated 'Youngii' trees grow straight and develop strong caliper. I estimate they produce a tree twice as tall with five times the stem caliper in one year in the nursery, when compared to budded plants. This is a great advantage for commercial production. But in the landscape, we observe that these trees continue to produce tall leader growth and do not weep gracefully as we expect from 'Youngii'. However, hard pruning to a downward growing lateral will put an end to the central leader, and by the time the plant reaches 3- to 4-inch stem caliper, it is behaving the way a weeping tree should The weeping habit is a characteristic of the adult phase. It can be restored by a combination of plant size, time, and pruning to a weak lateral branch.

In practice, the landscape performance of trees is governed primarily by the genetics of the cultivar. But in certain plants, the propagation technique used can have an impact for years to come on the plant's form and potential for success. We must look to the landscape occasionally to view the performance of the plants we propagate, then in some cases, take a second look at our propagation technique.

Comparison of Propagation Methods on Red Maple

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When we talk about propagation objectives of red maples, we always have in mind the numbers we want to plant in the field and the quality of seedlings, softwood cuttings, or tissue-culture liners.

We at McGill's Nursery try to start with the best possible plant, so we can dig the best possible product 1 or 2 years down the road.

Besides this, our goal is to have a live tree in every hole Just to give you a little information, we went through our records of many years and came up with the following percentages in comparing budding, softwood cuttings, and tissue-culture plants:

Budding	Loss as seedlings	3%
	Loss when budded	15 to 20%
	Loss to tractors	---
	Culls and incompatibility (incompatibility depended on cultivar and age of trees harvested)	15 to 25%
	Total loss	33 to 48%
Softwood cuttings.	Average loss when planted	10 to 15%
	Loss to tractor damage, culls, and high shanks	20 to 25%
	Total lost	30 to 40%
Tissue-culture plants:	Average loss at planting	5%
	Loss to tractors, culls	10 to 15%
	Total lost	15 to 20%

From this comparison you can understand why we at McGill Nursery are very happy with our red maple tissue culture program.

In the last seven years we have not made a softwood cutting, but we do a little bit of budding once in a while. The reason for this is the tissue culture laboratory is short on a given red maple cultivar.

Our tissue-culture plants are produced by Microplant Nurseries in Gervais, Oregon. Microplant is a joint venture of A McGill & Son and Knollview Nurseries.

At the moment we grow 15 cultivars of red maple from tissue-culture. Our planting season in the greenhouse starts on April 1 and lasts until the end of August. During that period we handle 500,000 little red maples from the tissue culture laboratory; besides these we handle many other plants such as crabapples, birches, cherries, etc.

We usually keep our greenhouses 100% full and I consider the greenhouse a plant factory. It takes from 8 to 10 weeks to produce a field-ready red maple liner

When I have a sizeable number (50 to 60,000) ready for the field, we make a field planting. Thanks to our drip-irrigation system we can make red maple plantings in spring, summer, or fall. The liners are planted by mechanical planter, 12 in. apart and 44-in row spacing. When we receive the little tissue-cultured plants from the lab they are very tender and it is our job in the greenhouse to make it as easy as possible for them to get used to all elements of Mother Nature.

As soon as we unpack the boxes we plant them in plastic tents with intermittent mist to maintain a high humidity. During this process we try to lower the humidity by opening up part of the tent so the little plants can get used to the outside environment. In our tent area we maintain 40% shade

The lab ships us the plants in small plastic containers (30 to 40 plants per container) The planting crew lifts the plantlets out of the containers and plants them in small 1 3/4- × 2-in. deep pots (80 to a flat). When the roots are not too long a planter can plant 5000 plants a day.

The soil mix must be a well-draining soilless greenhouse mix. The mix consists of 50% hemlock bark and 50% Premoist (W.R Grace Product) When I water the plants before planting I add some Benlate and calcium nitrate. The stock mix is 2-lb calcium nitrate and 2-lb Benlate mixed in 2 gal of water and run through a 1:200 Smith Injector.

While growing in the greenhouse some grading is necessary. Without grading, big-leaf plants will shade out the smaller plants and you lose 10% of your crop.

The next move is the transfer from the shade area to the main greenhouse with no shade. This takes a little watching, a little hand-misting for a day, then they are on their own As soon as the plants are outside in the main greenhouse we start a fertilizing program until they are about eight inches tall Then we move them outside and cut the fertilizer off. The plants keep growing till the fertilizer is exhausted and reach a height of about 12 to 16 inches. At that time they have hardened off and are ready for the planter.

The growing of these tissue-cultured plants seems difficult in the beginning, but after you get some experience with them, you never want to go back to softwood cuttings.

Understocks for Rare *Acer* Species

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This short summation of the trials of interspecific grafting represents only about 25% of the almost 200 species of *Acer* (maple). New species are still being identified, especially out of China. These tests were made over a twenty-year period to determine the compatible and acceptable understock for the desired species and/or cultivars of some of the common and rare maples.

Grafting on proper understock is necessary because:

1) Cultivars generally do not come true from seed, cannot be named for the parent, and must be propagated only asexually.

2) Seed from most desirable species is extremely rare, unobtainable, or the germination often may be entirely undependable. Also, many species are quite easily hybridized in open pollination situations found in collections or arboreta.

3) While it is possible to put roots on almost any species or cultivar, these rooted plants often lack vigor and will fail in a period of one to eight or more years. There are exceptions to this within certain species.

Compatible understock is quite specific in most cases. The scion or "bud" may be rejected in one to three or more years if the correct understock is not used even though a graft union may appear successful the first month or so.

For commercial use the understock should have a wide range of adaptability for soils and climate. For example, although *A. circinatum* will accept all cultivars of *A. palmatum* and other related species, it will not grow well in many regions. *Acer palmatum* is very widely adaptable and grafts more readily Understock should be chosen for the ready availability of seed and seedlings. Many species are too rare to consider

A good general rule for selecting understock species is to follow the taxonomic SERIES classification, or certainly choose within the SECTION (Van Gelderen, 1988). Also, there are "milky" sap groups and "non-milky" groups Grafting must be within that character. For example, *A. platanoides* (milky) would be the choice for *A. cappadocicum*, *A. catalpifolium*, *A. lobelii* and their cultivars They would not graft on *A. pseudoplatanus* (non-milky). The reverse would also be true.

Immediately, there are exceptions Occasionally successful grafts are made on distantly related species. *Acer griseum* is difficult to propagate (Fordham, 1969). I have had success using *A. rubrum* for *A. griseum*, *A. triflorum*, and *A. maximowiczianum*. Several of us (Hughes; Cave, personal correspondence) (Vertrees, 1987) have had success using *A buergerianum* for *A. triflorum*, *A. maximowiczianum*, and *A. mandschuricum*; the latter species being very difficult to propagate. Success of these grafts is low (percentage) and limited, but at least is possible

I would caution evaluating interspecific grafts too soon. Incompatibility may not appear for three years or more and rejection may be only partial, giving a constantly weak graft.

The list in Table 1 is far from complete. Many rare species and their cultivars should be tried Other propagators have approached this problem with varying success, and I am sure others will find new successes in various interspecific trials in the future.

Table 1. Species that can be used for interspecific grafting of selected *Acer* species.

Acer scion	*Acer* understock choice
aidzuense	*ginnala, tataricum*
amplum	*platanoides*
buergerianum cvs	*buergerianum*
campbellii	*palmatum*
campestre cvs	*campestre*
capillipes	*davidii*
cappadocicum	*platanoides, campestre*
circinatum cvs	*palmatum*
coreaceum	*pseudoplatanus*
craibianum	*crataegifolium, davidii*
(*creticum*) *sempervirens*	Which see[1]
davidii cvs	*davidii*
diabolicum	*rubrum* (L)
divergens	*campestre*
erianthum	*palmatum* (L)
flabellatum	*palmatum*
forrestii	*davidii*
franchettii	*pseudoplatanus* (P) *rubrum* (L)
fulvescens	*platanoides*
ginnala cvs	*ginnala, tataricum*
griseum	*griseum* (L) *rubrum* (L)
grosseri	*davidii*
heldreichii	*pseudoplatanus*
hookeri	*davidii* (L) *crataegifolium* (L)
hyrcanum	*pseudoplatanus*
ibericum	*campestre* (L) *monspessulanum*
japonicum cvs	*palmatum*
kawakamii	*davidii*
laevigatum	*palmatum*
lobelii	*platanoides*
macrophyllum cvs	*macrophyllum*
mandschuricum	*rubrum* (L) *buergerianum* (L) *griseum* (P)
maximowiczianum (*nikoense*)	*rubrum* (L) *buergerianum* (L) *griseum* (P)
maximowiczii	*davidii*
mayrii	*platanoides*
micranthum	*davidii*
miyabei	*platanoides, campestre*
mono cvs	*truncatum ssp mono, platanoides*
monspessulanum	*campestre*
(*morrisonense*) *rubescens*,	Which see
(*nikoense*) *maximowiczianum*,	Which see
oblongum	*buergerianum*
obtusifolium (*syriacum*)	*campestre*
oliverianum	*palmatum*

Table 1. *Continued*

(*orientale*) *sempervirens*,	Which see
paxii	*buergerianum*
pectinatum	*davidii*
pensylvanicum cvs	*davidii*, *pensylvanicum*
pentaphyllum	*pseudoplatanus*, *saccharinum*, *saccharum*, *rubrum*
platanoides cvs.	*platanoides*
pseudoplatanus cvs.	*pseudoplatanus*
pseudo-sieboldianum cvs	*palmatum*
pycnanthum	*rubrum*
rubescens (*morrisonense*)	*davidii*
rubrum cvs	*rubrum*
rufinerve cvs	*davidii*
saccharinum cvs	*saccharinum*
saccharum cvs	*saccharum*
seminovii	*ginnala*
sempervirens (*orientale*)	*campestre*
shirasawanum cvs	*palmatum*
sieboldianum cvs	*palmatum*
sterculianum	*pseudoplatanus*
(*syriacum*) *obtusifolium*	Which see
takeshimense	*palmatum*
taronense	*davidii*
tataricum	*ginnala*, *tataricum*
tegmentosum	*davidii*
tenuifolium	*palmatum*
triflorum	*rubrum*, *griseum* (P), *buergerianum* (L)
truncatum	*truncatum* ssp *mono*, *platanoides*
turcomanicum	*campestre*
tschonoskii cvs	*davidii*
wardii	*davidii*(L), *palmatum* (L)
wilsonii	*palmatum*

Note
cvs = cultivars of species
(P) = Poor success, (L) = Limited success, worth more testing
[1] which see = see text

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VOICE: This is for Linda. How do you know what procedures or guidelines to use in propagating native plants when you can find nothing in the literature—such as for seed germination?

LINDA McMAHAN: We use some standard, easy germination tests, using a limited number of seeds. We do not have a laboratory yet, so we just try germinating seeds in small quantities in petri dishes under a variety of conditions. Then if these don't work we go to more sophisticated trials.

VOICE: Have you considered using tissue culture with your natives?

LINDA McMAHAN: Yes, we do—mainly as a means of getting rid of any diseases in some kinds of plants. But tissue culture is generally geared to get a lot of plants of one kind, whereas we want to propagate a few plants of a lot of different kinds in our work with the rare plants.

VOICE: Could one of you comment on thorniness in regard to juvenility?

KEITH WARREN: Juvenility is a phase of plant growth, characterized by non-flowering growth and often thorniness There is a period where the change takes place gradually. We don't understand juvenility in plants too well. Plants can move back and forth—we know that—in and out of juvenility, in one direction or the other. Repeated heavy pruning of honeylocust (not tissue-cultured honeylocust) will cause juvenility to return. Plants started from budding or from cuttings in our fields do not have thorns but will flower, whereas the same age tissue-cultured plants do not flower but will have thorns.

VOICE: Will thorns persist permanently in 2-year seedlings trees, especially if there are a lot of thorns?

KEITH WARREN: No If you grow crabapples from seed you will see that there are a good percentage with thorns. 'Snowdrift' probably produced thorns when it was a young seedling. The adult, thornless phase is brought on by slow growing conditions or by being grafted onto a dwarfing rootstock.

VOICE: Why do *Acer* trees fail after so many years when they are on their own roots?

J.D. VERTREES: I don't know—but the root systems are not as strong as those from seedlings They don't have the seedling vigor. Many kinds of plants are like that. Many Asiatic maples on their own roots have poor root systems This is also the opinion of many people over the world who are propagating and growing maples

Harvesting of Bareroot Nursery Plants

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Carlton Plants is currently producing over 500 cultivars of deciduous trees and shrubs. All items are harvested, handled, and delivered as bareroot plants. This creates some unique challenges when it comes to harvesting, storage, and finally, transplanting of our products.

There are many factors that influence the harvesting dates of deciduous trees and shrubs. As an Oregon nursery, we employ several methods for determining the proper digging date to meet both production and sales objectives.

The major factors that influence our decision are: (not necessarily in this order.)

1) General health and condition of the plants.
2) Carbohydrate reserves in the root system.
3) Visual defoliation status of the plants.
4) Field conditions and weather.
5) Requested delivery dates from our customers.
6) Past history of the plants regarding specific digging dates.

In Oregon, we are always anxious to begin harvesting before the fall rains begin. However, we must be patient when it comes to harvesting a live product. Some operations may be successfully manipulated to accommodate our schedules and some may not.

To elaborate on this decision-making process, let's look at each one of the major factors considered and some of the following examples that relates to each.

General Health and Condition of the Plants. This is a very important factor to consider when you are preparing to severely shock the plant materials by lifting them out of the soil and exposing them to handling and dehydration. Plants must be grown properly in the first place to overcome such a shock. An example that would indicate the importance of this factor is *Gleditsia triacanthos* f. *inermis* 'Skyline' and 'Imperial' (Shademaster and Imperial thornless honeylocust). Several of the more popular cultivars of locust, including these two, are subject to a certain canker disease that becomes more severe if the plant is stressed prior to harvesting from lack of moisture or any other form of predisposition. A healthy plant may usually be described as a plant with good color, lustrous leaves, and a regular growth habit.

Carbohydrate Reserves. Starch testing of the roots just prior to lifting has become a method that we are still developing at our nursery. Although it is not as accurate as laboratory techniques such as enzyme assays or gas chromotography, it is a much more practical dormancy assay for use in a nursery setting. The process is simply to collect random root samples from the cultivars to be tested and remove any soil or organic matter by lightly scrubbing the surface. At this point a root cross section is removed and placed on a microscope slide. By applying a very small amount of Lugol's strong iodine solution (available through laboratory chemical supply companies) to the sample and immediately observing this stained section under a low, 10 × 30 power microscope, one can see the stored, carbohydrate filled cells in the phloem, phloem rays, and the pith. With experience one may relate this visual observation to a physical percentage of dormancy. The collection of data based on visual starch contents in the root system prior to harvesting is becoming a part of our evaluation program to determine proper harvest dates.

Visual Defoliation Status. This has been the tried and true method for determining dormancy in our industry for years. Although we no longer rely on this one factor to completely determine our digging dates, we still use it as part of the overall program. A specific example of where starch testing and the visual defoliation status of the plant may give differing results would be in *Fraxinus pennsylvanica* or *F. americana* cultivars (green or white ash cultivars). Cultivars of both species may be deceiving when it comes to defoliation versus dormancy. They have their own schedules that cannot be altered without damage to the plants or reducing transplant percentages. Several years worth of data have shown that in Oregon, when the ash cultivars are 60% defoliated they are usually only about 30% dormant as determined from their stored starch content in the root systems Much of the carbohydrate reserves needed for survival and transplant root regeneration are still moving downwards in the limbs and main trunk of the trees.

Field and Weather Conditions. These are the most uncontrollable factors that influence our digging dates. No matter how much data you have to base your digging dates on, these two can still be the limiting factor in any operation They are the ones to make notes about and learn from for future planning. An example that goes beyond the obvious connotation, such as a piece of equipment that is inoperable due to the field conditions, or a severe freeze during harvest that blackens every cultivar to some degree, could be seen in our *Hydrangea macrophylla* cultivars. We have found that hydrangeas are very brittle. Knowing this, we would not want to harvest them in wet conditions for fear of root damage or breakage.

Delivery Dates. We must be sensitive to the delivery dates that have been requested by our customers. In certain parts of the country, the main spring selling season may come very early or it may come very late compared to ours. When possible, we must schedule our digging to meet the needs of our customers This may mean harvesting certain cultivars prior to physical defoliation and allowing them to complete their dormancy storage requirements in the refrigerated cold storage area. It might also mean keeping them in the cold storage area for an extended period of time and root packing them to retain moisture or using a polymer anti-desiccant to help reduce moisture stress at transplant time We are constantly looking for ways to manipulate the plant materials or our facilities to meet the service requirements of our customers.

Past History. Finally, past history measured by credits and claims is a factor that is also a continual learning process. Not only do we have to be concerned with the factors that influence harvesting, but those that influence transplanting and growth for our customers as well. This information has led to the sharing of techniques, such as forcing of items like *Crataegus* (hawthorn), and *Betula* (birch), to get the plants growing before transplanting or trunk wrapping the *Liriodendron* (tuliptree). This helps us all to be better prepared to handle and transplant our products.

In summary, the harvesting of bareroot trees and shrubs must incorporate all of these factors into the decision making process All participants must be considered: the customer, the plant materials, and the grower.

Effect of Slow-Release Fertilizer Rate on Root and Shoot Growth of Container-Grown *Kalmia latifolia* 'Elf', 'Freckles', and 'Goodrich'

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***Kalmia latifolia* 'Elf', 'Freckles' and 'Goodrich' were transplanted from 1 gal (#1) containers into 3 gal (#3) containers in a fir bark/sphagnum peat medium (4:1, v/v) amended with Micromax at 1.75 lb/yd^3. Osmocote 18-6-12 was topdressed in a split application at the following rates: 0.5 lb N/yd^3, 1.0 lb N/yd^3, and 2.0 lb N/yd^3. Results indicated that growth response to fertilizer rate was cultivar-dependent. 'Elf' shoot and root growth increased with increasing fertility while shoot growth of 'Goodrich' was not increased at the high rate and its root growth decreased as fertility increased. Foliage color of all three cultivars was improved by increasing fertility; however, the flower-bud set decreased as the fertilizer rate increased.**

INTRODUCTION

Mountain laurel, *Kalmia latifolia*, grows native throughout the eastern United States and is known for its showy flowers that open in spring. It is related to the rhododendrons and azaleas Recent introductions of horticulturally-superior cultivars have increased interest in the commercial potential of this shrub. However, the lack of knowledge of mountain laurel's cultural requirements hampers its successful production In general, mountain laurel is considered to have the same cultural requirements as other ericaceous plants with special importance being attached to the need for low fertility, proper drainage, and aeration (Jaynes, 1988; Bir and Bilderback, 1989; Hummel et al., 1990) The shortage of knowledge is particularly acute in the area of container production. Jaynes (1988) indicated that an optimal container medium and fertilizer regime for mountain laurel production is not known. Bir and Bilderback (1989) visited mountain laurel nurseries in the eastern United States, surveyed growers nationwide by telephone, and considered the most recent mountain laurel research from their own and other scientist's programs, and reached the conclusion that "we aren't even close to having all the answers for growing excellent mountain laurel consistently, but with nurserymen and researchers working together we are making progress".

The purpose of the present research was to determine the effect of slow-release fertilizer rate on shoot and root growth and flower bud formation of the mountain laurel cultivars, 'Elf', 'Goodrich' and 'Freckles', grown in three-gallon containers.

MATERIALS AND METHODS

Three mountain laurel cultivars 'Elf', considered easy to grow; 'Freckles' also easy to grow in containers, and 'Goodrich', considered difficult to grow (Bir and Bilderback, 1989; Hummel et al , 1990; Jaynes, 1988) were transplanted the last week of April, 1988, from 1-gal (#1) containers into 3-gal (#3) containers filled with a fir bark/sphagnum peat medium (4:1, v/v). The growing medium was amended by incorporating Micromax micronutrient mix (Sierra Chemical Company, Milpitas, Calif.) at the rate of 1.75 lb/yd³ (1038 g/m³). A slow-release fertilizer, Osmocote 18-6-12 (18N-2 6P-10K, Sierra) was applied by topdressing the containers at the following three rates of nitrogen· 0.5 lb N/yd³ (297 g/m³), 1.0 lb N/yd³ (593 g/m³), and 2 0 lb N/yd³ (1187 g/m³) The fertilizer was topdressed in a split application with 1/2 applied early in the season (May 23, 1988) and the other half applied in midseason (July 15, 1988). Uniform plants were selected for the experiment and each plant was measured at transplant time for an initial height and width. All plants were grown over the summer on a gravel nursery bed and watered according to standard nursery practice with overhead sprinkler irrigation.

November 2, 1988, the Virginia Tech Extraction Method (VTEM, also known as the pour-through method) was used to collect extracts of the growing medium for specific conductivity (soluble salts) and pH measurements (Wright, 1987; Yeager et al., 1983). Beginning November 4, 1988, the following growth and development measurements were made on all plants: *Foliage color* was visually evaluated on a scale of 1 to 5 (1 = brown [dead]—to 5 = deep green colored leaves). *Flower-bud set* was evaluated according to the following 1 to 5 scale: 1=no buds to 5=plant heavily loaded with buds. The height and width of the top growth was measured and later combined into a growth index ([height increase + width increase]/2) Plants were also evaluated for *root growth* visible at the periphery of the root ball. *Root length* was rated from 1 to 5 (1 = no visible roots to 5 = roots circling container bottom) *Root ball density* was rated 1 to 4 (1 = no roots visible to 4 = solid root ball with little soil visible) *Plant dry weight* was measured by severing the stems just above the crown and drying in a drying oven until no additional weight loss was measured.

The experiment was designed as a randomized complete block with 36 replications of each cultivar and fertilizer treatment. VTEM was done on 6 replicates of each cultivar and fertilizer treatment. Analysis of variance (ANOVA) was performed on each cultivar to determine the significance of fertilizer treatments and a Waller-Duncan K-ratio t test was used to make treatment comparisons (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Shoot Growth, Foliage Color and Bud Set. Cultivars were analyzed separately because they have very different growth habits and performance in containers. 'Elf' has a narrow, upright growth habit while 'Freckles' and 'Goodrich' tend to spread. 'Goodrich', as indicated previously (Jaynes, 1988; Bir and Bilderback, 1989; Hummel et al., 1990), was difficult to grow in containers while 'Freckles' and 'Elf' grew more readily.

'Elf' shoot growth, as measured by both dry weight and growth index, and 'Freckles' shoot growth, as measured by dry weight, increased significantly with increasing fertilizer rate (Table 1) Dry weight of 'Goodrich' and growth indices of 'Freckles' and 'Goodrich' were significantly greater when the nitrogen rate was increased from 0 5 to 1.0 lb/yd³, however, growth of these cultivars was not significantly increased at 2.0 lb N/yd³ The shoot growth response of 'Elf' to the high fertility level is most likely a genetic difference related to the fact that 'Elf' is one of the easier cultivars to grow in containers. Bir and Bilderback (1989) surveyed mountain laurel growers throughout the United States concerning which cultivar they "liked best in containers" and found that 'Elf' and 'Carol' were the most often listed as "best". In contrast, 'Goodrich' appeared on the "worst" list.

Table 1. Effect of Osmocote 18-6-12 on growth and development of three-gallon container-grown *Kalmia latifolia* cultivars, 'Elf', 'Freckles' and 'Goodrich'

Fertilizer rate lb N/yd^3	Foliage color[z]	Root length[y]	Root density[x]	Flower buds[w]	Dry weight (gm)	Growth index[v] (cm)
			'Elf'			
2.0	5.0 a[u]	4.4 a	3.9 a	2.7 c	175.7 a	16.0 a
1.0	3.9 b	4.2[x]ab	3.8 a	3.4 b	140.0 b	13.2 b
0.5	3.2 c	4.1 b	3.5 b	3.9 a	97.5 c	7.5 c
			'Freckles'			
2.0	4.8 a	3.9 a	3.2 b	2.4 c	132.9 a	12.6 a
1.0	4.1 b	4.1 a	3.8 a	3.0 b	114.6 b	11.6 a
0.5	3.5 c	3.7 a	3.5 ab	3.8 a	76.4 c	5.3 b
			'Goodrich'			
2.0	4.6 a	3.2 b	2.5 b	2.1 b	85.5 a	8.8 a
1.0	4.2 b	3.6 a	2.6 b	2.9 a	77.2 a	7.8 a
0.5	3.5 c	3.9 a	3.1 a	3.5 a	52.3 b	4.4 b

[z] Foliage color was rated from 1=brown (dead)—to 5=deep green.
[y] Root length was rated from 1=no visible roots—to 5=roots circling container bottom.
[x] Root density was rated from 1=no roots visible—to 4=solid root ball
[w] Flower bud set was rated from 1=no buds—to 5=heavily budded
[v] Growth index = (height increase + width increase)/2.
[u] Numbers within cultivars and columns followed by the same letter are not significantly different at the 5% level using a Waller-Duncan K-ratio t test

Foliage color and flower-bud set results are shown in Table 1. As the nitrogen rate increased, the foliage color rating of all three cultivars increased indicating plants at higher nitrogen rates had darker green leaves. Nitrogen rates had the opposite effect on flower bud set (Table 1). For 'Elf' and 'Freckles', as the nitrogen rate increased, the flower bud rating decreased indicating plants at the higher nitrogen rates had fewer flower buds. Flower bud set of 'Goodrich' was significantly decreased only at the highest, 2.0 lb N/yd^3, rate.

Root Growth. 'Elf' root length rating was greatest at the 2.0 and 1.0 lb N/yd^3 rates; however, the difference between the 1.0 and 0.5 lb N/yd^3 rates was not significant. 'Elf' root density was greatest at the 2.0 and 1.0 lb/yd^3 nitrogen rates. Nitrogen rate had no significant effect on 'Freckles' root length. 'Freckles' root density rating was greater at the 1.0 lb N/yd³ than at the 2 0 lb N/yd³ rate but neither rate was significantly different from the 0.5 lb N/yd³ rate. 'Goodrich' roots were shortest at the 2.0 lb/yd³ nitrogen rate. Root density of 'Goodrich' was greatest in the 0.5 lb N/yd³ treatment. The finding that root growth of 'Elf' was greater at the medium and high fertilizer rates while root growth of 'Freckles' and 'Goodrich' was, in general, greater at the low and medium fertilizer rates is comparable to the shoot growth results for these three cultivars.

Soluble Salts and pH. Fertilizer rate had no effect on pH of 3-gal container-grown 'Elf', 'Freckles' and 'Goodrich' plants in this experiment (Table 2). Although soluble salt levels increased as the fertilizer rate increased, only the 2.0 lb N/yd³ rate was significantly greater than the 0 5 and 1 0 lb N/yd³ rates. VTEM was done at the end of the growing season, November 2, while the fertilizer was applied in split applications on 23 May and 15 July. This may account for the relatively low levels of soluble salts in the VTEM extracts in this experiment. Further research is needed to determine the soluble salt level(s) associated with optimal growth of these mountain laurel cultivars.

Table 2. Effect of Osmocote 18-6-12 on end of season conductivity and pH as determined by the VTEM on three-gallon container-grown *Kalmia latifolia* cultivars 'Elf', 'Goodrich' and 'Freckles'

	'Elf'		'Freckles'		'Goodrich'	
Fertilizer rate lb N/yd³	Conductivity[z] (µS/cm)	pH	Conductivity (µS/cm)	pH	Conductivity (µS/cm)	pH
2 0	182 3 a[y]	4.2 a	213 2 a	4 4 a	254 3 a	4.1 a
1 0	122 3 b	4 0 a	122 3 b	4 3 a	130 3 b	4 1 a
0.5	103 7 b	4 1 a	92 3 b	4 2 a	104 8 b	4 2 a

[z] Soluble salts were extracted from the container by the pour-through (VTEM) method and electrical conductivity of the solution measured with Radiometer, Inc Model CDM80 conductivity meter To convert units in the table from µS/cm to mmho/cm, multiply by 0.001

[y] Numbers within cultivars and columns followed by the same letter are not significantly

When the results of all growth and development parameters for the three mountain laurel cultivars in this experiment are taken into consideration, several conclusions seem warranted. The first, and not unexpected, conclusion is that mountain laurel growth response to fertility is cultivar dependent A cultivar like 'Elf' responded to increasing fertilizer levels and produced more shoot and root growth Shoot growth of a cultivar like 'Goodrich' was not increased at the highest fertilizer rate and root growth of this cultivar decreased with increasing fertility.

In this experiment, foliage color of all three cultivars improved as the fertilizer rate increased; however, the effect of fertilizer on flower-bud set was just the opposite Flower-bud set decreased as fertilizer rate increased. A second, and again not unusual, conclusion is that mountain laurel plants fertilized to produce the maximum vegetative growth and deepest green leaves will likely not produce the greatest number of flowers the next spring. To produce high-quality mountain laurel the grower needs to understand the growth response of each cultivar to container culture, and, if it proves impossible to do all three, the grower may have to determine whether producing rapid growth, a well-developed root system, or flower-covered plants is more desirable

It is essential that researchers and nursery growers continue to work together to develop the information needed to produce high-quality mountain laurel in containers.

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Germination of Madrona Seed

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INTRODUCTION

Nursery plants are propagated by seeds for many reasons (Hartmann and Kester, 1983). One important objective of seedling production is to have uniform germination, emergence, and growth of the seedlings Seed from many commonly grown north and south temperate zone plants often exhibit one or more types of dormancy which may require an after-ripening period in nature, or an artificial chemical/physical manipulation for germination Physiological dormancy is a common dormancy encountered. It is usually broken in nature by a chill period (Dirr and Heuser, 1987; Hartmann and Kester, 1983). Artificially this may sometimes be done with the application of gibberellic acid (Bretzloff and Pellett, 1979) Artificial removal of these various dormancies usually leads to increased and more uniform germination and ultimately results in more uniform plants at sales time. This research was designed to more accurately determine the germination requirements of a native Pacific Northwest plant, the Pacific madrona (*Arbutus menziesii* Pursh).

Arbutus menziesii is a small to medium tree with a geographical distribution from southeastern British Columbia and southern Vancouver Island to southern California on the western side of the Cascade, Coast, and Sierra mountains Growing season precipitation (Apr.-Sept.) varies from 2.5 cm to 100+ cm (1 in. to 40+ in).

The landscape attributes of this evergreen tree include white ericoid, urceolate flowers arranged in panicles in May, showy fruit colored from light orange to crimson, striking exfoliating bark and an excellent tolerance to drought. Throughout its range there is much variation in flower size, fruit color and size, and bark characteristics. The madrona does not tolerate wet conditions nor does it seem to transplant easily. There are isolated stands in the Cascade mountains, well removed from the normal range, the clones of which may prove to be hardier

Little is found in the literature on madrona propagation and cultural practices for nursery production. The only reported dormancy of madrona seed is physiological dormancy requiring a chill period (Macdonald, 1990; Schopmeyer, 1974)

The present research was designed first to determine how best to propagate the madrona from seed and then to use the seedlings for research on container production methods, transplant methods, cutting propagation, and hardiness testing.

MATERIALS AND METHODS

Results of preliminary trials at WSU-Puyallup had indicated that madrona seed did need a cold stratification period and that gibberellic acid (GA_3) had little effect on hastening germination (Maleike and Hummel, unpublished data)

An experiment was started in 1988 to compare the germination of half-sibling seed collected from native trees growing at two different geographic locations Fruits were collected from individual trees located on HWY 101 at the southern end of Discovery Bay, Washington (Blyn) and about 16 mi. south of the intersection of HWY 410 and 123 (Cayuse) in the Cascade mountains.

The seeds were separated from the pulp by maceration, flotation, and decantation, and were stored dry at 4°C until used in the experiment. The seeds were sown on a sterile, moistened peat-lite mix in 8.5×13×6 cm plastic containers and given cold-moist stratification periods of 0, 20, 40, 60 and 80 days. The experiment was a 2 x 5 factorial in a completely random design. There were 20 seeds per replication (container) and 5 replications. The experiment was planned so that all the seeds (containers) were placed under the mist at the same time. The mist was on 30 sec every 30 min from 0900 to 1500. Percent germination and mean days to germination were measured. Germination percentages were arc-sine transformed for statistical analysis. Analysis of variance (ANOVA) was performed on the data and the orthogonal polynomial trend comparison procedure (Gomez and Gomez, 1984) was used to evaluate the effect of stratification period on seed germination.

RESULTS AND DISCUSSION

Results of this experiment, in agreement with earlier reports (Macdonald, 1990; Schopmeyer, 1974), indicated madrona seed requires a period of cold stratification (Figure 1). ANOVA of percent germination data indicated the interaction between maternal tree and cold stratification period was significant at the 1% level Analysis of percent germination data for each tree indicated there were significant linear and quadratic effects (1% level) for cold stratification treatment in both Blyn and Cayuse. Germination percentage increased with increasing time in cold stratification up to 60 days (Figure 1). After 60 days there was a decline in percentage germination with both seed sources. While the seeds of trees of both provenance sources exhibited increased germination percentage with increasing time in cold stratification up to 60 days, the seeds from Blyn (the tree from sea level elevation) reached maximum germination at both 40 and 60 days. The seeds from the tree from the higher elevation in the Cascades, Cayuse, reached their highest germination percentage at 60 days of cold. Percent germination of Blyn and Cayuse seed was not significantly different at 0 and 60 days of cold stratification.

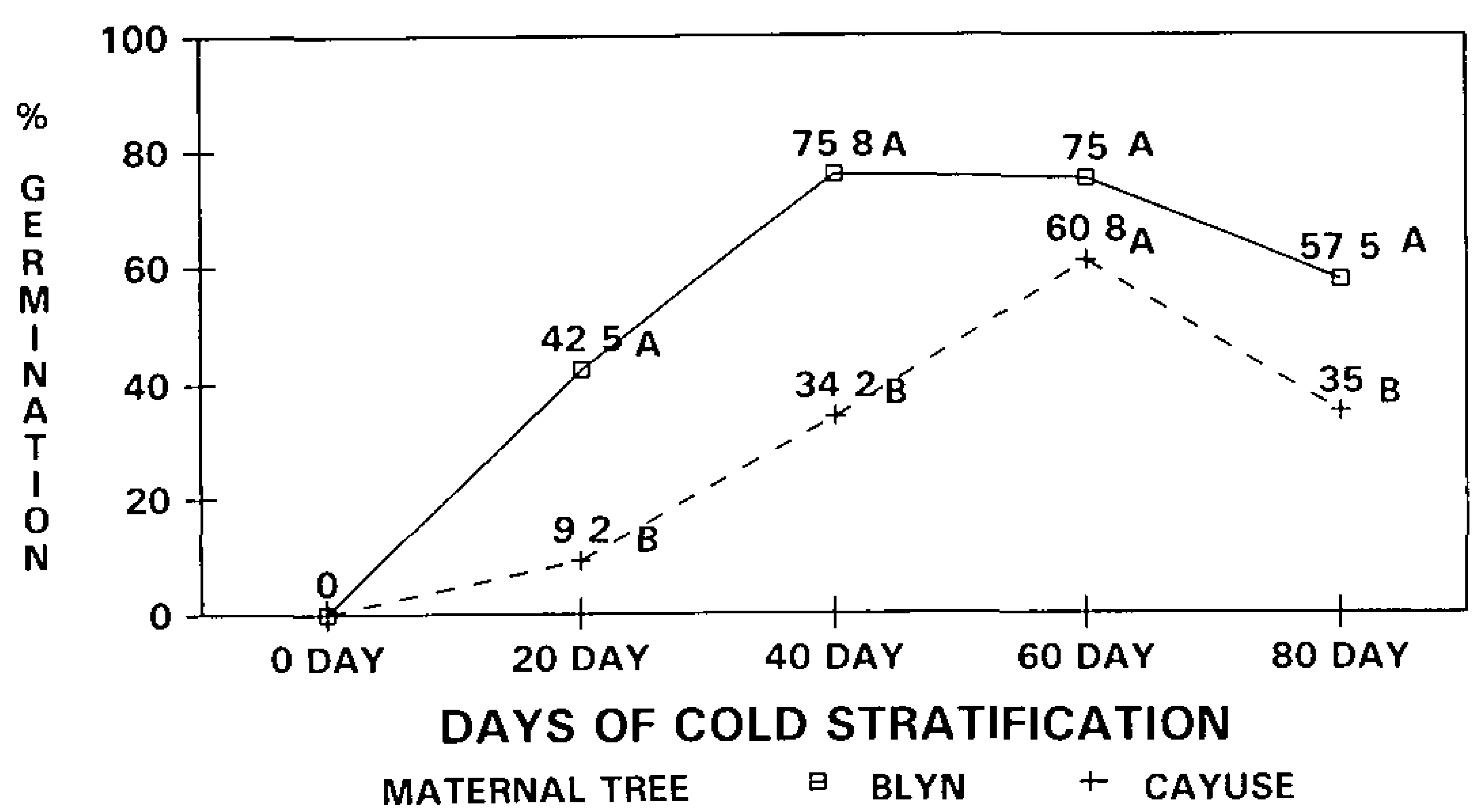

Figure 1. Effect of cold stratification on germination percentage of madrona seed collected from trees growing at two different geographic locations Means within cold stratification day followed by the same letter are not significantly different at the 1% level.

However, the differences were significant (1% level) at 20, 40 and 80 days with Cayuse having a lower germination percentage than Blyn.

Mean days to germination (Hartmann and Kester, 1983) is an indicator of the degree of uniformity of seed germination. The longer the average time to germination, the greater will be the size (age) difference between the seedlings Results of ANOVA of mean days to germination data indicated the interaction between maternal tree and cold stratification and the main effect of maternal tree were not significant. Linear and quadratic effects of cold stratification on mean days to germination were significant at the 1% level (Figure 2). The mean days to germination of the madrona seedlings from both trees was similar with the fastest germination occurring after 60 and 80 days of cold treatment (Figure 2).

This research shows that uniform seedlings of madrona can be obtained quickly

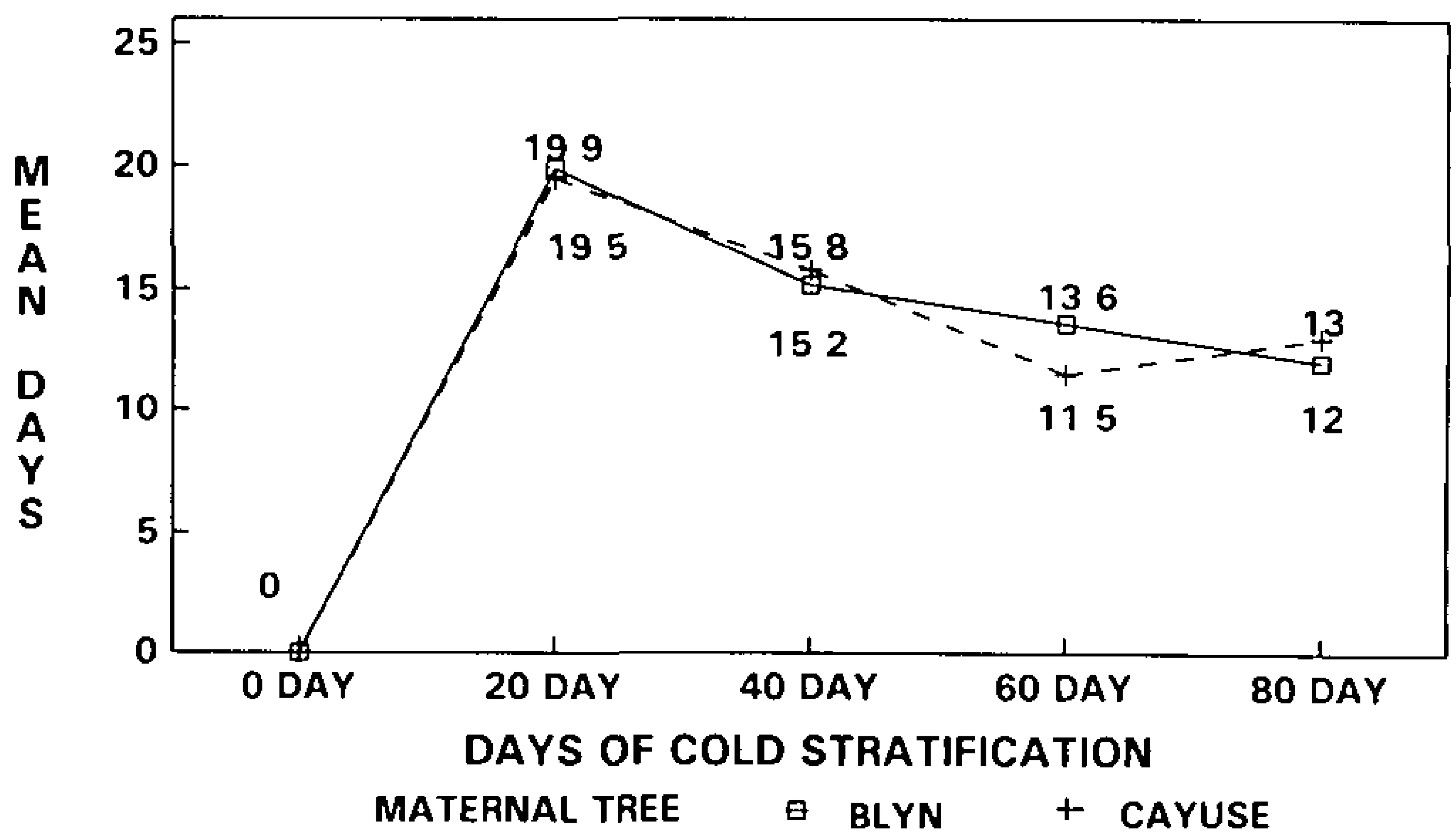

Figure 2. Effect of cold stratification on mean days to germination of madrona seed collected from trees growing at two different geographic locations

if the seeds are given a 60 day cold period before germination. Madrona seedlings are similar to seedlings of rhododendron, azalea, *Kalmia, Pieris* and other ericaceous plants in size at germination; however they develop more rapidly than those of some of the other family members. If the seed are germinated in mid-to late-winter inside, a sizable # 1 (1 gal) plant may be obtained by the second growing season.

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Germination of *Cornus canadensis* Seed

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INTRODUCTION

Cornus canadensis (bunchberry or dwarf cornel) is a Pacific Northwest native perennial that attains a height of 7 to 20+ cm (3 to 9+ in) and spreads by subsurface stems Bunchberry ranges from Greenland across northern Canada to Alaska and as far south as Maryland, South Dakota, New Mexico and California (Dirr 1990; Schopmeyer, 1974). This low-growing, herbaceous plant generally grows best in moist, shady areas but tolerates drier shady areas also. It has few pest problems.

Bunchberry flowers are small, greenish-white terminal clusters, subtended by four showy white bracts borne in a fashion similar to *Cornus florida* and *C. kousa*. The fruits are 1/4 in. scarlet clusters of drupes, ripening in August and continuing to be effective into the winter. Autumn color is light red to crimson.

Propagation has been by digging mats of the material, seed, and more recently, by tissue culture (Dirr and Heuser, 1987; McMillan-Browse, 1979; Bruce Briggs, Briggs Nursery, Olympia, Washington, personal communication) Propagation of bunchberry by seed seems to be the method of choice for the small grower It has been reported that the seed has a double dormancy in this species caused by a physiologically dormant embryo and a hard impenetrable endocarp (Schopmeyer, 1974). The hard seed coat normally delays germination until the second spring after maturity (McMillan-Browse, 1979), but germination may be enhanced by a sulfuric acid treatment followed by cold stratification, or 3 to 5 months warm stratification followed by 3 months of cold (Dirr and Heuser, 1987, McMillan-Browse, 1979).

Seed coat dormancy occurs when the seed coat is impermeable to water or gas exchange, or when the seed coat offers mechanical resistance to seedling emergence. In nature, hard seed coats are normally degraded by microbial decomposition (McMillan-Browse, 1979). Artificially the seed coat may be softened, eliminated, or rendered ineffective by hot water, concentrated sulfuric acid, mechanical scratching, mechanical removal, or warm-moist stratification (microbial decomposition). Warm-moist stratification is also used to mature a rudimentary embryo (Dirr and Heuser, 1987; Hartmann and Kester, 1983). Physiologically dormant embryos may be induced to germinate by cold-moist stratification, or by soaking in a gibberellic acid (GA_3) solution (Hartmann and Kester, 1983).

Growers in Washington have reported difficulty in germinating bunchberry seed even though the seed was considered viable. This research was designed to determine some of the factors affecting bunchberry seed dormancy and to attempt to use these procedures to afford quick, uniform germination in nursery practice

MATERIALS AND METHODS

Seeds of *C. canadensis* were collected from a native stand in the Cascade Mountains about 22 miles east of Enumclaw, Washington on the south side of State Route 410. The seed was separated from the pulp by maceration, floatation, and decantation. The floatation and decantation procedure was repeated many times because of the mucilaginous nature of the slurry which resulted from the first maceration. The cleaned seed were stored at 4°C until used.

Seeds were separated into 5 replications of 18 seeds each and sown in a sterile, moistened peat-lite mix in 8 5×13×6 cm plastic containers. A 2×4×2 factorial set of treatments in a completely random design was applied as follows: scarification in concentrated sulfuric acid for 0 or 30 min; 24 hour gibberellic acid (GA_3) soak at 0, 100, 500, or 900 ppm, and cold, moist stratification at 2 to 4°C for 60 or 120 days. All treatments were put under mist on 18 July, 1986. The mist was on from 0900 to 1500 every 30 min for 30 sec. Percent germination and mean days to germination were recorded. Germination percentages were arc-sine transformed for statistical analysis. Analysis of variance (ANOVA) was performed on the data (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

ANOVA results for germination percentage and mean days to germination indicated both two and three factor interactions were significant. Because of this, ANOVA was done by factor for each of the three factors in this experiment. When the F-test was significant, a t-test was used to compare GA_3 treatments. In general, treating bunchberry seed with GA_3 enhanced percent germination (Table 1). Within a GA_3 treatment and a cold stratification treatment, sulfuric acid had either no significant effect or decreased germination percentage The difference in germination percentage between the 120 day and 60 day cold with 30 min acid scarification was significant; however, with no acid scarification, the cold treatment difference was significant only in the 100 ppm GA_3 treatment.

Table 1. Effect of cold stratification, sulfuric acid scarification, and gibberellic acid (GA_3) on the germination percentage of bunchberry seed

	60 day cold		120 day cold		0 min acid[y]	30 min acid
	0 min	30 min	0 min	30 min	120-60 cold	120-60 cold
0 GA_3	26 7 a A[z]	0 0 a B	18 8 a A	4 5 a B	- 7 9 NS	4 5*
100 GA_3	21 1 a A	8 9 b A	40 0 b A	50 0 b A	18 9*	41 1**
500 GA_3	35 6 a A	24 4 c A	46 6 b A	45 6 b A	11 0 NS	21 2**
900 GA_3	41 1 a A	26 7 c A	47 8 b A	46 9 b A	6 7 NS	20 2*

[z] Means within columns followed by the same lower case letter are not significantly different at the 5% level, and means between sulfuric acid times within cold periods and GA_3 treatments followed by the same uppercase letter are not significantly different at the 5% level according to F-values and t-tests

[y] In the last 2 columns, the effect of cold treatment within sulfuric acid and GA_3 treatment is presented as the difference between the 120 day cold and the 60 day cold treatment means (120-60 cold) and the significance of the cold treatment is indicated as follows

** = significance at the 1% level, * = significance at the 5% level, NS = not significant

Mean days to germination (Hartmann and Kester, 1983) is an indicator of uniformity of germination. The longer the mean days to germination, the greater will be the size (age) difference between the seedlings. At the 100, 500 and 900 ppm

GA_3 levels in the 120 day cold treatment, sulfuric acid scarification decreased mean days to germination (Table 2).

Table 2. Effect of cold stratification, sulfuric acid scarification, and gibberellic acid (GA_3) on the germination percentage of bunchberry seed.

	60 day cold		120 day cold		0 min acid[y]	30 min acid
	0 min	30 min	0 min	30 min	120-60 cold	120-60 cold
0 GA_3	19 8 a A[z]	0.0 a B	15 8 a A	12 0 a A	- 4 0 NS	12 0*
100 GA_3	18.7 a A	14 2 b A	15.9 a A	12 9 a B	-2 8 NS	-1 3 NS
500 GA_3	16 5 a A	14 0 c A	15 3 a A	6 8 a B	-1 2 NS	-7.2**
900 GA_3	14 9 a A	13 5 c A	13 1 a A	6.0 a B	-1 8 NS	-7 5**

[z] Means within columns followed by the same lower case letter are not significantly different at the 5% level, and means between sulfuric acid times within cold periods and GA_3 treatments followed by the same uppercase letter are not significantly different at the 5% level according to F-values and t-tests

[y] In the last 2 columns, the effect of cold treatment within sulfuric acid and GA_3 treatment is presented as the difference between the 120 day cold and the 60 day cold treatment means (120-60 cold) and the significance of the cold treatment is indicated as follows

** = significance at the 1% level, * = significance at the 5% level, NS = not significant

Cornus canadensis seed germination was enhanced by 120 days cold stratification The necessity of using sulfuric acid is questionable; however, it did reduce mean days to germination when used in conjunction with GA_3 and 120 days of cold stratification. *Cornus canadensis* has a physiologically dormant seed, but the role of the seed coat in germination needs further investigation.

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STEVE ADAMSON: Ray — what time of year did you collect your madrone seed and how did you clean the seed?

RAY MALEIKE: The seed was collected in early October We cleaned it in a Waring blender with the blades covered with Tygon tubing. This beat and macerated the pulp so the seeds could come out. By mixing, flotation, and decanting with water we got the pulp off and the seed would sink We would do the same thing with *Cornus canadensis* seed

VOICE: Did you have any problems with the seed germinating during the cleaning process?

RAY MALEIKE: We did not have any seed germination during cleaning, storage, or stratification. We stored the seed in plastic bags at 4° C. The seed would start germinating after about 3 days when they were brought out into warm conditions.

VOICE: What was your medium for growing the madrone seedlings?

RAY MALEIKE: Ground bark with a little sand in it. We just grew them along with the rhododendrons, azaleas, etc. We transplanted the seedlings at the second or third true leaf.

BRUCE BRIGGS: Ray, did you have any problems with fireblight?

RAY MALEIKE: No, we didn't have any problems in the greenhouse with either damping-off or fireblight, but once the plants were out in the field we started seeing some problems there But our soil is a heavy clay loam that does not drain very well, which may partially be the cause of some of these problems.

BRUCE BRIGGS: Question for Rita Hummel Would you comment on blooming in your *Kalmia* plants?

RITA HUMMEL: Some years they bloom heavily as they did this year, but they did not bloom last year in the field. It may be a more or less alternate blooming plant

WILBUR BLUHM: On the Willamette University campus at Salem just south of here they have quite a large planting of *Kalmia* and they have had excellent bloom now two years in a row.

Correlation of Phenolics with Etiolated and Light-Grown Shoots Of *Carpinus betulus* Stock Plants[4]

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Phenolic compounds are believed to play an important role in adventitious root formation, though the mechanism by which phenolics act is still largely unknown. In this study, changes in methanol-extractable phenolic compounds were characterized during the early growth of light-grown shoots and etiolated shoots of *Carpinus betulus* L. 'Fastigiata'. Two dimensional thin-layer chromatography of stem extracts produced twenty-eight fluorescent spots, many of which were tentatively identified as specific phenolics or belonging to a particular class of phenolic compounds. Changes in phenolic compounds were followed for 7 weeks in light-grown shoots or 4 weeks in previously etiolated and then light-grown shoots. Etiolated shoots initially had fewer phenolic compounds, but by the second week of exposure to light had a phenolic composition similar to light grown shoots at week 0. Some of the phenolic compounds in light-grown shoots disappeared after 7 weeks.

INTRODUCTION

European hornbeam (*Carpinus betulus* L.) is a desirable tree for landscape planting Propagation of *C betulus* by seed is inconsistent, and grafting is labor intensive and not always successful. Cutting propagation has proven most reliable, though rooting success varies among cultivars (Dirr and Heuser, 1987). Extensive work on the cutting propagation of *C betulus* 'Fastigiata' has been undertaken by Maynard (Maynard, 1990)

Stockplant etiolation (the exclusion of light) and stem banding during bud break and initial growth of new shoots increase the rooting of *C. betulus* softwood stem cuttings (Maynard, 1990; Maynard and Bassuk, 1987). Maynard (Maynard, 1990) found that rooting percentages of etiolated stem cuttings remained high through 12 weeks of greening while rooting of light-grown stem cuttings decreased rapidly in that time, such that etiolation extended the time for which rooting remained at an acceptable level.

Some phenolic compounds are believed to affect adventitious root formation by preventing the degradation of auxin, by forming auxin-phenol complexes, or by acting as rooting inhibitors (Haissig, 1986; Wilson and Van Staden, 1990). Extractable phenolic compounds have been found to differ between etiolated and light-grown stem tissues (Herman and Hess, 1963; Vieitez and Ballester, 1988), and have been correlated with the success of rooting of stem cuttings

[4] Poster presentation

This study observed the changes in phenolic compounds during the greening of etiolated shoots and growth of light-grown shoots of *C. betulus* 'Fastigiata', and correlated these changes and the rooting potential of cuttings from etiolated versus light-grown stockplants.

MATERIALS AND METHODS

One-year-old ramets of *C betulus* 'Fastigiata' propagated by stem cuttings the previous season and placed in cold storage (5° C) in December, 1989, were removed over a four week period in February, 1990. The plants were repotted into 12.7 cm diameter plastic containers in a medium of 1 sandy loam soil. 1 spaghnum peat:2 perlite (by vol) and grown in a greenhouse with a 31°C day/11°C night temperature regime. At bud break, half of the stock plants were etiolated as described by Maynard and Bassuk (1987). Briefly, plants were placed in a black cloth enclosure until the etiolated shoots reached 4 to 6 cm in length, which took about 7 d, and were then allowed to turn green gradually by exposing the plants to increasing light levels over 7 to 10 d. Shoots from both light-grown and etiolated plants were collected for chemical analysis at weekly intervals, up to week 7 for light-grown plants and week 4 for etiolated plants. Week 0, the start of sampling, was designated as the day the etiolated stockplants were first removed from the black cloth enclosure, and when light-grown shoots were 4 to 6 cm in length. Light-grown shoots were greened from budbreak, and thus exposed to light about 7 d longer than etiolated shoots.

The phenolic compounds of excised stems were extracted twice with 1 ml absolute MeOH (methanol) at 70°C for 10 min. The crude extracts were dried under N_2 and redissolved in 80% MeOH. Fifty mg fresh weight equivalents (FWE) aliquots of each crude extract sample were spotted near one corner of a thin-layer chromatography (TLC) sheet (cellulose without fluorescent indicator, 20 cm × 20 cm, Eastman Kodak #13255, Rochester, NY), and chromatographed in the first dimension using n-butanol acetic acid:H_2O (BAW,4 1:2.2 by vol) and in the second dimension using 15% aqueous acetic acid.

Additional procedures to aid in the identification of phenolic compounds used stems from light-grown stockplants collected from weeks 0 and 3 Acid hydrolysis (Ribereau-Gayon, 1972) allowed for the identification of free phenolic acids (aglycones). After MeOH extraction, a 100 mg FWE sample was hydrolyzed in 1 ml 2N HCl for 45 min at 95°C Aglycones were taken up in excess diethyl ether, dried under N_2, redissolved in 80% MeOH and chromatographed two dimensionally (2-D) in BAW and 15% acetic acid or 2-D in BAW and Forestal (acetic acid: H^2O:HCl, 30:3:10 by vol). A procedure described by Steck (1967) was used for the separation and identification of free forms of caffeic, p-coumaric, and ferulic acid and their derivatives, which behave similarly in common chromatography solvents.

Phenolics on the chromatograms were examined under ultraviolet (UV) light and were then fumed with ammonia (NH_3) and examined under UV or white light to note color changes characteristic of certain classes of phenolic compounds (Harborne, 1984; Ribereau-Gayon, 1972). For comparison, phenolic standards were chromatographed and evaluated by the same methods used for extracted material.

Relative concentrations of phenylalanine and tyrosine were compared between etiolated and light-grown tissues at the onset of the experiment using 50 mg FWE samples spotted on Whatman 3MM chromatography paper and co-chromatographed (1-D in BAW) with the corresponding standards These chromatograms were then sprayed with ninhydrin and heated for 3 min at 105° C.

RESULTS AND DISCUSSION

The 2-D chromatographic separation of methanol extracts from *C. betulus* shoots (in BAW and 15% acetic acid) consistently yielded a pattern of up to 28 spots which varied in quantity and intensity over the first 4 weeks of greening etiolated and first 7 weeks of light-grown shoot growth (Figure 1). In the first two weeks, fewer phenolic compounds were present in extracts of greening etiolated shoots than of light-grown shoots. Phenylalanine, the major precursor to phenolic synthesis, was present in visually detectable levels on the chromatogram of extracts of etiolated shoots at the end of the etiolation treatment (before greening, week 0), but not in light-grown material. Not until the second week of greening (3 weeks after

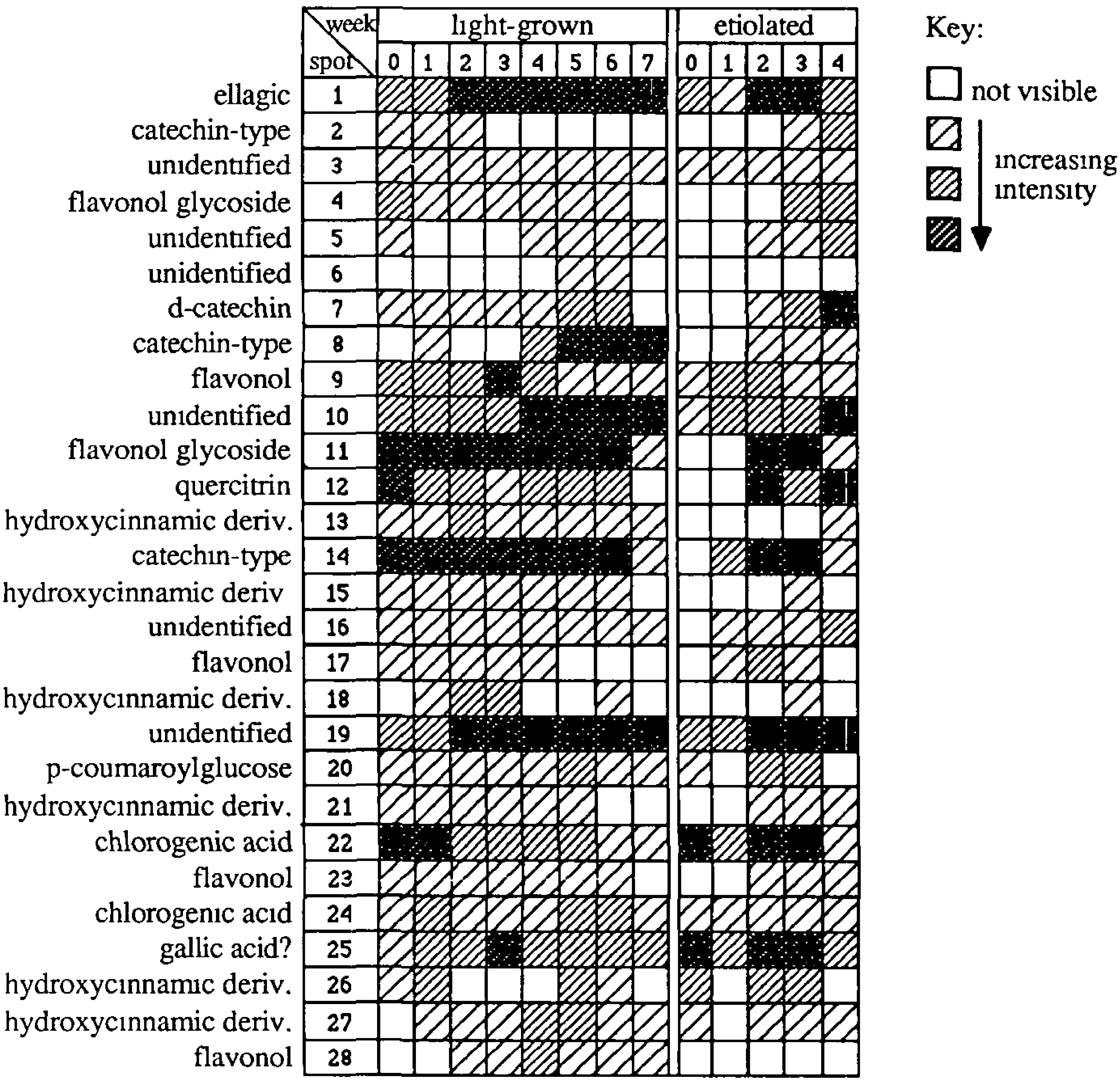

Figure 1. Relative intensities of the compounds separated by two-dimensional chromatography of methanol extracts of *C betulus* stem segments.

budbreak) was the pattern of spots from extracts of etiolated shoots similar, in intensity or number of compounds separated, to that of light-grown shoots at week 0. Phenolic compounds in light-grown material began to decrease in number and intensity by week 7. Several compounds (such as #1, #3, #19, and #22) were present in extracts of light-grown and etiolated shoots at week 0.

Several of the compounds were tentatively identified (summarized in Table 1) by comparing their colors and R_fs to phenolic standards and published data Identities of several of the classes of different phenolic compounds (ie. flavonols, catechins, and hydroxycinnamic acids) were speculated based on the fact that the

Table 1: Tentative identification and characteristics of compounds from separated crude extracts of *C betulus* shoots

TLC spot #	Tentative identification	R_f BAW	R_f 15% AA	Source/procedure for identification
1	ellagic acid	30	02	B
2	catechin type	50	05	A
3	unidentified	.47	16	-
4	flavonol glycoside	54	22	2, A, C
5	unidentified	80	12	-
6	unidentified	73	21	-
7	d-catechin	64	34	B
8	catechin type	37	.32	A
9	flavonol type	37	39	2, A, C
10	unidentified	62	40	-
11	flavonol glycoside	71	41	2, A, C
12	quercitrin	81	44	2, B, C
13	hydroxycinnamic derivative	.78	47	2, 3, A, C
14	catechol	89	47	B
15	hydroxycinnamic derivative	87	51	2, 3, A, C
16	unidentified	58	51	-
17	flavonol type	67	54	2, A, C
18	hydroxycinnamic derivative	.45	62	2, 3, A, C
19	unidentified	63	65	-
20	p-coumaroylglucose	.75	64	1, 4, B
21	hydroxycinnamic derivative	81	69	2, 3, A, C
22	trans-chlorogenic acid	69	70	1, 4, B
23	flavonol type	81	78	2, A, C
24	cis-chlorogenic acid	.68	80	1, 4, B
25	gallic acid conjugate	37	80	A, C
26	hydroxycinnamic derivative	83	86	2, 3, A, C
27	hydroxycinnamic derivative	62	87	2, 3, A, C
28	flavonol type	27	80	2, A, C

Key to sources / procedures

1 - Challice and Williams, 1966
2 - Harborne, 1984
3 - Ribereau-Gayon, 1972
4 - Steck, 1967

A - color characteristics under UV and after fuming with NH_3
B - comparisons with standards (R_f and color changes)
C - comparison to identified products of acid hydrolysis

colors of aglycones (standards) and their derivatives are often similar, even though their relative mobilities are usually different. Several aglycones which have been previously identified in *C. betulus* (Bate-Smith, 1962), including myricetin, quercetin, and kaempferol (three flavonols commonly found in plants) and caffeic acid (a hydroxycinnamic acid) were identified after acid hydrolysis of crude extracts. Compounds #3, #5, #6, #10, #16, and #19 were not identified, but were similar to each other in color.

Correlations between these phenolic compounds and their effect on adventitious root formation can be made based on rooting and anatomy data of similar material collected by Maynard (1990). It has been suggested that phenolic compounds may be important in the rooting process by interacting directly with 1H-indole-3-acetic acid (IAA) and the process of adventitious root formation, or by acting as precursors to lignin formation (Haissig, 1986) Hydroxycinnamic acids which are converted to cinnamyl alcohols are important precursors to lignin. Doud and Carlson (1977), Schmidt (1986), and Maynard (1990) each found that etiolated stems were less lignified and contained fewer sclereids than light-grown stems. The formation of sclereids in putative root initiation loci has been correlated with a decrease in the adventitious root formation on cuttings of both *Tilia tomentosa* (Schmidt, 1986) and *C betulus* (Maynard, 1990), presumably by usurping available initiation sites. Maynard (1990) found that the xylem of light-grown *C. betulus* shoots sampled 7 to 14 d after budbreak was becoming lignified and sclereids were forming, whereas it was not until 4 to 6 weeks of greening that substantial lignification began to occur in initially etiolated shoots. Hydroxycinnamic acids were present in light-grown shoots at week 0, about 7 d after budbreak, but did not appear in initially etiolated shoots until 2 to 3 weeks of greening. This lag in hydroxycinnamic acid production seems to correlate well with the lag in lignin formation in initially etiolated shoots, and speculates a possible role these hydroxycinnamic acids might play in the formation of lignin and the ability of cuttings from etiolated stockplants to have a higher success of rooting for a longer period of time than light-grown stockplants. The disappearance of hydroxycinnamic acids in light-grown shoots by week 7 might represent their incorporation into lignin or other secondary plant products

Overall, there were few direct correlations of the presence or absence of phenolic compounds and the success of rooting. The complement of phenolics present in etiolated shoots at week 2 was similar to the phenolics present in light-grown shoots at week 0. The success of rooting was nearly identical for both light-grown and etiolated stem cuttings at week 2 (87.5% and 90.5%, respectively). However, by week 6 in light-grown shoots, when most phenolics were still similar to week 2, rooting of light-grown shoots had decreased to 50%.

It has been proposed that the presence or absence of specific phenolic compounds may have a profound effect on the rate of success of adventitious root formation, by acting either as rooting promoters or as rooting inhibitors. Ortho-dihydroxyphenolics are generally regarded as being more effective than other phenolics in inhibiting the oxidation and destruction of IAA by the auxin oxidase complex (Haissig, 1986; Wilson and Van Staden, 1990). Chlorogenic acid, a common plant o-dihydroxyphenolic, was present early in the growth of both light-grown and etiolated *C. betulus* shoots, and decreased in light-grown shoots at a time when rooting success was also decreasing (week 6, 50% rooting). Several of the compounds identified as possibly being flavonols or hydroxycinnamic acids (which may also be o-dihydroxyphenolics) followed similar patterns Ellagic acid derivatives may be rooting inhibitors of cuttings from light-grown chestnut (*Castanea*) stockplants (Vieitez and Ballester, 1988) In this study ellagic acid (compound #1) was present in both etiolated and light-grown shoots, and did not correlate well with rooting success.

The most apparent effect of light during new shoot growth was the lag in phenolic compound production in previously etiolated shoots relative to light-grown shoots sampled at a similar time period. The changes in phenolic compounds in both greening etiolated and light-grown tissues paralleled the anatomical changes noted by Maynard (1990). The correlations between the changes in phenolic compounds observed in this study and the changes in rooting potential and stem anatomy observed by Maynard (1990) suggests a need for further research to examine the activity of phenolic compounds in both etiolated and light-grown plant material.

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Fertigation and Nitrogen Movement in Field Nurseries

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INTRODUCTION

Water use efficiency and nutrient movement are among the most important factors facing nurserymen. Soil loss due to erosion can be reduced by 92% (Cripps and Bates, 1987) and plant growth increased (Skroch, et al , 1986) by planting ground covers instead of keeping aisles bare.

Nitrogen (N) is the fertilizer element used in greatest quantity by nurseries EPA has set a limit of 10 ppm nitrate-N as the maximum level tolerated in drinking water All North Carolina water has been designated as "highest use - drinking water"; that is, all fresh water for nursery use can legally be claimed for drinking water and must meet the 10 ppm nitrate-N limit. North Carolina nurseries need to: (1) use the most efficient means for irrigating crops, (2) use the least N fertilizer resulting in profitable growth, (3) know whether 10 ppm nitrate-N or more leave the nursery and, (4) adopt practices that limit the runoff potential for nitrate-N.

WATER USE EFFICIENCY

We normally get 42 to 54 in of rainfall per year in Western North Carolina. If rain fell evenly each year, we would not need to irrigate Unfortunately, if we depend upon average rainfall, we cannot grow plants good enough to compete on today's market. Most irrigation is solid-set impact sprinklers with portable pipe for moving systems from field to field. The trend is towards travelling gun irrigation for larger shade tree and conifer growers, mostly because of cost.

These irrigation systems wet everything in the field They effectively activate herbicides and soil-active insecticide They also break tender tissue, knock over newly set transplants and cause erosion if not calibrated properly. We use these systems because we have learned how to make them work on our hilly nurseries, but they do waste valuable water.

Drip or trickle irrigation delivers water at low pressures, usually working at under 15 psi. As a result, smaller, less expensive pumps are needed. Water flows through very small openings in irrigation tubing so any savings in pumps are lost in purchasing water-filtering systems and miles of tubing. Drip irrigation applies water to the soil near plants so that the crop plant gets efficient use of the water and no fertilizer is washed away.

Research The reasons for using drip irrigation instead of overhead irrigation are to use less water or grow a better plant. Currently water is plentiful in Western North Carolina so the switch to drip or trickle irrigation has been slow. We have conducted research on shade trees that indicated flowering dogwood, river birch and linden trees grow faster when irrigated with drip rather than overhead irrigation (Bir and Warren, 1988; Bir and Bonaminio, 1987). In practice, nurseries that are currently using drip irrigation are growing trees in one year less field time than similar nurseries using overhead irrigation

Crop survival once a plant goes to the landscape can also be affected by the type of irrigation used. Our research into drip versus overhead irrigation has shown that with some species a significantly larger number of roots exists inside the harvested rootball of B&B trees when they are grown under drip instead of overhead irrigation (Bir and Warren, 1988).

Conclusion. Drip irrigation can be used to grow larger B&B shade trees with more roots using less water.

FERTIGATION

A grower using drip or trickle irrigation has a system that applies water efficiently enough to include fertilizer in the irrigation water (fertigation). Most overhead irrigation systems are too inefficient to economically apply liquid fertilizers because they apply fertilizer to areas where trees will not benefit from it.

Most western North Carolina soils are heavily weathered clays that are highly acidic and low in calcium, magnesium and phosphorous. The most efficient means for applying these elements and correcting soil acidity is to surface apply dolomitic limestone and a source of phosphorous, then mix them thoroughly with the topsoil Only N needs to be surface applied during most crop cycles.

Research. We've found little information available concerning fertigation. As a result, we established experiments comparing surface fertilizer applications and fertigation on flowering dogwood, red maple and mountain laurel We fertilized with standard N.C. Extension recommendation (0.25 oz N per plant the first year plants are in the field, 0.5 oz the second year and 1 0 oz the third year). Granular urea was applied to bare soil in March before vegetative growth began. Fertigation treatments were established so that plants received half, standard and twice the recommended rate of total N per year. Fertilizer N (urea dissolved in water) was applied by injecting into the irrigation system as buds were swelling in the spring and weekly for the next seven weeks (a total of eight applications).

Results varied somewhat by species However, after three seasons of growth, larger plants of each species were produced with fertigation using only half the N used as when topdressing granular fertilizer (Bir, et al , 1991). We attribute this to actually reaching the plants with more fertilizer.

After two years in a similar experiment with eastern hemlock, willow oak, and yellowwood, there is no statistical difference in growth between one-quarter-rate N applied by fertigation and normal rates of granular fertilizer applied to the surface. All plants in this test are drip irrigated.

Conclusions N applied to field nurseries can be reduced by at least one half if plants are drip irrigated and N fed through the irrigation system.

NUTRIENT MOVEMENT

Research. Thanks to a startup grant from the Horticultural Research Institute, we are investigating N movement in three field nurseries. They are located on either sandy loam, clay loam or clay soils in hardiness zones 7 and 8 of western North Carolina. Two nurseries draw water from adjacent streams, applying it either through a traveling gun or solid-set impact irrigation. Their runoff flows to ditches or drain tile then back to the streams The third nursery drip irrigates, drawing water from ponds All runoff returns to these ponds

During 1990 and 1991 we sampled water from these nurseries before they were fertilized, then a day, a week, two weeks and four weeks after fertilizing. Samples were taken from the water supply and where water would return from the nurseries as well as from ditches and drain tiles. In no case did nitrate-N approach concentrations of 10 ppm.

All of these nurseries allow some vegetation to grow between tree rows. Low levels of nitrogen might have been captured by non-crop vegetation within the nursery. However, vegetation is not allowed to grow near nursery stock where the greatest concentration of fertilizer is applied If the level of fertilizer applied is greater than can be used by nursery stock or it leaches deeper into the soil than feeder roots extend, nutrient pollution of the subsoil and, potentially, ground water, could occur.

To evaluate nutrient movement in the soil profile, soil cores to a depth of 5 ft or to water-bearing layers of soil shallower than 5 ft were collected. Soil from each depth was analyzed for ammonium and nitrate-N content. Samples were taken in each of these nurseries before planting and after the first year of production.

Analysis of these samples indicates that nitrate-N levels before planting did not exceed 4 ppm in the top 5 ft of soil. However, levels increased following the first year of fertilizer application at distances of 6 and 18 in. from the base of the tree but did not increase at 36 in. from the tree (Fig. 1). The 6-inch core was taken from a bare soil area, the 18-in. core from the edge of the sod aisle and the 36 in. core from within the sod aisle (Bir and Hoyt, 1991).

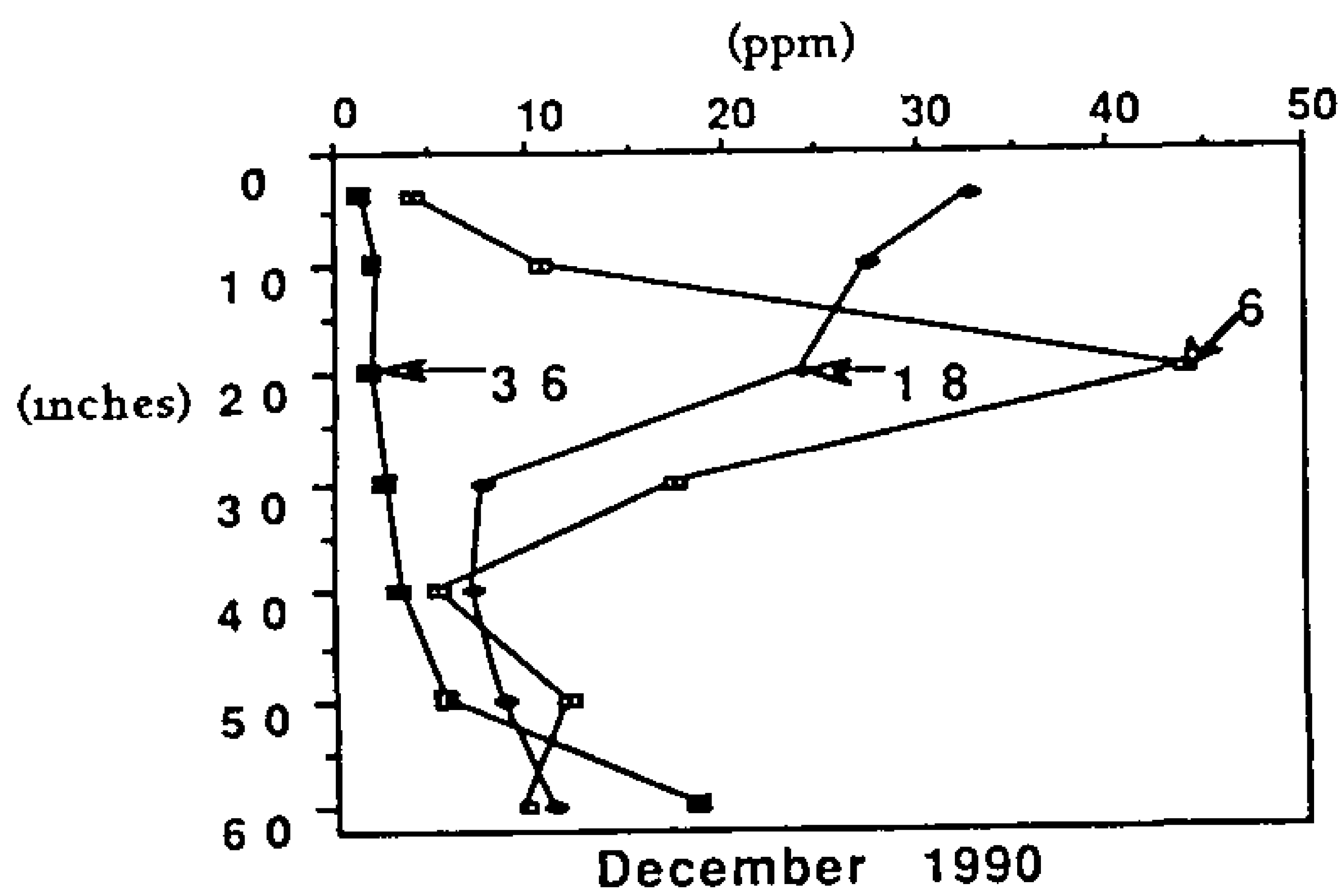

Fig. 1. Soil nitrate-N in cores sampled at 6, 18, and 36 inches from the plant (ppm)

Conclusion. Very preliminary data indicates that field nurseries fertilized at rates not exceeding 150 lb nitrogen per acre may not be causing pollution due to nitrate-N runoff.

Nitrate-N levels are increasing in soils beneath the effective feeding zone of deciduous tree crops in late fall following spring application of nitrogen during the first year of production We will continue to determine whether or not these levels continue to increase.

OVERALL CONCLUSIONS

• Drip irrigation can reduce the amount of water needed to grow some field nursery crops while not reducing plant growth.

• If nitrate pollution is a problem in field nurseries, the amount of N applied can be reduced by fertilizing with drip irrigation without reducing growth

• Nitrates that escape the target crop appear to be captured by sod barriers adjacent to production areas.

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Recycling Runoff Water for Irrigation

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Container nurseries are facing one of the biggest challenges of their time. Pressures are increasing to utilize resources more effectively and to work in an environmentally sound manner. Water use and containment of fertilizer and pesticide runoff are two of the most critical concerns. Recycling nursery runoff for irrigation provides an effective means for reusing water resources and minimizing runoff of fertilizer or other amendments into the environment.

INTRODUCTION

Hines Nurseries, Inc. is comprised of three wholesale container nurseries located in Santa Ana, California, Vacaville, California; and Houston, Texas. All three sites have recycling systems The system in Houston, Texas, will be discussed as an example of how recycling functions.

COMPONENTS OF THE SYSTEM

Irrigation water is pumped out of one of two wells at the nursery. The largest well feeds a large main reservoir, which has a capacity of 12-million gal. This main reservoir contains water from this well, storm water runoff and recycled irrigation water from the nursery

Water is pumped out of this reservoir by a series of pumps. This water irrigates most of the nursery. All of this irrigation runoff water is channeled through a series of ditches and pump stations, to a central collection or recycle reservoir. Before entering this pond, the water passes through sediment traps to prevent any large debris from entering this reservoir

When the water in this body of water reaches a certain level, dictated by floats in a wet well in a pump station, water is automatically pumped back to the main reservoir. There it is blended with well water, and the process is repeated.

A separate well with a smaller reservoir feeds another section of the nursery which does not ever receive recycled runoff water. Water pumped out of this smaller reservoir flows through piping to mist propagation liner areas, bedding plant production or areas where the grower should have more initial control of fertility and salt levels. All of this runoff water will also eventually find its way to the recycle reservoir, then back to the main reservoir for reuse over the larger part of the nursery

PERMITS AND GUIDELINES

Hines Nurseries in Houston is permitted by the Texas Water Commission to dispose of some reservoir water in the nursery when certain guidelines are met. The permit is fairly involved, but certain key points of interest will indicate how the permit process works.

The nursery is required to collect the first half inch of precipitation from a storm event. The recycle pump stations are equipped with rain gauges, and the pumps cut off after one-half inch of rain has fallen.

A provision in the permit allows for discharging water from the main reservoir. Certain criteria must be met in order to discharge. Flow rates in nearby creeks must be at a certain flow rate resulting from a storm. Additionally, guidelines on reservoir water pH, pesticides and nutrient levels must be observed. Once discharging occurs, the nursery must keep and make correct samplings for a series of tests that the permit spells out.

The nursery must keep monthly self-reporting forms for notification of discharges. We must also keep reports of quarterly pesticide levels for the main reservoir.

Fort Bend Subsidence District, which oversees water use in the local area, requires another permit regulating the amount of water pumped out of the wells

Again, good record keeping on water use is the key to complying with permits such as this. The recycle system greatly increases water-use efficiency and reduces the need to draw continually on these underground sources.

FERTILITY AND WATER QUALITY MANAGEMENT

Fertility monitoring is essential in a recycling system. Liquid feed injectors now must be set to compensate for the amount of fertilizer returned to the reservoir. Several times during the week the technical services department tracks certain key components of the water such as electrical conductivity, pH, and total N.

The primary source of fertility for the nursery is slow-release fertilizer, which is incorporated into the growing media. A percentage of this is leached from the containers and returns to the main reservoir. Adjustments are then made manually at the fertilizer-injector station to realign the fertility for field irrigation water The amounts vary with the time of year Temperature, rainfall, and initial liquid-feed settings will all affect the fertility levels wanted in the main reservoir.

With proper monitoring of water quality, a recycling system can greatly reduce the liquid feed a container nursery normally would require.

CONCLUSION

A recycling system benefits a container nursery by capturing water and fertilizer for reuse By complying with containment regulations, the nursery is also helping maintain the quality of the surrounding environment.

Environment-Friendly Plant Production System: The Closed, Insulated Pallet[1]

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The Closed, Insulated Pallet System (CIPS) conserves resources. Plastic mulch, rigid plastic containers, poly for overwintering, fumigation covers and herbicides can be eliminated; fertilizer and water inputs can be reduced by 80% to 90% by conversion to CIPS. Benefits of CIPS include: environmental effects of production are reduced or eliminated, productivity is increased, differential costs of production are comparable or less than in conventional systems, marginal or non-productive land can be used, and labor conditions and labor efficiency are enhanced.

INTRODUCTION

Greenhouse and nursery growers require new production technology to meet current multiple challenges. Challenges include: (1) elimination of production-related pollution, such as waste water discharge and aerial drift; (2) reduction and conservation of energy, chemical, soil and water resources; (3) elimination of marked seasonal fluctuation in labor, and total annual labor requirement through palletization and mechanization, (4) effective integration of biological controls, beneficial microorganisms and provision of plant production environment to enhance plants' ability to withstand pathogens and insects; (5) prevention of temperature extremes and rapid temperature fluctuations in the plant-root environment; (6) more efficient plant shipping and handling. The new closed, insulated pallet system designed to meet these challenges is a buffered, plant-driven system with high-use efficiency of resource inputs and no waste discharge from the system. CIPS is being developed and evaluated by an interdisciplinary research team from Oregon State University; Oregon Graduate Institute; USDA Horticulture Crops Research Laboratory; the Ohio State University; the Boskoop Nursery Stock Research Station, BIOSYS, and Briggs Nursery, Inc.

A number of approaches have been evaluated to reduce the amount and composition of runoff water from nursery and greenhouse production areas including: (1) collecting and recycling irrigation/fertigation water, (2) increasing irrigation system efficiency, such as with drip systems, and (3) decreasing fertilizer application rates and improving the timing of applications. Although each of these methods has merit, none takes a comprehensive approach to addressing the many production and environmental challenges facing our industry.

METHODS AND MATERIALS

The pallet is comprised of a base unit (tray) and a top (lid). The top and base define a plant-root compartment Plant-root containers are inserted into the root compartment through holes in the pallet top. A collar sealing to the plant stem(s) and extending and sealing to the pallet top results in an essentially continuous, sealed top (lid) that is moisture impermeable, radiation opaque, radiation reflective and thermally-insulated to prevent moisture and heat exchange between the shoot aerial environment above the pallet lid and the enclosed root chamber. The plant-root environment enclosed within the pallet is isolated from the shoot environment.

The shell of the prototype pallet used in this research is fiberglass with a white gel coat. The pallet top is insulated with two inches of urethane foam within the lid combined with the one inch thick urethane foam board collar and amorphous urethane foam that seals plant stems to the pallet collar-lid. The collar and amorphous urethane foam are covered by reflective, opaque aluminum foil. The sidewalls of the pallet are covered by a perimeter insulating urethane foam board one-inch thick extending from the base of the pallet upward to the lid The bottom of the pallet base is not insulated and is placed in direct contact with the underlying earth to allow conductive heat transfer between the water reservoir in the pallet base and the earth.

In the USDA-SBIR Phase 1 research, each individual rigid, black polyethylene plastic one-gal container was placed in the root compartment in contact with a 6- × 6-inch square base by 9-in. high capillary pedestal of rockwool. However, the plant roots were not contained within the containers, and the rockwool was compressed and heavy when wet. Therefore, in subsequent experiments a pouch basket supporting a cross-shaped capillary mat of Troy Flo-Thru Moisturizing Mat and root pouches have been used. Root pouches, 3-liter volume, of 3-ply polypropylene spunbound-meltdown-spunbound 1.2-1.4 ounces/yard fabric from Kimberly-Clark Corporation had a coating of latex containing copper hydroxide (25-100 grams of copper hydroxide from Griffin Agricultural Chemicals per liter of latex carrier) for root containment and regulation of root growth

Plants and moist medium with uniformly incorporated dolomite or gypsum are placed into the root pouch sitting on the cross-shaped capillary mat within the pouch basket extending beneath the pallet lid. Initially, only irrigation water is applied to the top surface of the medium to establish capillarity; gravitational water is allowed to drain from the pouches leaving only absorptive and capillary water within the medium. Fertilizer is then placed on the top surface of the root medium and the moisture-impermeable collar sealed to the plant stem and to the surrounding lid to create a sealed surface

The pallet lid with sealed-in pouch baskets is transported and placed onto the pallet base. The flaps of the capillary mat drop into the water reservoir within the pallet base. Water moves upward from the pallet reservoir into the medium by adsorption and capillarity. After absorption and capillary equilibrium are achieved, further movement of water upward will be in response to plant uptake to support growth and transpiration. Within the top-sealed root pouch, gravitational and evaporative movement of water does not occur. Therefore, no leaching or convection of fertilizer in solution occurs. Fertilizer ion removal by direct root contact before or after diffusion of ions along chemical gradients is plant driven. Fertilizer ions diffuse along a chemical gradient from the fertilizer reservoir at the top of the medium to the root, movement of fertilizer ions is in response to uptake by the plant roots.

Research and evaluation of materials for CIPS is ongoing.

RESULTS AND DISCUSSION

Thermodynamics and Spectral Characteristics of CIPS[2]. The effects of the rates and extremes of daily and seasonal temperature changes of the two production systems on the survival and growth of 16 woody plant species were evaluated. Data to date indicate very little daily fluctuation of root temperatures within the CIP (closed, insulated pallet) and very slow rates of change of root temperatures within the CIP in response to rapid changes in air temperature.

The spectron SE590 loaned from NASA AMES was used to acquire spectral data The spectrometer has 250 discrete bands across 400 to 1100 namomethers (10^{-9}). The sensor measures the brightness of the plants and pallets. Reflection from plants in individual containers sitting on gravel was approximately 10% of the energy in the visible wave lengths. The covered pallets reflected about 40% of the energy.

Fertilizer and Irrigation Water Dynamics[3]. In CIPS compared with the traditional, overhead sprinkler system (TOSS), plant growth in bark medium was two- to three-fold greater. Fifteen-fold greater plant growth was obtained in CIPS with vermiculite-peat medium than in TOSS with bark medium. Root growth and distribution (horizontal and vertical distribution of roots within the medium) was significantly greater in CIPS than in TOSS Ninety percent less water was used in CIPS compared with the open container, and plant growth (grams fresh weight) was significantly greater in CIPS

Beneficial Microorganisms in CIPS.

A) Bacterial agents[4]. Plant growth was significantly increased in the CIPS by addition of biocontrol bacterial agents. Plant growth in TOSS was not significantly increased by addition of biocontrol bacterial agents. In CIPS, biocontrol bacterial agents significantly increased plant growth (gfw-shoots) in the absence of phytophthora inoculum (66.8 compared with 51.4 gfw).

B) Biocontrol nematode agents[5]. In the traditional, overhead sprinkler-irrigated system (TOSS), the biocontrol nematode was effective with all eight plant species. In the closed, insulated pallet system (CIPS), the biocontrol nematode, *Steinernema carpocapsae*, was effective in only four of the eight plant species, with these four species, the highest efficacy was obtained in *Ilex wilsonii* and *Potentilla.* In CIPS, in the plant root matrix of *Viburnum*, *Amelanchier*, miniature rose and *Chrysanthemum* (= *Dendranthema*, "Florists' chrysanthemums") there were factors that inhibited the survival or efficacy of the biocontrol nematode.

Differential Cost Analysis[6]. Annual costs were hypothesized to vary significantly by system. The following costs were compared: (1) land utilization, (2) surface preparation of production area, (3) mechanization, (4) plant containers, (5) specific labor, (6) fertilizer and pesticides, (7) irrigation water, and (8) annual plant shelter. Based on initial assumptions, the preliminary analysis indicates that the annual costs for the Closed, Insulated Pallet Production System with partial automation are as low as or lower than those for the other five production systems. We are continuing to detail and modify cost analysis of the plant-driven system

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[2] Principal investigators Dr Dale Kirk and Bob Schnekenburger, BioResource Engineers,

Oregon State University; and Dr James Robbins, Gary Briggs and Mark Clark of Briggs Nursery, Inc

[3] Principal investigators Dr James Robbins and Bruce Briggs of Briggs Nursery, Inc; Dr James L Green and Bryan Blackburn of the Horticulture Department, Oregon State University, and Dr Wes Jarrell, Environmental Science and Engineering Dept , Oregon Graduate Institute

[4] Principal investigators Dr Robert Linderman, Plant Pathologist, USDA-ARS Horticulture Crops Research Laboratory, Corvallis, Oregon, Dr James L Green (Hort Dept , Oregon State University, Corvallis, OR 97331; and Dr James Robbins, Briggs Nursery, Inc

[5] Principal investigators Dr Kirk Smith, Senior Entomologist, BIOSYS; Dr J L Green, OSU Hort Dept , and Dr James Robbins, Briggs Nursery, Inc

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Polyethylene Recycling

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The above topic could fill volumes This presentation is not that large, and the following may serve as an outline·

1) We have a problem that will not go away.
2) We have tried several ideas.
3) We have new ideas.
4) We have some ideas for results.

THE PROBLEM

By now, we all know about the problem. Polyethylene is a wonderful material. Many of its attributes make it useful. It is lightweight, durable, and low cost. Those attributes make it hard to get rid of, too.

It floats, making it stay on top of the water when it washes into streams, rivers, and oceans. Sea turtles eat it, birds get tangled in it, and man finds it repulsive in the environment.

And, it is low cost, which makes its collection and recycling less attractive. The majority of plastics that are going to the landfill are doing so because they cannot be recovered at a profit.

Polyethylene recycling bears about as much similarity to soda bottle recycling as aluminum can recycling does to scrap iron It is a different world.

In 1989, about 20 billion lb per year of plastics were estimated to be going into landfills. The EPA said that 25% or 5-billion lb of it should be recycled by 1992. To do so would require at least the following:

1) About 50 recycling facilities with 1-million lb per year capacities. There are only a few that size in the world.

2) About 500 6-inch pelletizing extruders.

3) Hundreds of millions of dollars for capital.

According to the proceedings of the University of Florida Plastics Recycling Fair (1990) if all the reclaimed resin could be converted into products, any one of the following could be done:

1) Converted into 15-lb fence posts, a fence could be zig-zagged across the United States every four miles from the Gulf of Mexico to Canada, every year.

2)A car stop could be made and assigned to every registered vehicle every year in the United States.

3)Each year 625,000 three bedroom homes could be built.

4)A continuous bench could be built down the median of every major interstate highway in the United States every year.

IDEAS WE HAVE TRIED

Post Consumer. Most of the major container manufacturers have tried pilot programs to use post-consumer polyethylene for producing nursery containers. The most successful material is reprocessed pellets from dairy bottles. Wellman, Eaglebrook, and others produce this type of material for resale (Resource Recycling Update). The cost is a few cents more than prime virgin resin (Plastic News), and its main regular use is in multi-layer detergent bottles, which have a center layer of post-consumer resin for promotional reasons, or similar products.

Reprocessed dairy-bottle resin is also used for sheet-vacuum formed nursery pots (Plastic Recycling Update). The alternative material for that process would be virgin dairy-bottle resin. So, the reclaimed resin is competitive for that application. However, for most nursery container production, injection and blow molding, the economics of post-consumer polyethylene are such that the collection, cleaning, drying and reprocessing are more than the material is worth.

To contrast polyethylene with soda bottles consider the following.

Polyethylene	Soda Bottles
Moderate service life (bottles) to "long" service life (films)	Short service life (soda bottles)
Moderate degradation to near total degradation in service	Little degradation in service
Paper labels, glue, tape, present in scrap	Polymer labels, no glue
Dirty, "in weather" handling	Food package handling
No deposit support	Supported by deposit laws
Cost to reclaim about 35¢/lb	Cost to reclaim about 30¢/lb
Virgin resin 35¢/lb	Virgin resin 65¢/lb

Nursery Containers. Recycling nursery containers into nursery containers has been done. Costs of collecting, shipping, grinding, cleaning, and reprocessing with new polymer to maintain quality have made pilot samples very high. No major manufacturer believes recycling nursery containers can be done in quantity without a higher cost in the end product. New EPA standards and permit requirements for wash water will raise the cost even more

Who would pay the costs?

Greenhouse Films. Greenhouse film can be reclaimed and used in injection-molded nursery containers. However, most of the film is low density polyethylene, which is soft. Outdoor growing containers need to be stiff. Therefore, the film produces a less desirable product. A container made from 100% low density film would be as soft as a soft laundry basket. Therefore, only a small percentage in the container is practical.

In a recent pilot project test, a quantity of carefully collected greenhouse film was received in large rolls to test for nursery container production.

Some of the minor problems were the following:

- Tape
- Dirt, rocks
- Chemical residue
- Leaves, sticks, twigs

The major problem was ultraviolet light and oxidation degradation

What we would really would like to do in many cases is to get a maximum service life out of film and them recycle it. However, it may be so degraded that it has no value.

Evidently, most greenhouse film at the end of its service life today is either landfilled, burned, or buried.

Product Recycling no Solution. We need to recognize that recycling is good because it can give us two or more uses for the same raw material. We also need to recognize that product recycling will not reduce disposal in the long run.

If the producers of polymers pour 50 billion pounds of polymer into the huge general market funnel every year, then no matter how many times these polymers run around and around the lip of the funnel as recycled products, they will eventually exit the funnel to some form of disposal

SOME NEW IDEAS

Chemical Recycling. The prospect of chemical recycling is the most interesting development in recycling yet. Regardless of the method used, chemical recycling reduces polymer waste to basic chemical building blocks for reuse as polymers, fuels, or other chemicals

The raw materials are not lost when the polymer goes to disposal. Chemical recycling plants will probably be huge, complex, high volume, and very expensive; but the chemical industry is probably best able to deal with the technology and volumes involved.

The following processes are among those under way:

- *Selective dissolution.* Mixed polymers are dissolved and separated by polymer type, yielding high quality pure polymer (Lynch, 1989).
- *Refinery recycling.* One hundred barrel-per-day refining units produce hydrocarbon products from mixed plastic slurries (Leaversuch).
- *Cracking.* Refinery recycling uses catalytic cracking units like those used for crude oil
- *Prolysis* Polymer waste heated in the absence of oxygen yields oil or gas.
- *Depolymerization.* Chemical breakdown of the polymer chain yields monomers or building blocks for other polymers.
- *Electrokinetic.* An electric arc reduces polymers to industrial gases.

Alternative Fuel. Polyethylene is an excellent candidate as an alternative fuel. Carbon dioxide and water vapor, the combustion byproducts of polyethylene, are the same as those of candle wax. The only impurity would be chemical stabilizers, which are only present in parts per million.

Polyethylene burns very hot and has 18,000 to 19,000 BTUs/lb. No. 6 fuel oil (Bunker "C") has approximately 20,000 BTUs/lb. Natural gas is also a hydrocarbon that burns with carbon dioxide and water vapor as byproducts. It has 60,000 BTUs/lb. In some paper mills, polyethylene is being burned with wood bark to produce steam for electricity.

Soil Disposal In an effort to find an economical method of disposal, some people have made a small particle of highly densified polyethylene containing calcium carbonate for weight and are producing a micronugget shape to blend with soil mix The process is low cost, and additives may be included for water retention, pH adjustment, and fertilization. The calcium carbonate prevents floating

At the present, no tests have been made for soil problems with a polyethylene nugget component, but polyethylene is inert and degradation in the soil would be very slow. Also, dirt, tape, glue, leaves, and twigs would not affect this disposal method.

SUGGESTIONS

Proactive. Be proactive, not reactive. Do not wait for the government to mandate disposal methods Establish a research and development budget. Get a consultant to review the situation in your area. Make a disposal plan.

Focus. Focus on one item as an association or local group. Identify one item and find solutions for disposal of that item (greenhouse film, for example).

Realism Plastics are often less costly than more traditional materials, even if the true disposal costs are included. Be realistic about those costs. There is a real cost to proper recycling and disposal It cannot and should not be ignored The problem will not go away by itself

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Broker/Hauler/Processor
Most plastics, film

Coastal Plastics
Dartmouth, Nova Scotia
(902) 469-8681
Rachael Martin, General Manager
Processor/end user
LDPE grocery sacks

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Innovations In Container Production

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Nursery container plant producers have been struggling with a number of chronic problems since containers were first introduced. A few of these include keeping water available throughout the day and the season, reducing labor requirements, minimizing water runoff, moderating temperature extremes in the root zone of exposed containers and reducing spread of water-borne pathogens. During the past few years several ideas have been tried as possible solutions to these problems.

In-ground containers were discussed at this meeting last year. Since that time a number of nursery producers and researchers throughout the Southeast have tried this idea and are pleased with the early results.

Other innovations have been subirrigation, Environmental Friendly containers, Soil Sock and the Poly-Jacket/Water Saver. Also, growers now seem more interested in automated potting machines.

Over the past two years I have worked with some innovative nursery producers who have developed special containers. During this same time, Dr. Ron Shumack and I were looking at a project that paralleled these individuals' efforts.

Our project was to demonstrate the effects of subirrigation, or collecting leachate in 2-in. saucers at the base of a container, vs. traditional irrigation. The idea was to show the possible detrimental effects of leaving plants in standing water.

However, we discovered that live oaks grown with a constant reservoir of water at the bottom of a container had a significant increase in growth (12.5 ft) over traditional drip irrigation. Shumard oaks showed no difference in either of the treatments (Tilt, et al 1990).

The importance of this finding is that both trees did as well or better in the saucers with a constant reservoir of water. With our current concern for water conservation and reduction of runoff, this was an enlightening observation.

Bob Rigsby, Rigsby Nursery, Fort Myers, Florida saw our article and called to discuss his experience with a similar idea. Rigsby has developed and patented a new container called Environmental Friendly Containers, or EFC His containers have raised holes on the side with no holes at the bottom. This has the same effect of creating a reservoir of water at the base of the container. He has tested the container and has reported the following benefits of EFC over traditional containers.

1) Increased growth
2) Reduced turnover due to increased weight
3) Reduced water requirements and reduced runoff
4) Elimination of rooting out
5) Possible reduction in water-transmitted root-rot fungi
6) Greater shelf life for retail store and reduced maintenance for interiorscapes

Rigsby has evaluated these containers in ground, above ground by themselves and using a container in a container to increase the water reservoir and reduce heat stress.

The "Soil Sock" was developed by Johnny Thomas, a nurseryman in Enterprise, Mississippi. It is a foam liner that fits into a wire basket and reportedly offers the advantages of root pruning, insulation from temperature extremes, ability to plant the entire container, and lower cost than the traditional containers. Fifty- and 100-gal Soil Sock containers sell for about $13 50 and $25, while 50- and 100-gal traditional containers sell for about $32 and $50.

The Soil Sock may possibly be used instead of burlap as the basket liner for B&B plants. Roots grow into the foam liner and are root pruned. When planted, the roots grow through the foam into the surrounding soil. The foam breaks down into a powder over time.

Dan Milbocker (1987) reported on the Low Profile container at the Southern Nurserymen's Association Research Conference A limitation was the problem of building and shipping the wooden boxes used for the containers.

We are currently evaluating these ideas at the Mobile Research Experiment Station using the following treatments· *Containers in saucers of water maintained* at a constant depth of two inches. The 20-gal traditional containers and the Soil Sock containers are part of the sub-irrigation treatment. The EFC container is compared with the subirrigation treatments since there is a two-inch reservoir of water at its base. Drip irrigation is supplied to control plants by Roberts 2-spot spitters (avocado, low-flow) in each container. All containers including the Low Profile container were supplied with an equal amount of medium.

The following information represents one year's data and should not be considered conclusive since the test is still in progress. Data was collected on height and caliper. Temperatures were monitored throughout the experiment.

No differences were found for any of the treatments for Bradford pear. This could be expected since this tree is tolerant of a wide variety of environmental extremes. The pecan had increased height and caliper in all the subirrigation treatments including the EFC container (Table 1). The foam container with traditional drip irrigation had the least growth. The large evaporative surface area may make it difficult to maintain adequate moisture. When the constant reservoir is added, the foam containers perform as well as the others. It appears after one year's data that growth increase is due to the greater availability of water in the three subirrigation treatments

Table 1. Effects of containers and irrigation on growth of pecan trees after one year

	Low profile	Control drip	Control subirr	EFC	Foam drip	Foam subirr
Height (ft)	5 8 bcd[1]	5 7 cd	6 4 ab	6 3 abc	5 4 d	6 6 a
Caliper (in)	1.0 bc	.99 cd	1 15 a	1 13 a	0.92 de	1 1 ab

[1]Means followed by the same letter are not significantly different at the 5% level (DMRT)

Weekly temperature data indicated that the Soil Sock did offer a reduction in extreme summer temperatures over traditional containers but provided no insulation effect against low winter temperatures. Subirrigation treatments also resulted in lower summer temperatures but not as low as the Soil Sock. Average August temperatures were 101°F for the traditional black containers and 96°F for the subirrigation black containers and 91°F for the Soil Sock containers. It has not yet been determined if the reduced temperatures will result in increased growth.

Anderson Die and Manufacturing Company, 2425 S E. Moores St Portland, Oregon 97222, is just now marketing a container called a Poly Jacket. It consists of a thermal cone that snaps into one of two bases, the Water Saver and the Insulator. The cone offers insulation and stability and remains at the nursery when plants are sold The Insulator base keeps the 3-gal container above the saucer while offering insulation from extreme temperatures. The Water Saver base allows the container to sit in one inch of standing water. The 3-gal container is slipped down into the inverted cone, creating a dead air space designed to provide insulation. This container has not been tested, but trials will be set up this fall.

The Poly Jackets cost $2 00 each for quantities from 100 to 200, going down to $1.65 each for numbers over 5,000 According to the manufacturer, the products will last a minimum of five years.

One other exciting trend that has been long overdue is an increased emphasis in automation. Potting machines have been available for the greenhouse industry for several years. Last year two companies introduced potting machines for the nursery industry that will handle at least one-gal and possibly 2 to 3 gal in the near future. Due to the cost, we have not been able to evaluate these machines

The companies making the equipment are Precision Measurements, 553 E Pylon Drive, Raleigh, NC 27607, 919-755-0383, and Universal Fabrications, Hillside, Vinegar Hill, Sandy, Beds SG191PR, England, 0767-680457, Fax 0767-691114. Precision Measurements produces the Air Pruning Transplant System, which requires the use of a bottomless inverted container propagation system to be compatible. Universal Fabricators produces the Fully Automatic Repotting Machine ($50,000-$60,000) that utilizes a cork screw extraction method from standard 4-in. containers

A number of new products and ideas for the nursery industry have been introduced. We need to continue our research with the support and cooperation of the nursery industry The industry should adopt new proven technology as soon as it is available. Not only is competition strong in our own country, competition from imports is a real possibility. Finally, we need to take the lead in adopting practices that help us live up to our projected image of an environmentally responsible Green Industry

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Breaking The Language Barrier

R. Denny Blew
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Our company is called "a miniature United Nations". In our 16 years we at Centerton Nursery have achieved phenomenal growth. The credit must go to our employees, who have represented 11 nations This has enabled us to gain some insight to human barriers.

"What do you see when you look at an immigrant?" Those who consider hiring immigrants see barriers. "What do you see when you look at an immigrant?" The answer to that lies in what you see . . . . . in yourself.

Our international corps developed in an effort to repay a debt, I was once an immigrant. My dad took a job in Ecuador, South America I know what it's like to be thrown into a culture where you don't speak the language—to be the outsider.

There were other Americans in Ecuador I watched them "hermitize", erecting micro-Americas of card clubs and coffee klatches from which they never emerged.

But I was encouraged by my new-found Ecuadorian friends to immerse myself in their society. This I did and received compassion and understanding in return I learned to speak another language, studied a rich culture and stood atop snow-capped mountains. My family dined with presidents and ambassadors. We cultivated friendships that will endure for generations.

These gratuities were available to anyone that did not build a barrier It is a debt that I can never fully repay.

Years later I left my family behind and traveled to the states for my first semester of college. Shortly after, I received a letter from my father In it he said something that I have never forgotten. He said "Son, I'm proud you're my son. And I'm proud of the things you can accomplish. But now you must take the full responsibilities of a man. And if I could send you off with a piece of advice about responsibility, it would be this· Everyone on this earth owes a debt to society. Sometimes this debt has been paid by whispering one kind word, and sometimes it has been paid by making an unpopular decision that hurt a few but helped many. Nevertheless it is a debt, and if we are to fulfill our responsibilities as human beings, we must spend our lives repaying that debt"

I kept that letter. And since then I've kept the conviction that by doing everything we can to repay the debt each of us owes to society, we can dismantle the barriers that stand between human cultures

The best advice I can give for breaking the language barrier is to become fluent in "human". Smiles and handshakes aren't restricted by language. Sincere eye contact has nothing to do with linguistics.

Ben Franklin said "Well done is much better than well said." It's what we do. not what we say, that counts. And forget about words. Words can get us into trouble. Let me illustrate this by destroying our idea of what the word America means.

Who are we? Americans? What is America? We know that America is named for Amerigo Vespucci, the Italian explorer who discovered Brazil. The word "America" was first used on a map of the New World for what is now known as South America. So where is America? We share the name "America" with more than two dozen other countries!

Early in my travels I put my foot in my mouth by using this "America" term. Others around me did not agree that "America" was the sole possession of the United States. Now when I address someone from another part of the world I never call myself an American. They may choose to use the term that way; that's their prerogative. But I say that I am a citizen of the United States of North America.

This may sound like a frivolous semantic detail, but I assure you it's the stuff that successful diplomats and negotiators are made of! The point is, what we do is a much more effective communicator than what we say, and is much less likely to be misinterpreted. Let's be conscious of the positive and negative powers of words. Then maybe we can break some barriers!

What makes an American in the sense that you and I would use the word? Let me tell you about a fellow who settled in my town ten years ago. Pedro was born in a one-room house in Ayotitlán, a pueblo nestled in the mountains south of Guadalajara, Mexico. The town had no running water or electricity. His home had a dirt floor and mud walls. Pedro worked his father's farm until the tender age of 13. Then his father started a conversation that went something as follows:

"Pedro, you are a man now."

"I am, father?"

"Yes And it is time you went out into the world."

"It is, father?"

"Yes, Pedro. Tell me, my son, do you like to eat?"

"Oh, yes father, I like to eat!"

"Well, it is settled then You must find yourself a job. Make what money you can Eat, and what money is left over, send home to support your family."

With eight months' wages his father hired a transportation specialist (otherwise known as a coyote), to smuggle the boy across the Texas border. And for the next 15 years Pedro traversed North America, following the seasonal progression of crops. Pedro remembered his father's words, and faithfully sent money home to his family every month.

Today Centerton Nursery employs 10% of Ayotitlán's population. I have been there myself, and believe me, it is of a different time. The town was preparing a celebration for the installation of the first telephone, a pay phone to be placed on the central corner of the four-block metropolis. Everyone welcomed me personally. Each addressed me as "patrón" (lord and master). They called me a white man, and they told me that I am the first white man ever to enter Ayotitlan

The town prepared for my visit: a colorful parade, a huge fiesta and a 21-piece orchestra that played the sourest music I ever heard. I had guided trips to volcanoes. I was taken to the bullfights and bequeathed with cooked goats in my honor. I got a tour of each home, a toast of some strange alcoholic beverage in each home, followed by an escort to the chicken fights (of which I remember very little). Yet, another debt I can never fully repay.

Whenever I tell Pedro's story, people say, "What a tough life! That's so terrible!"

Was it tough? You bet it was! Is it terrible? You tell me. Is it so terrible that today Pedro has nearly finished paying off his third mortgage? Is it so terrible that he has become the one to whom others turn in time of need? Is it terrible that Pedro is bilingual? Is it terrible that he thinks so far ahead that I frequently find myself trying to catch up? Is it terrible that his survival skills compare to that of a puma? Is it terrible that the tough life lessons in Pedro's experience have helped him bring his beautiful wife and children into a financial situation that places them in the top percentages?

It is not so terrible that Pedro is Centerton Nursery's Operations Manager and our top income earner. He is "a man's man." And it certainly is not terrible that he could be no more my brother, had he come from the same womb. What is terrible, is that most of us in this country cannot appreciate the meaning of "tough". That is a barrier!

The irony of this story is that if you were to ask Pedro his nationality, he would reply "Oh, I am Mexican!" But he is grossly mistaken. Because in the purest sense of the word, Pedro is a classic American This United States is a country of immigrants, and he is the living embodiment of his American ancestors the Italian that landed at Ellis Island 75 years ago; the Irishman that escaped to our shores 150 years ago; or the Hessian (like in my family), that arrived as a soldier 215 years ago, hired by the British as a mercenary, to subdue the tea burners of 1776. Like these other immigrants who achieved the American dream, Pedro is as much an American as you or I.

The lesson here is that what has brought us to what we are in this country today is that what we are is a country of toughened, hungry immigrants. And immigrants have a track record for uncovering opportunities. We are the living legacy of that ability. We and our country, are the product of that immigrant strength, and we can wear that distinction... with pride

Let's assume our responsibilities of paying our debts by utilizing our actions to tear down our barriers. What do you see when you look at an immigrant? There are no barriers but those that we build around ourselves. I'll tell you what I see when I look at an immigrant. I see a fire in his eyes and a burning desire for achievement in his guts. I see this country's heritage I see the exciting story of our future revitalization before my eyes. When I look at an immigrant, I'm proud to share the space he occupies. Because what I see...is a true American.

The Center for Urban Ecology's Dogwood Anthracnose Research Program

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Periodically, new forest diseases suddenly arise which can have significant and lasting effects on the environment. Chestnut blight, which was introduced into the United States at the turn of the century, and Dutch elm disease, which appeared in the early 1930s, are the most noted examples. Recently, two of our native dogwood, the flowering dogwood, *Cornus florida* L., and the western flowering dogwood, *C. nuttallii* Audub., have been threatened by a new disease (Byther and Davidson, 1979; Hibben and Daughtry, 1988; Salogga and Ammirati, 1983). Dogwood anthracnose, caused by a coelomycetous fungus in the genus *Discula,* was first reported affecting *C. florida* in the northeast in the mid 1970s (Hibben and Daughtry, 1988). Interestingly, the disease was also found affecting *C. nuttallii* in the Pacific Northwest at about the same time and now occurs in Washington, Oregon, Idaho and British Columbia (Byther and Davidson, 1979).

In about 15 years dogwood anthracnose has moved south along the Appalachian Chain to northern Georgia and as far west as northwestern Alabama. Almost 20 percent of the natural range of *C. florida* is now affected.

The disease is of particular concern to the National Park Service because of its mandate to preserve and protect natural resources for future generations. The flowering dogwood is a prominent understory species in many parks of the East including the parks of the Appalachian Chain; Shenandoah National Park, the Blue Ridge Parkway, and the Great Smokey Mountains; as well as smaller, yet heavily visited parks, such as Harpers Ferry National Historical Park in West Virginia, Rock Creek Park in the heart of Washington, D.C., and the Catoctin Mountain Park, which surrounds Camp David in Maryland. Not only is the dogwood a significant aesthetic element in these parks, but most importantly, it provides a major source of food for over 40 species of birds and 12 mammals (Mitchell, et al. 1988).

In 1983 dogwood anthracnose was confirmed in Catocin Mountain Park, a 6000 acre national park located in north-central Maryland. A survey conducted in 1984 found that 33% of the dogwoods were dead and only 30% of the stems were free of disease symptoms (Mielke and Langdon, 1986). A second survey conducted four years later determined that the loss had risen to 79% in the survey plots (Schneeberger and Jackson, 1989). The rapid spread and severity of the disease prompted the National Park Service and the U.S. Department of Agriculture to support and conduct studies to further our understanding of this new disease and to determine the impact it will have on our native dogwoods. The following discussion will review some of the initiatives undertaken by the Center for Urban Ecology.

Critical to understanding and management of this disease is knowledge of the pathogen, particularly since the specific identity of the fungus had not been made. The Center has supported Dr. Scott Redlin of the USDA's Systematic Botany and

Mycology Laboratory in describing and identifying the *Discula* sp. associated with the disease. Other species of *Discula* are known to cause anthracnose diseases of other tree species; however, Dr. Redlin has determined that the dogwood pathogen is a new species of *Discula*. The description and species name will soon be published in the Journal Mycologia. The origin of this pathogen is still in question. However, its sudden occurrence on both coasts at approximately the same time supports the theory that it was a recent introduction to the United States

Controlled inoculations, which provide reliable and uniform infection, are essential in conducting many tests such as screening resistance, testing fungicides, and determining the environmental parameters necessary for infection and disease development. However, like other anthracnose diseases caused by pathogens in the genus *Discula*, successful artificial inoculations is difficult to achieve. At the Center we are exploring the use of excised leaf discs maintained in water agar as a testing alternative to whole plant inoculation. We have found that successful infection can be achieved if discs are wounded by heating the center of the disc prior to inoculation. We are exploring this technique as a potential mechanism for rapidly determining disease resistance or susceptibility.

There are over 40 species in the genus *Cornus*, yet only two are recognized as highly susceptible to dogwood anthracnose. We are currently examining other species of *Cornus*, both exotic and native, for field resistance or susceptibility to the disease. Potted saplings of both native and exotic species are being placed in a forest environment where the natural disease incidence and severity are high and the probability for infection is good. These will be evaluated over several years for leaf spot and dieback and compared with *C. florida* controls. Leaf discs from these species are also being tested in the bioassay as part of the species study.

The National Park Service is participating with other agencies in testing several major commercial cultivars of *C florida* for resistance to natural infection. Cultivar plantings are being established at six locations along the East Coast where they will be evaluated over several years. The Center is maintaining one planting at Catoctin Mountain Park and one at the Center's experimental nursery in Alexandria, Virginia. The project is being coordinated by the USDA Forest Service, Southeastern Forest Experiment Station.

In order to increase the options for managing the disease in ornamental landscape, the Center is cooperating with the USDA Agricultural Research Service's Florist and Nursery Crops Laboratory at Beltsville, Maryland, in evaluating alternatives to conventional fungicide treatments. Vegetable and petroleum oils such as neem and Sun Spray, are being tested on containerized trees maintained in the forest where the disease is well established. It is hoped that some oils may be sufficiently protective and eradicative to control dogwood anthracnose in landscape settings.

The long term development and progression of the disease is being monitored in a series of permanent one-tenth acre plots established in Catoctin Mountain Park, Rock Creek Park,and Prince William Forest Park in Virginia. In each plot all dogwoods over six feet tall are mapped and monitored annually for disease development. Dogwood regeneration within the plot is also being evaluated.

In the event that dogwood anthracnose may eliminate the flowering dogwood in some parks, an effort is being made to preserve the dogwood germplasm. Through a cooperative program between the National Park Service, the Soil Conservation

Service, and Agricultural Research Service, seed has been collected from several parks and will be cleaned and then preserved by liquid nitrogen cryo-preservation It is hoped that dogwood anthracnose will not eliminate this valuable species and that seed storage will not be necessary to preserve the native genotypes. However, only through a better understanding of the disease and its effect on the natural and ornamental landscape will we be able to anticipate the consequences of dogwood anthracnose and manage the disease wherever practical.

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Propagation Under the Pines

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For the past ten years, we have done most of our summer propagation under a loblolly pine overstory. Initially we did this due to the lack of a better area. However, our success through years of refinement has kept us from looking for a better system.

We use Lerio 18- x 18-in. flats, which hold 64/flat of the #425 peat pots—a round, 2 1/4-in diameter, 3-in. deep pot. I like the Lerio flat because an employee is 62% more efficient when he moves it than he is when he moves a 10- x 20-in flat

Old flats are not sterilized, and we project a minimum of four years of use out of new ones. With this in mind, the high cost of the flat is easier to digest. Disregarding the time value of money, it's less than 1/2 ¢ per unit per year.

The propagation medium we use is four parts pine bark, two parts horticultural-grade perlite, one part peatmoss. The pine bark is not screened and is the same as is used in container production Because of the high fertility levels maintained in the containers, we do not incorporate any fertilizer in the propagation mix. Without fertilizer in the propagation mix, we are producing market-standard one-gal plants in one year and 3-gal plants in two years. Furthermore, some of the faster-growing liners are pushed to yield 2- and 3-gal material in just one season. This is all done without adding any supplemental heat at anytime to the liners

We use a slightly different propagation medium when rooting plants such as photinia. This medium is pine bark, sand and peat moss (6:1·1, v/v/v).

As the flats are filled, they are put into place and watered. The mist heads are nothing more than Rainbird sprinklers that are also used in production. A four foot piece of saran cloth is placed around the area to keep the wind from desiccating the cuttings.

We begin to take our broad-leaved cuttings around the first of July. Cuttings approximately 4-in. long are removed from the container plants, and banded together in bundles. Once banded, succulent terminals are snipped from the cuttings using hand clippers. Soft terminals are removed since they wilt first and would be more subject to disease entry

Except for Japanese hollies and a few other small-leaved, easy-to-root plants, most cuttings, including azaleas, are stripped of their lower leaves to improve rooting. However, this practice has been partially eliminated with the increased use of liquid hormones.

Once the cuttings are bundled in the field, they are brought into the cooler pine propagation area where they will be dipped in a Benlate fungicide solution The crew leader dips the cuttings while the team is still in the field taking additional cuttings Cuttings are drained before dipping in hormone. All Japanese hollies are dipped in a 5,000-ppm K-IBA solution. Chinese and Foster hollies and photinia are given a three-second dip in a 10,000 ppm K-IBA solution

Over the years, azaleas have been primarily rooted using Hormodin #1. However, this summer we had excellent results using a concentration of approximately 1320 ppm K-IBA on unstripped azalea cuttings. This concentration is made by dissolving 5 g of the hormone in one gallon of water. Once treated, all cuttings are stuck two per peat pot. Workers are paid between one and 1 1/2 ¢ per cutting depending on the plant and the amount of cutting prepared and performed.

Crew leaders monitor the water requirements of the plants during their daily work routine. All propagation zones are connected to solenoid valves, which are connected to automatic irrigation control boxes for further management efficiency. The 5/32-in. nozzle that comes in the sprinkler sometimes is replaced with a 1/8-in. nozzle if two plants with differing water requirements are placed in the area or if a plant is being hardened next to one that is freshly stuck Except for monitoring the daily water needs of the plants, the game is now over.

The biggest and maybe only complaint I would have with our system is that all flats must be moved in the fall for overwintering if they are not to be lined out immediately. The cost to do this is minimal. On the positive side, however, our propagation survival rate using this method last year was 94% rooting survival of Chinese hollies, 97% of Japanese hollies and 99.7% of evergreen azaleas. That's right, 99,700 azaleas rooting out of every 100,000 planted. We lost fewer than 5 total flats out of more than 1500. In addition to these plants, spirea, euonymus, forsythia, crape myrtle, cotoneaster and barberry are rooted this way. Once your liners are in their overwintering structure and you anticipate temperatures in the single digits, cover your liners with a poly blanket.

Now let's look at this from a cost standpoint. Assume the Lerio flat costs $1.10 and has a projected four-year life Since this style of peat pot is not pre-punched with a drainage hole, holes must be made in the bottom of the pots Our labor cost to punch holes, fill the flat, and double stick the cuttings is approximately 4 1/2 ¢ of which 3¢ is to stick two cuttings. The peat pot costs around 3 7/10 ¢. Our direct cost is already 8 1/2 ¢ excluding the media cost and the cost to move the flat. I don't know about you, but to me that may be too much money. Or is it? Whatever your answer is, most of our dime is gone. Don't forget we're not heating this liner, and the overhead associated with a mist system or propagation facility is not there Neither are the accompanying headaches such as clogged nozzles and electrical problems.

Knowing that our system worked, we tried experimenting this summer with some additional ways to refine it and more importantly some ways to do it for less Realizing we could not reach our desired goal under the pines, we cleaned out some production houses, herbicided them and decided to propagate directly in these houses.

Feeling that our per unit cost was too much using the #425 pot, we looked for a new peat pot that was similar in size, especially in depth, which I feel is very important for producing a good-quality liner. My reason for liking peat pots is that you start with a new sterile rooting environment annually without sterilizing or cleaning individual pots We found a new peat pot that was pre-punched and, luckily, ready to load into a 10- x 20-in. tray We bought enough to stick two houses of azaleas. In one house we used a liquid hormone on unstripped cuttings. Because the peat pots were pre-punched and much easier to fill, we were able to cut the per unit labor cost to 2 3/10 ¢. Since the new peat pots (#220) cost around 2 3/10 ¢ and the one-year tray is 6/10 ¢ per unit, the per unit cost was reduced to around 5 ¢.

I still felt we had problems with this system. One, I felt we could to it for less; two, we were using only 58% of the actual floor space; and three, we wanted to go back to the Lerio tray to improve efficiency.

Tackling these three problems became easier with one trip to MANTS. It was there I found out that Lerio had come out with a plastic insert the same size as their #225 cup or #425 peat pot. By propagating in this insert, we were able to reduce our total cost to between 3 1/2 - 4 1/2 ¢ per cell. In addition, flats were put down in a fashion that they would not have to be moved from the time they were filled until they were lined out. We now used 74% of the house. A 20 x 96 ft house will hold over 40,000 2 1/4-in. liners.

Our system uses no mechanization, and we are now producing two cuttings where one was being produced before. In addition, it appears at the present that our success rate may be just as good as it was under the pines. If so, expansion only requires the emptying of a growing house and a piece of shade cloth. Until we are sure of the house system though, Lerio flats and the #225 plastic inserts may have a home under the pines at Saunders Bros. With our success rate and a cost of less than a nickel, would you change?

I would like to touch on a second propagation system that we have found to be equally effective at our nursery. This system is nothing more than using old railroad ties to form the exterior walls of raised propagation beds. We stick boxwood cuttings in the bed from July through March as time allows. In addition, dwarf Alberta spruce cuttings are stuck in late summer, and they root well Plants rooted using this system can be left in the beds until time permits for their planting out. This system worked extremely well with slow-growing plants such as *Euonymus alata* 'Compacta' that shouldn't be occupying valuable production space The medium consists of two parts coarse sand to one part peatmoss Like the previously mentioned system, water is regulated from centrally located irrigation control boxes using Rainbird 20A overhead sprinklers. Shade cloth is left on the house the entire year. The success rate is very good. If space is one of your worries, consider this. In two houses that are a combined 2400 sq ft, we stuck almost 164,000 cuttings. That's 68 cuttings per square foot of total house space, or one cutting every 2 1/10 in.

These two systems that I have discussed today may not be the right way to propagate plants, they are, however, our way.

What does it cost you to propagate your plants? If you don't know now, think about it during your leisure time this fall and next spring. That's exactly what I'll be doing.

The Effects of Selected Herbicides on Propagation of Chestnut Oaks in Containers.

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Chestnut oak, *Quercus prinus,* is a medium-sized tree native to poor, dry, upland, and rocky soils from southern Maine to South Carolina and Alabama. The acorns are sweet and highly prized for wildlife food, while the bark is rich in tannin (Dirr, 1983). With the introduction of deep containers for tree production the trend has shifted to seed propagation in containers. Propagation in containers allows year-round production and reduces transplanting shock when transplanting to the field.

Because of increasing hand labor cost, many people are using herbicides to control weeds in seed beds. South (1984) reported nurseries in the past have relied upon fumigation with methyl bromide for weed control. Herbicides are an alternative to soil fumigation.

Graunke and Gouin (1983) tested several herbicides with mixed results on northern red oak, black walnut, loblolly pine, dogwood, and tulip poplar. Devinrol and Modown applied in combination reduced population and growth of dogwood and tulip poplar, and Ronstar reduced population and growth in tulip poplar. Geyer and Long (1991) tested several herbicides on the seeds of black locust, honeylocust, and Kentucky coffee tree. Lasso, Lorox, Surflan, and Dacthal were not harmful to Kentucky coffee tree. Only Lasso, Dacthal, or the combination were safe on black locust

In a similar test (Warmund, et al., 1980) with the same 3 species in containers, the following herbicides were evaluated Lasso, Dacthal, Enid, EPTC, Devrinol, Surflan, and Ronstar. EPTC and Ronstar caused reduction in survival of Kentucky coffee tree and reduced the survival and growth rate of honeylocust Black locust survival and growth rate was affected by Lasso, Enid, Devrinol, and Surflan.

Little information is available on herbicide use with container trees grown in a soilless potting medium. The objective of this study was to evaluate the effect of several herbicides on germination and growth of chestnut oak in tree containers.

MATERIALS AND METHODS

Chestnut oak acorns were gathered on 24 October 1990, placed in plastic bags and maintained at 38°F On 12 December acorns were sown in 3 5/8 × 6 in band tree pots 1 1/2-in. deep in a pine bark-sand potting medium (6:1, v/v), amended with 5 lb of dolomitic lime and 1 5 lb of Micromix per cu yd.

Plants were treated with 9 herbicides at their recommended rates: Southern Weed Grass Control 2.68G, Ronstar 2G, Rout 3G, Gallery 75DF, Devrinol 5G, Devrinol 50WP, Snapshot 2.5TG, Dimension 1G, and Treflan 5G.

These herbicides were applied at three different stages of growth. The first application was before emergence of the seedlings (preemergence, 17 December); second application was after oak emergence when the first true leaves began to unfold and expand (early postemergence, 22 January); and the third application was when the first true leaves had matured (late postemergence, 21 February). Mature leaves were defined as fully expanded, with a waxy cuticle, and reduced leaf pubescence Granular herbicides were applied with a hand-held shaker, Devrinol 50WP and Gallery 75DF were applied with a CO_2 backpack sprayer at a rate of 20 GPA.

The experimental design was a randomized complete block with 5 replications of 5 plants each Trees were grown in a double polyethylene greenhouse and watered as needed. Beginning 26 January 1991, all trees were fertilized once a week with 150 ppm N using a Peter's 20-20-20 fertilizer.

Trees were evaluated at 30, 60, and 90 days after treatment (DAT) for phytotoxicity and growth rate At 30 DAT the seedlings were counted to establish germination percentage. Herbicide injury ratings were made at 30, 60,and 90 DAT Trees were rated on a scale of 1 to 5 with 1=healthy and 5=dead. Root fresh and dry weights were taken at 60 and 90 DAT on the preemergence treatments, 30 and 60 DAT on the early postemergence treatments, and 30 DAT on the late postemergence treatments. Only the fresh weight data is presented Primary, or tap roots, and secondary roots were weighed separately.

RESULTS AND DISCUSSION

Preemergence Treatments.

Germination Only Devrinol 50WP suppressed germination when applied before the germination of the oak seedlings. Average germination of the control treatment was 80%, while the Devrinol 50WP treatment had 50% germination (data not shown). The granular formulation of Devrinol did not cause any suppression of chestnut oak germination.

Growth Rate. Several herbicides affected the growth rate of the germinating seedlings. The new herbicide from Monsanto, Dimension 1G (currently being marketed for use on turf) caused the greatest suppression of height growth during the first 30 days following treatment (Fig.1). Pots treated with Dimension 1G had about 1/3 the growth of most other treatments. Devrinol 50WP and Snapshot 2.5 TG caused slight suppression compared to the control; however, during the following 30 days (60 DAT), these 2 treatments were among the 3 treatments with the greatest growth rate. At 90 DAT, the plants initial growth flush had slowed and no differences occurred among treatments

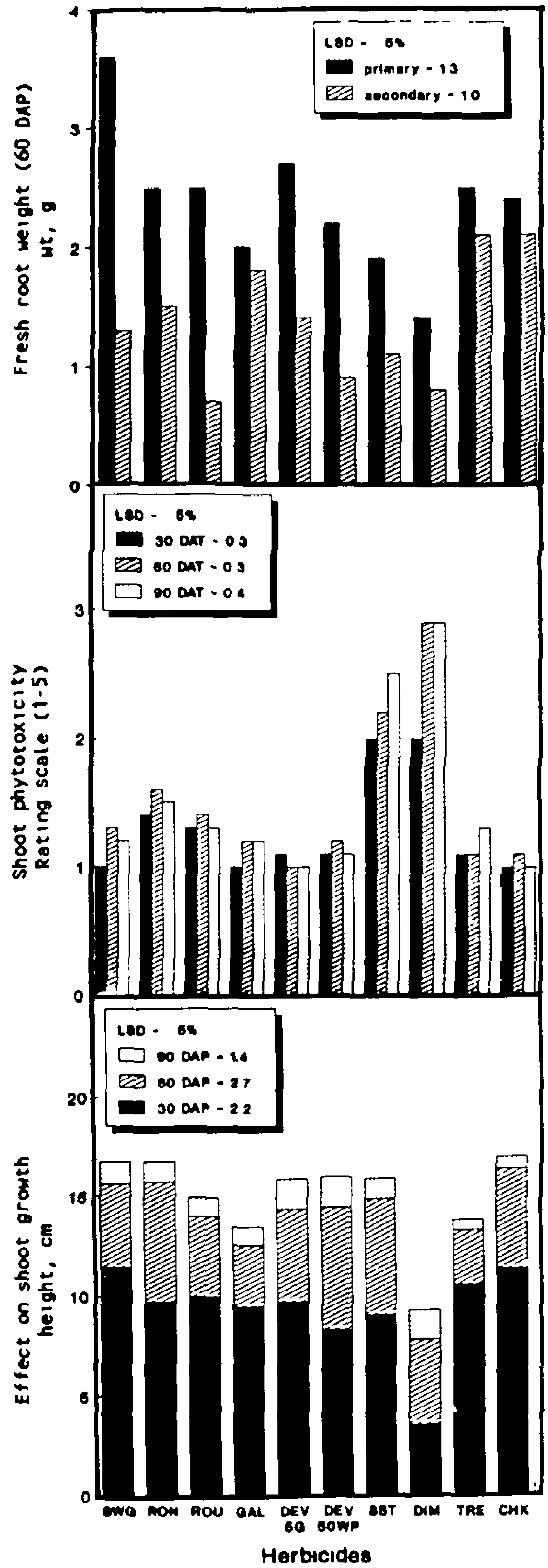
Phytotoxicity The greatest injury in the preemergence treatments occurred with Dimension 1G and Snapshot 2.5 TG (Fig. 1) Foliar burn and leaf distortion in these two treatments were evident throughout the study. Ronstar also caused slight leaf distortion throughout the study; however, plant growth was not affected.

Root Growth Dimension 1G herbicide suppressed both shoot and root growth when applied preemergence to oak seedlings (Fig. 1). Separating the root system (primary or tap root vs. secondary roots) showed that Rout 3G, Devrinol 50WP, and Dimension 1G suppressed secondary root development at 60 DAT At 90 DAT there were no differences in root fresh weight.

Results of the preemergence portion of this study show that Dimension 1G, Snapshot 2.5 TG, and Devrinol 50WP caused unacceptable injury to germinating chestnut oak seedlings. Rout and Ronstar caused minor injury, which the plants quickly outgrew. Devrinol 50WP also suppressed germination.

Early Postemergence.

The early postemergence treatments were applied at 30 days after potting when the first true leaves began to unfold and expand. Therefore, no germination effects occurred. None of the herbicides affected growth rate when compared to the control plants.



[z]SWG - Southern Weed Grass
Ron - Ronstar
Rou - Rout
Gal - Gallery
Dev 5G - Devrinol 5G
Dev 50WP - Devrinol 50WP
SST - Snapshot
Dim - Dimension
Tre - Treflan
Chk - Check

Figure 1. Effects of preemergence herbicides on chestnut oak

Phytotoxicity. Herbicide application during leaf expansion caused herbicide injury in several treatments. Sixty days after potting, or 30 DAT of the postemergence application, Rout, Gallery, Southern Weed Grass, Ronstar, and Snapshot 2 5 TG caused minor foliar injury or leaf distortion (data not shown). Except in the Ronstar treatment injury from these herbicides persisted throughout the duration of the experiment. This injury did not affect the growth rate or tree height at the end of the study.

One major difference between the two methods of application was the response with Dimension 1G and Devrinol 50WP. If applied after germination these herbicides had no negative effects From a practical standpoint, this information can help growers fit these herbicides into their weed control program.

Root Growth. Ronstar, Gallery, Devrinol 5G, and Snapshot 2.5 G suppressed secondary-root growth about 50% compared to the nontreated plants (Fig. 2).

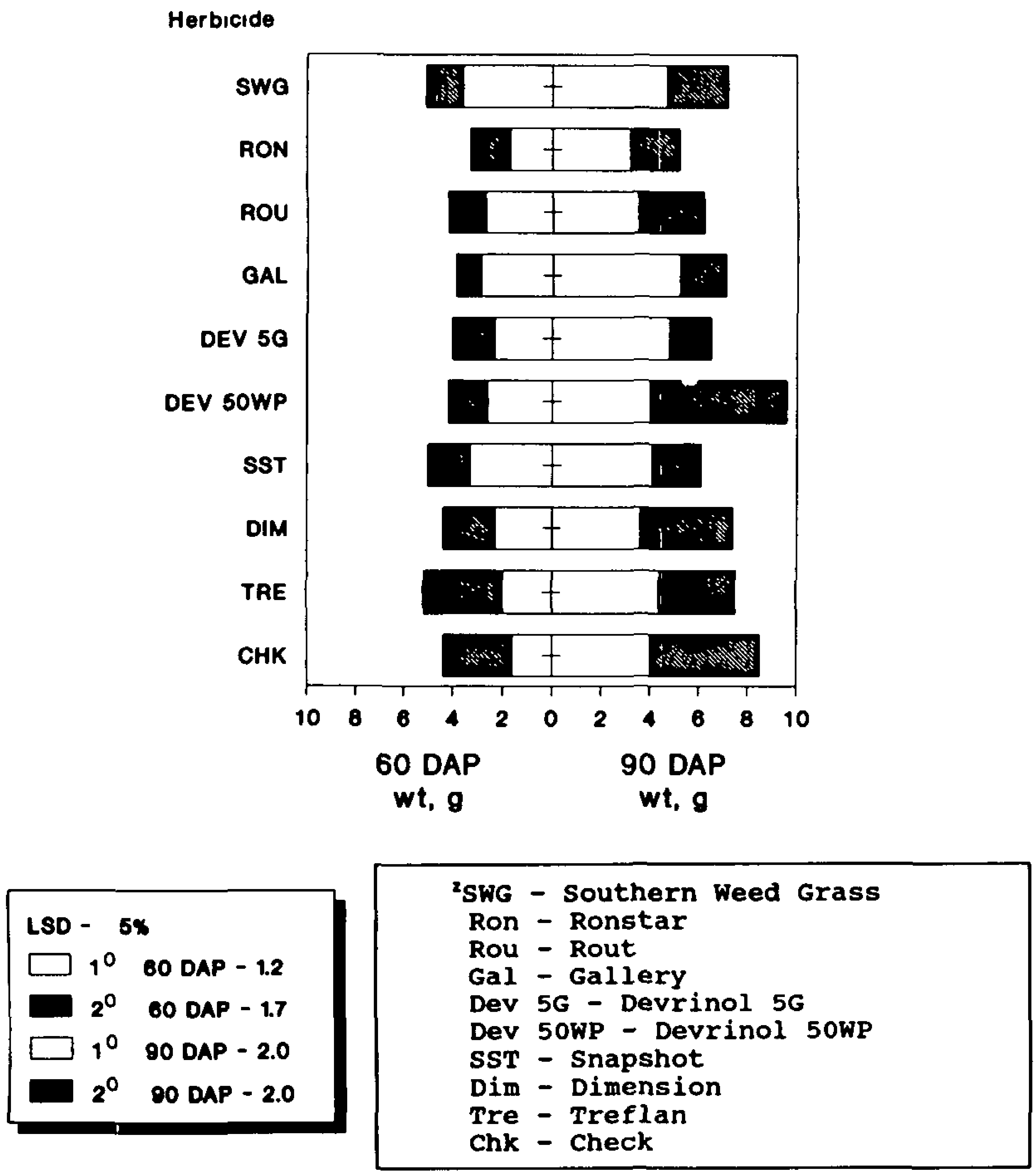


Figure 2. Postemergence herbicide effects on fresh root weight

Secondary roots are important in the establishment and growth of transplanted seedlings since they function primarily in the absorption of water and minerals (Gilman, 1990) These herbicides should be carefully evaluated before applying them at the early postemergence stage of container-grown seedlings.

Late Postemergence. Treated plants did not differ from controls at either 30 or 60 days after treatment.

This study shows that for maximum safety, herbicide application to container-grown chestnut oak seedlings should be delayed until the leaves have matured. If herbicide application before this time is necessary, the herbicide should be carefully evaluated with each tree species to avoid injury.

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Gibberellic Acid, Scarification, and Stratification Treatments for Quicker Germination of Fringetree Seed

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White fringetree, *Chionanthus virginicus* is a native plant of exceptional ornamental value for its fleecy white bloom in midspring. Unfortunately, it is not well known by the average homeowner nor is it readily available in landscape nurseries or garden centers. Nurseries propagate fringetree by seed. Seeds require two years to germinate and remain in the seed bed an additional two years before transplanting to the field. Seedlings are grown in the field for three to four years to produce a salable size plant 3 to 4 ft. Six- to 7-ft fringetrees are in demand, but they require a total of 10 or more years to produce from seed (Hiscock, 1990).

Up to 1987, propagation of white fringetree by cuttings had not been successful (Dirr, 1990; Dirr and Heuser, 1987). At the Southern Region Plant Propagators' Society meeting in October 1990, a grower reported successful development of a population of rootable juvenile plants. The grower successfully rooted cuttings from 4% of a large seedling population. The daughter plants in turn could be rooted. Whether or not this rootability will be a fixed trait is unknown Chinese fringtree, *C. retusus,* can be propagated in commercial numbers by rooting just-hardened stem cuttings about six weeks after full bloom (Russell, 1983; Witte, 1984)

White fringetree typically begins blooming and fruiting after plants are five-to-eight years old. It is dioecious, or polygamo-dioecious; however, individual plants are generally all male or all female. Peak bloom occurs around May 15 to May 20 in Knoxville,Tenn In the deep southern part of the U.S., flowering time may be in late March or April (Gill and Pogge, 1974). The USDA Woody Plant Seed Manual states that seed should be harvested in September or October (Gill and Pogge, 1974), when the fruits have turned deep purple In Knoxville, fruit begins to turn color as early as mid-July. Full coloration and ripening occurs by the first week of August. Collections must be made before birds take the fruits or fruit drop occurs.

White fringetree seed possesses a double dormancy, sometimes called a two-phase dormancy (Dirr, 1990, Dirr and Heuser, 1987, Gill and Pogge, 1974; Hartmann and Kester, 1983; Kester, 1960). This type of dormancy is generally characterized by a hard or impermeable seed coat and a rudimentary or dormant epicotyl (Hartmann and Kester, 1983). In white fringetree dormancy is fairly complex and also seems to involve inhibitors in the endosperm (Hartmann and Kester, 1983) All these dormancy conditions must be overcome in proper sequence.

The seedcoat must first be degraded so water may be imbibed. During a following cold moist period of stratification inhibitors are degraded and embryo dormancy overcome (Fordham, 1960; Gill and Pogge, 1974; Hartmann and Kester, 1983). Three to five months of warm stratification may be required to allow for microbial decomposition of the endocarp, followed by imbibition of water and radicle (root) emergence Then at least three-months cold stratification is required to overcome the epicotyl dormancy, at which time shoots emerge (Dirr, 1990; Fordham, 1960; Gill and Pogge, 1974; Hartmann and Kester, 1983).

Germination may be erratic and has been reported as early as one week after stratification was completed and as late as one year later (Fordham, 1960). First-year seedlings do not put on much shoot extension.

Chionanthus propagation by grafting has been reported but no mention has been made in the literature of its commercial feasibility. Bean reports that *Chionanthus* may be grafted onto *Fraxinus*, but the plants resulting from this union are not as healthy or long-lived as those on their own roots (Bean, 1970). This is probably due to the relatively distant relationship of fringetree to ash

Frett extracted embryos from August-collected seed and incubated them on a gibberellic acid:nutrient solution. The embryos greened up and produced both shoots and roots (Dirr, 1990). Gibberellic acid (GA_3) is known to have a role in seed germination and stimulates alpha-amylase activity in the aleurone layer of some seeds (Hartmann and Kester, 1983). GA_3 can also partially substitute for the chilling requirement in some types of dormancy (Wittwer, 1968).

Based on this knowledge, we designed an experiment to test gibberellic acid soaks on whole or scarified fringetree seed, followed by different periods of warm and cold stratification. The objective was to induce seed germination in one year.

METHODS AND MATERIALS

Ripe fruits were collected from three white fringetrees on the University of Tennessee Ag campus. Seeds were cleaned 1 August 1989, and stored dry in a refrigerator On 20 August 1989, seeds were divided into two groups of 560 seeds each The control group of seeds was left whole. Seeds in the other group were scarified by nicking the hilum end, using a sharp knife to remove a chip of the bony seedcoat. The radicle of the embryo is located on the opposite end of the seed from the hilum. The shape of the seed is not always a good clue as to which end is which, and a 10× hand lens aided identification. We were careful not to penetrate the thin brown seedcoat.

GA_3 was dissolved in aqueous potassium hydroxide, the pH adjusted to 9 0 and diluted to yield 300 ppm solution. On 24 August 1989, each group of seeds was divided in half and each half placed in a separate beaker containing 250 ml GA_3 solution. The remaining seeds were placed in separate beakers containing distilled water. The four beakers were then placed under vacuum at 20 in. Hg (-68Kpa) for 24 hours. Shortly after vacuum was pulled, air (or gas) bubbles were seen escaping from some seeds. Some whole seeds floated initially, but sank.

Seeds were planted 25 August 1989, in a pine bark.peat moss mix (3:1, v/v). Individual tubes measuring 2 5/8 × 2 5/8 × 5 in. deep were used, with 40 tubes per tray. Thus, one tray contained 10 single seed replications of each of the four combinations of scarification x GA treatment. Trays were placed on raised benches in a propagation greenhouse equipped with a Biotherm hot water system. Medium temperature at 2-in. (5 cm) depth was about 70°F (21°C). Seeds in the outside bed were planted one-half inch deep and covered. Soil and medium temperatures were recorded weekly.

Groups of trays were moved to a 36 to 41°F (3-5°C) cold storage after two, three and four months on the heated benches and rotated out of cold storage to a warm greenhouse after three or four months.

This experiment was set up as a randomized complete block design with a factorial arrangement of treatments. Seven stratification treatments x two scarification treatments (nicked or whole) x two GA_3 treatments (GA_3 or water) x four replications x 10 seed per treatment totals 1120 seeds in the experiment.

RESULTS AND DISCUSSION

We were successful in obtaining early germination of some seed. Seventy-five of the total number of seeds (960) in the six stratification treatments produced shoots by 13 July 1990. Those seeds in the outside bed have not yet (March 1991) produced any shoots and are being monitored for germination this spring.

The difference between treatments using Chi square analysis was not significant due to low germination. However, we noticed the following.

The normal sequence of emergence occurred with the radicle rooting down first, followed by shoot emergence, which was both hypogeal and epigeal in the nicked seeds. In this report, germination refers to emergence of both radicle and shoot, and radicle emergence refers to emergence of the root but not the shoot.

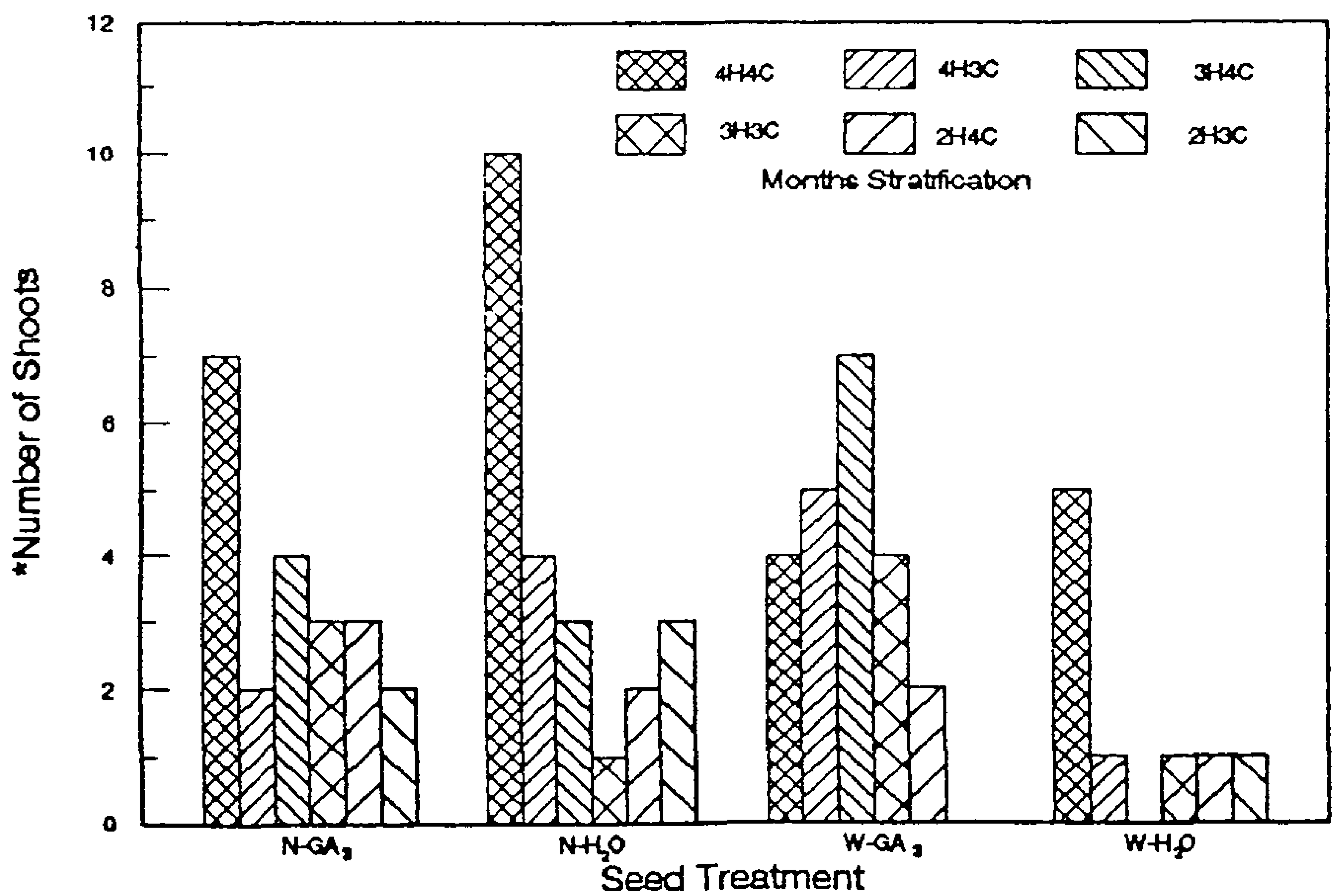

Figure 1. Germination of *Chionanthus virginicus* seed after scarification (N=nicked, W=whole), gibberellic acid infusion (GA_3=gibberellic acid, H_2O=water), and six stratification treatments (H=warm, C=cold), *40 seeds per bar

Figure 1 shows germination in each of 24 treatment combinations. We think germination may be better after longer warm stratification periods.

Figure 2 shows the total number of seed with either radicle emergence alone or with complete germination for each of the stratification treatments, disregarding scarification and gibberellic acid treatment. Many more seed produced roots alone than produced shoots or roots and shoots. Shoot emergence occurred erratically all summer and into late fall.

Figure 3 shows the total number of seed with either radicle emergence alone or with complete germination for each of the stratification/GA_3 combinations, disregarding stratification treatment.

Scavenger mites, earthworms and scavenger nematodes infested the decaying seed, but their presence was considered as a secondary factor in the seed mortality.

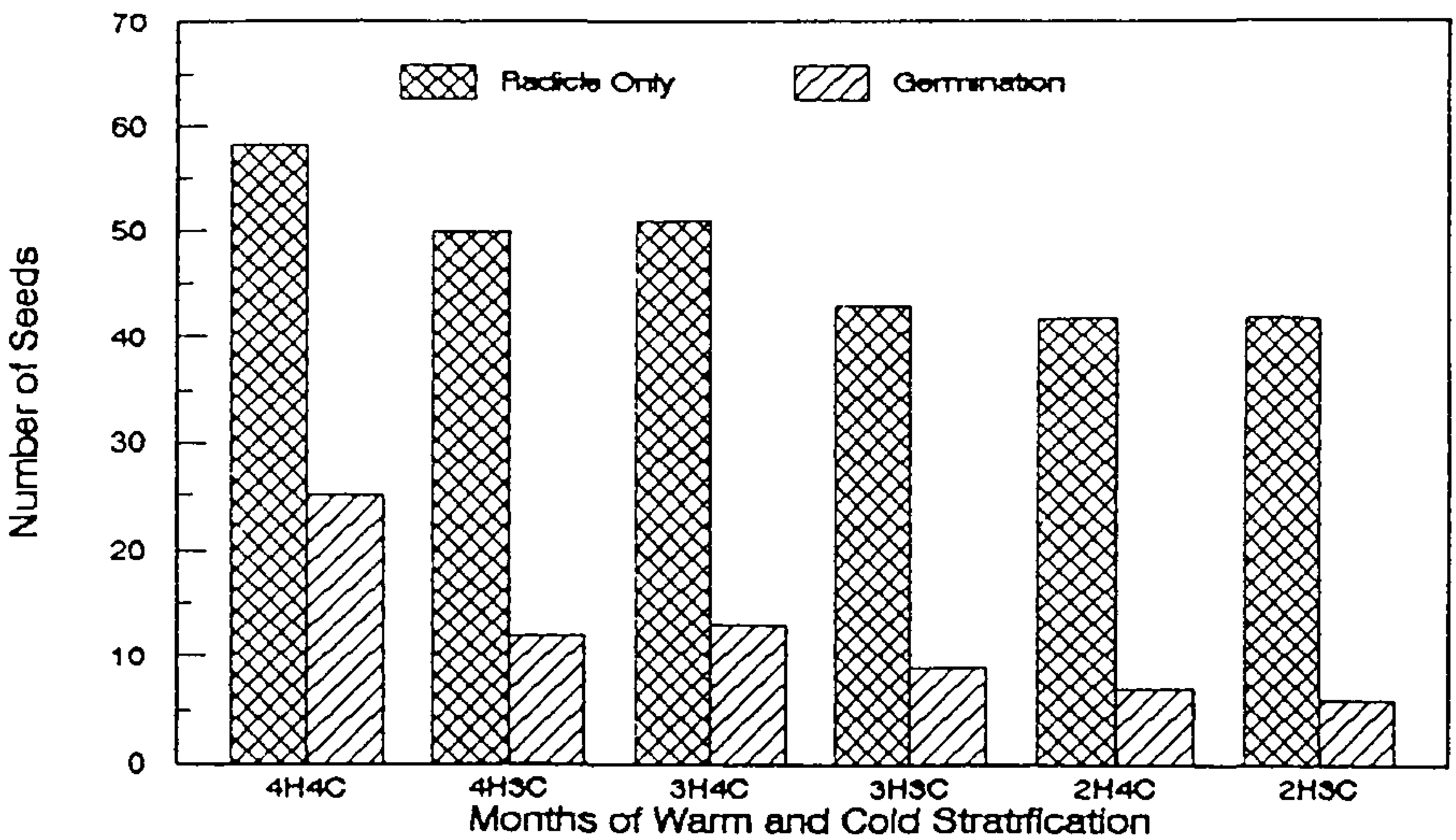

Figure 2. Total number of seed with either radicle emergence or complete germination for each stratification treatment (H=warm, C=cold), disregarding scarification and gibberellic acid treatments Each pair of bars represents total number out of 160 seeds

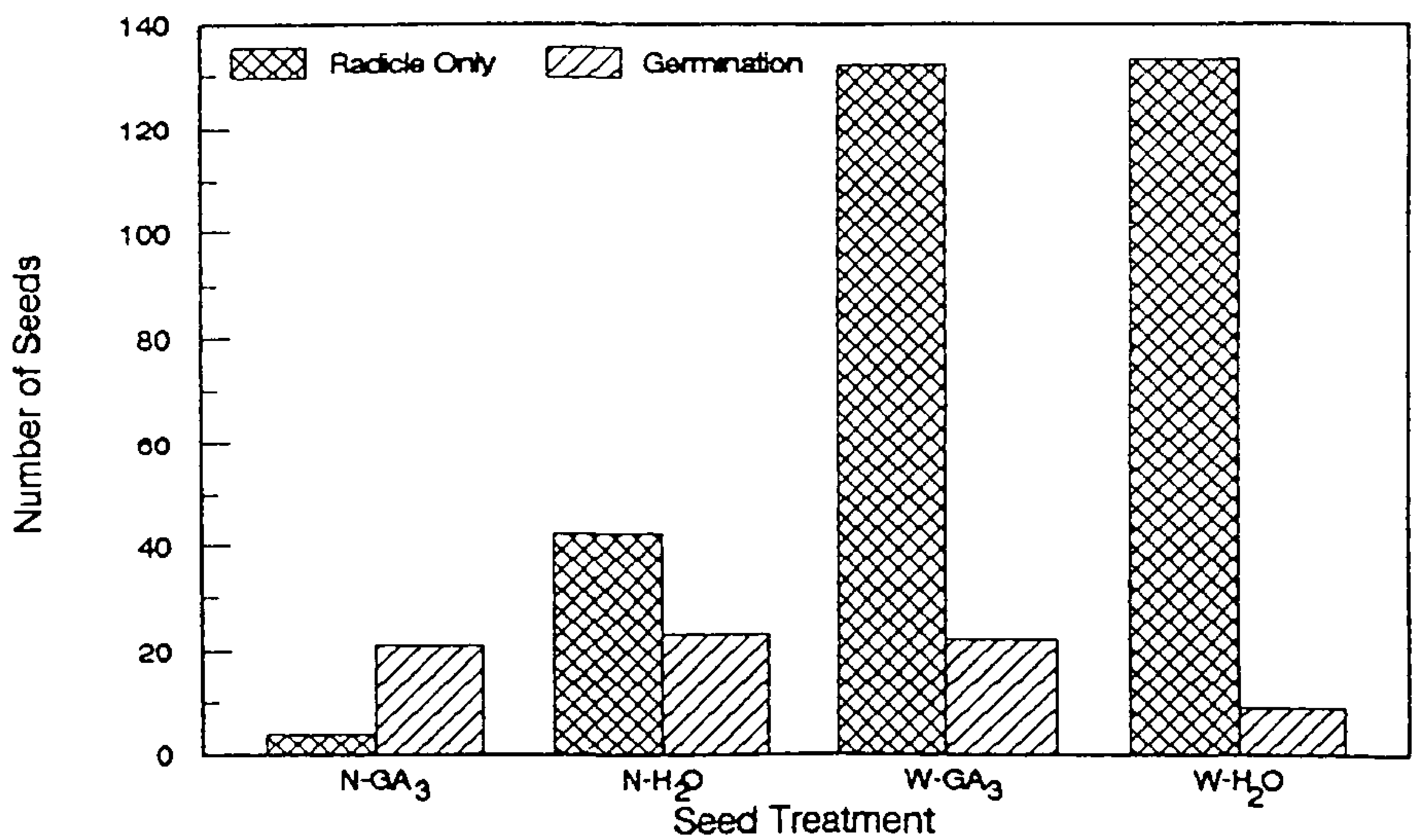

Figure 3. Total number seed with either radicle emergence or complete germination for each scarification (N=nicked, W=whole), gibberellic acid combination (GA_3=gibberellic acid,

H_2O=water), disregarding stratification treatment Each pair of bars represents total number out of 240 seeds

CONTINUING STUDIES

The above observations encouraged us to repeat the experiment with some modifications. A second experiment is underway with the following changes:

1) Pro-Mix B medium to avoid potential problems with scavenger mites, nematodes, earthworms or other microfauna.

2) Electric heating pads instead of the Bio-Therm system to provide more uniform heat with better control of the 80°F (26 5°C) target temperature.

3) Seeds drilled instead of nicked A mechanical drill press equipped with a stop helped prevent penetration of the inner seed coat and endosperm

4) Two additional seed treatments; non-vacuum treatments using nicked and whole seed to show whether or not the vacuum is damaging the seed, and whether or not gibberellic acid must go into the seed.

5) Two- and three-month heat stratification periods eliminated and a five-month heat and a five-month cold stratification added.

6) Turface applied over the medium surface in each tube to prevent splattering when watering and to moderate algae growth.

7) Plexiglass growth chambers used for accessory seed lots to enable visual observation of radicle elongation

8) Trays covered with black plastic during warm stratification to help maintain uniform temperature and moisture and to prevent algae growth.

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Outdoor Mist Propagation

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INTRODUCTION

Over the last 35 years Angelica Nurseries has grown to its present size of approximately 2,000 acres. Along with the increase in acreage and production has come a need for large quantities of high quality rooted cuttings.

In our propagation department we produce nearly 90% of our own plant material by cuttings, seed, and grafting. Our annual rooted-cutting production is nearly 750,000 of which 500,000 are rooted in outdoor mist beds.

Our system of propagation is exceptionally well suited to our production needs. It is a low-cost, highly efficient method of producing large numbers of high quality, uniformly rooted cuttings

MATERIALS AND METHODS

The construction of the outdoor rooting beds is very simple. The materials needed are 8-ft fence posts, treated 2×4s, reed matting (6 × 25 ft), railroad ties, concrete sand, 1/2-in. crushed stone, 4-mil plastic, 4-in. perforated drain pipe, mist line with sprinklers, misting controller, and time clock.

Site selection is very important. Ideally the location should be relatively level, well drained, and, if possible, protected by a windbreak. Our mist bed is protected by a tall evergreen hedge on two sides. Bed dimensions can vary to suit the need of the individual grower. A 6- ×100-ft bed works well for us. The beds are grouped in pairs, giving us better use of the available growing space.

Once the bed has been laid out, a 24-in. deep trench is cut in the center of each The drain pipe is placed in this trench and the trench is filled with 1/2-in. crushed stone. The lower end of the drain pipe is routed to a field drain of suitable size to handle the flow from heavy rains.

A layer of 4-mil plastic is placed across the pair of beds and cut open over each drain trench. At this stage the railroad ties are placed in the proper location and the plastic is covered with a layer of one-inch crushed stone. Concrete sand is then added to bring the level to the top of the ties.

Fence posts, 2 × 4s, and reed matting are finally installed to provide a wind barrier so that the mist from the sprinklers falls uniformly on the bed. The mist line is placed next to the central row of railroad ties. Misters are spaced 8-ft apart We are using a mist controller with six zones that is activated by an on/off clock

PROPAGATION PROCEDURE

The first plants to be prepared for outdoor rooting are *Taxus, Juniperus,* and *Thuja.* We do this during the month of March We collect the cuttings well in advance of preparing them and store them in our cold-storage building at 34°F When the weather makes it unfit to work outside, we move indoors and start preparing the cuttings. We strip off the lower needles, cut to 6-in length, and bundle into bunches of 50 cuttings that are secured with a rubber band.

Once bundled, the cuttings are placed in plastic bags and stored in our cold storage facility at 34°F until sticking time, generally between April 15 and May 1.

Prior to sticking, the bundled cuttings are dipped in a solution of Dip 'N Grow for 10 sec. The solution strength varies from 1000 to 2000 ppm depending on the genus.

Thuja are stuck at a 2- × 2-in. spacing, and *Taxus* and *Juniperus* are stuck at a 1 1/2- × 1 1/2-in spacing. The sticking depth is 1 1/2 in. A board with nails placed at the correct spacing, is used as a template to mark the spacing on the moist sand.

From the time the cuttings are stuck until they are well rooted, keeping the foliage moist is of prime importance. Misting duration and interval vary with the daily weather conditions We check and adjust mist settings every hour Cuttings are allowed to dry slightly in the morning before the mist starts, and again in the evening by shutting the mist off about one-half hour before sunset. This limits the spread of disease.

We complete all of the softwood cuttings within a three-week period. We root many of our deciduous shrubs at this time—*Viburnum, Euonymus alata* 'Compacta', *Hamamelis, Berberis,* and *Platanus* x *acerifolia*—to name a few. Deciduous plants are collected in the early morning while fully turgid and are prepared the same day. The leaves are trimmed to allow plants to be stuck at a 2- × 2-in. spacing. All cuttings are wounded with a triple-bladed razor The wound is approximately 1-1/2-in. long and is made on two sides of the cutting.

Finally, we prepare our *Ilex* cuttings during the last week in July. *I.* x *meserveae* and *I.* x *aquipernyi* cultivars are taken at this time as well as *I.* 'Nellie R. Stevens'.

Dip 'N Grow is again the hormone of our choice for *Ilex* and shrubs, at 1000 to 2000 ppm. The prepared cuttings are stuck the same day they are prepared. Rooting takes from 4 to 14 weeks. Deciduous plants root very quickly. The evergreens, *Taxus* in particular, are much slower. After rooting we apply 8 lb per 1000 sq ft of Sierra 17-6-12 plus minor elements.

OVERWINTERING

Taxus, Thuja and *Juniperus* are all well rooted by late November. We cover these with a light layer of loose salt hay. *Ilex* and deciduous shrubs are covered with a thermal blanket of straw sandwiched between two layers of 4-mil poly. Both groups of cuttings are uncovered about March 1. Once the deciduous plants are uncovered, it is important not to let them freeze before they are pulled.

Spring Planting. All cuttings of deciduous shrubs are pulled in the spring, before budbreak, and are placed on a long strip of plastic. The roots are covered with moist peatmoss and the plants and plastic are rolled up jelly roll style. This bundle is then stored in cold storage at 34°F until planting is possible, sometimes as long as 2 1/2 months from the time they are pulled.

Ilex, Taxus, Thuja and *Juniperus* are pulled at planting time (around May 1). By that time they have an extensive root system. Rooted cuttings must be kept moist after pulling. We use peatmoss bags to keep them from drying out. Cuttings are immediately planted in beds in the field using a 3-row onion planter, which plants 50,000 cuttings per day. In three years time, our *Taxus* is about 8 to 12 in. tall and ready for transplanting.

Sandbed Reconditioning. After all cuttings are removed, approximately 4 in. of sand is taken out of each bed. Fresh sand is added with a front-end loader just before each particular type of plant is stuck. The sand we use is very clean and using it immediately limits weed problems.

SUMMARY

Outdoor mist propagation is an inexpensive, highly efficient method of producing large quantities of high quality, uniformly rooted cuttings. This is the first and one of the most important steps in producing high-quality landscape plant material.

Back to the Basics in Propagation

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AUXINS

Powder (talc) formulations of auxins are still used to stimulate rooting of cuttings. A problem with talcs is that they may not be uniformly applied at the base of cuttings and they are easily removed when cuttings are inserted into the propagation medium. Spray or quick-dip applications of 1 to 5 sec are the preferred methods to apply auxins since a more uniform response and potentially better penetration of auxins occurs. Indolebutyric acid (IBA) and naphthalene acetic acid (NAA) are the two most common forms of auxin used singly or in combination in commercial propagation.

LOSS OF PROPAGATION CHEMICALS

Propagation and nursery production will be less reliant on chemicals in the future. Technical-grade auxin can no longer be used in commercial propagation. The EPA considers IBA to be moderately toxic with an LD50 of 100, even though for 50 years this chemical has been safely used. Currently, technical-grade IBA has a conditional registration. Plant propagators can buy registered, formulated products containing IBA, such as Dip 'N Grow which contains 1% IBA and 0.5% NAA. These products can be serially diluted down to lower concentrations. Other alternatives to IBA may include P-ITB (Rootal), which is a phenyl indole-3-thiolobutyrate product, that may clear EPA registration. The Dupont Co. has recently cancelled all ornamental uses for Benlate (Benomyl), which was the most widely used fungicide for propagation and ornamental use. No longer can it be used in dips and drenches for cuttings. Some possible substitutes include: Topsin M (Atochem N.A.), Domain (Sierra-Grace) and Cleary 3336 (W.A. Cleary). Always conduct small tests before trying new products in your propagation system.

The beneficial fungus *Gliocladium virens* may be an alternative to Benlate. It has been cleared by the EPA for biological control of *Rhizoctonia colani* and *Pythium ultimum*, which are two of the principle pathogens causing damping-off diseases.

CULTURAL PRACTICES TO ENHANCE ROOTING

With the reliance on fewer chemicals, there will continue to be a greater need to use sound cultural techniques to enhance rooting. Cultural practices include sanitation, stock plant manipulation, stress reduction, temperature and light manipulation, water management, and fertilization practices.

Sanitation. Good sanitation practices include taking cuttings from nutritionally fit and disease-free stockplants or container plants. Cleaning the propagation work area and propagation beds should be standard routine. For cleaning benches and walkways and sanitizing propagation tools, consider using Agribrom (oxidizing biocide), Physan 20 (benzly chloride), household beach, pine disinfectant, or Green-Shield. Dilute household vinegar is good for control of algae along walkways. Methyl bromide has been an effective gas sterilant for killing pathogens, insects and weeds in propagation media. This chemical is currently banned for horticultural use in Holland, since it gets into the aquifer system It may be no longer available in the USA in the future Propagators have used chemical drenches to avoid pasteurizing propagation media. Pasteurization (165°F/74°C) may be used more in the future. Water chlorination is also effective in reducing pathogens and potential algae problems in propagation.

Drench Cuttings. Many nurseries dip cuttings into chemicals then quick-dip with auxin Most use dilute bleach solutions, Agribrom, Physon 20 or various fungicides for broad-spectrum control of damping-off organisms Agri-strep (agricultural streptomycin) helps control bacterial problems, and one biological control, *Agrobacterium* spp. helps prevent crown gall of hardwood rose cuttings. Once a cutting or plant becomes infected with a bacterium, there is no effective control other than rouging and destroying the cuttings. Again, always conduct small tests with a control before wide-scale use of a chemical.

Temperature. Bottom heat can significantly speed up root formation and development. Intermittent mist lowers the temperature of the propagation media through evaporative cooling. Medium temperature can be raised by using hot water PVC pipes, commercially available plastic tubes or electric cables Root initiation is optimum under somewhat higher temperatures than root development (elongation). The exact optima vary with species (Hartmann, et al , 1991)

Timing and Scheduling. Taking cuttings at the optimum time of year is more critical than using auxins. Softwood cuttings from the first growth flush must be taken in early spring. This is often the only time to get successful rooting with more difficult-to-root species Semihardwood cuttings with more lignified tissues are taken in late spring into summer. These cuttings are less stress susceptible Hardwood cuttings are taken when a plant is dormant during late fall or winter. The October 15, 1991, edition of the American Nurseryman has an excellent series of articles describing timing, scheduling and other propagation techniques.

Commercial priorities drive scheduling in a nursery. When cuttings are stuck may be determined by heavy shipping demands in the spring, availability of propagation space and efficient use of personnel, rather than the optimum biological time to take cuttings. However, with some species it is critical that cuttings be taken during a specific period if successful rooting is to occur. For example, *Ulmus parvifolia* cuttings must be taken 6 to 8 weeks after budbreak (Whitcomb, 1982). As a general rule of thumb, more difficult-to-root plants are stuck early in the propagation season. Easier-to-root cuttings can be taken later in the season since they require less time and propagation space.

Records. It is critical that good records be maintained. With such large numbers of different cultivars and species both written records and pictures are important Both show new propagation personnel how to propagate plants, and what optimum results should look like Video tapes can be effective in training personnel; most people want to learn and improve their skills when given the proper environment and encouragement.

Juvenility and Maturity. Auxins will only speed up and enhance the rooting process if cuttings have the genetic potential to root. This is particularly true with difficult-to-root species or cuttings taken from physiologically mature stockplants, which do not respond to auxin application.

Research in biotechnology systems using agrobacterium to incorporate genes into tobacco plants indicates that those genes responsible for making the plant tissue respond to auxin application, and thus root, are more critical than those responsible for the actual production of auxin (Hartmann, et al , 1991). This makes sense if one considers that as a plant becomes physiologically mature, certain genes that affect the rooting process are turned on and off. In the future, there may be opportunities to incorporate genes that increase tissue receptivity to auxin into higher plants. For the present, there are a number of techniques to manipulate stock plants to retard maturity and increase rooting success.

Stock-Plant Manipulation. Rooting can be enhanced by reducing nitrogen fertilization in stock plants to maintain an optimum carbohydrate/nitrogen ratio The C/N ratio affects rooting of rose hardwood cuttings, (Hambrick, et al., 1991) Likewise, rooting can be enhanced by manipulating light intensity, taking basal vs. apical cuttings, more closely spacing stock plants and utilizing pruning, girdling and layering techniques (Davies and Hartmann, 1987). The effect of most of these procedures is species dependent

Stress Reduction. It is important to collect cuttings early in the day when shoots are turgid and stockplants are not under water stress. Cuttings should be maintained under low light, high relative humidity and cool conditions until stuck. Cuttings of some species can be stored in a refrigerator for 6 hours to 2 months prior to sticking.

Direct Sticking vs. Propagating in Community Flats. The majority of nursery cuttings are now direct stuck in small liner pots in liner flats rather than a large community flat of 50-200 cuttings bunched together. Direct sticking avoids the production step of shifting rooted cuttings into liner pots, and is thus more labor efficient. Direct sticking avoids transplant shock from having roots disturbed during shifting up. However, direct sticking takes more propagation space so it is not cost effective for poor-rooting species.

Wounding and Stripping Cuttings. For many species, wounding the cutting base and stripping off needles at the cutting base is an unjustified production cost. With certain species these techniques can increase rooting by: (1) allowing greater uptake of liquid auxin solutions; (2) creating a "sink" area where accumulation of naturally occurring auxin, carbohydrates and other root-promoting metabolites can occur; (3) stimulating cell division essential for root-primordia formation; and (4) improving the contact area between the cutting base and propagation media for better cutting water relations.

Low Tech. If it works and it is cost effective, use it. There is little purpose in purchasing elaborate propagation equipment and facilities if a proportional economic gain does not occur. If you have success rooting cuttings in simple plastic bags, cold frames or inexpensive hoop propagation houses, use them.

Intermittent Mist. Intermittent mist systems have revolutionized the rooting of cuttings. Now propagators can propagate over a much longer time period and are not limited to using dormant hardwood cuttings for only a few months of the year Intermittent mist allows higher light levels which are important for root development and faster turnover of rooted cuttings (Svenson and Davies, 1989).

A disadvantage of mist is that the evaporative cooling, which is important for reducing heat stress to the cutting, may cause too low a temperature in the medium. Likewise, nutrients are rapidly leached from cuttings, which is a considerable problem for more difficult-to-root species, maintained under mist for longer time periods (Davies and Hartmann, 1987).

Alternatives to Mist. Mist tents can reduce the amount of mist needed. Likewise, contact polyethylene systems allow semihardwood and hardwood cuttings to be stuck, watered-in and then covered, thus avoiding the need to mist. These are commercially important where light intensity and temperature can be controlled. The fog system using centripetal foggers, (Agritech System), high pressure fogging (Mee System) or ultrasonic humidifier nozzles (Ultrasonics Ltd.), produce water droplets <20µm that remain suspended in the air as a vapor. Evaporative cooling occurs without the leaching and media saturation problems of larger sized intermittent mist water droplets.

SEXUAL AND ASEXUAL PROPAGATION

Sexual propagation by seed remains an important propagation system for nursery crops. For many shade and flowering trees it is the most common means of propagation. Nursery propagators frequently combine sexual and asexual propagation techniques by growing seedling rootstocks and grafting or budding with selected cultivars.

Seed propagation is generally cheaper than asexual propagation. Most seed (except apomictic seed) are produced through meiosis and fertilization, which enables a diverse genetic base for a seedling population. Therefore, plants are more tolerant of varying growing conditions and pests, as opposed to genetically uniform asexually (clonally) produced plants with the same genes and resistance level. Advisors to the Global Releaf program for planting millions of shade trees in the United States to combat the greenhouse effect, are recommending planting native species produced from seed to give a broad genetic base.

For sexual propagation to be successful in a nursery, it is critical that only the best seed be utilized, that marginal seedlings be rouged and that only the most uniform seedlings be allowed to continue in the nursery production system.

It is critical that the propagator know the seed provenance or the original geographic source of the seed, so that the plant produced is adapted to have sufficient cold and heat tolerance to reach maximum potential growth. *Cercis canadensis* from seed collected in Texas will not have sufficient cold hardiness to survive in Ohio. Ecotypes of this species from seed collected in Ohio and grown in Texas may not be tolerant enough of the higher heat stress conditions, nor will they obtain the same growth potential of plants from locally collected Texas seed. Seed should be collected from regions that are ecotypically similar to where the plant will be grown.

DO NOT PROPAGATE EVERY ITEM YOU SELL

It simply may not be cost effective to propagate 400 plus species and cultivars. It is important that a nursery grow the correct product mix to service its clientele, but few nurseries make a profit on every item they propagate. If a custom propagator or other reliable nursery source can propagate rooted liners, seedlings or tissue-culture liners more cheaply than you can, it is better to buy the liner material and finish off the nursery crop with your system. A nursery needs to make a profit on every item propagated.

GENERAL PROPAGATION MAXIM, RULES AND GOALS

(1) Do not overmist; (2) consider alternative propagation systems other than mist, such as contact polyethylene systems, fog or layering with hard-to-root cuttings; (3) remember a cutting will not efficiently absorb nutrients until roots are formed but relies on the residual nutrition of the stock plant; (4) consider preincorporating or topdressing with slow-release fertilizers or applying liquid fertilizer after roots are initiated; (5) wean cuttings from mist as quickly as possible; and (6) maintain the plants *momentum by taking cuttings during the time of the year when rooting is* optimal (Davies, 1988)

SOURCES FOR PRACTICAL PROPAGATION INFORMATION

Some excellent sources on how to propagate specific species and cultivars can be found in:

1) American Nurseryman Magazine
2) Combined Proceedings of the International Plant Propagators' Society
3) Practical Plant Propagation for Nursery Growers (Macdonald)
4) The Reference Manual of Woody Plant Propagation (Dirr and Heuser)
5) Plant Propagation—Principles and Practices (Hartmann, Kester and Davies)

All of these are fully referenced below.

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Container Tree and Shrub Propagation and Production in Oklahoma

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Container tree and shrub propagation in Oklahoma is a broad topic, so I will describe several techniques we use that might be of interest, plus some general topics such as spacing and potting media.

TREE PROPAGATION AND PRODUCTION

Grafting. We produce ash in no. 5 and no. 10 containers We found that a barefoot liner for a no 5 had too large a root system to fit in the container, so we had to look for an alternative.

The method we chose was to bench graft the ash in February using scion wood with a terminal bud. After grafting, the liner is potted in a bottomless 4-in. container and placed on a wire bench. The graft union is then covered with ground pine bark Callusing takes place on the bench.

The liner is removed from the greenhouse in late April to early May and potted in a no. 2 container. The liner remains in this no. 2 container until late fall or early spring and is then shifted to a no. 5 container.

The no. 10 ash is different. A finished product of 1 1/4 in. with branching is required, so we grow these liners in the field for two years and then dig them bareroot and transplant to a no. 10 container where they are grown for one more year.

We use a similar method for producing a no. 5 ornamental pear and ornamental plum We bench graft both these items starting in January. We use scion wood with a terminal bud for the pears. This type of wood is not available for the ornamental plum, so we staple a strip of paper around the scion when the graft is planted so the shoot will grow straight.

After the grafts are made, they are placed in bundles of 25 and hot callused in a waxed chicken box packed in shingle tow This hot callusing takes 5 to 10 days

When a good callus has formed at the union, the grafts are removed from the boxes and potted in 4-in. bottomless containers placed on a wire bench in a greenhouse and the graft union covered with ground pine bark

The grafts are removed from the greenhouse in late April or early May and transplanted to a no. 2 container.

Tissue Culture. This is becoming a more important part of our production process The plants we produce from tissue culture are: 'Heritage' birch, selected crab- apples, kwansan cherry, French lilacs, 'Autumn Blaze' and 'Red Sunset' maple. All these plants are purchased from Microplant Nurseries, Inc.[1] The Heritage birch and French lilacs are purchased as microcuttings and all others are rooted.

When the tissue culture plants are received in March, they are hardened off or rooted inside a plastic tent inside a greenhouse. The "tent" is placed over a wire

[1] Microplant Nurseries, Inc , 13357 Portland Road N E , Gervais, Oregon, 97026, phone 503-792-3969

bench and the plants dibbled into 2-in. square bottomless containers. The rooted plantlets take about one week to harden off, then the tent is removed. The unrooted cultures take 10 to 14 days to root, before the tent is removed.

All cultivars except French lilacs and 'Heritage' birch are transplanted to a no. 2 container in late April to early May Shade structures are used for all crabapples and maples.

The 'Heritage' birch and French lilacs remain in the propagation area. As they produce a flush of growth, the new growth is removed and re-stuck inside one of the tent structures. This allows us to build the numbers more cost effectively. These plants are transplanted to no. 2 containers the following spring.

Seedling Production. All trees that we can grow from seed we start in 4-in. bottomless containers placed in trays on a wire bench four to five inches above the ground. With the exception of the larger dogwoods and redbuds all other 4-in. seedlings are transplanted to no 2 containers the following spring. The larger dogwood and redbud are transplanted to no. 5 containers.

DECIDUOUS SHRUB PROPAGATION AND PRODUCTION

We produce shrubs in no 2 and no. 5 containers. These are rooted from softwood cuttings stuck in bottomless containers on wire benches and transplanted to no. 2 containers the following spring. Some are lined out in the field to grow on and are then dug bareroot and planted in no 5 containers.

EQUIPMENT

Every container-tree nursery with overhead irrigation needs a mist blower. The second priority is a mechanized planting machine.

GROWING MEDIUM

The mix we use consists of 40% hardwood bark and 60% pine bark. The pine bark is used fresh off the log; the hardwood is composted for six weeks, turned every 10 days. Seven pounds of 34-0-0 fertilizer is added to the hardwood to assist in the composting We also add 20% ground pine to the hardwood at the time of composting.

The trace elements and other ingredients are added at the time of planting. To each cubic yard we add 1 lb Dursban, 1.5 lb magnesium oxide (58%); 1.5 lb 0-46-0; 2 lb iron sulphate (not black); 2 lb sulphur; 3 oz frit trace elements, #504 HF; 8 1/3 lb 24-5-8 High N from Sierra.

SPACING

We use two widths center-to-center, 17 and 24 in. On both widths the trees are offset. However the trees on 17-in. centers are grown on a bed system with a 24-in aisle. This coming year we plan to switch to a 20-in. bed system.

OVERWINTERING

We move all our salable plants off of the main growing areas to a shipping area during the winter. In this location the plants are pushed can to can and covered with a layer of straw. Some items we overwinter inside stacked three deep.

Cleft Grafting of *Magnolia grandiflora*

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Magnolia grandiflora produced from seeds are highly irregular in form, leaf texture, density, cold hardiness, and bloom characteristics. Seeds from uniform trees produce offspring of diverse phenotypes. Opportunities exist for asexual propagation of many very fine selections. Some cultivars that we produce are 'Little Gem', 'Glen St Mary', 'Samuel Sommer', and 'Russet'. 'Edith Bogue', 'Claudia Wannamaker', 'D D Blancher' and 'Bracken's Brown Beauty' are other cultivars with market potential. I think 'Little Gem' and 'D.D. Blancher' are the best cultivars.

Over the years we have made numerous attempts to root several cultivars 'Samuel Sommer' roots fairly well; the other cultivars year after year have been almost total failures. Two years ago a friend, Mitchell McGee of Poplarville, Mississippi, called to tell me of his success with cleft grafting magnolias. I made a special trip to visit, and the following procedure is one that he worked out. In January 1991 I followed his procedure and was pleased with the results.

Container-grown seedling *M. grandiflora* of 1/2- to 5/8-in caliber are used for understock. Containers can be full 7-in., or 1, 2, 3 or 5 gal. Full 1 or 2 gal are ideal. We generally transplant rootstock from a liner pot in early spring and grow one full growing season to reach desired caliper.

In December or January dormant understocks are moved from outdoor growing areas into a heated greenhouse. After two or three weeks above 55°F, plants initiate growth. Benches with seating are set up inside the greenhouse. The benches should be high enough for the grafter's knees to be below the table Grafting is best done on the corners of the bench table

Grafting scion wood should be collected from dormant plants of the desired cultivar The scion wood should be as fresh as possible, and should be kept moist by wet burlap bags covering a plastic container while storing.

Any type of heavy grafting knife is suitable. We use a Freunde 217 The knife should be sterilized frequently by dipping into alcohol and air drying. Budding rubbers are 3/8 in. wide and 8 in long. The grafter should sit at the bench corner and wrap his thumb with duct tape to prevent injury. The grafter should cut the rootstock 1 1/4 to 1 1/2 in. above the soil line and remove any remaining lower leaves. Next he should shave the surface of the rootstock to make it smooth and level. Then make a 1- to 1 1/4-in perpendicular cut at the widest point down into the rootstock.

The scion is a single leaf node Terminals can be used. The best scion wood is within 6 leaf nodes of the terminal of any branch The single-node scion stem is 3/4- to 1-in long. The leaf should be trimmed by 50% to 75% depending on the size. Holding the scion in the left hand (if you are right-handed) with the thumb and fore-finger holding the leaf petiole, trim the scion stem into a wedge. Make the wide part of the wedge on the same side as the bud and leaf petiole. Using your grafting knife, open the rootstock slightly and wedge the trimmed scion into one side of the rootstock, matching cambium layers as best as you can. The wide part of the wedge should be visible. The narrow part of the wedge is obscured by the rootstock.

Manipulating the scion with your finger tips during preparation and while inserting into rootstock is a skill that cannot be described easily in print. Practice will allow you to master this phase of the grafting process

Once the scion is inserted and aligned, the graft should be wrapped from the bottom to the top The very top of the rootstock surface should not be covered by the budding rubber. Cover the graft with a 32-oz styrofoam cup. Mound clean fine pine bark or other similar material two inches on top of the soil and around the base of the cup Firm and pack the material to seal the graft.

The grafted containers should remain in the greenhouse. Soil moisture levels should be maintained at moderate levels The mounded bark medium should be kept moist at all times. After four to five weeks, cups should be lifted, suckers from the rootstock removed, and grafts resealed You will notice a sticky sap covering the grafted area. This is normal Rootstocks should be suckered again in four more weeks

Ten to 12 weeks after grafting, the scion should show signs of growth. At this time, lift the cup but do not remove completely. Be sure the greenhouse is not subject to wind and blowing. The cups are light and blow off easily, which could let the graft dry out Two weeks after moderate aeration remove the cup totally. Cups should be removed when the first leaf of the scion begins to expand fully. Topdress lightly two weeks after the cup is removed and the scion is growing. The rubber should be removed when the graft is four to six inches tall. Grafted plants can be transplanted into 7-, 10- or 15-gal containers once the graft is 10 in. tall. Be careful not to break the graft union during transplanting.

Plants grafted in January are now 4 ft tall and beautiful. Due to some mismanagement on my part, our percentages were lower than I had hoped for—50% overall. We did get 72% on one sizable group of 'Little Gem' Through closer attention to water management and more care of the hardening phase, I feel we can obtain 80- to 85% success

Grafting shows promise as a way to mass produce *M. grandiflora* cultivars for us. We have been more encouraged by grafting than by rooting cuttings.

Germplasm Program at the USNA

Edward Garvey
U S National Arboretum, 3501 New York Avenue, N E , Washington, DC 20002

The United States National Arboretum has established a germplasm repository for woody landscape plants It is part of the National Plant Germplasm System (NPGS) and shares its goals and objectives of collecting, establishing, maintaining, distributing, evaluating, and preserving high levels of genetic diversity inherent in its target species

Advisory Groups. This repository is unlike the other NPGS sites in that it's responsible for 175 genera of woody plants versus one to 40 for most collections. Because of this, we must conduct many of our activities differently; we rely heavily on cooperators

Advisory groups are the first major cooperative effort common to all NPGS crops. These groups advise the NPGS on how to carry out its objectives with a particular crop. The Crop Advisory Committee for Woody Landscape Plants is a very strong group composed of representatives from the nursery industry, the botanic community, the universities, Forest Service and American Association of Nurseryman NPGS curators are ex-officio members. But we also involve cooperators throughout the system

Plant Exploration. The Woody Landscape Plant Crop Advisory Committee (WLP-CAC) gave very clear recommendations on areas of the world where plant collecting is required. The United States and the People's Republic of China are co-priorities. Japan, Korea, USSR, Turkey and Eastern Europe are also priorities In addition, we, at the repository, have formed a plant exploration committee to implement these recommendation using staff and resources of not only the USNA, but also interested cooperating institutions.

Three members of the committee, Paul Meyer, Director of the Morris Arboretum in Philadelphia, Pennsylvania, Peter Bristol with the Holden Arboretum in Mentor, Ohio, and Lawrence Lee of the USNA, just returned from the People's Republic of China where they visited a number of institutions and negotiated future plant-collecting trips. The group was well received, and over the next three to four months, we will be setting up a long-term six-year cooperative plant exploration program with the People's Republic of China. We should be able to go back next year, fall 1992, for a six- or eight-week plant-collecting trip. Each trip we hope to include some different U S. institutions as cooperators

Plant Maintenance As I said earlier, we are responsible for 175 genera of woody landscape plants. Over the next 5 to 6 years, the repository will gain access to about 50 acres of excellent land at Glenn Dale, Maryland. Even 10 times this amount of acreage would be insufficient. Resources for supplies and labor are also insufficient. That leads us to our next cooperative venture Many botanic gardens, the Forest Service, universities and others are interested in developing and maintaining good collections of various plant groups Within the American Association of

Botanic Gardens and Arboreta (AABGA), the Plant Collections Committee has developed a program where member institutions developed these North American collections. Cooperation with this group will greatly assist us in carrying out our objectives The Forest Service has established a number of provenance tests over the years which are excellent germplasm sources. They would like us to cooperate with them.

Plant Distribution. Using this germplasm is fundamental to our program It must be available to the nurserymen who get it to the U.S. citizen and to the researcher. All of our accessions are available except when the plants are too small or unhealthy or the demand is too great. An example is, *Cornus kousa var. angustata* collected on the 1980 Sino-American Botanical Expedition Trip. We are just now getting enough propagating wood to propagate it. We will propagate it and distribute the plants.

We do not have a catalog of our collections, but if you are looking for something, call our Plant Record Office. If we have it and it's not readily commercially available, we will be glad to send some cuttings or seeds if available.

Evaluation. We do not have the resources to do significant amounts of evaluation, but through cooperation with others, evaluations can be made. An example: The USNA has a fairly good collection of *Ilex* (holly). Harold Pellett at the University of Minnesota submitted a proposal to the NPGS to evaluate this collection for maximum winter cold hardiness. It was accepted and funded. We shipped to him large amounts of stem tissue for his tests When the research is complete, he will send us copies of the raw data, which we will record with the accessions.

Benefits.

1) This program should support the breeding programs of this country, those at the USNA as well as other institutions When a deficiency is noted for a plant, a collection will be available that the researcher can screen for the desired trait without going back to native populations, which may not still be available.

2) Nurserymen can screen these collections for new and desirable landscape plants.

3) Researchers can screen these collections for finding new chemicals for use in pest control, industrial, and medical compounds.

4) Botanists and others, through study of these collections, can learn more about plant life or life in general.

5) Fifty years from now or even 20 years from now when new landscape characteristics or other needs are identified, collections representing the genetic diversity of the species will be available to study.

Additional Requests for Cooperation. Many of you are excellent plantsmen and outdoorsmen and know of unique populations or individual plants of natives. I would very much like to know of them; and if you think they may be hardy to the USNA (7B), please, send me seeds or cuttings. I ask for as much information on the site and population as you can provide. This information and plant material would then be available to others. If the site looks protected or you can establish a collection at your place and would be willing to honor propagation requests, I could use my resources elsewhere.

If you have the knowledge and resources to set up a good germplasm collection of a particular species, I'd be very glad to work with you to help you get additional plants or to publicize your collection. I will not support exclusiveness but I will ask you to distribute seeds or cuttings when requested and to maintain accurate inventory and accession records.

If you go on plant-collecting trips, either in the United States or abroad, and are collecting from native temperate populations of woody species, I may be very interested in getting seeds Again, information on the collection site, and characteristics of the plant are needed.

Good germplasm collections support all of our programs, and are important to all of us.

Straight Line Sticking

Charles H. Parkerson
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QUALITY

Quality is the characteristic that makes a nursery profitable. If we have quality people producing a quality product and provide quality service, our business is assured of success The start of quality in the nursery is the propagation department. The purpose of this paper is to share with you the simple method we use to begin our quest for quality.

MATERIALS AND SUPPLIES

Medium: 1-yd pine bark + 1-yd perlite + 6 lb lime + 1 1/2 lb Micro-Max (for azaleas 2 × the perlite)

Mixer: Boulding & Lawson Twister II Mixer

Pots: Multi-cavity tray 18, 24 and 36 pots/uncut tray TLC Polyform, Inc., Phone 612-542-2240

Filler: Bouldin & Lawson Model 134 Mini-Flat Filler

Hopper: Salvaged State Highway Department salt spreader

Conveyor: 12 1/2 ft × 12 in wide with 10-in. belt, 1 HP (110 volt, 20 amps) variable speed reversing motor EZ-FLOW Conveyor, Phone 201-842-4964.

METHODS AND PROCEDURES

Cuttings are collected, cut to size, and grouped together into hand-size bundles using a rubber band. We then treat with K-IBA and store until needed in a walk-in cooler

The flat filler and supply hopper are set up at the front door of the greenhouse. The drive conveyor section is attached directly to the flat filler. On this section we install six quick-connect trays for holding the cuttings Ten additional conveyor sections are hooked together and placed on the ground Plug into the electrical system, and you are ready to go.

The system requires the following labor:

- 1—Mixing soil and moving conveyors
- 1—Filling flats
- 6—Sticking cuttings
- 1—Supplying cuttings to sticking crew
- 1—Unloading conveyor with finished cuttings

New trays are placed on the flat-filler conveyor and filled with the rooting medium, which exits directly onto the drive conveyor section. The sticking crew is divided, half standing or sitting, on each side of the conveyor Bundles of cuttings are placed in trays in front of each person sticking the cuttings. Each person inserts the required number of cuttings into each cavity of the rooting tray as it passes. The tray then proceeds down the conveyor system, is unloaded and placed on the ground where the rooting process begins

DISCUSSION

Advantages of the system:

1) The rooting medium is the same in every cell of every tray. Consistent volume and compaction of the rooting medium is a tremendous advantage for the rooting process. Moisture, air and other variables are more easily managed

2) The system is fast. A 10-member crew can stick 15,000 cuttings per hour on a consistent basis.

3) The sticking crew is not exhausted at the end of the day Tired? Yes, but not exhausted.

Disadvantages of the system.

1) The rooting medium must be uniform with no large chunks, the sticking process is going so fast the sticking crew doesn't have time to coax a cutting into the rooting medium.

2) The EZ-FLOW conveyors are temperamental at times They must be set up with care to assure that they are in absolute alignment.

3) The system has an economy of scale. If you have less than 500 cuttings, it's almost as easy to set the trays in the house and stick the cuttings on your hands and knees

SUMMARY

I am convinced that the benefits of "Straight Line Sticking" far outweigh the disadvantages Economical plants can be produced starting us on the road to our ultimate quest for quality.

The Acclimation of Tissue Cultured Plants

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A PRACTICUM

Success in acclimating tissue cultured plants balances on the fulcrum of carefulness. Tissue cultured plants are similar to a newborn baby in an incubator. The work is critical and each stage demands close attention. Trained professionals assure that the process can be done successfully.

I have developed seven Ps that direct us through each stage of the process:

Proper Prior Planning Precludes Pitiful Poor Performance

STAGE I—PREARRIVAL

Know when your tissue will be delivered from the lab. This date must be no surprise. Prepare the soil mix, pots and trays. I use Sunshine #4 potting directly into 218 Jiffy pots in 1020 trays. Sterilize the mist and fog area. Clorox beach diluted 15 to 1 through a Hozon (Hyponex Brass Siphon Mixer) proportioner works well.

Arrange the shade and tenting area. The house should be shaded 55%. The actual work tent must also be shaded 55%. Finally, place a plastic tent over the bench area.

Drenching the soil is the final step in prearrival. Drench with 9 oz calcium nitrate and substitute for Benlate (8 oz) in 3 gal of water through a Hozon proportioner.

STAGE II—ARRIVAL

Inspect your plants! Have the packages been broken? Do the plants appear scorched? Are they dried or burned? Plants that arrive in poor condition have little chance of survival. After inspection you may begin potting.

Grade the plants by size as you pot them. Keep the mist handy in a spray bottle and spray as you pot each tray. Hold the humidity as high as possible. Speed is essential Inspect and pot as soon as possible, and return to high humidity quickly.

STAGE III—POSTPOTTING CARE

This stage easily divides into six substages. The first stage requires maintaining high humidity without overwatering or drenching the plants. Keep a dome over the individual trays for five days.

The second stage begins on day five, now we begin plastic removal. Whether over the tray or over the whole area roll the plastic up beginning two hours per day. Gradually increase each day for five days.

Day seven marks the beginning of the third stage, and is the day of the first fertilizer application. The application is as follows:

20-10-20 Peter's

4 oz/3 gal through Hozon proportioner

On this day also begin the first fungicide application. Rotate the following fungicides and repeat this entire rotation every ten days:

Chipco 26019—7th day

Daconil 2787—17th day

Kocide 101 or Blueshield—27th day

On the 10th to the 14th day we remove the plastic completely. This is the fourth stage in postpotting care. Note this is not shade removal but plastic removal. Removal is best done on a cloudy day This process reduces humidity.

On the 14th day roll back the shade cloth for the first time. Gradually begin rolling it back a few hours at a time until day 21

During the fifth stage plants are fertilized twice weekly. Maples are more tolerant of nitrogen than birches. New plants must be studied and fertilizer balanced according to trial and error.

This brings us to the final stage of postpotting care, which is the removal from the entire greenhouse.

FINAL ACCLIMATION

Gradually reduce the mist and continue the fertilizer and fungicide programs. Every 30 days we grade to prevent the shading of plants by overshadowing. In eight to ten weeks we remove the plants from shade and mist house.

If the weather permits, we put them into another house with no shade or high humidity. Here we water them regularly. In 12 to 14 weeks plants are ready for the field or containers.

We normally begin our operation in mid- to late January. We try to have the plants ready to ship in mid-April. However, plants can be acclimated any time of the year with the usual weather considerations.

Finally, I would again emphasize the great importance of speed in dealing with newly delivered tissue. Watch the humidity in those early stages of the process Observe carefully the responses during the different stages. Observation is still our greatest instructor.

Propagating vs. Selling Liners: Can You Sell What You Propagate?

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When deciding whether or not to grow and sell rooted liners, first consider the requirements for marketing your product. Often more time is spent gathering information on growing and caring for plants than on selling them. Because most nurseries are owner operated, the owner must not only know how to produce the plants but also know how to sell them.

I have developed six major categories which you as a professional should carefully plan and execute to establish a successful liner business.

Marketing. Marketing your product is number one Without a marketing plan to sell what you produce you will soon be out of business You must determine what cultivars or varieties of liners will sell best You must also determine the quantities that should be grown to meet the anticipated demand without overproducing, and what size the liners should be to meet the market you are targeting. Timeliness is also a key factor. The liners must be ready when the market is ready.

Be prepared to advertise the liners you grow Catalogs or price lists should be assembled listing sizes and prices. Advertising in trade publications and listing in their classified sections helps you target your sales. Trade shows are an excellent opportunity to display your products and to meet potential customers Be sure to select trade shows in areas that you are best able to serve.

Trade association membership is an important part of being in the nursery industry. Local, state and national associations provide legislative assistance, and give members an opportunity to meet others in their field of production. It is important for your name to be familiar in the trade when you are a grower.

Stock Plant Selection. Stock plant selection is the key to producing healthy, vigorous liners. Cuttings should be from either established stock blocks or existing inventory, plants should exhibit vigorous growth and be the desired form of the species A proper fertility balance should be maintained in stock plants to aid in rooting cuttings And most important, stock plants should be free of any form of pest

Production Techniques. Production techniques vary from nursery to nursery depending upon geography, species of plants, and the target market. Your intended market will affect your choice of rooting media, container size, and pre- and post-rooting conditions.

Your rooting media should be compatible with the media used by the grower buying your liners in order for your customers to get good root extension. The media should be of a consistency that drains well while retaining enough moisture to maintain vigorous growth

Containers in a vast array of sizes and designs are available from many manufacturers The main consideration in choosing container sizes should be what best fits your customers' needs, not necessarily your own. Containers from 1 3/4 to 3 in. are suggested for liners going into 1-gal containers. Liners for 3-gal production should be in 3- to 4-in. containers.

Getting the cuttings off to a good start under optimum conditions is the most critical step in growing healthy vigorous liners. At Bennett's Creek Nursery we call this our "Intensive Care Unit", with detailed attention given to moisture, temperature and pest control.

Postrooting conditions or hardening-off is the final stage in preparing rooted liners for shipping. Our rooted liners are removed from the optimal conditions of the "Intensive Care Unit" to acclimate them to field conditions. Intermittent mist is replaced with daily watering as needed, and light intensity is increased to firm up the stems and new growth.

Consistency. Consistency is crucial in developing your liner business. Maintaining plant quality requires keeping plants pest free along with proper pruning to produce full, multibranched liners. Maintaining consistent liner sizes from year to year and having liners available when needed by customers will lead to repeat customers.

Packaging. Liner packaging is another consideration in the process of growing liners to sell. The less stress a liner endures the better that liner will transplant and grow in the field. Liners are usually packed in boxes or in trays. Each method has pros and cons, and you must select what works best for your customers

Boxes or crates are the most widely used packaging method. The pros for boxing include shipping more liners per square foot and needing no shelving in the shipping trucks. The negative side to boxing is obvious because box stacking leads to damaged plants if the bottom boxes get crushed during shipping. Liner water and light requirements need immediate attention during both packaging and unpackaging.

When liners are shipped in trays, less breakage and damage occurs One of the main advantages of using trays is that immediate unpacking upon receipt of a shipment is not required. The negative side of using trays is that shelving is required in the shipping trucks.

Shipping. Your final major decision will be how to ship your liners. Because freight charges add to the overall cost of liners, it is important to consider the shipping cost per unit for whatever method of shipping is used. Decide what geographical areas you want to serve and the minimum quantities you are willing to ship. You have better control over the handling of your liners if you use your own trucks or trailers.

Other available shipping services include common carriers, parcel services, air freight, and independent truckers Each of these alternatives has advantages and drawbacks, but you must be sure when using any of these services that your liners are packaged to withstand rough handling.

Bottom Line. Quality, consistency and timeliness are the bottom-line for producing liners that customers will reorder from year to year

A Look at Propagation at a Diversified Nursery

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Mr. Amon Baucom started Baucom's Nursery in 1956. Mr. Baucom is still active in the business. His two sons Chip and Gary are now also involved. Mr Baucom had the foresight to convert a grading, landscape business to a container nursery and also started seven retail stores in Charlotte.

The goal of our company is to offer a full product line, with salable plants every day of the year.

In June 1988 ground was broken in Mt. Dora, Florida for a second nursery. Its purpose was to have a facility in a warmer climate to produce foliage and germinate seed.

Baucom's Nursery totals 300 acres in use including both the Florida and North Carolina operations Two and one-half million square feet are under greenhouse plastic, of which 360,000 square feet are under mist.

I am attempting today to show very briefly the diversity of the propagation at our nursery. Each nursery present today has its own methods based on its own variables. I would like to share some ideas we have gained through trial and error.

WOODY ORNAMENTAL PROPAGATION

For many years we propagated azaleas in a 96-count tray. During the winter two cuttings were planted in a 4-in. pot. Fuel costs were continuing to rise and we could not invest in heat to grow these cuttings into liners by spring. We realized that we were not utilizing warm-weather conditions for liner growth We also felt using individual 4-in. pots required unnecessary labor and changed to an insert tray. Our propagation mix for azaleas, junipers and other ornamentals is bark and peat (3:2, v/v) with 8 lb of lime.

During azalea propagation, cuttings are made early in the cool morning hours, and we coordinate our irrigation to insure stock plants are moist. We take cuttings approximately 4-in. long, strip the lower leaves (one inch) and pinch the center bud.

Woods Rooting Compound is used at a mixture of 1 part Woods to 15 parts water. Each liner cell contains two cuttings.

Every 7 to 10 days we spray Cleary 3336 WP in the evening after misting is stopped We use Scotts Southern Weed Control following rooting As a preventative measure, we alternate Banrot at 9 oz/100 gal and Subdue at 1.7 oz per 100 gal as a drench through a Smith injector at an interval of 45 days. Scotts 22-3-10 is topdressed at 6 to 7 lb/100 sq ft Nutritional and pH levels are monitored regularly.

To reduce heat cost, temperature in the propagation house is maintained at 36°F throughout the winter.

Liners are pruned up to three times in the flat before planting. Azalea liners are maintained through the winter and potted to 1-gal containers the following spring beginning in mid-April.

We feel we benefit from direct sticking our cuttings into a liner tray by establishing roots during summer months. With minimal heat through winter, we can grow an established liner for spring We also feel we are more productive by using trays as opposed to individual 4-in. pots

Dwarf Nandina. Cuttings are made nearly year round except when growth is new in the spring. Woods Rooting Compound is used at 1:12 dilution. We direct stick our cuttings into 1-gal cans. Care must be taken to avoid over misting during rooting. Cuttings usually are sold in one-gal containers and some are shifted up to 3 gal.

Leyland Cypress. Cuttings are made in January. They are about 12 in long and are wounded on both sides Woods Rooting Compound is used at 1.4 dilution. These cuttings are direct stuck in 1-gal cans in cold frames and root in about 3 months. One-gal cans allow heavy growth for transplanting into 3-gal cans.

Juniper. Juniper cuttings are made November through mid-February. One cutting per cell is stuck in our 24-cell tray. Woods Rooting Compound is used in 1:5 to 1:10 dilutions.

Most of our ornamentals are propagated in the fall in our 24-cell trays Depending on the plant's growth habits, each liner contains one or two cuttings.

HERBACEOUS PLANT PROPAGATION

Poinsettia. In April we purchase 22,000 rooted cuttings from the Paul Ecke Company, which become stock plants The cuttings are potted into 3-gal cans in a bark, peat and vermiculite (13:6:1, v/v/v) medium with 6 lb/cu yd Osmocote incorporated. They are liquid fed using Total Grow 20-10-20 at 200 to 300 ppm

Until summer the stock plants are maintained between 62 and 65°F. When weather is consistently warmer, plants are moved from the greenhouse to an outdoor shade house, where the cuttings are made.

Starting in July, poinsettia cuttings are made from 6·00 a.m until the stock plants show stress from the heat of the day, usually around 11:30 a.m. As the cuttings are made, they are transported every 15 minutes from the shade house to the greenhouse in styrofoam coolers. The lower leaves are removed and the cuttings are stuck 1/2- to 3/4-in deep directly in the 6-, 6 1/2- or 8-in. containers or hanging baskets in which they will be sold.

For probably 25 years poinsettias were stuck in individual rooting cubes. Maintaining and transplanting those cuttings was difficult and involved more time and labor. Cuttings must be misted even on a cloudy day to prevent leaf burn.

It is also important to prevent stretching of the cuttings during propagation. Five days after sticking we spray the cuttings with a mixture of 1500 ppm Cycocel and 2500 ppm B-Nine. Following rooting, all cuttings are hand pinched before the pots are spaced.

A regular pesticide program is essential As we all know, the cuttings will only be as good as the stock. A monthly soil drench plan consists of Banrot, a combination of Clearys and Truban or Subdue. Our insecticide program consists of Orthene-Talstar, Orthene-Tame or Thiodon. A monthly application of Safer Soap is applied for white fly control. Fungus gnats are a real problem because of propagation conditions and are treated with a Vydate drench.

Perennials. Seeds are germinated in January for a March planting into a 1-gal container. Our soil is a mixture of bark and peat (7:3, v/v) with 8 lb of lime, 10 lb of 22-3-10 and one lb of Step (Scotts Trace Element Package) incorporated per cubic yard.

Immediately after potting Scotts Southern Weed Control is applied. Proper watering and drying techniques are best to control height and bud set. Growth retardants such as B-Nine are used at 2500 ppm only as a last resort.

Geraniums. Our propagation starts with the purchase of unrooted cuttings which we direct stick into 6-in pots and put under mist. After rooting, the 6-in. geraniums are spaced on tables where most will be grown until they are sold. Some may be shifted to 10-in. pots for sales

When we have space and need cuttings, we take them from the 6- and 10-in. plants. The process also serves to pinch the plants. In addition geraniums are treated with Florel to stimulate lateral branching This must be done two weeks before normal pinching.

Seed Germination for Bedding Plants. In a year we germinate close to 16 million seeds We grow 22 flower and 9 vegetable types. Seeds are sown with Bouldin & Lawson or Blackmore machines in plug trays containing 128, 200 or 400 cells. Each cell may contain from one to ten seeds. After they are sown, trays are topdressed with a light coat of vermiculite and watered.

During the winter months seeds are germinated in a germination chamber we call the hot box. This chamber, which is equipped with a humidifier, is kept at 82°F. Seeds germinate in 4 to 14 days After seeds germinate, trays are moved to the greenhouse and maintained until seedlings are transplanted.

The greenhouse is kept at 68°F and is well ventilated. We fertilize the seedlings with water-soluble Total Grow 20-10-20 at 75 ppm.

Our pesticide program consists of a weekly Vydate drench along with Banrot, Subdue, or Chipco.

Control of watering, fertilizer and temperature are the best growth regulators and least expensive, but to prevent stretching B-Nine is used one time on seedlings.

All sowing schedules are arranged on a computer. Each schedule gives sowing dates, transplanting dates to bedding flats and tentative sale dates. The computer also maintains the inventory for each item.

Germination of Doubly Dormant Woody Ornamental Seeds

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INTRODUCTION

Many temperate zone plants have developed highly specialized organs for protection from would-be foragers, drought, and temperature extremes. For example, *Opuntia* spines protect it from animals; barley awns help dissipate heat; corms, bulbs and tubers serve as reservoirs of food and water; winter bud scales protect shoot apices form cold winter winds; and seed serve to transmit genetic information accumulated in response to the environment to new generations (Janick, 1986).

Probably the most important adaptation and the most intriguing mechanism temperate plants have developed is the ability to survive the long winter months in a state of rest Herbaceous perennials survive by underground storage structures, woody plants by winter buds and massive root systems, and annual plants by seeds (Khan, et al. 1977, Oosting, 1956).

Seeds are the primary means of surviving and increasing the population. Seeds rest through conditions unfavorable for growth by mechanisms best described in two categories, quiescence and dormancy "A quiescent seed is readily germinable with non-specific trigger agents, such as sufficient moisture and optimum temperature" (Jann and Amen, 1977) Annual plants, for the most part, fall within this category in that they germinate rapidly, grow, flower, set seed, and die in one season These plants produce many seeds so that at least a few will germinate and mature to produce more seed

True seed dormancy is the inability of a seed to germinate, even under conditions that are normally considered favorable for germination (Jann and Amen, 1977). Dormant seed germinates in response to specific triggering agents, which are environmental factors correlated to their respective inhibition mechanisms.

After the dormancy requirements have been satisfied, the seed is capable of germination Physiologically, germination is the sequential process including resumption of previously depressed metabolic pathways and the differentiation of oxidative and synthetic pathways This ultimately brings the embryonic axis into a state of active growth, which was temporarily suspended during quiescence or dormancy Morphologically, germination is the transformation of an embryo into an actively growing seedling (Jann and Amen, 1977).

SEED QUIESCENCE AND DORMANCY

The common inhibitor mechanisms include the following:

Seed Coat Impermeability.This mechanism involves the inability of water or gasses to enter the seed either by an impermeable seed coat or by seed coat resistance to swelling (Khan, et al., 1977)

Most species with an impermeable seed coat will germinate rapidly after the seed coat is made permeable (Hartmann, et al , 1990; Krugman, et al., 1974; Macdonald, 1986). Seed coat impermeability is reversed in nature by various environmental factors including mechanical abrasion, alternate freezing and thawing, attack by soil microorganisms, passage through the digestive tract of animals and fire (Hartmann, et al., 1990). Most seed of the Fabaceae (Leguminoseae) family have an impermeable covering, as do many species of Sapotaceae, Ericaceae, Rhamnaceae, Anacardiaceae, and Sapindaceae families (Krugman, et al., 1974) Seed coat impermeability is due to presence of a layer of palisade-like macrosclerid cells (Hartmann, et al., 1990). They are especially thick-walled with a waxy external cuticle.

Any process that alters the seed covering to make it permeable to water and gases is called scarification. Seeds can be mechanically scarified by rubbing on sandpaper, cutting with a file, or cracking in a vise (Hartmann, et al., 1990; Krugman, et al , 1974; Macdonald, 1986). Large lots of seeds can be scarified in large motor-driven tumblers with an abrasive lining (Macdonald, 1986). After the scarification process is complete, the seed coat should be dull and not deeply pitted or cracked (Hartmann, et al., 1990) Scarified seeds are more susceptible to pathogens and do not store as well as non-scarified seed (Krugman, et al., 1974; Macdonald, 1986).

Water soaks will soften some hard seed coats (Macdonald, 1986) Hot water (170-212°F) can sometimes be used but care must be taken to avoid high-temperature injury to the embryo. Seed that has been treated with a hot water soak is alluring to rodents so must be protected from them.

Acid scarification is a common method of modifying seed coats and is easy to perform. Seeds are soaked in full strength sulfuric acid (H_2SO_4, specific gravity 1.84) for different lengths of time based upon the seed coat thickness (Hartmann, et al., 1990; Krugman, et al., 1974; Macdonald, 1986) Acid scarification is a convenient method that leaves the seed clean, firm and unswollen (Krugman, et al , 1974). The drawbacks of acid are the safety hazards to personnel and the need to determine accurately the length of treatment time (Krugman, et al., 1974). As with hot water treatments, seeds that have been treated with acid may attract rodents.

After-Ripening Requirement. This type indicates the presence of an undeveloped or rudimentary embryo, the presence of chemical germination inhibitors, or the lack of chemical stimulus Any one or combination of these will maintain the seed in dormancy until a cold temperature stratification (moist-chilling) period occurs. This results in a maturation of the embryo, removal of inhibitors, or the production of chemical promoters (Khan, et al., 1977).

After-ripening requirements are usually satisfied by stratification (moist-chilling). Temperatures from 33 to 41°F allow certain physiological changes within the embryo to occur (Hartmann, et al., 1990). Most of the changes are biochemical, but seeds of many species have immature embryos that must grow and develop before germination is possible (Krugman, et al., 1974; Macdonald, 1986). Rudolf (1961) reported that 60% of over 400 woody plant species tested required some after-ripening to prompt germination

Many different techniques have been developed and many are specific to the species involved, the equipment to be used, or personal preference. The critical factors require the use of a high-moisture-holding medium, adequate aeration, and proper temperatures (Hartmann, et al., 1990; Krugman, et al., 1974).

Many chemicals, such as gibberellin (GA), cytokinin, and ethylene, have been used to promote seed germination Of all these, GA has the most pronounced effect (Hartmann, et al., 1990). ". . . GA will stimulate germination in seeds where dormancy or quiescence is imposed by a wide variety of mechanisms, eg. incomplete embryo development, mechanically resistant seed coats, presence of germination inhibitors, and factors relating to the physiological competence of the embryo axis (Jones and Stoddart, 1977). GA has been used to replace cold stratification of *Corylus avellana* seed (Brinkman, 1974; Frankland and Wareing, 1966; Jarvis and Wilson, 1977). Exogenously applied GA activity in *Corylus* appears to affect germination at two sites, the embryonic axis, stimulating growth, and the cotyledon, stimulating carbohydrate metabolism (Jarvis, et al., 1978). Other woody species where GA soaks of 200-500 ppm for 24 hours have been shown to replace moist chilling include *Carpinus caroliniana* (Bretzloff and Pellett, 1979), *Vaccinium ashei* (Ballington, 1976), *Prunus persica* (Hundal and Khajuria, 1979), *V. macrocarpon* (Devlin and Karczmarczyk, 1975), *Fagus sylvatica* (Franklan and Wareing, 1966), *Liquidambar styraciflua* (Burns, 1967), *Ulmus* sp., *Pinus sylvestris, Picea glauca,* and *Picea pungens* (Grover, 1962).

Exogenous GA has been demonstrated to improve seed germination and shorten the moisture-chilling period of several woody ornamental plants, and GA combined with moist-chilling may be used to germinate seed of species from GA that applications has been demonstrated in many woody species, including *Quercus rubra* (Vogt, 1970), *Pyrus pashia* (Dhillon and Sharma, 1987), *C. caroliniana* (Bretzloff and Pellett, 1979), *Acer tataricum* (Nikolaeva, et al., 1973), and *Ostrya virginiana* (Newman, 1981).

Seeds of many woody species have several forms of dormancy and are called doubly dormant (Bonner, et al. 1974; Dirr and Heuser, 1987; Hartmann, et al., 1990; Macdonald, 1986). More than 14% of the species and cultivars listed by Dirr and Heuser (1987) require combinations of dormancy treatments to induce seed germination. The most common form is an impermeable seed coat along with an internal dormancy requiring after-ripening. Any of the seed coat scarification treatments followed by moist chilling will satisfactorily remove both forms of dormancy (Bonner, et al. 1974; Dirr and Heuser, 1987; Hartmann, et al., 1990; Macdonald, 1986).

Some species have a hard seed coat that is not completely impermeable and a warm stratification period of several months may degrade the coat enough for organic acids and microorganisms to act on the seed coat or "bony" endocarp and allow imbibition (Hartmann, et al., 1990; Khan, et al., 1977; Krugman, et al., 1974; Macdonald, 1986).

Warm followed by cold stratification is a treatment used on woody species with under-developed embryos The warm temperature promotes embryo maturation. The epicotyl is dormant in many species, such as *Davidia involucrata, Paeonia suffruticosa, Chionathus retusus,* and *Aesculus parviflora* (Macdonald, 1986), but the radicle is not (Dirr and Heuser, 1987, Krugman, et al., 1974; Macdonald, 1986). A warm temperature period (constant 50-77°F or 68 and 86°F alternating diurnally) allows the radicle to emerge and become established. The following cold temperature period removes epicotyl dormancy (Krugman, et al., 1974; Macdonald, 1986). Seeds naturally receive this warm-cold treatment during the summer-winter seasons (Macdonald, 1986). Germination generally then occurs 18 months after fertilization.

Nandina seeds, which have an under-developed or rudimentary embryo (Dirr and Heuser, 1987), are best handled by collecting the berries during late fall to midwinter, and storing them in a cool and dry place until the following spring. Then soak the berries for 24 hours in water, macerate the flesh from the seed, sow the seed in flats or pots of pine bark, and place the containers under shade with irrigation The seed will then germinate in late October. During the warm summer months, the rudimentary embryo matures and germinates during the cooler months

Doubly dormant seeds collected during the late summer and planted immediately, taking advantage of the warm soils, will often germinate the following spring. However, seed collected, stored and planted in the fall will usually germinate the second spring (Dirr and Heuser, 1987). Early collection may avoid the hard seed coat condition (Macdonald, 1986).

Seed collected while still green, prior to the development of thick seed coats or prior to the accumulation of inhibitors in the seed coat, can be sown immediately for germination during the following spring. Unchilled mature *Malus* will germinate if the seed coat is removed (Powell, 1987) Many species collected green will germinate immediately upon sowing (Sandahl, 1941).

In seeds of species requiring a warm temperature stratification period followed by moist-chilling, exogenous GA has been demonstrated to replace the warm phase and shorten the cold phase (Macdonald, 1986; Newman, 1981; Simancik, 1970; Wicislinska, 1977) GA does not seem to be the only factor in removing dormancy but possibly induces embryo maturation. Moist-chilling then removes any other form of dormancy. GA effects are also enhanced with scarification (Newman, 1981; Simancik, 1970).

Photoblasticity. Photoblasticity is the requirement of exposure to light, which releases or initiates hormonal control of germination (Khan, et al., 1977).

TECHNIQUES FOR BREAKING SEED DORMANCY.

Approximately two-thirds of the tree species native to North America yielding sound seed will not germinate under favorable conditions (Krugman, et al., 1977). Under natural conditions, morphological and physiological changes necessary for the removal of dormancy take place gradually in response to varying environmental factors. "By duplicating key conditions of the natural environment in the laboratory or nursery, dormant seeds can be induced to germinate" (Krugman, et al., 1977).

Delayed germination due to dormancy is a serious problem to the nurseryman (Krugman, et al., 1977). Natural irregular germination occurring over a two or three year period leads to irregularly aged stock, ties up bed space, hampers direct-seeding operations, and increases the time sown seed is exposed to predators, disease, and adverse weather conditions (Krugman, et al., 1977; Macdonald, 1986).

FINAL POINTERS

Study the literature first when attempting to germinate woody plant seeds that are doubly dormant or of an unfamiliar species. The Proceedings of the International Plant Propagators' Society is an indispensable reference for the propagator, and their indices are a good place to start. Other good references include: The reference manual of woody plant propagation: From seed to tissue culture by M.A. Dirr and C.W. Heuser, Jr (1987); Plant propagation: Principles and practices, 5th ed., by H.T. Hartmann, D E. Kester, and F T. Davies, Jr. (1990); Practical woody plant propagation for nursery growers, vol. 1., by B. Macdonald (1986); and Seeds of woody plants in the United States, published by the USDA Forest Service (1974) All of these books should be on the ready-reference shelf of any serious propagator.

Controlled temperature germination chambers are a must for seed treatment. Many growers simply sow the seed and place the containers under a greenhouse bench or under shade for warm stratification. This is not satisfactory due to poor sanitation and little temperature control Expensive seed-treatment chambers can be purchased or chambers can be constructed from discarded refrigerators or incubators. Refrigerated truck boxes that are no longer road worthy can easily be converted into large germination chambers (Macdonald, 1986).

The germination environment is critical. The seed must be sound and clean. The pre-germination medium must be pathogen-free, have a high moisture-holding capacity, and be well aerated (Hartmann, et al., 1990). Finally, the germination chamber must have precise temperature control Any temperature extreme during pre-germination treatment may induce secondary dormancy, which is usually very difficult to break (Dirr and Heuser, 1987; Hartmann, et al , 1990, Macdonald, 1986).

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Fire Ants: Research Activities and New Regulations

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HISTORY

Imported fire ants are unique pests causing a wide variety of problems ranging from medical, to agricultural, to structural, to ecological. The imported fire ant has been in the United States only a short time, as the first specimens of the black imported fire ant (BIFA), *Solenopsis richteri,* were collected in Mobile in 1928. They were introduced into the port of Mobile around 1918, possibly from discarded ballast or packing from cargo ships. Until 1912 and the passage of the Plant Quarantine Act, it was common practice to discard packing from ships once they were unloaded. *Soleopsis richteri* spread very slowly after its introduction into the United States. By 1931, BIFA was found in only three counties, Mobile and Fairhope in Alabama and Baldwin County, Florida. Sometime within the next 10 years, another species of imported fire ant arrived on our shores, again in Mobile. This new invader, the red imported fire ant (RIFA), *S. invicta,* proved to be much more adaptable and rapidly displaced *S. richerti*. By the late forties, it was the dominant species of imported fire ant. Alabama (along with its neighbor Mississippi) holds the distinction of having both species within its borders. All other states within the USDA quarantine has only the red imported fire ant. As if these

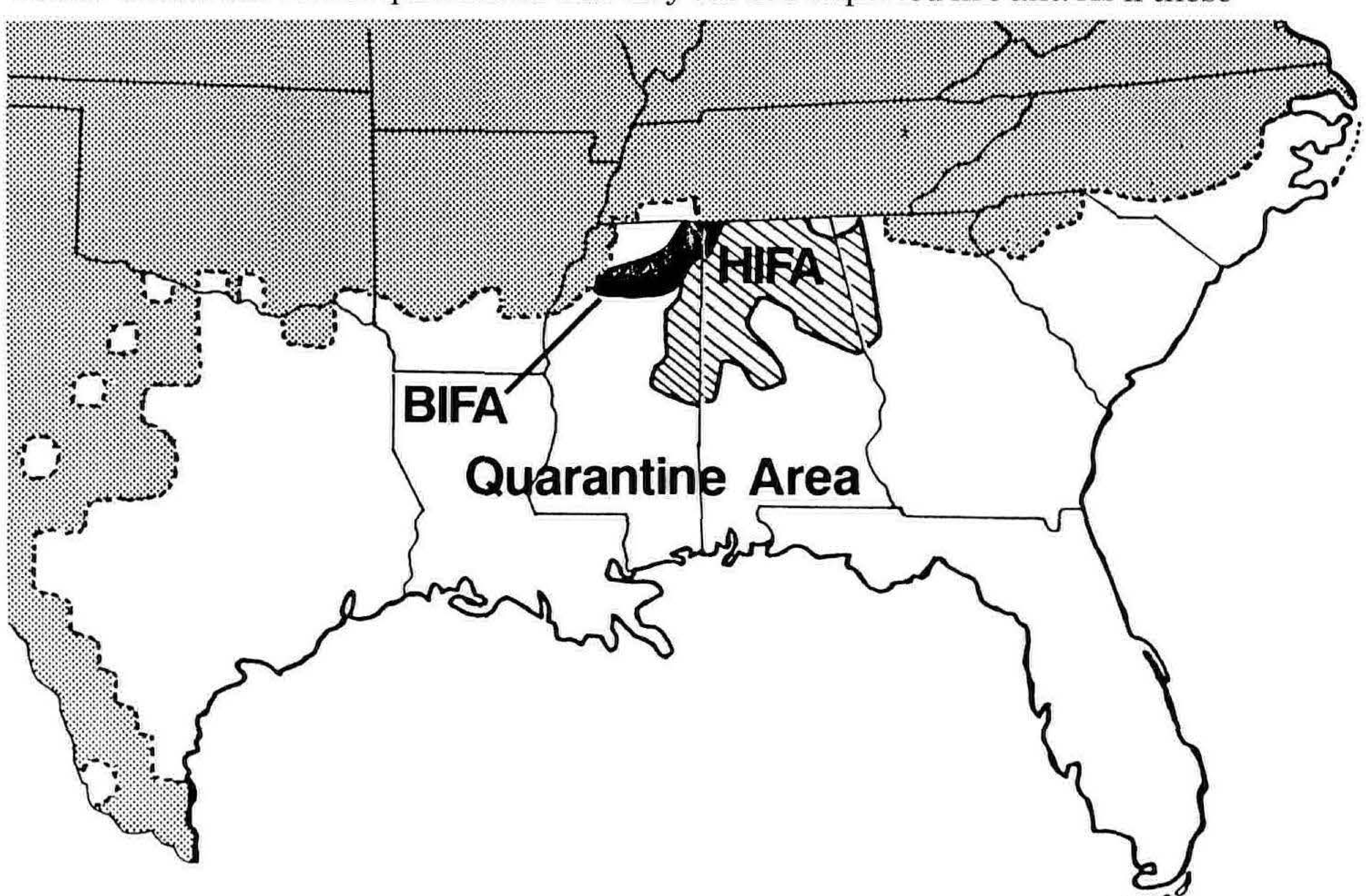
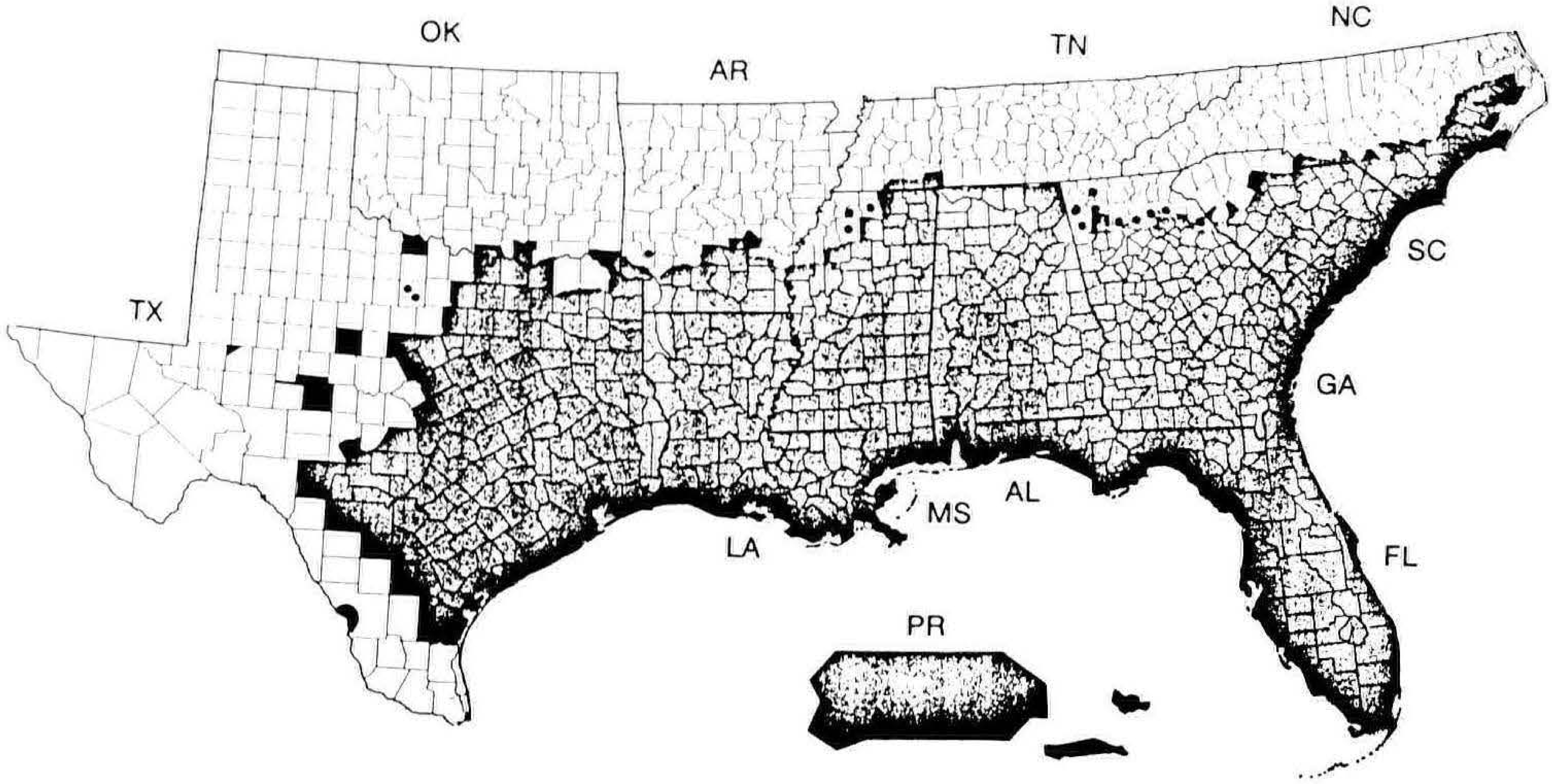


Figure 1. Current known distribution of the black imported fire ant (BIFA) and the hybrid imported fire ant (HIFA) within the currently delineated quarantined area.

were not bad enough, in recent years, analysis of specimens has revealed the existence of a hybrid (HIFA) between the two imported fire ants. This hybrid has, for the most part, displaced the black imported fire ant. Data indicates that this viable hybrid is as cold-hardy as BIFA (from which it cannot be distinguished morphologically) and has the aggressiveness and high adaptability of RIFA. Again, Alabama (along with Mississippi and northwest Georgia) have been singled out for the dubious distinction of having this pest within their borders (Fig. 1).

How did we spread these pests throughout the Southeast? Unfortunately, through nursery stock. There would have been a steady advance of these ants



Conditions of Movement
Counties entirely colored are completely regulated; counties partially colored are partially regulated.

Regulated area

Restrictions are imposed on the movement of regulated articles as follows: From red areas into or through white areas.

Consult your State or Federal plant protection inspector or your county agent for assistance regarding exact areas under regulation and requirements for moving regulated articles. For detailed information see 7CFR 301.81 for quarantine and regulations.

Figure 2. Imported fire ant quarantines

through normal mating flights (ca. 20 km/year). However, establishment of secondary infestations through movement of infested nursery stock in the 1950s rapidly distributed them through much of the present range (Fig. 2). We fully expect RIFA to expand its territory north and west. From our current knowledge, we can expect them to infest most of California as well as parts of Oregon, Washington and British Columbia. They could even reach as far north as ca. 50 km south of Juneau, Alaska. Along the eastern coast of the United States, they could expand their range as far north as Staten Island, NY. Figure 3 illustrates the potential of RIFA to infest rural areas. They also pose a threat as an urban pest. We have already seen them in urban areas far outside their normal climatic range. Isolated infestations of RIFA have been eliminated from Newton, KS; Washington, DC; Philadelphia, PA; and St. Louis, MO. Currently, RIFA are established in

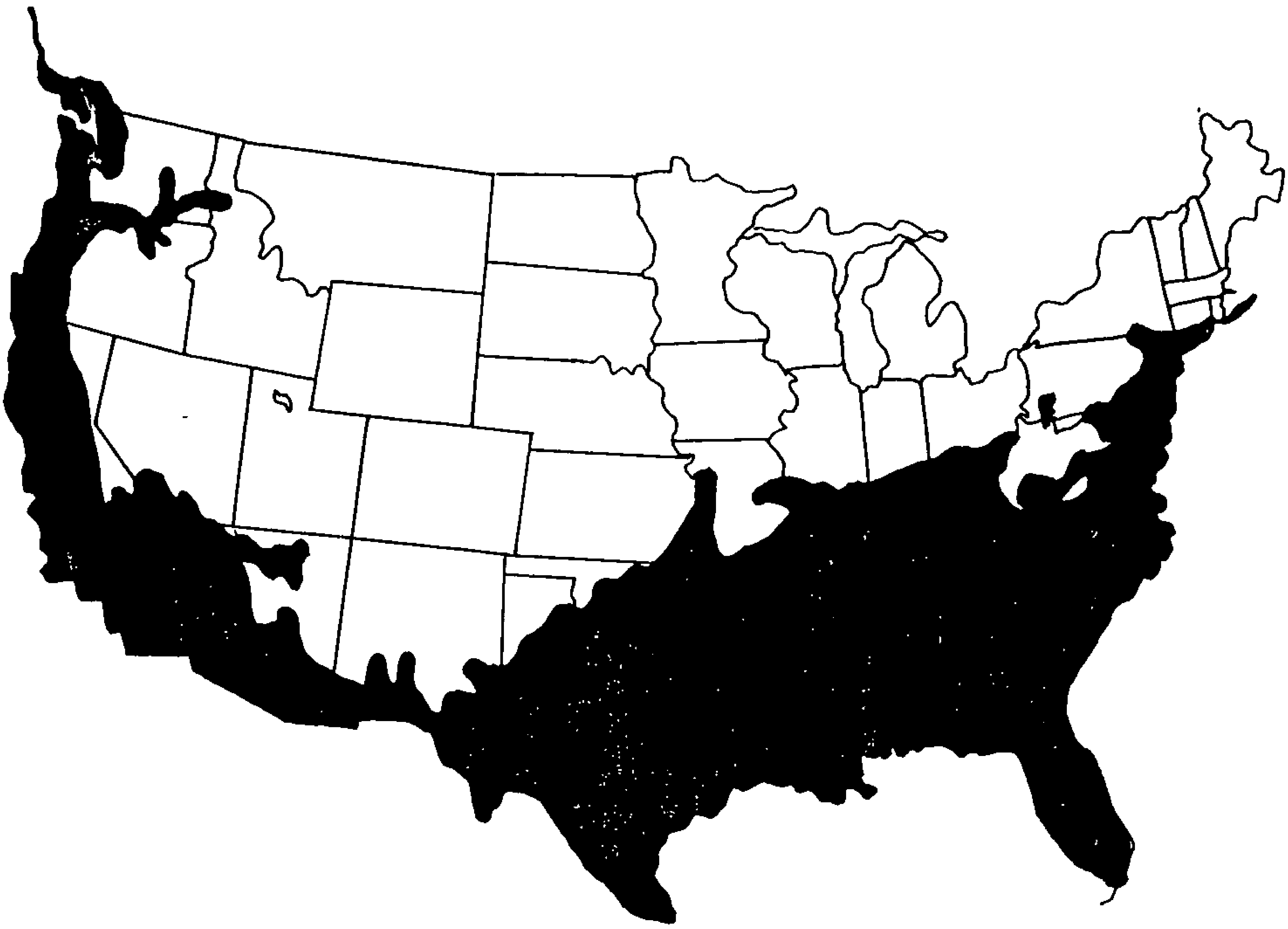


Figure 3. Potential area of infestation for the red imported fire ant in North America north to Mexico

Nashville, TN and Lubbock, TX.

CURRENT RESEARCH ACTIVITIES

There are a very limited number of chemicals labeled for imported fire ant quarantine We are constantly screening candidates for possible use. Recently, a new synthetic pyrethroid, bifenthrin produced by FMC Corporation has shown exceptional potential

Bifenthrin has a wide spectrum of activity against mites and insects on field, fruit and nut crops as well as on ornamentals. Formulations include 2EC, 10WP, 0.2G and a flowable. Chemically, bifenthrin is known as cyclopropanecarboxylic acid, (2 methyl [1,1'-biphenyl] -3-yl) methyl 3-(2-chloro-3,3,3-trifluoro-1- propenyl) -2,2-dimethylcyclopropanecarboxylate).

A liquid formulation, marketed as Capture 2EC, is currently registered for foliar application on cotton for a wide range of pests including spider mites, the boll weevil, the cotton bud worm, plant bugs, pink boll worm and armyworms. Application rates range from 0.02-0 1 lb AI/acre.

A powdered formulation (Talstar 10WP) is registered for foliar use on ornamentals and non-bearing fruit and nut trees It is labeled for use against numerous pests including aphids, scales, lacebugs, caterpillars, leafminers, Japanese beetles, spider mites, et cetera. Rates of application range from 0.004-0 02 lb AI/10 gallon of finished spray More recently, Talstar 80% Flowable (0.66 lb AI/gal flowable formulation) was registered for similar ornamental use, pest spectrum and rate range. A granular formulation (Capture 0 2G) is currently being tested and evaluated for consideration for use in IFA quarantine.

Bifenthrin is very stable in sterile water under acidic, neutral and basic pH conditions. Bifenthrin has a low water solubility (less than 0.1 ppb). The compound is bound tightly to soil and possesses a low mobility in sand and is immobile in other soils.

We began our first trials with bifenthrin in December of 1988. In the 34 months since then, numerous other evaluations have been initiated and most remain ongoing at this time. Evaluations have been made concerning dose rates, formulations, application techniques, and varying geographic/environmental conditions. The majority of trials were carried out at the Imported Fire Ant Station in Gulfport, MS. However, several other trials have been conducted at other sites including Miami, FL; Whiteville, NC, Campo, TX; Tifton, GA; Mobile, AL; and Monticello, FL.

Incorporation of insecticides into media is the most common method of application utilized by the IFA quarantine due to cost and labor involved Both granular

Table 1. Residual activity of various formulations of bifenthrin incorporatedinto potting media

Trial no	Date initiated	Trial location	Formulation	Initial theoretical dose (ppm)	Potting media	Residual activity* in months
I	Dec 88	Gulfport, MS	0.3G	72.6	Stronglite	34
II **	Nov 89	Gulfport, MS	0 2G	100.0	Stronglite	19
	Miami, FL	0 2G	100 0	Stronglite 19		
	Whiteville, NC		0 2G	100.0	Stronglite	16***
III **	Dec 89	Gulfport, MS	10WP	12 5	Stronglite	23
				25 0	Stronglite	23
				50 0	Stronglite	23
				100 0	Stronglite	23
IV	Jan 90	El Campo, TX	0 2G	25 0	Nursery Mix	22
				50 0	Nursery Mix	22
			10WP	25 0	Nursery Mix	22
				100 0	Nursery Mix	
V	Mar 90	Gulfport, MS	0 2G	12 5	Stronglite	20
				25 0	Stronglite	20
				50 0	Stronglite	20
				75 0	Stronglite	20
				100 0	Stronglite	20
VI	Sep 90	Gulfport, MS	10WP	25 0	Stronglite	13
				16 6	Baccto	13
				30 1	Dodd's	13
				8 9	Lab Mix	13

* Number of months showing 100% queen mortality in standard laboratory bioassay, trials on-going unless otherwise stated

**Results final

*** Trial accidently destroyed

and wettable powder formulations of bifenthrin can be used in this manner. In the trials conducted to date, a predetermined quantity of bifenthrin (based upon amount of soil to be treated, bulk density of the soil and formulation of bifenthrin) was incorporated into media using a 2 cu ft capacity cement mixer. The mixture was blended for at least one hour to assure a thorough mix. The media were placed in standard gallon containers and subjected to normal horticultural practices.

The trials summarized here (Table 1) are arranged in more or less chronological order. Five of the six trials are still on-going The longest residual activity to date is 33 months and was achieved with the 0.3G formulation. The 0 2G formulation has reached 19-months residual activity at 100 ppm. This trial was terminated after we ran out of media to evaluate. At dose rates as low as 12.5 ppm, 22 months residual activity has currently been achieved. Because of our relative success at 12 5 ppm and above, a further evaluation was undertaken using even lower rates of 2.5, 5.0 and 10 0 ppm The 10 ppm rate achieved 100% efficacy through 11 months post-treatment. The lower rates have shown extremely variable results. We believe the cause of this variability is due to the unevenness of the blend caused by the small amount of material used to achieve those rates.

Another method of application is the drench treatment. These can be formulated using either EC or WP formulations of bifenthrin. Nursery pots are filled with media and drenched using various rates of solution (based on amount of soil to be treated, bulk density of the soil and formulation) The amount of finished solution was 1/5 the volume of the container.

The initial drench trial showed 100% efficacy for 6 months. This trial had to be terminated due to lack of material The second trial was begun in June of last year using both the 2EC and 10WP formulations applied at 100 and 200 ppm. Results to date continue to show 100% efficacy.

Bifenthrin is a highly effective, residual treatment for control of IFA in containerized nursery stock. A variety of use patterns have been evaluated for treatment of containerized plants. Due to registration status, as well as efficacy, a recommendation has been made that Talstar 10WP be adopted for IFA quarantine program use on containerized plants as soon as possible. Consideration is being made by USDA, with input from the Imported Fire Ant Working Group, on how best to accomplish this. A FIFRA Section 24C (state and local needs) label has been granted at this writing by all the state of Louisiana within the quarantine area.

Recommended use patterns, dose rates and certification periods are as follows

USE PATTERN	FORMULATION	DOSE RATE	CERTIFICATION PERIOD
Incorporation	10WP	50 ppm	1 year
Drench	10WP	25 ppm	6 months
Topical	10WP	25 ppm	6 months

Following completion of current and future trials, it should be possible to offer additional certification periods based on lower dose rates and use patterns Studies are also underway evaluating the efficacy of bifenthrin on grass sod and balled -and- burlapped nursery stock.

Hardy Geranium and Perennial Propagation

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INTRODUCTION

In the 1980s the gardening public's demand for greater variety combined with nostalgia for long established favorites helped fuel the resurgence of some old time perennials. These perennials were made new to the public by the introduction of many improved cultivars.

In response to this demand our nursery, like many others, found itself not only growing perennial in ever increasing numbers, but soon establishing a perennial program as an extension of our regular operations. At present we propagate mostly by cuttings and divisions and grow 490 cultivars in containers ranging in size from liners to a 1-gal container

HARDY GERANIUM PROPAGATION

Cutting Propagation: Time of Year and Cutting Stock. Material for propagation comes from field and containerized plants, the latter being overwintered in unheated polyhouses. Our work with root cuttings has not given consistent results and we rely primarily on herbaceous cuttings and division. Species and cultivars that respond more readily to divisions are *Geranium endressii* 'Wargrave Pink', *G himalayense* 'Gravetye' [syn., *G. grandiflorum* 'Alpinum'], *G. macrorrhizum, G macrorrhizum*, 'Bevan's Variety', *G.* × *oxonianum* 'Johnson', *G. himalayense* 'Plenum', and *G* × *oxonianum* 'Claridge Druce'. The types that respond to herbaceous cutting propagation are· *G. sanguinium, G. sanguinium* var *striatum* [syn 'Lancastriense'], *G. sanguinium* 'Sheperds Warning', *G.* × *oxonianum* 'Claridge Druce', and *G macrorrhizum.*

Cutting propagation occurs in both March and June. March cuttings are taken from containerized plants brought into a heated (65°F) polyhouse the previous month. June cuttings generally come from field plants, although containerized plants have been used as well All stock plants are drenched with the fungicide Banrot every 4 to 6 weeks, and no herbicides are used.

Readiness for Propagation and Processing. Actual cutting harvest begins when approximately 1/4 of the plants are in flower. Material is cut early in the morning, misted to keep moist, and stored if necessary for one day in a cooler set at 36 to 40°F. Trimmed cuttings consist of 2-3 nodes, with 1/4 in. of stem present under the basal node. The latter makes it possible to place the cutting deeply enough in the soil to ensure good anchorage. *Geranium macrorrhizum* and G. × *oxonianum* differ slightly from the above in that the cutting material is pulled, not cut, from the stock clump, thus leaving the basal sheath intact.

Rooting Medium, Shading, Mist Cycles, Sanitation. All cuttings are treated with #8 Hormex rooting hormone powder and rooted in a 73 Growing Systems cell pack using a high porosity soilless mix containing pine bark, perlite, vermiculite, and peat. A 50% shade cloth covers the polyhouse in the summer, but shading in our area is not required in spring. Mist cycles run for an average of 10 seconds with the frequency being decreased as rooting progresses. For example, in March in an enclosed polyhouse the following frequency has been common:

- 20 min between cycles prior to rooting.
- 30 min just after root initiation (10-14 days).
- 40 min to hardening off.

By contrast the interval between cycles in June in a ventilated polyhouse is much less.

- 5-10 min between cycles prior to rooting
- 20 min at root initiation.
- 30 min to hardening off

Plants are removed from mist when roots are at the edge of the plug; in spring, this ranges from 20-30 days; in summer, about half that time is required. Propagation benches are treated with a disinfectant (Greenshield, a Whitmire Product) and as a preventative treatment, a fungicide drench with Banrot is given right after sticking.

Propagation by Divisions. All taxa of geraniums are propagated by field divisions. Digging occurs in June or July if the weather is cool for February sales and November to January (weather permitting) for spring sales.

After digging, the foliage is trimmed to 2-4 in. and the plants are processed to yield divisions of one to three eyes

If storage prior to potting is necessary, the cooler is set at 36-40°F in summer In winter, the plants are covered with plastic and kept on trailers or stored on the ground in a minimally heated polyhouse.

Divisions are potted in the same mix used for cuttings. A preventative fungicide drench of Banrot is applied as soon as possible.

OTHER PERENNLALS

Aside from the hardy geranium, our line of perennials ranges from achillea to veronica. With such a wide variety it is difficult to generalize regarding propagation and growing. However, the following can be said with some degree of confidence.

We propagate mainly by cuttings and divisions, with most cuttings being taken in June, July and August prior to flowering If cuttings are done early enough in the season, often a second set can be taken without harm to the stock plants. The 1-gal plants are saleable within 8 weeks. Cuttings 2 to 4 in. in length are stuck directly into a 2 1/4 in liner pot Rooting powder is used when necessary, with careful records being kept from year to year.

Other propagation details are identical to those for the summer time geranium program discussed earlier. For example, all the following are common to the propagation of both crops: the soil mix, the timing in the mist cycles, the amount of shading covering the polyhouses and sanitation practices.

In contrast to cuttings which can be taken anytime, timing is critical when perennials are propagated by division Often the timing is specific even for individual cultivars of a perennial. A helpful reference is the "Manual of Herbaceous Ornamental Plants" by Steven M Still.

FERTILIZATION

Fertilization of all our stock, once it is rooted is identical. Liquid fertilizer composed of calcium, ammonium, and potassium nitrate is mixed on site and is applied at every watering. This is supplemented with trace elements and sulfuric acid, the latter added to reduce the alkalinity of our water supply Depending on the season, the concentration ranges between 2 0 and 3.0 mmhos, with the higher concentration being applied in the spring No fertilization occurs between October and March.

Seed Priming for Improved Germination in Herbaceous Perennial Plants

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Seed germination is an important component for the efficient production of annual and many herbaceous perennial plants. The high cost of greenhouse production, coupled with the increasing expense of seed, make techniques for increased germination efficiency an important consideration for the greenhouse manager. There is a trend for increased seedling plug production for herbaceous perennials which demands high seed germination. A demand which can sometimes be difficult to achieve considering that many herbaceous perennials have not been subjected to the same breeding selection and seed quality considerations as annual plants (i.e. petunia).

Seed priming is a seed pre-treatment which can significantly enhance germination efficiency in a diverse group of seed-grown plants including agronomic, vegetable and flower crops (Bradford, 1986; Finch-Savage, 1991). In some cases, germination percentage can be improved by seed priming This is particularly evident for poor quality seed lots or seeds germinated under less than optimum environmental conditions (Bradford, 1986). However, for greenhouse production, the primary benefit of seed priming is in uniformity and speed of germination. This is illustrated in Figure 1 for the germination rate of primed compared to untreated purple coneflower (*Echinacea purpurea*) seed. Seed germination commences earlier

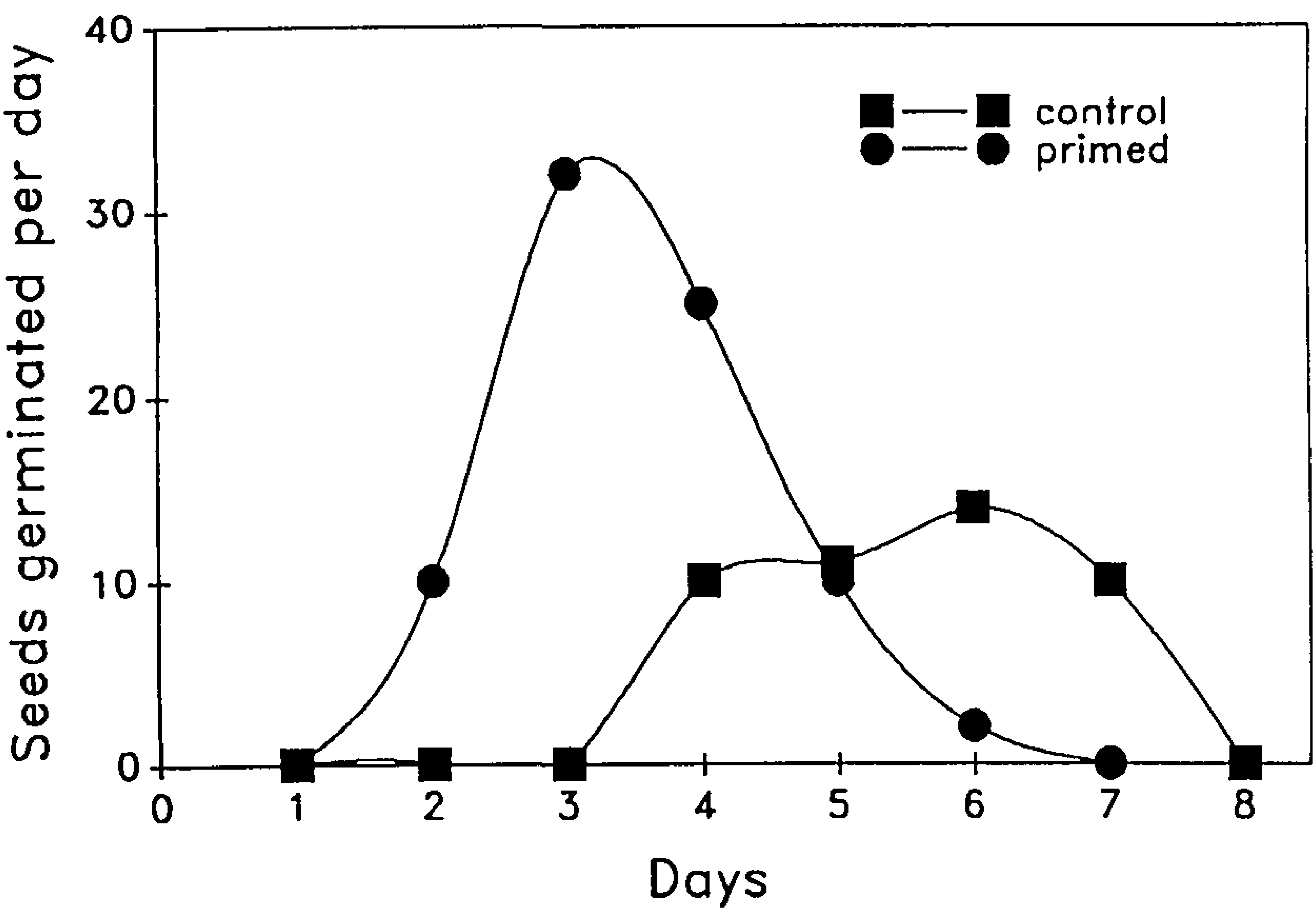

Figure 1. Germination rate in primed compared to untreated control seed of purple coneflower

in primed seed and proceeds in a highly desirable, uniform fashion. Radicle emergence is complete between 2 and 4 days of germination. This translates into a shorter period of time required for seeds to be in specialized germination chambers and for a more uniform crop in the greenhouse

Seed priming can be accomplished in several ways. Seeds may be imbibed in an osmotic solution containing various salts or polyethylene glycol (PEG). This is termed osmotic priming or osmoconditioning A second technique uses the matrix potential properties of vermiculite or several calcined clays to treat seed by solid matrix priming or matriconditioning. This is a newer technique which has shown potential for large seeded crops like soybean and sweet corn (Parera and Cantliffe, 1991). A third technique is low temperature priming. Low temperature priming is usually combined with osmotic seed priming Usual temperatures are 10 or 15°C coupled with osmotic potentials of -5 to -15 bars depending on the species being treated (Bradford, 1986).

Regardless of the seed treatment used to prime seed, the basic concept behind priming is the same. Priming uses osmotic or matrix forces optimized for a particular temperature to hold seeds in the lag phase of water uptake during germination. Figure 2 illustrates the typical phases of water uptake associated with germination. Following the rapid water uptake characteristic of imbibition, there is a period of time where water uptake cannot increase until physiological changes have occurred within the seed. This lag phase prepares the seed for radicle emergence. The seed is irreversibly committed to germination once it has entered this phase of water uptake associated with radicle emergence The seed will not survive if it experiences drying during the phase of radicle emergence. However, the seed can be dried during the earlier lag phase of germination without detrimental results. Primed seeds are held in the lag phase for 1 to 15 days to allow the

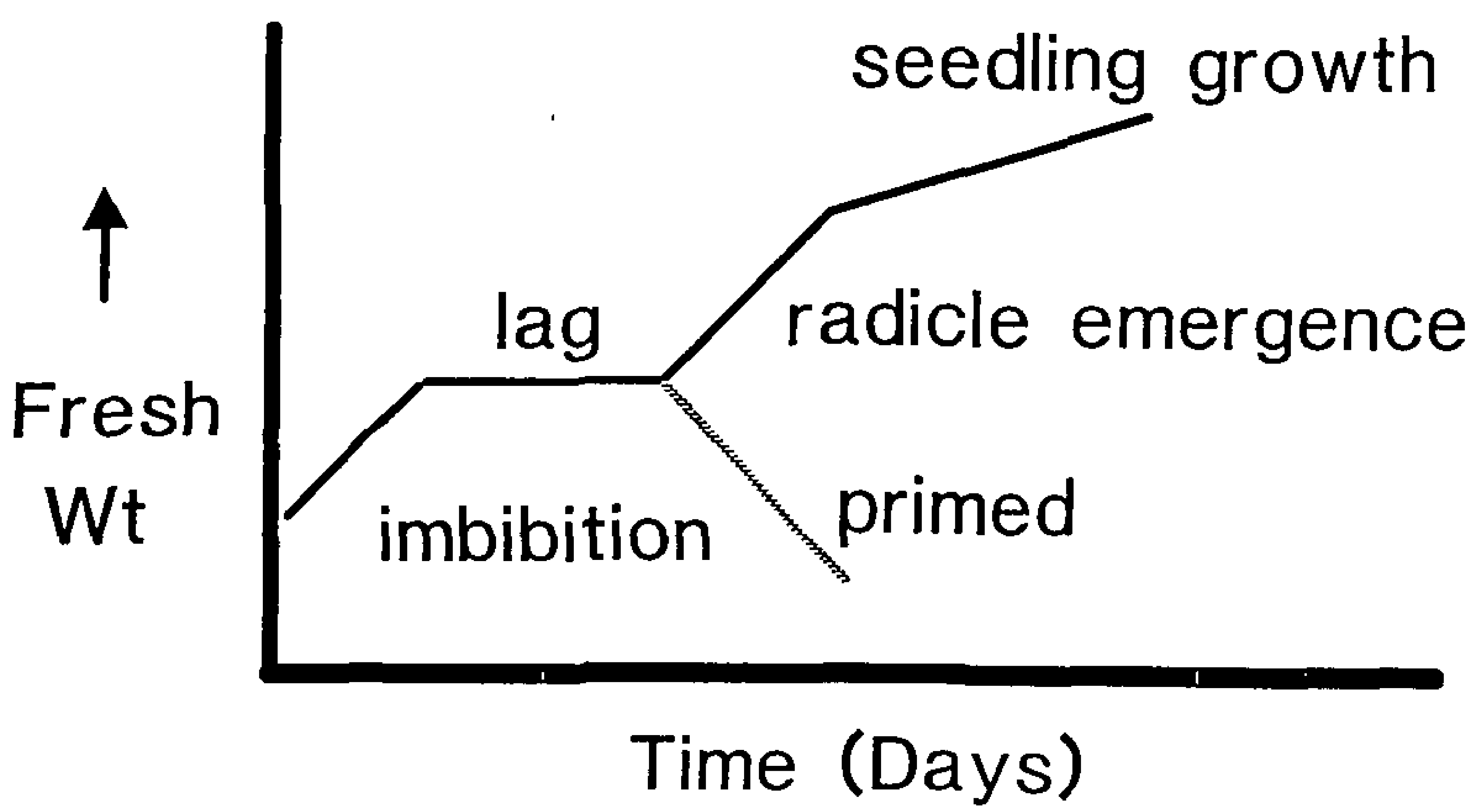

Figure 2. Schematic representation of uptake water the phases of uptake during seed germination

physiological changes within the seed to proceed while the seed remains uncommitted to germination. After primed seeds have been dried back to about their original moisture content, the seeds have become "invigorated" (Heydecker et al., 1975) and will subsequently display superior germination characteristics

The optimum priming treatment can vary between species or even seed lots (Heydecker, 1977). Osmotic priming has been the technique most extensively studied and is being used commercially by several seed companies for vegetable and annual flower seed. To my knowledge, there are no seed companies currently offering primed seed for herbaceous perennials However, the technique of seed priming is not difficult and perennial growers may wish to experiment with priming to gauge the potential benefits priming may have to their production schemes.

There are three basic parameters to be considered for devising a protocol for osmotically priming a particular seed lot. These are the priming temperature, osmotic potential of the priming solution and the length of time the seeds are treated in the priming solution. The preliminary experiments you develop for testing priming protocols should include a temperature range from 10 to 25°C, priming solutions with PEG 6000 (also sold as PEG 8000) from -5 to -15 bars (200 to 350 grams added slowly to a liter of water) and a priming duration of 5 to 15 days. You may want to start with a standard priming protocol of 15°C -10 bars (PEG 6000 at 270 grams in a liter of water) and prime for 10 days. This may indicate to you if seed priming deserves your further attention and whether you should invest in the effort to fine tune a priming protocol

The seed priming protocol we use for purple coneflower seed is indicative of a technique for priming small amounts of seed which could be adapted to your conditions Up to 1000 to 3000 seeds can be primed in a 500 ml priming solution. Less seed should be used for large seeded crops because excessive water removal from seed imbibition can change the concentration of PEG in solution. Seeds can be primed in 750 to 1,000 ml Erlenmeyer flasks or Mason jars. Seeds may simply be submerged in the solution, but we prefer to loosely pack the seed into a cheesecloth sac suspended in the solution. Aerating the solution is essential for optimal priming results This can be accomplished by placing a glass tube two-thirds of the way into the solution and bubbling air through the tube. One bubble per second is an adequate rate. Air can be delivered from a compressed air tank through the proper regulator or the room air (if it is clean) can be circulated through the solution with an aquarium pump Place an air export tube into the lid of the container, but otherwise have the container closed to avoid water evaporation from the solution. Clean and sterilize the priming container and bubbling tube between uses to avoid the potential for carryover pathogen problems.

Following priming, the seeds should be rinsed free of the osmotic solution and dried quickly at room temperature by forcing air over a single layer of seed placed on a paper towel. Do not heat seeds to dry them. Seeds should dry down to approximately their original dry weight (within 5%) This should be checked by weighing the seeds before and after priming. Store seeds in a closed container at 5°C Check the seed weight periodically to make sure seeds have not absorbed any water during storage. Germinate seeds soon after priming (within six months) The results for three seed priming protocols for purple coneflower are presented in Table 1. The results are presented as a percentage improvement in germination percent or rate for primed seed compared to untreated control seeds. Four

Table 1. Improvement in seed germination percentage and rate for seeds from four seedlots of purple coneflower treated by several priming protocols

Seed priming protocol			Seedlots							
Duration	Osmotic potential	Temperature	Germination (%)				Germination rate (%)			
(Days)	(Bars)	(°C)	P_1	P_2	B_1	B_2	P_1	P_2	B_1	B_2
4	-5	25	5[z]	39	3	48	37	106	46	375
10	-10	15	13	76	20	73	65	236	78	130
20	-15	10	16	55	25	67	170	683	238	263

[z]Percent improvement in germination for primed seed compared to the control

commercial seedlots were treated and included two seedlots of open pollinated purple coneflower designated P_1 and P_2 and two seed lots of the cultivar 'Bright Star', designated B_1 and B_2. Two of the seedlots (P_1, B_1) were high quality seed lots and displayed only a small improvement in germination percent. However, all seed lots showed a substantial improvement in germination rate over untreated control seed Similar results (especially in germination rate) have been shown for vegetable and annual flower seed and should be expected for many herbaceous perennial crops *However, the added cost of handling primed seed may preclude many seed* companies from priming the low volume of perennial seed offered by their companies. This means that the added advantages of primed seed for herbaceous perennial crops may only be experienced by growers willing to experiment with this technique for themselves.

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Micropropagation of *Alstroemeria* Hybrids

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Alstroemeria hybrids are grown for their cut flowers and, more recently, as potted and garden plants. Their beautiful, large inflorescences with colors of purple, lavender, red, pink, yellow, orange, white and bicolors have made them the tenth most popular cut flower at the Dutch flower auction. At the auction, their U.S. dollar value in 1990 was approximately $35,263,000 In addition to having beautiful colors, the flowers have long postharvest vase lives of 2-3 weeks. The plants prefer cool temperatures for growth, and once flowering has been initiated, an everblooming habit produces a high yield of flowers until flowering has ceased.

Alstroemeria is traditionally propagated asexually by the division of their rhizomes. The triploid nature of most commercial cut flower cultivars makes asexual propagation essential. However, this procedure is too slow and tedious for large, commercial propagators. Consequently, the dissemination of new cultivars is delayed and the cost of propagules is inflated Seed propagation from diploid and tetraploid *Alstroemeria* is possible and is used in the United States to produce mixed hybrids for large potted plants. However, due to the heterozygous nature of current cultivars, it is difficult to obtain consistent lines. Breeders are trying to develop homogeneous inbred seed lines and F1 hybrids, but at this point seeds are not commercially available.

Commercial propagators of *Alstroemeria* have resorted to rapid proliferation through micropropagation as a way to produce large numbers of clones. *In vitro* propagation can produce very large quantities of plants in a small space and is independent of the weather. In addition, pathogen free plants can be produced.

Research on the micropropagation of *Alstromeria* has been ongoing at the University of Connecticut since 1985 when our breeding program began. The following paper will summarize the information we have learned about propagation procedures from Stage I to Stage IV. Additional information on micropropagation of *Alstroemeria* which was learned from commercial and private laboratories and from published papers will also be presented. References will be given for work which was not completed in our laboratory.

STAGE 1—INITIATION OF ASEPTIC CULTURES

If seeds are used as the original explant source, it is very easy to start a culture. Simply place the seeds in 5% sodium hypochlorite for 10-15 minutes with constant stirring, rinse theseeds twice in sterile deionized water, and culture at 17-19°C. The

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temperature is very important for quick germination in 10-14 days.

In situations where asexual clones are desirable, seed germination cannot be used. It is often very difficult to disinfect underground storage organs such as rhizomes, and *Alstromeria* is no exception A procedure has been outlined which will give 100% clean explants if proper techniques are followed

Terminal rhizome tips approximately 0.5-1.5 cm in length should be freshly harvested from actively growing plants. None of the shoots behind the growing point should be included with the growing tip Apical shoots should be used for the initial explant because they will have a faster multiplication rate than lateral shoots arising from the rhizome. Although some success culturing vegetative or floral shoots has been reported (Ziv et al., 1973), these are not the ideal tissues to use for micropropagation.

When harvesting rhizome tips, they should be placed in plastic bags or moist paper towels to prevent dessication. They should not be placed in water because of the potential uptake of pathogens by the vascular system may cause problems. Rhizome tips should have all visible media particles cleaned off under running tap, water with a fine bristled brush. The explants are then placed in 3% Korsolin (Ferrosan Co., 4600 Kose, Denmark) or 1% sodium hypochlorite for 10 min. Korsolin is a commercial greenhouse bench disinfectant which contains 3 8% formaldehyde and 8% glutaraldehyde. Explants are taken to the laminar flow hood after the initial sterilization step and placed in sterile distilled water before subsequent treatments. Explants further cleaned under a dissecting microscope and subsequently placed in 1% sodium hypochlorite for 5 min. followed by sterile water. The 2-4 outer leaves surrounding the explant should then be aseptically removed to expose the small growing point and rhizome. This piece is placed in 0.5% sodium hypochlorite for 1 minute and then sterile water until cultured. Most explants willproduce a whitish exudate at the point of incision; although this looks like a bacterium infection, it is not a contaminant

STAGE II - MULTIPLICATION

The components of the nutrient medium are critical for the proper development of *Alstromeria* rhizomes. When KH_2P0_4 levels were varied and all other Murashige and Skoog (MS) (1962) levels maintained the same, explants receiving KH_2PO_4 levels of 1.25-2.5 mM produced the most shoots and growing points and greatest fresh weight (Elliott, et al , 1992) Smith and Bridgen examined effects of variations in nitrogen, calcium, iron and magnesium concentrations on the growth and proliferation of rhizome explants *in vitro*. They observed significant linear responses to increased nitrogen up to 80 mM, but no differences to varying $NH_4:NO_3$ ratios. Low levels of $CaCl_2$ ranging from 0.09-0.3 mM were superior to high levels. When iron in the form of ferric EDTA was examined at levels up to 1 mM, treatments from 0.01-0.5 mM had the best response over time Magnesium sulfate levels up to 15 mM were tested and the highest level was superior for plant growth when Gel-Gro was used as a medium solidifier.

Experiments examining pH values of 5, 6, and 7 showed no differences; experiments examining sucrose levels from 1-5% demonstrated 3-4% sucrose is optimal (Pierik et al., 1988). In Smith and Bridgen's research (1992), rhizomes growing on media solidified with agar were compared to rhizomes on media solidified with Gel-Gro. In all cases, plantlets grew best when the medium was solidified with

Table 1. *Alstroemeria* medium

	Elements	Concentration (mM)
Macronutrients	NH_4NO_3	20.0
	KH_2PO_4	1.25
	KNO_3	19.0
	NH_4Cl	20.0
	$CaCl_2{\cdot}2H_2O$	0 3
	$MgSO_4{\cdot}7H_2O$	15 0
	NaFe-EDTA	0.1
Micronutrients	Murashige and Skoog levels	
Organics	Murashige and Skoog vitamins 30 g liter^{-1} sucrose	
Growth regulators (suggested ranges)		
Stage I and II:	4-22 µM Benzylaminopurine (1-5 mg liter^{-1}) (BAP) 0.054 µM Naphthaleneacetic acid (0.01 mg liter^{-1}) (NAA)	
Stage III.	0.54-2 7 µM NAA (0.1-0.5 mg liter^{-1}]	
Solidifying agent	1.2g liter^{-1} Gel Gro (w/v)	
Medium pH	5 6±0.1	

Gel-Gro. Although refinements of the *Alstroemeria* medium continue, a medium is presented in Table 1 which considers the data as well as important nutrient rates.

The type of cytokinin and its concentration are important factors for *in vitro* multiplication of *Alstroemeria*. Kinetin, 6-benzylaminopurine (BAP), and 6-(gamma, gamma) dimethylallylaminopurine (2iP) stimulate the branching of rhizomes and the latter two suppress the elongation of shoots as their concentration is increased (Gabryszewska and Hempel, 1985; Pierik et al 1988). BAP is most often recommended for *Alstroemeria* micropropagation in the range from 4.4-22 µM for increased numbers of rhizome branches and shorter lengths of erect shoots. Due to the variability in cultivar responses, there is no exact concentration of cytokinin to recommend; each laboratory should test their cultivars at the recommended levels. Levels of cytokinin greater that 25 μM should be avoided due to the increased probability of mutations

The auxins, naphthaleneacetic acid (NAA) and indole-3-butyric acid (IBA) have been reported not to affect multiplication rates other than in an inhibitory role when applied at concentrations greater than 5 μM, (Pierik et al. 1988) However, earlier reports have shown stimulated growth when low levels of IBA or NAA are added to the multiplication medium (Gabryszewska and Hempel, 1985). Experience in our laboratory has shown advantages to adding a low level of NAA (Bridgen et al., 1990)

Experiments on the influence of temperature of rhizome multiplication have demonstrated that cultures growing at 18°C produce less of the black/brownish exudate than those growing at higher temperatures (Pierik et al , 1988). The exudate is common on some *Alstroemeria* cultivars, but is not a contaminate. Multiplication rates of rhizomes were not affected by temperatures in the range of 15-21°C. Temperatures as low as 8°C have been used successfully (Lin and Monette, 1987), but most commercial laboratories now grow *Alstroemeria* at 18±1°C

Irradiance levels from 1.5-9.7 W/m^2 were tested on *Alstroemeria* and showed no significant effect on multiplication rates; however, shoot length was decreased as irradiance increased (Pierik et al, 1988). Work done in our laboratory has shown high light as a disadvantage for multiplication. There is a negative correlation in the number of propagules produced as irradiance increases from 50 to 300μ mol s^{-1} m^{-2}. Also, when photoperiods between 8 and 16 hours were tested, no difference in the multiplication rate was noticed. Reports of a 1-2 week dark period at the beginning of the culture state it is either advantageous Lin and Monette, 1987) or of no harm to the plants (Pierik et al , 1988).

After cultures are established, the fastest multiplication will continue if explant divisions consist of a single growing point with a single shoot attached. The shoot should be decapitated at isolation to a length of 5 mm.

The length of the multiplication cycle and the number of cycles are also important factors for rhizome multiplication. A higher multiplication rate with less and shorter upright shoots was observed when plantlets were subcultured every 3 weeks for 5 cycles than when they were subcultured every 3.75, 5, or 7 5 weeks with 4, 3, or 2 cycles, respectively (Pierik et al , 1988).

Liquid media have been shown to have higher multiplication rates at lower cytokinin levels than semi-solid media, however vitrification is often a problem (Pierik et al , 1988) Commercial laboratories currently avoid liquid media for *Alstroemeria* due to vitrification problems.

STAGE III - ROOTING

Alhough the actual root development of *Alstroemeria* occurs during Stage IV, root initiation begins in Stage III. The initial explants will usually contain a growing bud with 2-3 additional, decapitated lateral shoots; this is slightly larger than explants for Stage II. Cytokinins should be left out of the Stage III medium. For optimal rooting, NAA should be added from 0.54-2.7 μM. IBA is adequate for root initiation, but it is less effective than NAA (Gabryszewska and Hempel, 1985).

Although no data are presented, Pierik et al. (1988) state that higher sucrose levels of 5% are better for rooting than the 3% used for stage II. They also state that a photoperiod of 16 hours is superior to 8 hours and that a pH of 6 is better than pH values of 5 or 7

STAGE IV - ACCLIMATION

After 3-4 weeks on the Stage III medium, roots will be visible on the *Alstroemeria*. Plantlets can then be removed from the culture vessel and washed under warm tap water to remove the medium. Plugs or pots approximately 2.5 - 3 cm in size can be filled with pasteurized and pH-adjusted peat moss and used at this stage.

After removal from the culture vessels, plantlets can be acclimated in two ways They can be placed into a secondary growth room with high humidity and 12-16 hours of light or they can be placed into a shaded greenhouse. If the greenhouse is used, the plantlets should be tightly covered with plastic or placed in a fog or mist house to maintain high humidity After 4-6 weeks, plantlets may be removed from the secondary growth room, transplanted into larger pots and moved to the regular growing area. Fungicide should be applied regularly, as needed, to acclimating plantlets.

CONCLUSION

The micropropagation of *Alstroemeria* has been studied intensively during the past 6 years. This presentation reviews important aspects and procedures for success during Stages I-IV. However, this paper does not suggest one growth regulator formula for the successful culture of all cultivars. Micropropagators of *Alstroemeria* must realize that cultivars vary with their response to growth regulators and environmental conditions. Each laboratory should dedicate some resources to determine the optimum procedures for its specific cultivars.

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Propagating Herbaceous Perennials: More Than Meets the Eye

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INTRODUCTION

Herbaceous perennials are one of the fastest growing segments of ornamental horticulture. Like woody perennials, they live from year to year. However, in most instances they are grown primarily for their floral display The plantsmen propagating and raising herbaceous perennials are neither traditional floriculturists nor nurserymen, but something in between, and use many of the cultural methods common to both groups.

Herbaceous perennials grow above ground during the growing season, but with the onset of short days and freezing weather, the tops die and the plant retreats to an underground storage organ. These storage organs assume many sizes, shapes and names They may be fibrous roots, bulbs, tuberous roots, tubers, rhizomes, stolons, crowns, or pips. These storage organs all share the same function, acting as a reservoir of growth regulators, water, and nutrients which propel the plant into growth the following season. They also share many propagation similarities with woody plants; many are propagated by shoot cuttings and many are propagated by seed In other ways they are different. Due to the presence of an underground storage organ that is easily lifted from the ground and stored, many are commercially propagated by division of that dormant organ Only one perennial, *Paeonia suffruticosa*, the tree peony (and really a subshrub), is propagated by grafting.

My objective in this presentation is to give an overview of herbaceous perennial propagation methods (Table 1), concentrating on root cuttings and division. Seed and shoot tip propagation will be lightly covered and tissue culture propagation has and will be adequately covered by other speakers.

SEED

Although most herbaceous perennials can be propagated by seed, this method has the same inherent advantages and disadvantages as for woody plants. The seed is a relatively inexpensive propagation unit and easily stored. However, seeds of some herbaceous perennials tend to be shorter lived than their woody counterparts, and there is an industry-wide problem of locating high-quality, true-to-name seed. Another characteristic of herbaceous perennial seeds is that they generally do not have as long or as deep a dormancy as do woody seeds; thus stratification requirements are usually shorter.

Scarification may be required of some, but can be abrogated For example, if *Baptisia* seed is collected fresh, before the seed hardens, it germinates readily. However, if it dries the seed must be scarified to effect germination.

Propagating some perennials from seed has the same disadvantage as for woody plants—plants with many different phenotypes are produced. For instance, *Heuchera micrantha* var *diversifolia* 'Palace Purple' is prized for its rich, bronze foliage It is easily propagated by seed and does not require stratification. Even though it has

Table 1. Propagation methods for herbaceous perennials

Name	Seed	Stem cuttings	Root cuttings	Division	Shoot tip culture
Acanthus spp	x		x	x	
Achillea spp (yarrow)		x		x	
Aconitum spp (monkshood)	x			x	
Aegopodium podagraria (goutweed)			x	x	
Ajuga spp (bugleweed)		x		x	
Alcea rosea (hollyhock)	x				
Anemone x *hybrida* (Japanese anemone)	x		x	x	
Anthemis tinctoria (golden marguerite)	x	x		x	
Aquilegia spp (columbine)	x				
Arabis spp (rock-cress)	x	x	x		
Armeria spp (sea pink)	x	x		x	
Artemisia spp (artemisia)		x		x	
Asarum europeaum (ginger)	x			x	
Asclepias tuberosa (butterfly weed)	x		x		
Aster spp (hardy aster)	x			x	x
Astilbe spp (false spirea)	x			x	x
Aubrietia deltoides (rock-cress)	x				
Aurinia spp (alyssum)	x	x			
Baptisia australis (baptisia)	x		x		
Bellis perennis (English daisy)	x				
Bergenia cordifolia (bergenia)	x		x	x	x
Brunnera macrophylla (Siberian bugloss)	x	x	x		
Campanula carpatica (Carpathian harebell)	x	x			
C medium (Canterbury bells)	x				
Catananche caerulea (cupid's dart)	x			x	
Centaurea spp (cornflower)	x			x	
Cerastium tomentosum (snow-in-summer)	x	x		x	
Ceratostigma plumbaginoides (plumbago)		x		x	
Cheiranthus spp (wallflower)	x				
Convallaria majalis (lily-of-the-valley)				x	
Coreopsis spp (coreopsis)	x	x		x	
Delphinium spp (larkspur)	x	x		x	
Dendranthema hybrids (garden mum)		x		x	
Dianthus barbatus (sweet William)	x				
Dicentra spp (bleeding heart)	x	x	x	x	
Dictamnus albus (gas plant)	x	x			
Digitalis purpurea (foxglove)	x				
Dodecatheon spp (shooting star)	x			x	
Doronicum spp (doronicum)	x			x	
Echinacea purpurea (purple coneflower)	x			x	
Echinops exaltatus (globe-thistle)	x		x	x	
E ritro (small globe-thistle)	x		x	x	
Erigeron spp (fleabane)	x	x		x	
Eryngium spp (sea holly)	x		x		
Euphorbia spp (spurge)	x	x			
Fallopia japonica [syn *Polygonum cuspidatum* (Mexican bamboo)			x		
Filipendula spp (filipendula)	x		x	x	
Gaillardia x *grandiflora* (blanket flower)	x		x		
Galium odoratum (woodruff)		x		x	
Gentiana spp (gentian)	x				
Geranium spp (crane's bill)	x	x	x	x	
Geum spp (geum)	x		x	x	
Gypsophila spp (baby's breath)	x	x	x		x
Helenium spp (helenium)				x	
Helianthemum spp (sun rose)		x			
Heliopsis spp (heliopsis)			x	x	

Table 1. Propagation methods for herbaceous perennials *(continued)*

Helleborus spp (hellebore)	x			x	
Hemerocallis spp (dayily)	x			x	x
Heuchera spp (coralbelis)	x	x		x	x
Hibiscus moscheutos (hardy hibiscus)	x			x	
Hosta spp (plantain-lily)	x			x	x
Iberis spp (candytuft)	x	x			
Kniphofia uvaria (red-hot-poker)	x			x	
Lamium maculatum (dead nettle)		x		x	
Lavandula angustifolia (lavender)	x	x		x	
Leucanthemum × *superbum* (shasta daisy)	x			x	x
Liatris spp (gay feather)	x			x	
Limonium spp (hardy statice)	x		x		
Linum perenne (perennial flax)	x	x			
Lobelia spp (cardinal flower)	x			x	
Lunaria annua (moneyplant)	x				
Lupinus spp (lupine)	x	x			
Lychnis chalcedonica (Maltese cross)	x			x	
Lysimachia clethroides (goose neck loosestrife)		x		x	
Lythrum salicaria (purple loosestrife)		x			x
Matricaria spp (feverfew)	x	x		x	
Mentha spp (mint)		x		x	
Mertensia virginica (Virginia bluebeils)	x		x	x	
Monarda didyma (beebalm)	x	x		x	
Myosotis spp (forget-me-not)		x		x	
Nepeta cataria (catmint)		x		x	
N × *faassenii* (catnip)		x			
Oenothera spp (evening primrose)	x				
Pachysandra terminalis (pachysandra)		x			
Paeonia lactiflora (herbaceous peony)			x	x	
Papaver orientale (oriental poppy)	x		x	x	
Penstemon spp (beardstongue)	x	x		x	
Phlox paniculata (summer phlox)		x	x	x	
P subulata (creeping phlox)		x		x	x
Physostegia virginiana (false dragonhead)	x	x		x	
Platycodon grandiflorum (balloon flower)	x	x			
Polemonium caeruleum (jacob's ladder)	x			x	
Potentilla spp (cinquefoil)	x			x	
Pulmonaria spp (lungwort)	x		x	x	x
Pulsatilla vulgaris (windflower)	x		x	x	
Rudbeckia spp (coneflower)	x		x	x	
Salvia spp (sage)	x			x	
Santolina spp (santolina)		x			
Saponaria ocymoides (soapwort)	x	x	x	x	
Saxifraga spp (saxifrage)				x	
Scabiosa caucasia (pincushion flower)	x	x		x	
Sedum spp (stonecrop)	x	x		x	
Sempervivum spp (hens and chicks)				x	
Solidago spp (goldenrod)		x			
Stachys byzantina (lamb's ear)				x	
Stokesia laevis (Stokes aster)	x		x	x	
Tanacetum coccineum (painted daisy)	x	x			
Teucrium chamaedrys (germander)		x		x	
Thalictrum aquilegifolium (meadowrue)	x	x		x	
Thymus spp (thyme)		x		x	
Tradescantia × *andersoniana* (spiderwort)				x	
Trollius spp (globe flower)	x		x		
Verbascum spp (mullein)	x		x		
Veronica spp (speedwell)	x	x		x	
Viola spp (violet)	x			x	
Waldsteinia ternata (barren strawberry)		x		x	
Yucca filamentosa (Spanish bayonet)	x		x	x	

a cultivar name which implies uniformity, green or off-color variants are produced and must be rouged out. If this is not done rigorously, many off-types enter the market. For the most desirable plants, selections should be made of the best types and they should be asexually propagated In contrast, *Campanula carptica* 'Weisse Clip' [syn 'White Clips'] and 'Blaue Clip ' [syn 'Blue Clips'] are also propagated by seed, but the populations are very uniform, so there is no practical reason to propagate it asexually

Knowing which plants should and can be propagated by seed is especially important to the perennial nurseryman, since their catalogs list many more selections—some nurseries grow as many as 4,000 taxa—than the average "woody" plant producer's catalog. While the perennial industry has experienced rapid growth in the last few years, the growth has also resulted in customers who no longer want the common seed-propagated plants like Shasta daisy, rather they are looking for named cultivars. The result is that, while seed propagation will always be important, greater emphasis will be placed on asexual propagation methods to propagate the new cultivars.

SHOOT CUTTINGS

Many perennials, like *Artemisia, Dianthus, Chrysanthemum* [=*Dendranthema, Leucanthemum, etc*], *Coreopsis, Lavandula,* and *Tricyrtis,* can be propagated by shoot tip cuttings. The principles and methods are similar to those for woody plants although most are easier to root. However the change from the juvenile to adult phase occurs within the growing season, so the propagator must time cutting collection to avoid flowering shoots which are either blind (no vegetative buds) or difficult to root One significant difference from woody cuttings is that little or no rooting hormone is necessary. If it is used, it is usually the equivalent of Hormodin #1. Another is that cuttings, since they are soft, non-woody tissue, are more susceptible to rotting in the propagation bench. This is easily overcome either by reducing the misting frequency, or by covering the plants with row cover material. This is a thin, white, light-weight fabric routinely used by European growers who prefer it to mist beds for herbaceous cuttings

ROOT CUTTINGS

Root cuttings are made from sections of root and should not be confused with rooted cuttings, which are shoot cuttings that are obtained from plants like *Armeria* or *Achillea* and already have roots attached when they are removed from the stock plant.

Root cuttings are a very useful method of asexual propagation, particularly for plants that produce little seed, have a growth habit that produces relatively few divisions or shoot tip cuttings Many plants in the borage family, like *Pulmonaria, Brunnera, Anchusa,* and *Mertensia*, have these characteristics, so are routinely propagated by root cuttings. This method can be efficient too. By using a combination of root cuttings and division, I have propagated nearly 100 salable-sized *Pulmonaria* plants from three root pieces that were approximately 10 inches long. Imagine what a root-bound, 2-gallon *Pulmonaria* would yield!

Root cuttings are usually thought to be only for plants with thick roots like *Acanthus mollis,* but thin-rooted perennials like *Phlox paniculata,* the summer phlox, willingly forms shoots on root cuttings also.

Root cuttings are usually gathered while the plants are dormant from November to February. The exceptions are *Papaver orientale*, the oriental poppy, which goes dormant in August, so cuttings can be taken anytime thereafter Another plant, *Anenome sylvestris*, forms shoots on roots still attached to the plant, so can be excised anytime from late September on and transplanted Root cuttings can be gathered from plants that are grown in the field, but are most easily gathered from container-grown stock plants. Container grown plants have the advantage of being readily available, and no roots are lost to digging. Further, the upper or crown part of the plant usually can be further divided or replanted The roots are shaken free of medium and washed, if necessary. They are removed from the stock plant with a knife or clippers, being careful to keep the roots oriented in the same direction. Next, the roots are sectioned into about 1-in. pieces. Many propagation books suggest making an angle cut on one end to denote the proximal or distal end, but most nurserymen just lay all the roots out in the same direction and section them in bundles. The bundles are packed into holding flats in the same position prior to insertion into the propagating medium

Cuttings can be propagated in two distinctly different ways. The easiest method is to bundle them into groups of about 15 sections and place them in an upright position in 72-cell pack flats The flats are then placed in a high-humidity chamber (the cuttings should be misted occasionally) in a shaded portion of a 60°F greenhouse where they can be observed for rooting. Light does not seem to inhibit shooting or rooting. As each cutting or group of cuttings shoots and begins to root, they are removed and transplanted. In the second method, the cuttings are packed in rows into a 3- to 4-in. deep flat. The flat is placed on the bench at a 45-degree angle, and alternate layers of cuttings and medium are placed each on top of the other until the flat is filled. Flats filled in this manner can hold 300 to 400 cuttings, depending of the root diameter and spacing.

While the polarity of a shoot cutting is very important, it is less so with root cuttings. Even though fastest shooting and rooting is obtained if cuttings are oriented in the upright, proximal (the end that was closest to the soil line) position, cuttings placed in a horizontal position appear to root equally well, but require more space.

Not all plants can be propagated by root cuttings nor is it desirable to propagate some plants by this method. For instance, variegated plants like *Brunnera microphylli* 'Hadspen Cream' can only be propagated by division When propagated by root cuttings, plants with green leaves result. This is because the origin of the shoot within the root tissue is different from the tissue that resulted in the variegation.

DIVISION

Division is one of the simplest and easiest methods to propagate perennials like *Astilbe, Hosta, Hemerocallis, Iris,* and *Paeonia*. With this method the storage organ is divided into sections containing at least one eye (bud), usually, but not always, while the plants are dormant. Late spring, just before bud break, seems to be the best time for most, although Iris and *Hemerocallis*, are best propagated during August, and peony during September. Division seems to be will adapted to plants that have a growth habit where multiple buds or eyes are produced on the storage organ.

The only astilbe that, when propagated by seed, yields reasonably homozygous populations is the *A. chinensis* group hybrid 'Pumila'. Even here, in order to maintain cultivar integrity, it should be propagated by division Otherwise, propagating *Astilbe* from seed is not recommended. Some tissue culture laboratories have recently begun selling astilbe from shoot tip cultures. While this may be reasonably safe for cultivars with pink and white flowers, it is not recommended for those with red flowers because of their propensity to sport naturally. Finally, all astilbes have a crown type growth habit where the shoots are compressed, so no shoots are available for tip cuttings. Thus, for the majority of astilbe, division remains the only reliable method to perpetuate cultivars.

Astilbes can be propagated at almost anytime during the growing season. However, the best time is in early spring, before buds break and shoot growth begins. The second best time, and a time that many nurserymen prefer because there is still time for a plant to establish that can then be sold the following year, is in August.

Astilbe is especially well adapted to container culture, so container-grown plants serve as the stock plants Best results can be obtained if the stock plants are not more than 1-year old The crowns on larger and older plants are too woody, contain few eyes (buds), and are generally more difficult to separate. Larger and more vigorous growing crowns of the arendsii and japonica types are best divided with a knife. *Astilbe simplicifolia* group hybrids tend to have more numerous, but smaller, buds and can often be separated by pulling them apart by hand

Replanting the eye at the correct depth is critical to the success of *Astilbe* propagation. The eye should be planted at or just below soil (medium) level

With most cultivars, planting a single eye in the spring should yield salable sized plant with as many as 10 eyes by the end of the growing season if the plant has been properly watered and fertilized. A vigorous 3-eye division is considered to be a standard sized division ready to be transplanted into a 1-gal container.

Paeonia lactiflora, the herbaceous peony, is, like astilbe, propagated by division. However, there are several major differences. First, even though many peonies are sold in containers through garden centers, it is not a container crop, it is best adapted to field culture and requires at least two years in the field to establish a vigorous plant that can be further divided. Second, peonies should be divided only in the late summer and early fall. It is at this time of the year when, with the onset of short days, buds are formed on the top of the tuberous root.

To divide peonies, the plants are dug from the field with a shovel, fork, or, for larger numbers, lifted with a potato digger, being careful to retain as much of the root system as possible In the digging process, the root system is shaken free of dirt. Using a stout handled knife or a pair of shears, cuts are made vertically through the tuberous root so that each division contains three or more eyes. Some divisions will contain more than three eyes, but there will not be a sufficiently large tuberous root to support it. There must be as much root as possible, although roots that are excessively long are trimmed back, so that the division can be either planted to the garden or placed into a container Replanting is especially critical in peonies Too many woody-plant nurseryman or garden center operators that buy peonies try to stuff a vigorous division in a small container Choose a large enough container so that the buds will be at about 1 in below the surface of the medium AFTER it is watered in If the eyes are far above or below the medium (or soil) level, peonies will flower poorly if at all

In summary, propagating herbaceous perennials is similar, but in many respects, easier than woody plants. However; knowledge of timing, treatment, and method is still critical. The major difference between woody and herbaceous perennial propagation is that the average perennial nursery grows many more taxa than its woody counterpart, thus knowledge of plants and their requirements assumes greater importance

RALPH SHUGERT: You mentioned scarification on small perennial seeds Forget the acid and use hot water scarification with these small seeds.

CHRIS CASH Would you comment on the need for mist with the Remay covered cuttings in the bench?

DAVE BEATTIE: In Europe where I have seen it done they use no additional mist. They water the crop in before covering and that is all. They are just shadding it to reduce moisture loss.

Propagation and Production of Three Members of the Ericaceae Family—*Epigaea repens, Gaultheria procumbens* and *Vaccinium vitis-idaea* var. *minus*

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Weston Nurseries, Inc , P O Box 186, Hopkinton, Massachuttes 01748

In the past few years native plants have become increasingly popular. Pressures put on propagators to meet this demand are overwhelming, and it is too easy to collect or purchase collected material of many native species. I believe that it is important to propagate these plants whenever possible and not destroy their native populations

Epigaea repens has been grown horticulturally for over 200 years; it was introduced in 1736. It is commonly known as the trailing arbutus, May-flower, or ground laurel. *Epigaea* is uncommon in gardens because of its tendency to fade away after transplanting from the wild. It grows best in a woodland setting on an acidic sandy loam Once established, one can look forward to its extremely fragrant white to pink flowers that appear in March through May. The glossy evergreen foliage lies flat on the ground and plants can attain a size of 2 ft in diameter. *Epigaea repens* is the state flower of Massachusetts.

As soon as the fruits form, I cut them in half to see if the seeds inside have ripened. The immature seed is white. As the seed ripens, it darkens until it is black. It is written that the seed ripens at the same time as wild strawberries. In Hopkinton, Mass., the seed ripens at the end of May. If one does not quickly collect the fruit, ants will make off with them. Not all plants will produce fruit *Epigaea* is dioecious with both male and female plants. Flowers tend to be larger and showier on the male plants. The fruits contain dozens of seeds Fruits are collected and put in a paper bag to dry. In about a week, after the fruits have dried, a stone is used to crush the fruits through a tea strainer. The cleaned seed is then put in a sealed container in a 40°F cooler until sowing.

Gaultheria procumbens, referred to as the checkerberry, creeping wintergreen, or winterberry, is native to North America and it was introduced horticulturally in 1762. It can readily be found in dry or moist woodlands but prefers growing in the partial shade in an acidic soil. Commonly, it is dug up in the spring as sods and replanted into the landscape. It has a lot of landscape appeal due to its glossy evergreen foliage and persistent red berries. Because of its creeping habit it forms an evergreen groundcover.

The berries from *Gaultheria* can be collected in the fall or the spring. I have found that the seed needs no pretreatment to germinate, even though many sources suggest 90 days of cold stratification. The berries are dried for three weeks prior to cleaning A stone is used to crush them through a strainer. The clean seed is put in a sealed container, in a 40°F cooler, until it is time to sow the seed.

Vaccinium vitis-idaea var. *minus* is native to the Northern U.S. and Canada and has been under cultivation since 1825. In its natural range it can be found growing in wet areas such as bogs or on mountain tops clinging to granite outcrops Its matlike growth rarely exceeds eight inches. The light pink to red blueberry-like flowers that appear in May give rise to red, cranberry-like fruits in August, hence the name mountain cranberry. It is also referred to as the lingonberry. Its glossy evergreen foliage turns mahogany tones in the autumn.

Since the 1930s, the Mezitt family and some close friends on the weekend of August the seventeenth have climbed Mt. Cardigan in New Hamphshire to collect *v. vitis-idaea* var. *minus* fruits. Most of the berries are macerated and turned into jam. A little of the macerate is saved and sifted through many strainers. The cleaned seed is mixed with a moistened mixture of one-part sphagnum peat moss and one-part washed concrete sand, and put in a 40°F cooler for 90 days to stratify. Seed will germinate with no stratification, but higher percentages can be received with stratification.

The week between Christmas and New Year is when I sow all my ericacous seeds, including *Epigaea, Gaultheria*, and *Vaccinium*. My sowing method was passed on to me by the late Edmund V. Mezitt. In the fall, before the ground freezes, I go into the woods under an oak canopy and collect the top 2 in. of decaying organic matter This material is almost black in our area. The sods are broken apart with a Royer shredder and sifted through a 2-in. mesh screen attached to a conveyor. The organic matter falling off the conveyor is very coarse textured. A bushel of this organic matter is put on the potting bench for a few days to dry The resulting semi-dry organic matter is hand screened through a 1/4-in. mesh.

Metal pans, which measure 3 ft × 6 ft × 6 in are used for sowing. The pans are lined with polyethylene. At the corners of the pans 4-in. pipes 6 in. in length are placed vertically. The pipes have one inch holes drilled in the sides toward the bottom of the pans. Two inches of washed pea stone is placed in the bottoms of the pans, coarse perlite is then added to within one inch of the top of the pans. The very coarse textured organic matter is spread to a depth of 1/2 in. on top of the perlite The whole pan is then packed, leveled, and 1/8 in. of screened organic matter is spread on top The whole pan is again packed and leveled. After sowing, the pan is subirrigated through the 4-in pipes until the organic matter glistens with moisture.

A tent is constructed with 2-mil clear polyethylene. The pan is siphoned out the next morning. Clear 60-watt light bulbs are placed 2 ft above the pans; they come on between 1:00 and 3.00 a.m.

In two weeks the seeds begin to germinate. One has to watch out for damping-off at this time Once the true leaves begin to appear, the seedlings are slowly hardened off The plastic on the tent is pulled from the sides of the pan and air is allowed to flow through the tent The tent is opened for a few hours and the time is gradually increased for 1 to 1 1/2 weeks. At the end of this time, the plastic tent is removed.

Seedlings are pricked off and planted into plug trays. Our mix contains 25% Weston Nurseries composted leaves, 25% coarse perlite, 25% sphagnum peat moss, and 25% composted southern pine bark To one yard of soil mix a 13 oz. coffee can of Aqua-gro and one pound of Osmocote 14-14-14 fertilizer is added. This soil mix has a pH of 5.5. The plug trays are then placed into a dip tank and subirrigated. A supplemental liquid feeding of 20-10-20 at a rate of 200 ppm is done every 2 weeks. The greenhouse is maintained at 60°F Clear 60-watt bulbs come on between 1:00 and 3:00 a.m.

Gaultheria responds well to fertilizer and the seedlings grow quickly. In 4 months from seed a full 2 1/4 in. pot plant can be produced with little effort.

Vaccinium grows slowly the first 6 months. If seedlings are brought back into a warm greenhouse for the following 6 months, they will triple in size.

The most picky of the plants to grow is the *Epigaea*. A full 1-qt potted plant requires two years from seed. After the second winter a ten percent loss is normal A quarter of a teaspoon of Osmocote can be added to established pots in April. If fertilizer is put on too late in the season, many of the plants will come through the winter dead Customers have commented both ways on the *Epigaea*—they grow or die. For those who have had problems growing this plant, I suggest it prefers a well drained sandy loam in the partial shade.

Overwintering these plants is done in a concrete block cold frame. The plants are covered with Remay (spun polyester) in December. White polyethylene is attached to the top of the cold frame and left there until March. The Remay is removed in the beginning of April. Snow fence is put on the frame for shade.

Weston Nurseries has chosen to produce these plants from seed because they are relatively inexpensive to produce At time of sale, in quart pots, sixty cents worth of labor and materials went into each plant

DICK BIR What was the temperature of the greenhouse when you were germinating the seeds?

CHRISTOPHER ROGERS: The house temperature is 60-65° F with the heat running under the bench.

JOE DALLON· You mentioned the collecting of humus form the woods. Do you think there may be a mycorrhizal association forming?

CHRISTOPHER ROGERS. I have heard such comments and that may be why we have not changed our methods.

The Effect of Organic Soil Amendments on the Growth and Development of *Kalmia latifolia*

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INTRODUCTION

As recently as 20 years ago horticulturists generally agreed that the addition of organic soil amendments to the planting hole would improve both the survival and subsequent growth of shrubs and trees transplanted into the landscape. However, about fifteen years ago evidence started to accumulate that has prompted re-evaluation

Research using peat and/or pine bark to amend backfill when planting woody plants as diverse as *Rhododendron* 'English Roseum' and *R* 'Hino-Degiri', shore juniper, *Ilex crenata* 'Helleri', flowering dogwood, sweet gum and silver maple in mineral soils (Corley, 1984; Schulte and Whitcomb, 1975) indicated that not only were we wasting our time when recommending organic matter but also wasting our customer's money (Hummel and Johnson, 1985). However, all of this research was done with individual planting holes. Other research showed that some cultivars of roses and evergreen azaleas did benefit from the addition of organic matter to an entire planting bed (Banko, 1986; Corley, 1983).

Mountain laurel, *Kalmia latifolia*, has long been recognized as one of the most desirable of landscape plants. However, producing a consistent crop of top quality field grown plants has been difficult. Initial survival of transplants had been disappointing, crop growth was often slow, and the quality of the crop was inconsistent. Recent advances in nutritional research have helped (Bir, 1987), but these problems remained so we decided to investigate the effect of pine bark or Canadian sphagnum peat as a soil amendment in field bed culture of mountain laurel seedlings.

MATERIALS AND METHODS TEST 1

One-year-old seedling *Kalmia latifolia* were transplanted into 5 x 60 ft beds at the Mountain Horticultural Crops Research Station in August 1986. Each of the 3 beds constituted a complete block. Amendment plots, 5 x 10 ft, were randomized within the beds. Seedling plants had been selected for uniformity from a crop grown from the same seed source. Plants were initially grown in a pine bark and peat medium (3:1,v/v) which had been amended with 7 lb of dolomitic limestone and 3 lb of Esmigran per cu yd. Peters 15-45-5 Rhododendron Special fertilizer was used throughout the production of these transplants

The seedlings were planted 2 ft apart in rows beginning 1 ft in from the edge of the plots with 15 plants per treatment Only the middle 9 plants were measured. Rows on the beds were 2 feet apart starting 1 1/2 ft in from the edge of the bed.

Amendment treatments were spread on top of beds to the depth indicated then tilled in to a depth of 8 in. Treatments were as follows:

- Control no amendment
- 2 in. of pine bark
- 4 in of pine bark
- 1 in. of Canadian sphagnum peat
- 2 in. of Canadian sphagnum peat
- 1 in. of Canadian sphagnum peat + 2 in. of pine bark

Pine bark used was the least expensive grade sold bagged as "mulch."

Prior to planting, soil fertility was corrected to N. C. Agricultural Extension Service (NCAES) suggestions. During the course of the experiment, plants were irrigated as necessary and fertilized according to NCAES suggestions. Before the 1987 and 1988 growing seasons, plants were pruned uniformity to induce the branching habit preferred by the nursery industry

RESULTS

Growth measurements reported are in the form of a Growth Index (GI) which was determined by measuring the maximum height of the plant and adding this figure to a representative width determined by measuring the maximum and minimum width, adding the figures together and dividing by two. This sum of height and width is then divided by two

Any amendment treatment was found to be beneficial in both survival and growth (Table 1). At the end of the third year, plants in the greater amounts of peat and pine bark had produced significantly more growth than the controls and those in two inches of pine bark.

Table 1. Growth and survival of *Kalmia latifolia* as affected by selected organic soil amendments

Treatment	Alive %	Growth index 2 yr	Growth index 3 yr
Control	78 a[1]	11.9 a	14.3 a
2 in bark	96 b	17.0 b	19.2 b
1 in. peat	96 b	18.0 b	20.8 bc
4 in bark	100 b	18.5 b	21.1 bcd
2 in peat	96 b	20.0 b	23.0 cd
1 in peat + 2 in bark	96 b	20.2 b	24.4 d

[1] Duncan's new multiple range test Numbers followed by the same letters are not significantly different from each other at the 5% level.

Despite the significant differences, some visitors were not convinced. One repeated question concerned the performance of these plants once they were planted into mineral soils in a typical landscape. Had they been pampered too much to be able to withstand the rigors of the average landscape?

To test landscape survival, we transplanted from each of the amendment treatments to tilled clay-loam soil in a south facing full sun location in mid May. There was 3 to 4 in. of new vegetative growth when the plants were moved. Plants were not irrigated but they were given a scant one inch pine bark mulch The new vegetative growth wilted each day and recovered each night for about a week. Fortunately, we got rain four days after transplanting.

All of the transplanted plants are still alive. They bloomed beautifully the year following transplanting. However, they are not thriving Mountain laurels in clay loam soils on south facing slopes in the full sun usually don't thrive in our area.

MATERIALS AND METHODS TEST 2

As with most research, questions remained. How much amendment was enough and how much was too much? Would named cultivars respond as well?

With support from the North Carolina Association of Nurserymen and plants provided by Briggs Nursery, Olympia, WA, we set up another test. Our treatments were:

- 2 in. of Canadian sphagnum peat
- 4 in. of Canadian sphagnum peat
- 3 in of pine bark
- 6 in. of pine bark.

All of our plants were propagated from tissue culture, grown on in quart pots, then selected for uniformity before planting—all in an attempt to minimize experimental error. Our test plants were *Rhododendron catawbiense* 'Gomer Waterer' and *R.* 'Gibraltar', and *K. latifolia* 'Ostbo Red'.

RESULTS

After two years of growth, there is a lot of variation in growth response which has translated into statistically significant differences for only the *R.* 'Gibraltar' growth index (Table 2).

Table 2. Growth of *Rhododendron* 'Gibraltar' as affected by selected soil amendments

Treatment	Growth index
Control	7.6 d[1]
2 in peat	12 3 ab
3 in pine bark	11.4 bc
4 in peat	14.6 a
6 in pine bark	9 6 cd

[1] Duncan's new multiple range test Numbers followed by the same letters are not significantly different from each other at the 5% level.

Applying peat or the lesser amount of pine bark significantly enhanced growth of rhododendron 'Gibraltar'. However, 6 in. of pine bark did not significantly enhance growth over no soil amendment This may have been due to excessive drying of soil since this plot required more frequent irrigation during the first 2 months of the test, i.e., until plants became established.

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DAVE THOMPSON: We found that when we power rotovated we destroyed the soil structure and the addition of organic matter did not help So we went back to plowing and disking My question to you is did you try any treatments with out power rotovating?

DICK BIR. Not in this experiment. I suspect you are working with better raw material than we are. I have not seen that in our clay soils. This is an example of doing what works best for you

RAY MALEIKE: Did you use the same amount of fertilizer per plant in your treatments?

DICK BIR: Yes, our standard recommendation in North Carolina is 1/4 oz of nitrogen per plant after planting; 1/2 oz the second year, and 1 oz the third year before bud break in the spring We use ammonium nitrate in this case.

Organic Wastes as Growing Media

Calvin Chong, R.A. Cline and **D.L. Rinker**
Ministry of Agriculture and Food, Horticultural Research Institute of Ontario, Vineland Station Ontario Canada L0R 2E0

The composting and reutilization of organic (biological) wastes have become a major part of the waste management cycle. In North America, this trend has accelerated in recent years as the cost of disposing of these waste by-products skyrocketed and suitable landfill sites became scarce.

The Ornamental Nursery Research Programme at the Horticultural Research Institute of Ontario (HRIO) has been evaluating the use of various organic waste by-products as growing medium ingredients or as substitutes for traditional organic products such as peat and bark. This paper highlights some of our recent investigations in this area of nursery culture.

MUSHROOM COMPOST

The mushroom industry generates large amounts of organic waste material The U.S. discards annually an estimated one billion tons of spent mushroom compost; Canada discards one quarter as much

The exploitation of this waste product as an amendment for large-scale crop production has been very limited. Researchers have suggested its potential for use in crop culture (Chong et al., 1987; Dallon, 1987; Wuest, 1991), but information on its use has been limited or not well defined, species response has been variable The high salt content of spent composts, which can be toxic to plants, appears to be largely responsible for concern about its use as a soil amendment or in potting mixes.

Studies at this institute showed that many ornamental shrub species grew well in containers amended with between 25 and 100% of spent mushroom compost (Chong et al., 1987, Chong et al, 1991, Chong et al., 1991). Species included cotoneaster, deutzia, dogwood, forsythia, juniper, ninebark, potentilla, rose, and weigela. The results also demonstrated little difference among media with freshly spent (high salt level), leached (low salt level), or aged (intermediate salt level) composts. Although growth of some species was moderately reduced or was not affected, most species grew more as the proportion of compost was increased in the media

Under our experimental conditions using trickle-irrigated containers, success in growing ornamental nursery crops with spent mushroom compost media was related to rapid and early leaching of high salts from the media (Fig. 1) Although our experiments included treatments with up to 100% compost, under normal cultural conditions no more than two thirds by volume is recommended due to shrinkage of the compost.

Use of mushroom compost should always be accompanied by appropriate soil tests for salts because of the potential for plant damage due to high salts In our experiments, high pH (up to 8.2, 1:2 soil: water extract), found initially in many of the compost formulations, had no detrimental effect on plant growth.

Recent research by Wuest (1991) has confirmed beneficial influence of spent mushroom compost with field crops

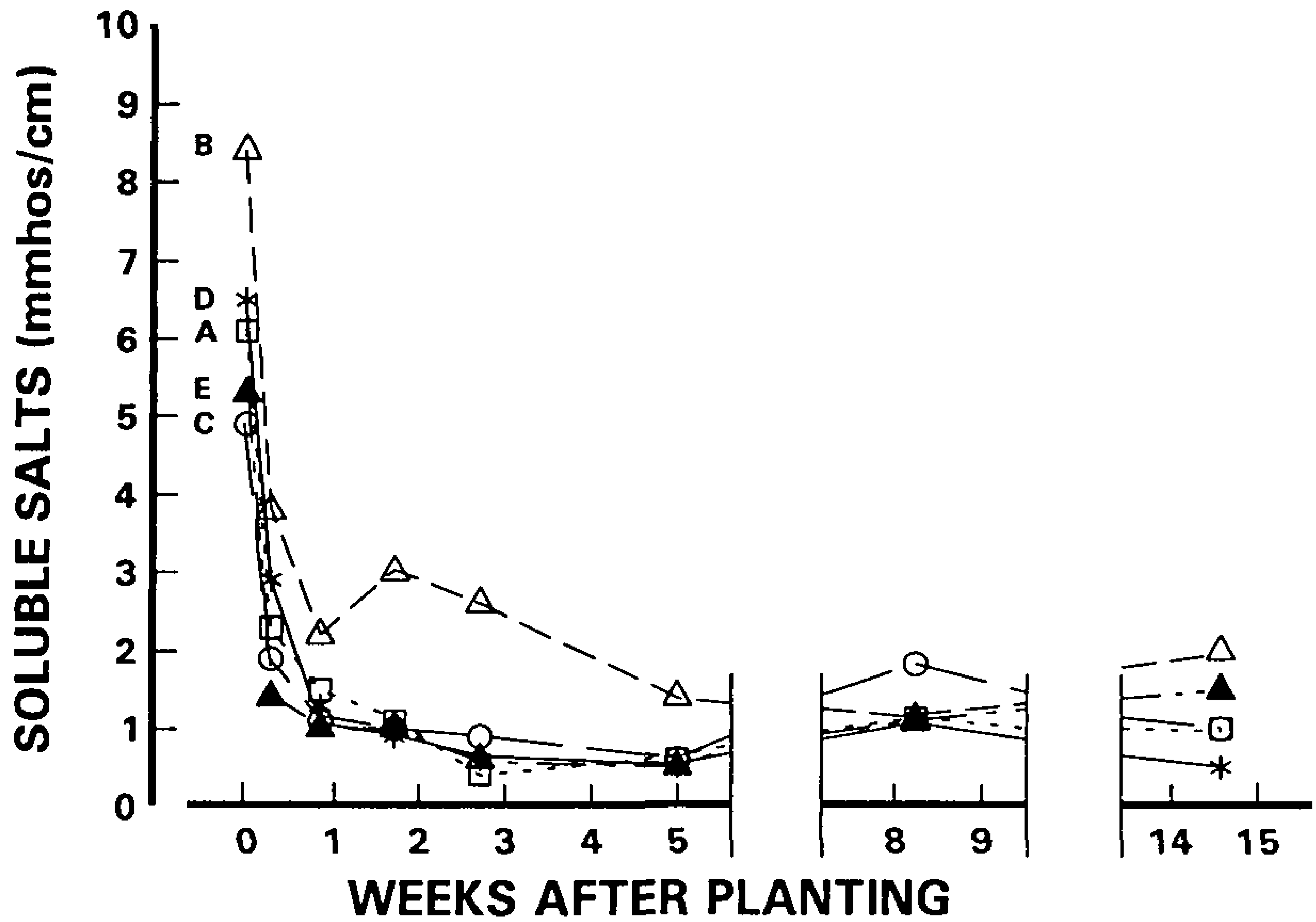

Figure 1. Initial elevated salt levels in spent mushroom compost (100%) media from five farms (A to E) are quickly leached from trickle-irrigated nursery containers

PAPERMILL SLUDGE

The paper manufacturing industry accumulates large quantities of organic wood waste products, often referred to as sludge There are three types of sludges. Primary sludge is derived directly from virgin wood and contains a great proportion of wood fibers. Secondary sludge is derived from primary sludge subjected to microbial decomposition with the addition of nitrogen and phosphorus. De-inked sludge is recycled from existing newsprint. Ontario produces annually about three quarter of a million tons of papermill sludge wastes.

Papermill sludge produced in Ontario is free of undesirable organic chemicals, and is low in heavy metals. The high fibrous matter makes it ideally suitable for improving the physical properties of growing mixes. Secondary sludge is a good source of plant nutrients such as nitrogen and phosphorus

Tests in conjunction with the Soil Management Research Program at this institute indicated that raw papermill sludge can be used as a soil conditioner and fertilizer for field-grown agricultural crops such as corn and grapes. Other studies indicated that papermill sludge mixed with soil can be effective for growing a variety of greenhouse crops, such as tomatoes, cucumbers and peppers (Cline and Chong, 1991). Growth of these crops was directly related to the amount of nitrogen present in the raw sludge. Related investigations in the Ornamental Nursery Research Program showed similar results when various nursery crops, including cotoneaster, dogwood, forsythia, spiraea, and weigela, were grown in container culture (Chong et al, 1987; Chong et al, 1988; Cline and Chong, 1991) As indicated with spirea (Fig 2), media with more than one-third by volume of raw papermill sludge depressed growth. This result may be due to the combined influence of increasing unavailability of nitrogen and increasing compaction of the media as the proportion of sludge increases in the media.

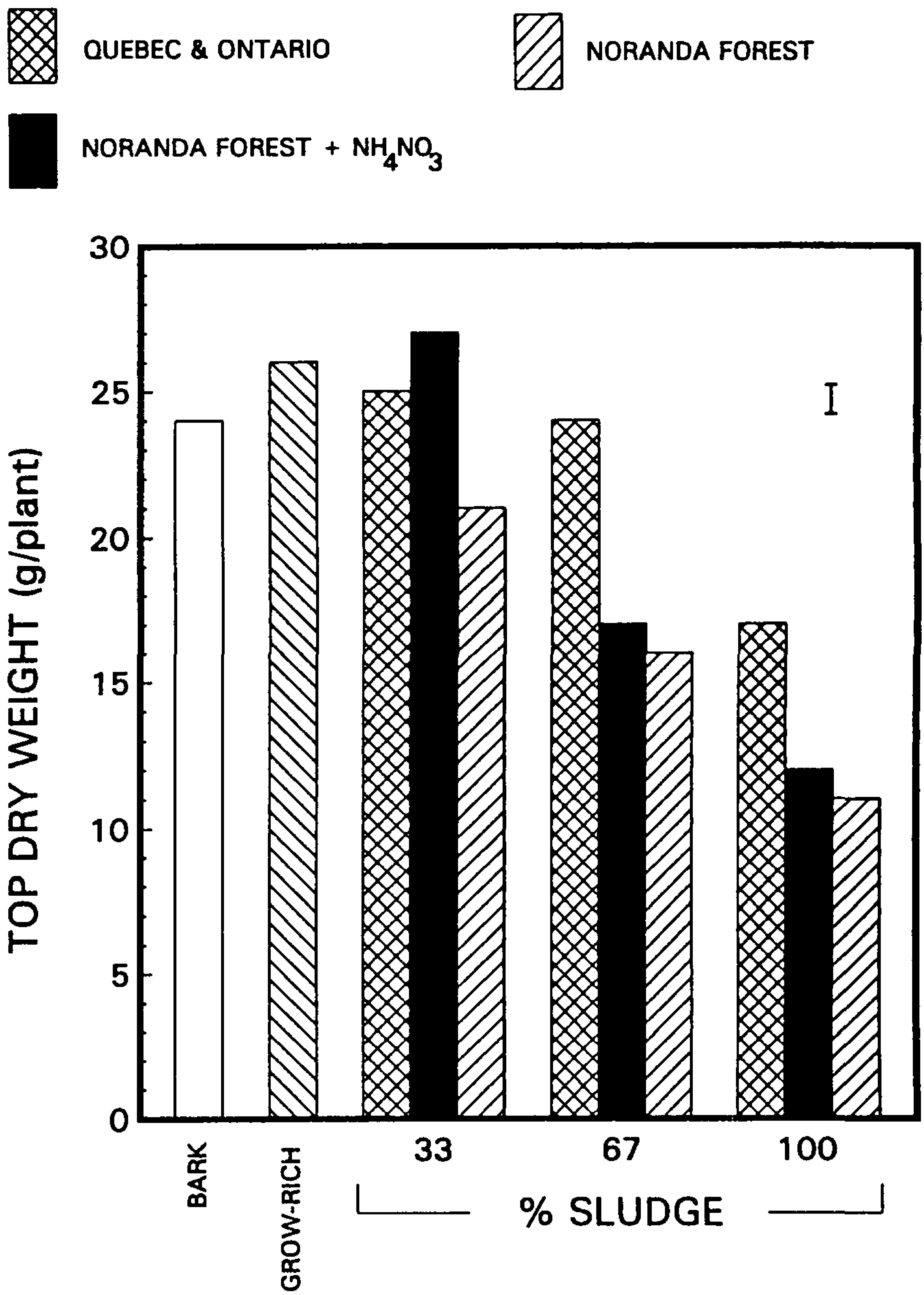

Figure 2. Top dry weight of spirea grown in #2 nursery containers with 100% bark (control medium), Grow-Rich, a brand-name medium made primarily from papermill sludge; and bark mixed with 33, 67 or 100% of two sources of raw papermill sludge, Quebec & Ontario and Noranda Forest (with or without 2 g ammonium nitrate per container) Vertical bar indicates LSD at 5% level of probability

The Grow-Rich medium (Fig 2) is produced by composting papermill sludge and other waste organic materials by Grow-Rich Inc., Niagara Falls, Ontario. At present, of over 270 large composting operations in the U.S., only four use papermill waste Grow-Rich is the only similar operation in Canada.

MUNICIPAL WASTE

Composted municipal residential waste offers another possibility for use in growing mixes. Several years ago, a demonstration project was initiated by the Ontario Ministry of the Environment (MOE), Ontario Centre for Resource Recovery, Downsview, to process and compost residential waste, with a view to marketing the end products as field or garden soil conditioners.

The recycling-composting process included multiple screenings, shredding, and separation by air and magnetic processes This resulted in a clean, easy-to-handle product. However, it contained small amounts of plastic and related synthetic materials, which made it visually unattractive.

A trial conducted at HRIO showed that when this composted waste was added to the container mix, growth of the ornamental species ninebark increased progressively with increasing amounts of the product (Table 1).

Regardless of medium, there were no apparent symptoms due to specific nutrient toxicity or deficiency. Leaf analysis from mid-July samples indicated small but significant increases in leaf nitrogen in plants grown with between 0 and 67% compost waste treatment (Table 1)

Relative compaction in each mix showed that only the 100% composted waste treatment subsided noticeably by the end of the season (Table 1).

Table 1. Effects of varying proportions of recycled composted municipal waste on top dry weight and leaf nitrogen content of ninebark and on medium compaction

	Composted municipal waste (%)				
	0	33	67	100	SE[z]
Top dry wt (g/plant)	97	116	127	133	7
Leaf nitrogen (%)	2.60	2.82	2.97	2.61	0.10
Medium compaction (cm)[y]	2.0	1.8	1.7	3.0	0.3

[z]Standard error of the mean

[y]Depth from container rim at the end of the growing season

CONCLUSION

Since the start of this research six years ago, there have been numerous enquiries as more and more nurseries consider organic wastes in their growing media. Various companies have been marketing or have been making preparations to produce more waste-amended growing media in commercial quantities for the nursery/landscape industry.

With increasing demand for container-grown ornamental plants, there will be an increased need for growing media Organic waste by-products such as the ones described in this paper will help meet this need and have positive environmental effects as well.

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PETER ORUM: A comment on the use of mushroom compost There is no doubt that we will be using these waste products in the future. We have used mushroom compost for 25 years in our mix. Before you use it, buy a good EC meter and test your mix. If you don't you may "burn" your plants up You must get your soluble salts down first or you could kill the roots on bare rooted plants before the level is leached down.

DAVE THOMPSON We use a wetting agent to aid leaching. We determined that it was not economical to use in our liner stage but larger sizes it was

SATURDAY AFTERNOON 7 DECEMBER 1991

The afternoon session was convened at 1.45 p.m. with Steven Verkade serving as Moderator.

Comparison of IBA to KIBA

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The rooting hormone KIBA (potassium salt of indolebutyric acid) deserves experimentation as a potential commercial rooting hormone. I will present a comparison of KIBA to IBA based upon observations and experimentation at Midwest GroundCovers.

To help understand the conclusions we have drawn, I will provide a brief explanation of our propagation systems at Midwest GroundCovers. Throughout a season lasting from March through October, we will propagate approximately 12 million cuttings. These cuttings range from groundcovers such as *Euonymus fortunei* 'Colorata' and *Pachysandra terminalis* cultivars to conifers such as *Juniperus chinensis* var. sargentii 'Viridis'. All cuttings are field prepared by cutting crews and then stored in a cooler. Once the sticking site is prepared, the sticking crews take the cuttings from the cooler, dip them in hormone, and stick them at the site. We use 8 cutters and 7 stickers—so speed is essential for these 12 million cuttings.

Certain criteria must be met before deciding on the use of a particular rooting hormone. Firstly, due to the large quantity of cuttings, the rooting hormone must be quick to apply. This rules out powders because of the added steps required to apply the powder

The second criteria is ease of mixing and use. We mix all of our hormones from the raw elements, therefore we need a hormone that will readily enter solution. After mixing, the sticking crew can easily understand proper application.

Cost effectiveness is the third criteria A large quantity of cuttings requires a large amount of hormone. Many of the premixed hormones are too expensive to purchase in the amounts that are required.

Lastly, will the hormone help us get the rooting percentages that are needed? This is the most important criteria because if the hormone does not work well, none of the other criteria are relevant.

These criteria must be considered when selecting or changing rooting hormones. Not meeting any one of these could eliminate it for our use.

KIBA differs from IBA in that KIBA has a potassium molecule that IBA does not have. This one difference gives KIBA an advantage that I like. Being a potassium salt, it will dissolve readily in water which makes mixing faster and easier. Alcohol or other organic dissolving agents, are not needed to get the KIBA into solution. By not using an organic dissolving agent, such as alcohol, potential mixing errors that can lead to burning or loss of the cutting are avoided.

Several drawbacks exist from not using alcohol. Alcohol is a sterilent, therefore more attention needs to be given to clean cuttings and a clean work area to prevent contamination. Also, a higher concentration of KIBA may be needed because alcohol serve as a carrying agent.

The concentration needed for desired rooting appears to vary between KIBA and IBA. For some plants, such as *Spiraea, Potentilla, Cotoneaster*, and *Thuja*, the concentration of KIBA needed is less than that of IBA. For other plants, such as

Juniperus chinensis var *procumbens*, *Rhus aromatica* 'Gro-Low', and *Berberis* varieties, the concentration for satisfactory rooting increased. The concentration did not change for plants, such as the varieties of *Juniperus horizontalis* , *Syringa*, and *Euonymus* . I am unable to explain these differences at this time as no pattern has developed. I would recommend beginning at your present IBA concentration and making the necessary adjustments as you experiment.

The useable storage life for IBA and KIBA solutions seems to be the same. However, I try to mix only enough solution needed for the crops being stuck at that time. Two to three months is the longest that I store a hormone solution

During the experiments with KIBA, I did not experience any shoot inhibiting effects that can occur with IBA. Cuttings of all plants developed good shoot formation and growth after root initiation Excessive callus growth without root development has not been a problem with KIBA. There have been no noticeable side effects to the plant material from using KIBA.

I have used KIBA on a variety of groundcovers, deciduous shrubs, junipers, vines, broadleaves, and perennials. Success was achieved with all species used in the experiments. With some crops, such as juniper cultivars and *Thuja* cultivars, rooting percentages actually increased. Success in rooting upright junipers was achieved with KIBA. Cultivars such as *J. chinensis* 'Mountbatten' and *J. virginiana* 'Cupressifolia' have done quite well (approximately 85%). Deciduous shrubs including *Cotoneaster, Rhus, Viburnum,* and *Chaenomeles* all responded well with no loss of rooting percentage. Broadleaves like *Buxus, Ilex,* and *Euonymus* improved slightly over IBA. With vines and perennials, there was no real difference between using IBA and KIBA. I have not experimented with any cuttings of ornamental trees or the large upright shrubs.

The availability of KIBA for nursery use is still experimental and is not availabe for general nursery use.

I have been very satisfied with the performance of KIBA on all crops tested. With its ease of mixing, increase in rooting percentages, and lack of side effects, KIBA should be tested on other plants I would recommend you experiment with KIBA if given the opportunity

VOICE: Where do you buy the KIBA and do you dilute it?

ED CARPENTER: From ICN Laboratories and we dilute with water.

Topophysis in Gymnosperms: An Architectural Approach to an Old Problem

Peter Del Tredici
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Topophysis is defined as the organizational status of a meristem which is determined by its position on the plant and which remains stable through vegetative propagation (Halle, et al , 1978; Molisch, 1938; Roulund, 1976) From a practical point of view, this means that if a lateral branch of a woody plant is rooted or grafted onto a seedling rootstock, the resulting propagule will continue growing in the same non-vertical orientation it maintained while it was still attached to its parent trunk. Try as one might to correct this orientation by tying the leader to a stake, the branch will continue its plagiotropic (horizontal) orientation once it reaches the top of the stake. From the propagator's perspective, the effects of topophysis are problematic because the propagules do not replicate the growth habit of the plant they were taken from.

In order to be properly understood, the phenomenon of topophysis must be examined within the conceptual framework of tree architecture, as defined by Halle, et al. (1978). In the context of the whole tree, topophysis can be considered a physiological state in that the hormonal signals emanating from an orthotropic (vertical) leader, which regulate the orientation of its subtending lateral branches, become fixed or "imprinted" on these branches—a kind of dendrological memory, if you will The persistence of these effects in subsequent vegetative propagules varies with the architecture of the species in question, the age of the plant, and location on the tree of the meristems used in propagation.

In the physiological literature topophysis is considered a manifestation of the lack of juvenility—a murky concept practically defined as a phase of growth in woody plants that is "characterized, apart from its morphological properties, by a greater readiness to form adventitious roots and an inability to form flowers" (Doorenbos, 1965). In the context of juvenility, topophysis is typically presented as an example of the irreversible changes that occur in meristems as part of the aging process (Robins, 1964). Borchert (Borchert, 1976) makes it clear, however, that this view is not altogether correct and that, over time, topophytic effects are often reversible The purpose of this paper is not to delve into the complexities of juvenility or the hormonal basis of the phenomenon of topophysis, but to look at the practical implications of topophysis as it relates to the issue of vegetative propagation.

The phenomenon of topophysis—which was first described by Vochilng in 1904 in *Araucaria heterophyllais*—is quite common among gymnosperms and numerous examples have been documented among the conifers, including species in the genera *Abies* (Busgen and Munch, 1929), *Agathis* (Molisch, 1938), *Araucaria* (Vochting, 1904), *Cephalotaxus* (personal observation), *Sequoia* (Libby and McCutchan, 1978; Bobbins, 1964), *Taxus* (Molisch, 1938; Robbins, 1964; Turner, 1958), and *Torreya* (personal observation). Many of the species within these genera are known to produce topophytic "cultivars"—often given the name 'Prostrata'—which possess branches with a more or less plagiotropic orientation and a secondarily derived dorsiventral needle arrangement. Predictably enough many of these cultivars are unstable in their growth habit, frequently throwing up "reversions" with an orthotropic orientation and a whorled needle arrangement. No doubt such instability, in conjunction with a misunderstanding of the causes of topophysis, has contributed to the nomenclatural confusion that surrounds many dwarf conifer cultivars in the nursery trade (Welch, 1979). In the genus *Taxus*, for example, the position of the cuttings on the parent plant is often reported to determine the cultivar name they receive (Borchert, 1976; Turner, 1958).

In my own work with the genus *Ginkgo*, the effects of topophysis can be seen clearly by the inability of plants propagated by cuttings or grafts from the lateral branches of old trees to grow orthotropically (Fig. 1). This means that vegetatively propagated ginkgos seldom show the dominant central leader and whorled branch arrangement typical of seedlings. Instead, the branches grow out at erratic angles, producing low branched trees with poor form from the point of view of use as street trees.

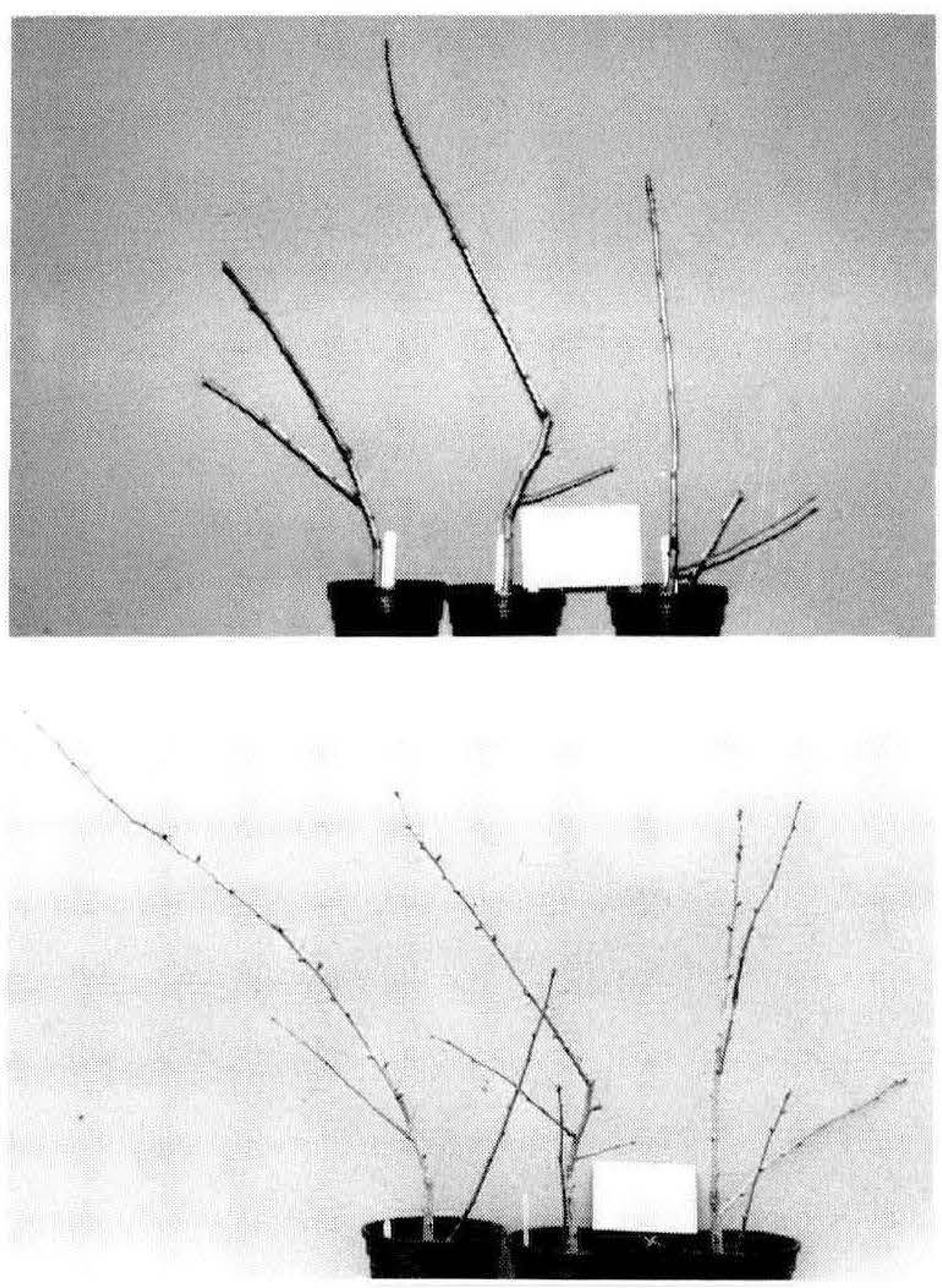

Figure 1. Topophysis in *Ginkgo biloba* 'Fastigiata'. Terminal softwood cuttings were taken from a single branch in August, 1981 and rooted under intermittent mist. (A) The two cuttings on the left were taken from plagiotropic lateral shoots while the one on the right was taken from the orthotropic terminal shoot. Photographed at four years of age in December 1985. (B) The same cuttings photographed in February 1991, at ten years of age, showing that their respective orientations have remained stable over a ten year period. For scale, the index card is 7 ×13 cm.

In China, where *Ginkgo* is cultivated for its edible nuts, the effects of topophysis are put to use rather than considered a problem as it is in the United States. Female trees which produce exceptionally large seeds are propagated by grafting lateral shoots onto seedling rootstocks. Compared to seed-grown trees, with their strong leader and whorled branches, grafted trees are spreading in form, produce no central leader and are scarcely more than 5 or 10 m tall (Fig. 2). From a commercial point of view, the characteristic vase-shaped form of these grafted trees is advantageous since it makes the seeds easier to harvest (Del Tredici, 1991). The stability of the form of these propagules offers clear evidence of long-lasting topophytic effects, and provides an example of "domestication" by selective propagation. It must be kept in mind, however, that it is the size and shape of the edible nut that defines these Chinese cultivars, not their growth habit.

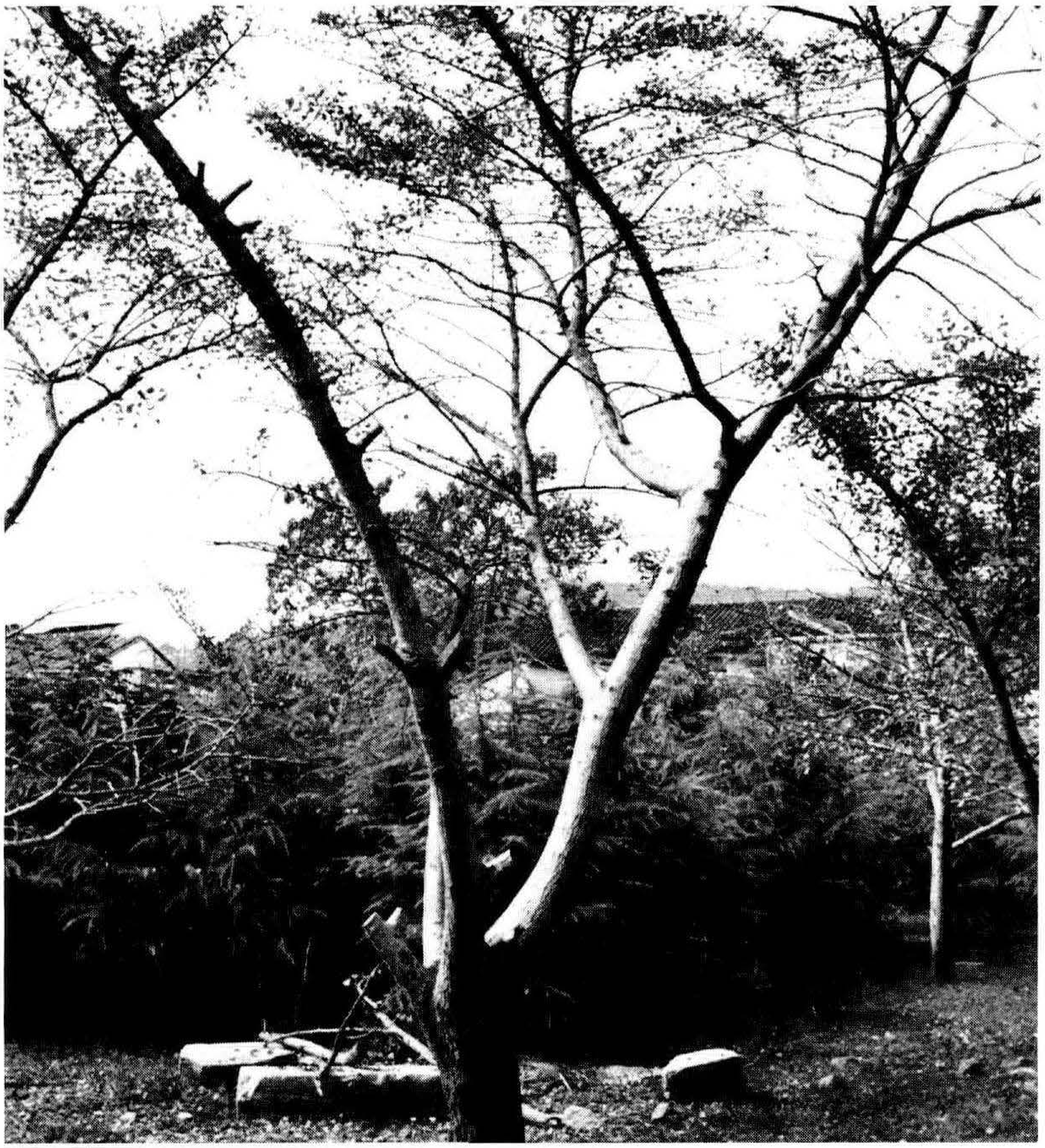

Figure 2. A grafted specimen of the commercially important *Ginkgo* cultivar 'King of Dongting Mountain' selected for its production of larger than normal nuts. The vase-shaped, leaderless from of such grafted ginkgos contrasts markedly with that of trees raised from seed. Photographed in October 1979 in Dongting Shan, Jiangsu Province,China.

In *Ginkgo*, the most practical way to circumvent the problem of topophysis is through the age-old practice of stooling, in which young stock plants are repeatedly cut back low to the ground to stimulate the production of numerous vertical replacement shoots which originate from dormant meristems embedded in the stem. When these vigorous terminals are used as propagation material—either as cuttings or grafts—they will produce vigorous, vertically growing trees (W. Flemmer III, personal communication) No doubt stooling would also be effective in overcoming topophytic effects in those conifer genera which, like *Ginkgo*, show a strong tendency to stump sprout following logging or heavy pruning (*Cephalotaxus*, *Cunninghamia*, *Sequoia*, *Taxus*, and *Torreya*) Many of these reiterative shoots — to use the terminology of tree architecture—probably originate from so-called detached meristems (Fink, 1984).

Other techniques for overcoming topophytic effects include: serial grafting of scions from mature trees onto seedling rootstocks, which has been used to rejuvenated clones of *Pseudotsuga* and *Picea* (John, 1983); and *in vitro* tissue culture, which has been reported to restore juvenility in mature clones of *Picea* (John, 1983) and *Sequoia* (Ball, 1978).

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Understanding Foliar Variegation as it Relates to Propagation

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Variegation can be defined as "varied in appearance as in one item possessing more than one color". Animals and plants can be variegated. In plants, variegation is manifested as streaks, spots, stripes, and blotches and is most apparent when it occurs on leaves and petals In many cases, the ornamental appeal of a plant is entirely based on its variegation pattern. For example, coleus hybrids (*Coleus* × *hybridus*) and rex begonias (*Begonia* × *rex-cultorum*) would not be considered ornamental if their leaves were entirely green Unfortunately, for many species the genetic and physiological control of variegation is poorly understood as most of our experience with variegation has come from casual observations of cultivated ornamental plants. Scientists do know, however, that the variegation is frequently caused by differences in the type or amount of pigments in cells The most conspicuous leaf pigments are generally the green chlorophylls and the red or purple pigments (generally anthocyanins).

For the plant propagator, knowing what controls variegation pattern in a given plant can be critical if offspring which are "true-to-type" are to be obtained I will not attempt to explain the complex genetics associated with the many forms of variegation nor will I discuss physiological problems such as mineral deficiencies and unwanted diseases, conditions whose symptoms can be described as "artificial" variegation Instead, I will outline the control of variegation patterns as it relates to both sexual and asexual (i.e. vegetative) plant propagation. For some of the described examples, there are no detailed scientific studies to verify the nature of the variegation. Nevertheless, this author has taken the liberty to list plants which he is confident fall into the category described.

There are two basic types of variegation, **cell lineage variegation** and **non-cell lineage variegation** (Kirk and Tilney-Bassett, 1978) Cell lineage variegation occurs when a plant is made up of two or more genetically distinct cell types (i.e. the plant is a genetic mosaic). The cells within the colony of uniquely-colored leaf cells are related to each other in that they are descendants by successive cell divisions of the original cell in which the color change occurred. The extent of variegation can be dependent on the stage of leaf development when the color change occurred. For example, if a cell's color change (i.e. genetic change) occurs when the leaf is very immature the uniquely-colored sector will be large, whereas if the color change happens very late in cell development only a tiny patch of uniquely-colored cells will be evident. As you will see with the description of chimeras below, the biological "rules" which govern the angles of cell divisions can have a large impact on the pattern of variegation in cases of cell lineage variegation.

In non-cell lineage variegation all of the cells in the leaf have the same genotype but only some of them express the genes responsible for certain pigments. There appears to be no relationship between the pattern of leaf cell division and the patterns of colors on the leaf. In most cases of non-cell lineage variegation it is the "geographic" location of a cell on the leaf, and not from which cell it descended, that determines its color. Therefore, within a given plant the patterns of variegation tend to be somewhat predictable (e g. all leaves possessing white veins on a green background).

CAUSES FOR CELL LINEAGE VARIEGATION

Chimeras

The most common cause for cell lineage variegation is chimerism Chimeras are genetic mosaics in that they are plants which possess more than one genotype In plants, chimeras owe their existence to the orderly patterns of cell division in the shoot apical meristem (i.e. shoot tip or terminal growing point). Most higher plants possess shoot apical meristems which have a layered arrangement of cells. Cells tend to divide perpendicularly to the surface of the meristem Because of this, cell layers tend to remain independent of each other and their appearance can best be described as rows of bricks on a wall Chimeras can arise when a mutation occurs in one cell in one layer but not in other cells in other layers With time, a whole cell layer becomes populated with mutant cells When this occurs a periclinal chimera is formed. It is only when an entire cell layer is uniform in genotype and genetically unique that a chimera which is stable enough to be propagated as "true-to-type" is formed.

Organs such as leaves have their origin in the shoot apex. If the shoot apex is composed of layers of mutant and normal cells, so too are the organs which arise from the apex The most common chimeras are those with white leaf edges on green leaves (Fig. 1). Since chlorophyll is not phenotypically expressed in the apical meristem, we tend to overlook the fact that the leaf's variegation pattern is a reflection of the arrangement of genetically green and genetically white cell layers in the shoot apical meristem.

Unfortunately, a plant's sex cells (i e the eggs and pollen) are derived from single cells which are ultimately derived from only one of the cell layers in the shoot apical meristem. Therefore, plant chimeras cannot be maintained by seed propagation. Seedlings of self—pollinated white and green chimeras will be either green or white depending on the position of the white and green cells in the tissue layers of the apical meristem. The white seedlings die soon after germination because they use up their stored sugars and cannot produce sugar without chlorophyll. In some yellow and green chimeras (e g. *Hosta sieboldiana* 'Frances Williams'), the yellow cells do possess a limited amount of chlorophyll and yellow seedlings would survive and grow more slowly (but would not be variegated).

Some vegetative propagation techniques can be used to perpetuate a chimeral plant. However, if the technique relies on adventitious shoots, the chimera will separate into its component genotypes. For example, leaf cuttings normally produced adventitious shoots from only one cell layer. Therefore, leaf cuttings from variegated leaves (e.g *Sansevieria trifasciata* 'Laurentii') will produce non-chimeral shoots. Chimeral separation also occurs when root cuttings are used and to some extent with most micropropagation techniques. The only way to propagate a true chimera so that the new plants are "true-to-type" is a technique which includes the terminal or axillary vegetative buds. Axillary buds contain the same layering arrangement as the terminal bud from which they arose (Marcotrigiano, 1990).

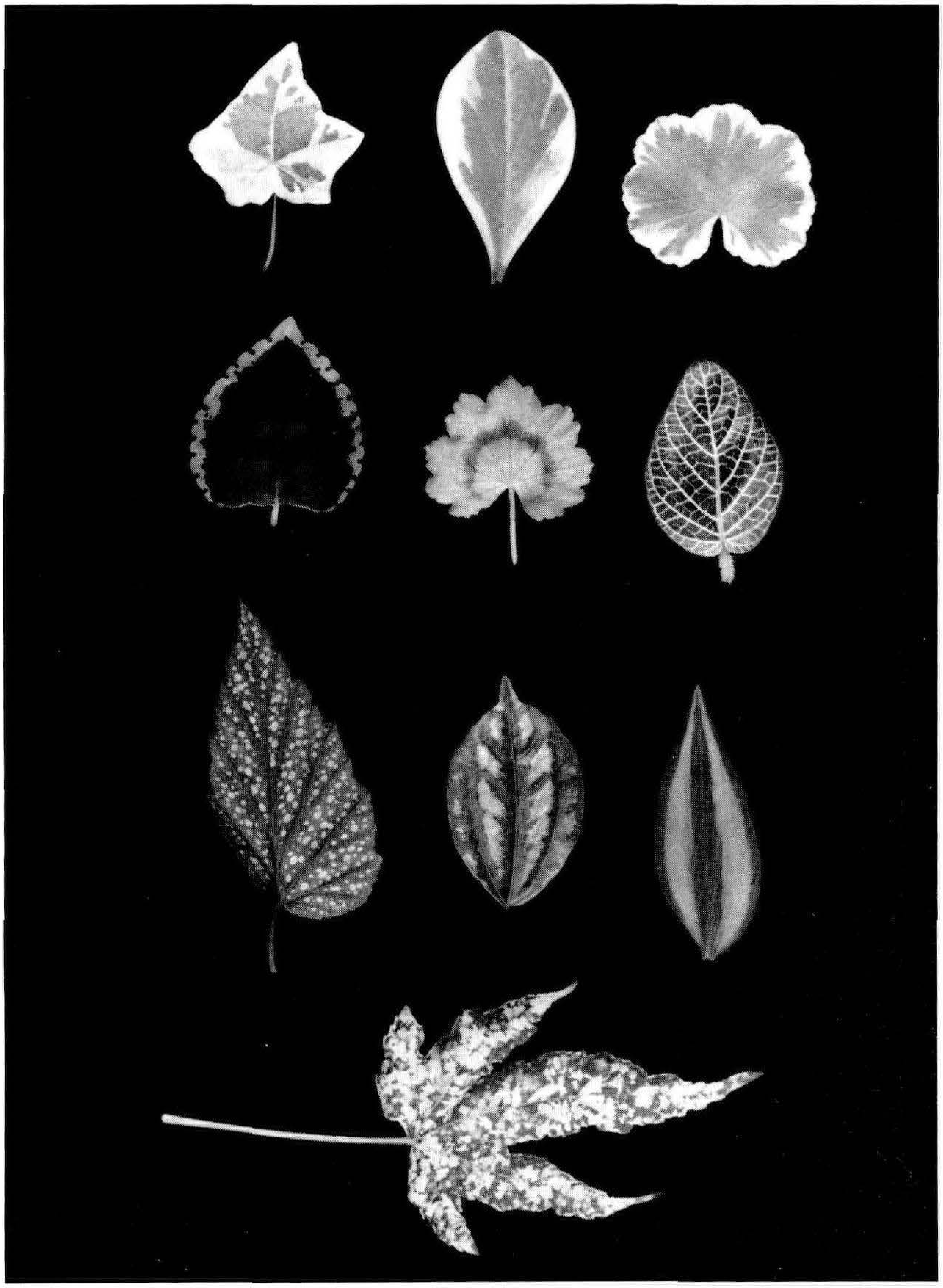

Figure 1. Variegated leaves. Top row: leaves taken from periclinal chimeras. They are (left to right) *Hedera helix* 'Glacier', *Peperomia obtusifolia* 'Albo-marginata', and *Pelargonum* x *hortorum* (cultivar?). Second row are leaves taken from plants where variegation is caused by gene expression for certain pigments in only some cells. They are (left to right), *Coleus* x *hybridus* 'Rose Wizard', *P.* x *hortorum* 'Alpha', and *Fittonia verschaffeltii* var. *argyroneura*. Third row are leaves from plants which sporadically produced leaf "blisters" or entire stripes of "blistered" tissue. They are (left to right) *B.* x *argenteo-guttata*, *Pilea cadierei*, and *Zebrina pendula*. Bottom row is a leaf of the virally infected ornamental abutilon, *Abutilon pictum* 'Thompsonii'.

Therefore, budding, stem grafting, leaf-bud cuttings, stem cuttings (including a bud), or whole plant divisions can be used to maintain chimerally variegated plants.

"Jumping Genes"

The scientific term "transposable genetic elements" refers to genes which have the ability to leave their position on the chromosome and relocate to another position. When they do this they often insert themselves into critical positions of other genes which effectively inactivates the other genes. The most familiar example of this effect is Indian dried corn which frequently possess small streaks and color blotches on the kernels. These streaks appear randomly (i.e. in no particular pattern) whenever gene action is blocked. So for example, if a gene which normally suppresses red pigment production is interfered with by the insertion of a "jumping gene", the red pigment can be produced The result is a colony of related red cells on a yellow background. The earlier this occurs in the development of the kernel the longer and wider the red streak. It is clearly documented that "jumping genes" can be sexually inherited On the practical side, there seems to be very little that one can do to control such genes. Recently, it has been proven that these genes result in color instabilities in snapdragon and petunia flowers. There are only a few documented cases where "jumping genes" effect leaf variegation. 'Jingle Bells' poinsettia bracts (actually modified leaves) appear to display the unstable variegation pattern typical of "jumping genes", although there has yet to be a thorough scientific study of this plant. With regard to maintaining the "jumping gene" variegation pattern, care should be taken to eliminate non-variegated sports since the variegation may not return in future generations even in cutting-propagated plants Tissue culture systems have been known to increase the activity of "jumping genes" and can lead to a wide range of unstable phenotypes (Marcotrigiano et al , 1990; Peschke et al., 1988).

CAUSES FOR NON-CELL LINEAGE VARIEGATION

Gene Expression

The most common cause for non-cell lineage variegation is differences in the expression of genes. Somehow, cells "know" in what position they are on a leaf. While all cells may have the genes necessary to make a pigment only those in the correct location will do so. Therefore, gene expression variegation usually results in a somewhat predictable variegation pattern from leaf to leaf. Gene expression variegation is common in animals For example, panda bears and bald eagles are variegated because cells in some positions are white while others are black, even though all the cells contain the necessary genetic information to contain pigment Their offspring inherit the same variegation pattern as their parents. In plants, there are a large number of species which display variegation due to gene expression. Some common examples are *C* x *hybridus*, *B.* x *rex-cultorvm*, and *Caladium* x *hortulanum* (Fig 1) Since all of the cells in the plant have the genetic information necessary to produce such striking patterns, the patterns are generally passed to offspring following seed propagation. However, in some plants the patterns caused by gene expression are somewhat variable just as height and skin tone vary in man, i e. there is a range of possibilities within the pattern. These slight variations can be due to the degree of expression of the genes responsible for the trait So, for example, some bald eagles may have whiter heads than others, although the basic pattern is the same for all bald eagles. If variation in offspring is undesirable, a selected desirable individual can be asexually propagated. Since all cells possess the same genetic potential, any asexual technique can be used to maintain the desired phenotype of the individual, even if it results in adventitious shoots rather than axillary shoots. Because asexual propagation is too costly in some species, breeders have selected plants which are fairly consistent in their expression of patterns even when seed propagated (e.g. many bicolored petunias).

"Blisters"

Several of the variegated plants which have silver specks, spots, and streaks on their leaves do not possess cells which are lacking the ability to produce chlorophyll. Instead, these plants go through unusual leaf development. In certain regions of the leaf, cells will pull away from the cells below them leaving what can best be described as a "blister" (Fig 1). This trait is actually a gene expression phenomenon (Hoch, 1980) and likewise poses no problems during propagation since it is passed on to sexual offspring or to plants propagated by any vegetative technique. Examples are *Pulmonaria officinalis* and many begonias (e.g. *B. maculata*).

"Beneficial" Virus

Most viruses, such as tobacco mosaic virus, which cause mosaic leaves are extremely detrimental to the health of the plant. In rare cases, the virus affects pigment production causing attractive variegation patterns without severely impairing the growth of the plant. For most viruses, infected plants do not transmit the virus to seed The most obvious foliar virus that causes attractive variegation is abutilon mosaic which in certain abutilon species (e.g. *Abutilon pictum* 'Thompsonii') causes a bright yellow and cream variegation pattern delineated by the veins of the leaf (Holmes, 1964) (Fig. 1) This virus can be seed or graft transmitted (Fulton, 1964). Many of the cultivars of florally striped tulips have a virus which create color 'breaks" (Fulton, 1964) Tulip "breaking" in some cultivars of tulip (*Tulipa* spp.) also causes leaf mottling and some stunting. This virus is naturally transmitted to daughter bulbs thereby perpetuating the phenotype It is possible that other uncharacterized variegated plants possess virus. Since seed transmission is rare, one way of testing is to propagate by seed and see if the pattern is maintained Grafting to non-variegated plants of the same species may also indicate whether or not a virus is present since viruses normally transmit through the graft union

CONCLUSIONS

The above discussion attempts to summarize some of the causes of foliar variegation. It is important to note that all variegated plants are not chimeras (Marcotrigiano and Stewart, 1984). Variegation can be influenced to some extent by environment (e.g. light levels) since gene expression is influenced by environment. In addition, whether variegation is caused by gene expression, virus, "jumping genes", "blisters", or chimerism, it should be noted that plants may possess more than one type of variegation. For example, *Pelargonium* × *hortorum* 'Mrs. Henry Cox', a zonal geranium, possesses tricolored leaves of green, white, and purple The purple ring is caused by gene expression and is stable through sexual propagation. The white leaf edge is caused by chimerism and if this pattern is desirable it can only be maintained by taking stem cuttings.

Determining the cause of variegation is best achieved by practical experience and utilization of the literature (Marcotrigiano, 1990, Peschke et al.; 1988). Fortunately, most forms of variegation can be maintained by any propagation technique. Chimerism is the only cause of variegation which imposes severe restrictions on the propagation technique used.

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Development and Dispersal of Some Woody Plant Seeds

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A major factor in the continuance of the plant species has been the remarkably effective procedures that have evolved for seed dispersal. Knowledge of these methods allows one involved in plant propagation to collect seeds when they are properly developed but before they are lost to the natural agencies of dispersal.

In autumn when the nesting season has passed and birds have reared their young, some species gather in multitudes and roam the countryside In nature's scheme of things, this timing coincides with the dispersal of many kinds of plant seeds Fleshy fruits containing seeds dependent on birds for dispersal ripen and change to a variety of highly attractive colors. Birds have no teeth, do not chew but gulp their food. Therefore, cleaned and undamaged seeds pass through the birds and are scattered about the countryside in their droppings.

Many other seeds that rely on wind for dispersal are contained in vertical capsules which when ripe open only at their tops Therefore, it takes strong winds to enter and carry the seeds away. Some that spread by wind are so firmly attached that it requires gale force winds to effect their release. This adaptation is designed to propel seeds greater distances.

Magnolia species

Magnolia fruits which are highly attractive to birds, ripen and are ready for collection about mid-September in the Boston, Mass., area. They have developed in colorful aggregates of follicles (called cones) When ripening occurs, the chambers split open and expose the highly conspicuous fruits. These are attached by slender cords called suspensors. This design makes fruits available to birds while still on the tree. If fruits happen to fall from the tree to the ground, they are consumed by creatures that have no interest in the fleshy outer portion and destroy the seeds by eating only the more highly nutritious embryo contents. Usually cones are symmetrical. However, if some chambers are not filled they are overgrown by those that are, and this leads to distorted shapes.

Euonymus and *Celastrus*

These two members of the Celastraceae also disperse seeds in a somewhat similar manner. *Celastrus scandens*, the American bittersweet, ripens its yellow capsules in the autumn, exposing bright red seed arils. The colorful fruits of euonymus dangle on slender stems. When they open they also reveal brilliantly attractive arils. In New England, in autumn, the outstanding fall color of *Euonymus* reveals its presence along wooded areas and roadsides, and tells of its successful dispersal.

Juniperus virginiana

In the northeast it is not uncommon to see red cedar as a pioneer woody plant along highways or on abandoned land Roaming flocks of birds stop at these locations to eat seeds found on the vegetation In the course of such visits red cedar seeds acquired elsewhere are left in their droppings.

Wide variation in plant shape and growth habit is found in these masses, some of which could have horticultural merit. Occasionally, one sees hedge-like rows of cedar plants growing beneath utility wires on which birds had perched.

Cedrus libani

The cedar of Lebanon was first introduced to cultivation from the Lebanon mountains of Syria in 1638. In the British Isles, one sees many spectacular specimens that thrive in that climate. However, when brought to the United States, those of Syrian origin proved hardy only as far north as Southern New York. The species is also found in the Anti-Taurus Mountains of Turkey where, at higher altitudes, the climate is quite severe At the turn of the century, Professor Charles S. Sargent of the Arnold Arboretum learned of this and arranged to have seeds collected from that region. They arrived at the Arnold Arboretum in 1902. This introduction was highly successful and those now found growing in the northern United States, no doubt, resulted from it, as throughout the years the Arnold Arboretum has provided seeds to botanic gardens and nurserymen. These superb trees were considered distinctive enough to be given a varietal name and are known as *C. libani* var. *stenocoma*.

In the Boston area pollen dispersal takes place about mid-October. The staminate strobili produce vast amounts of pollen and when a gust of wind moves the branch bearing them, the nearby air becomes yellowish. If the branch is shaken by hand a dense cloud of pollen arises. At this time the scales of the much smaller female strobili are open to receive the wind-borne pollen. Both male strobili and female cones are vertical. Spent staminate strobili often remain on the branches into the following summer.

In spring the pollinated female strobili start developing and achieve full size by autumn. However, at this stage they are immature and will not be ready to open and disperse their seeds until early autumn of the next year. It is not unusual to see cones of the first and second year on the same tree.

Harvesting is best done by removing the cones with pruning shears just before they open. If natural dispersal is allowed to take place, the cones disintegrate with the winged seeds being carried away by the wind while the heavier scales fall to the ground. When this occurs the central cone axis remains and can remain on the tree for many years. On occasion, one finds seedlings of *C. libani* var. *stenocoma* in the vicinity of the Arboretum's trees.

Pseudolarix kaempferi

Pseudolarix kaempferi, golden Larch, is a very beautiful deciduous member of the Pinaceae and is native to china. The oldest tree growing in the Arnold Arboretum is 93 years of age and has never presented any problems. It is monoecious with male and female flowers borne separately on the same tree. Each sex develops in individual clusters. These cones mature and start to shatter about mid-September and must be collected prior to that time.

Enkianthus

This member of the Ericaceae bears its flowers in clusters. They are bell-shaped and suspended on slender stems with the openings pointing downwards. Such orientation shelters the reproductive parts from rain. When fertilization has taken place, the capsules quickly turn upwards and assume a position they will maintain for ripening and dispersal.

Oxydendrurn arboreum

This beautiful tree, native to the Eastern United States, develops its flower clusters late in the season They terminate branches of the current season's growth and are produced in profusion When contrasted against the foliage of the mother tree, they present a very attractive picture.

Each flower cluster is composed of racemes on which individual flowers develop A raceme separated from the cluster shows the progression from flower to capsule. At the proximal end are fertilized capsules that have turned upward, followed by capsules that are in the process of turning up. Next on moving toward the distal end are pendulous open flowers, followed by flowers not yet open At dispersal time, all capsules are vertical or very close to vertical, despite the fact that many are borne on racemes positioned at various angles

New Markets for Native Plants

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A friend of mine was fond of quoting an ancient Chinese curse that went, "May you live in interesting times." I must admit that I never did understand what was supposed to be so bad about living in such a state of change and flux as we now find ourselves. These are exciting times! In the nursery trade as well as the "real" world. What do native plants have to do with any of this? The current fashionable focus on this group of plants provides many marketing opportunities.

It is finally becoming noticed, certainly not yet common knowledge, that growing and maintaining plants is positive and lifegiving to the gardener as well as to the planetary ecology at large. The increasing interest in natives provides a chance for growers, gardeners, researchers and the whole green industry to be viewed in a better, more positive light. We can be seen as friends of nature, pointing out forgotten (newly discovered?) interconnectedness between the plant world and the rest of the web of life—the wind, water, soil, and animal life. We can grow as a profession and respond to the ever changing needs of our increasingly sophisticated and ecologically conscious public. We must be prepared to meet the challenge of steering the focus of our industry beyond mere ornamentation to broader, more inclusive and lifegiving concepts.

The discussion of native plants single handedly brings horticulture into a broader context; the questions that are asked and their answers point to areas of expansion and potential improvement for our professional growth and marketing efforts. Is this plant better adapted to my site? What other purposes does it serve? Will it be more self sustaining? Will it look artificial or natural and comfortable?

All of this points to the need for more education—education that could and should point the way forward to a broader based and more widely appreciated field of activity.

By focusing on the restoration aspects of horticulture we can reach out to our natural allies in the environmental and conservation fields and provide a real answer to their most persistent question. What can I do to be a positive force ecologically? You can build or create a habitat, plant trees, landscape your pond or plant native wild flowers and grasses and take up butterfly attracting rather than lawn mowing.

New markets come in many sizes and shapes. Parks, municipalities and some landscape architects have successfully tried planting large numbers of small plants or plugs directly out in the landscape. Others have had growers provide "sods" of mixed plants that were installed in strips. Water tolerant plants are now grown in fiber mats or carpets and staked at the water line to provide erosion control and rapid plant cover in one fell swoop. People are selling wild flower hay that can be used as a mulch. Here in the mid-Atlantic especially, there is a crying need for a regional seed house providing local genotypes of grasses, forbs and shrubs.

Highway departments are now required to spend 1/2% of their landscape budgets on native plants with on highway construction . This regulation was championed by Ladybird Johnson. Municipalities are taking interest in landscaping traffic islands as ways to make their communities more attractive places to live and work.

Parks and aquariums have educational, interpretive and display areas that are increasingly being planted to native plants. Appropriately chosen plants can help lower maintenance costs and add a sense of harmony to landscapes that are often patterned after Disney World, rather than a feeling for the unique beauty of a specific site.

Schools are greatly expanding their environmental education programs. Someone has to provide for bogs, habitats and butterfly gardens as places to study and enjoy nature as well as gain an appreciation for the pivotal role that plants play in the whole process. What a great opportunity to encourage future plant people!

Several retail mail order firms have done quite well of late by either accenting the native plants they do grow or by specializing in native plants. It is becoming fashionable to tout the provenance of a given plant.

By making the connection between nature and the products they sell, leading retailers have increased sales in tough times, stretched their busy season right through the fall, and remade their image in a positive way. Garden centers can become involved in nature society plant sales, letting people know that they just might have that wild flower, groundcover or oakleaf hydrangea they've read, seen or heard about.

Home landscapers are yearning for ways to bring more life into their properties, to lower their energy costs, to enhance their sense of privacy and to mow less lawn. These plants can provide fertile ground for innovative solutions. Plants that attract butterflies are always good to add excitement and to give the feeling that the customer is receiving extra value. Native trees like sugar maple and ash are fantastic shade givers and they will not become pernicious weeds like Norway maple and Japanese honeysuckle have

Wetland water quality laws now in effect often specify that a good proportion, if not all of a disturbed area must be revegetated with native plants. Often plants of local provenance are to be given preference. There will be a good bit more wetlands work once the new highway bill becomes law. All classes of wetlands plants will be needed—grasses, forbs, trees, and shrubs.

Landfills and superfund sites all need to be revegetated. The Freshkills Landfill, not far from here, installed many thousands of trees and shrubs on highly visible edges and other special areas as well as 40,000 grass plugs in a one acre experimental area. The landfill consists of 1600 acres. All of this material was specified to be native plants. Many of these plants were custom grown for this project. The market is there for those nurseries specializing in these plants. It is crucial to get to be known for growing certain groups of plants. If you try to grow and be known for having everything, you will end up being known for nothing.

Fund raisers benefit both the organization and the supplier who is wise enough to be aligned with them. A local conservancy ordered small quantities of wild flowers for its May sale every year. We were friendly, flexible and patient; 2-years ago they were asked by the state highway department to consult and recommend strategies for planting several sweeps of indigenous Pennsylvania wild flowers over a 22 mi stretch of highway. Guess who they thought of first? Fifty thousand native grasses and forbs now grace that highway

Who knows where a little goodwill will lead? The new generation of landscape architects are much more sensitive to environmental concerns Many times I've heard, "Geez, if I'd have known that ironweed was available, I would have been using it for years!" Letting your client base know that you are happy to talk to them about custom growing a new plant or new sizes, etc. will reap dividends.

With this accent on native plants, it is not my intention to get people to stop growing exotics, not at all. Many plants from all over the world are fabulous and indispensable in our gardening palettes. We are challenged to gain a new appreciation of the beauty that we are surrounded by and to get over our inferiority complex about the desirability of our indigenous flora. New ways of appreciating the beauty and utility of these plants will naturally lead to new growth opportunities.

In summary, it is time to move beyond ornamentation toward an enlightened sense of utility; beyond pretty to embrace the multitudinous life-giving qualities that plants possess. Let's make that connection between today and tomorrow's green consumer and our green goods.

MONDAY MORNING 9 DECEMBER 1991

The morning session was convened at 8:00 a.m. with Joseph Dallon, Jr. serving as moderator.

IPM: How it is Done at Studebaker Nurseries, Inc.

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Nearly 40 years ago, as researchers noted building insect resistance to blanket pesticide cover sprays, an ecological approach to pest management began to develop that now is know as Integrated Pest Management (IPM). IPM incorporates not only chemical, but also biological, physical, mechanical, and cultural controls into a pest management system that can be more economically efficient and environmentally sound (Davidson and Cornell, 1988). Using **MULTIPLE** pest control tactics, built upon a regular program of monitoring pest levels, the IPM user **MANAGES** insect populations in order to minimize both economic damage to crops and hazard to the environment and humans Linda Fisher, the Assistant Administrator of Pesticides and Toxic Substances of the EPA, stated recently about pesticide usage, "Horticultural practitioners, will have to be prepared to adapt new methods or materials in all aspects of your operations You will have to find ways to use less pesticides and lower risks" (Fisher, 1991) This directive speaks to part of the reason for the burgeoning interest in IPM over the last decade, but the reasons go beyond the EPA's tightening policies.

WHY IPM?

Our industry finds itself in a period of transition from an over reliance on chemical pesticides As a result of wide spread prophylactic use of insecticides, an ever-growing number of insecticide-resistant pests have evolved, up to 800 species currently. Crop damage increases as do the applications of pesticides in effort to gain control With an estimated 90% of the insecticide applied not hitting the target pest, environmental contamination results (Metcalf and Luckmann, 1982). Beneficial predator insects are reduced and secondary insects can become serious primary pests. The presence of pesticides in food, water and every part of the ecosystem has fueled increasing environmental legislation resulting in less availability of pesticides in the future. Rising concern for worker safety and public exposure to widespread use of pesticides is building. Increasing costs of chemicals and the labor to apply them adds to the drive to cut back the amount of chemicals growers apply. With this in mind, we turned to IPM to provide a realistic alternative program for pest management that would satisfy our commitment to reduce chemical usage at our nursery

HOW IPM?

In 1988 a pilot IPM project was developed through the Ohio Cooperative Extension Service that began in 1989 at our nursery and two other southwestern Ohio nurseries. At our nursery, a dedicated worker was selected as the nursery scout and trained in techniques to monitor pest and disease incidence/abundance to enable us to make better informed pest control decisions Using routinely scheduled scouting, more spot spray (or no spray) applications are identified for many pests thus reducing the incidence of over-applying chemicals. Through use of pheromone traps and visual monitoring techniques, growing pest populations can be detected early and control measures can be properly timed to achieve a high level of economical and effective past control.

Beginning about mid-April, the scout begins his weekly monitoring checks. Since he cannot get to every nursery block in the time allotted, his monitoring is focused upon primarily saleable blocks containing key plants that are more susceptible to a wide variety of insect, diseases and cultural problems The primary target of scouting is to identify and quantify the level of key pests which are those usually present, usually damaging, and therefore, usually requiring control on key plants. Key diseases were also targeted for inspection on key plants in the IPM scouting plan:

I. 1991 IPM Scouting Plan

A. Saleable Block (weekly) vs. non-saleable blocks (bi-weekly)

II. Key insects

A. IPM easily detected
- bagworms
- pine sawfly
- caterpillars
- mite
- aphids
- scale

B. IPM not easily detected and controlled
- Peach tree, ash-lilac, banded ash, bronze birch borers
- black vine weevil
- Zimmerman moth
- European pine shoot moth
- leafhoppers

III. Key diseases

A. IPM non-chemical control
- fireblight
- nectria canker
- black knot
- septoria canker
- nutrient deficiencies
- bacteria leaf spot
- verticillium wilt
- crown gall

B. IPM Preventive chemical control
- apple scab
- rusts
- anthracnose
- juniper tip blight
- septoria leaf spot
- phythium
- phytophthora
- rhizoctonia
- botrytis

Key insects and diseases listed in A-category are more easily detected by regular systematic checking by a scout They can be managed with lessened chemical inputs through spot sprays where pest infestations are localized; through sanitized pruning to remove diseased tissue and other mostly cultural manipulations to reduce verticillium wilt, leaf spot in high pH problems.

The B-category of insects is not as easily monitored as their presence is often detected only after evidence of plant damage is discovered. Where possible, trapping procedures are used to determine dates key insects are first caught or observed by the scout on weekly checks. Selective, preventative pesticide sprays can then be applied within an optimal time frame to coincide with the pest's vulnerable or most damaging stage For example, we spray susceptible tree and shrub species 10 days after the capture of the first clearwing borer moth so as to just precede the larvae hatching and burrowing into the bark.

Where pheromone traps are not available for trapping the Zimmerman and European pine shoot moth or bronze birch borer adults, we refer to the "COINCIDE The Orton System of Pest Management" to determine effective timing of pesticide sprays using the blooming stage of *Viburnum opulus* and *V. dentatum* as indicator plants (Orton and Green, 1989). Suspected black vine weevil (BVW) infestations in *Taxus* are scouted using burlap traps or flat boards placed in the row under plants that are checked for hiding adults (Mulgrew, 1989). BVW presence and evaluation of pesticide applications can be monitored by using a box with fine screening to sift a thin layer of soil from directly under the plants and carefully checking for adults.

The B category of key diseases is usually controlled with traditional preventative chemical sprays. However, in drier years, apple scab and juniper tip blight incidence are lessened and sprays can be reduced accordingly, depending on scouting reports.

Weekly scouting reports provide a written report of pest and disease problems in specific blocks. The data recorded on the IPM Drive Around Form is **Block Number, Host Species and Cultivars, Type of Pest or Disease, Abundance** (none, trace, low, medium or heavy), **Incidence** (localized, scattered or general), **Life Stage** (egg, crawler, nymph, larvae, pupa, adult), **Damage** (none, trace, low, medium or heavy). The field manager uses the report to determine the appropriate pest management action necessary block by block. The scout follows a master IPM Scouting Plan which gives an overall mode of attack for the season. The Scouting Plan contains the following items: six plant **categories**, (conifers, junipers, *Thuja/Buxus*, deciduous shrubs, *Taxus*, trees), **saleable blocks to weekly scout** of each category by number, **non-saleable to scout bi-weekly** by number (or immediately if problems are found in salable blocks), and **key insects** and **key diseases** to monitor on each plant category. The master scouting plan is updated yearly by the field manager from past years scouting reports plus the semiannual Nursery Inspector's Report which is used as a "report card" of the IPM program Modifications are also made with input from personnel from the Ohio Cooperative Extension Service IPM program who periodically visit to scout pasts and to monitor our progress at the nursery.

It is imperative to the success of the objectives of the IPM program that the scout be allowed a block of dedicated time to complete the scouting plan Beginning mid-April, a scout is budgeted 3 hours daily in which to cover most all saleable categories in a week. Depending on the reports, the plan is amended as needed. More scouting emphasis is spent on categories where more problems are identified and at certain times of the year such as when bagworm larvae emerge from overwintering stage on *Thuja* species or the crawler stage of scale is emerging on *Euonymus alata* 'Compacta'. Scouting is planned for mid-day when insects are more active, the dew has evaporated from plants and the light is better for close visual inspection for pests.

When key insect infestations can be visually located, the scout flags the location with special colored tape so that spot spraying, sanitized pruning and other follow-up measures can be done more efficiently, along with the post-spray evaluations. To check mite infestation levels, the scout carries a small stick, a 17× hand lens and clipboard with a white sheet of paper. Forms of *Picea, Thuja* and *Juniperus* are monitored by striking a selected branch 3 times so that mites present are dislodged onto the paper and can be counted with the hand lens. This method enable the scout to detect and monitor mite levels well before damaging infestations are reached If through random checking throughout the block, levels of 20 to 25 mites per sample are recorded, then a miticide spray is scheduled immediately to prevent bronzing of foliage.

The placing of pheromone traps to monitor clear wing borer moths has greatly improved the timing and effectiveness of preventative insecticide sprays on borer susceptible trees in the nursery.

Scheduling spraying by calendar dates cannot account for differing environmental factors year to year that affect when pests appear and multiply. The pheromone traps allow the scout to know precisely when adult borers are first present and at what levels The trap contains a synthetic pheromone lure that attracts the male adult (changed bi-weekly) and a sticky coated surface that traps the moth which is changed weekly. The scouts quantify and identify which species of adult moths are present. In 1990 we were able to omit spray treatment on *Quercus* species for virtually no oak clear wing moths were caught in the traps. If peach tree and ash borer adults are still being trapped 6 weeks after the initial spray a second spray is then applied which is usually sufficient for the year. The use of pheromone traps has helped us significantly reduce the severity of damage from clearwing borer moths and the number of preventative sprays needed since IPM began in 1988.

When pests or diseases are located that cannot be identified, samples are sent with a completed information form to the Ohio Cooperative Extension Service Plant and Pest Diagnostic Clinic at Columbus, Ohio for assistance. They can confirm whether a pest or disease is at work, or if purely environmental factors are the primary factor and what recommendations should be followed to alleviate it. References used extensively for identification in our IPM program are listed in the literature cited (Johnson and Lyon, 1976; Nielson, 1989; Sinclair et al., 1987).

COSTS

"Controlling pests should always be approached from the view point of the reduction of a pest population in the most economical and efficient manner, and with the least environmental impact" (Mulgrew, 1989).

The IPM program, besides being a more environmentally friendly program is a more cost effective one for us when compared to blanket, preventative chemical sprays. Having a dedicated scout for 15 to 18 hours a week for 22 weeks is a significant expense. However, we find that every hour spent in IPM scouting equals one hour saved in spraying time. We also gain one more hour of equipment use for another nursery job. The cost of the chemicals that is saved by scouting is savings above the labor tradeoff. We figure that savings at about $2,000 for 1990. Overall insecticide use has been cut in half by using more spot sprays; fungicide use has not changed dramatically because preventative sprays/drenches are still regularly applied to prevent key diseases on propagation cuttings and on container grown plants.

The faithful use of IPM methods unquestionably reduces the amount of plants rendered non-saleable from pest damage. Aside from all the environmental considerations, this benefit of an IPM program is a very significant one in terms of preserving your nursery sales potential.

SAFER CONTROLS

By surveying many chemical alternatives we can select ones that give the highest control on target pests yet are less toxic to humans and the environment. During the last 3 years of our IPM program, we have tripled the amount of horticultural oil applied due to its safety to humans and the environment, and its reasonable cost for wide spectrum control of mite and scale populations The new lightweight 412 summer use oil can now be used relatively safely against immature forms of scale crawler, mealy bugs, aphids, leafhoppers and other soft bodied insects, instead of more toxic pesticides (Johnson, 1985). *Bacillus thuringiensis*, a naturally occurring bacterial pathogen can be substituted to control caterpillars instead of broader-spectrum Sevin which kills beneficial insects along with the target pest. Insecticidal soaps that leave no harmful residues are effectively used against aphids and the crawler stage of scale. By using less toxic alternatives, naturally occurring beneficials can be allowed over the years to regenerate and provide a measure of background control of damaging pests as levels of residual pesticides are reduced

CULTURAL CONTROLS

In trying to solve pest and disease problems the least toxic way, you may find that many plant problems may be managed by simply re-thinking and changing cultural or management practices. There are many and varied examples evident at every nursery that may have been done for many years which can be considered 'IPM Techniques' For example, red clover is cover cropped two years between nursery crops so in "feeding the soil" with organic matter, the stock may be healthier and more resistant to pest infestations Pre-plant treatment of deep tilling, installing drain tile and preparing level liner beds reduces drainage problems and root rot diseases. Tree species that suffer in high pH soils or are susceptible to verticillium wilt are carefully planted away from these areas. Weedy perimeters of fields that harbor insects are mowed regularly. Container grown magnolias are switched to drip irrigation to prevent bacterial leaf spot from overhead irrigation. Propagation watering/misting is scheduled so plants surfaces are dry by sundown to reduce foliar diseases. Improved *Malus* cultivars that have a proven scab and fireblight resistance are grown and customers are sold on the benefits of such. Scattered, over-grown blocks of plants that harbor diseases, weeds and insects are scheduled for clearing so cover crop can be sown. Planting procedures are modified to provide better access and coverage for spraying key plants for key pests, such as two rows of boxwood between four rows of pyramidal arborvitae Short weekly meetings are held between managers for sharing pest activity and information so others can act as secondary scouts.

The IPM frame of mind can spawn endless creative alternative solutions to "adapt new methods...in all aspects of your operations to use less pesticides and lower risks" (Fisher, 1991) To learn more about IPM and setting up a scouting program at your business, inquire about state sponsored programs in your locale or attend seminars at universities where IPM research is conducted. Dr. Richard Lindquist, Entomology Professor at Ohio State University and ORDC In Wooster, Ohio stated, "As we approach the 21st century, pest control will be more demanding for growers than ever before. It will be more effective and socially responsible than any time in the industry's past The growers who prosper will be those who adapt to this reality" (Lindquist, 1991). IPM is an idea whose time is here for everyone to be using now.

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Nutrient Runoff from Nurseries — Is it a Problem?

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Is nutrient runoff from nurseries a problem? If it is a problem, whose problem is it? How should we be involved in this issue? All of these are questions which growers are now asking. In this brief review of nutrient runoff, I hope to clear up some information and misinformation, and enable growers to make educated decisions for our future

PUBLIC PERCEPTION AND THE PROBLEM

One thing to keep in mind no matter what the issue is that to the public facts mean little—perception means everything. What an individual believes to be true has a stronger impact than that which can be proved by fact. An example of this comes from a recent meeting at our Department of Environmental Protection and Energy, by ostensibly scientific people. During that meeting to talk about the use of composted waste products a statement was made to justify elimination of the use of composted waste products on farmland. Several "facts" were mentioned. It was indicated that corn land was the obvious location to use these products — probably false since other crops can also benefit. Corn was also implicated as a heavy user of pesticides — false The statement was then made that since pesticides get into the groundwater, nutrients would also move into the groundwater. Studies of wells in agricultural areas of New Jersey have indicated no pesticide penetration into the groundwater. Nutrients, specifically nitrogen, do move into the groundwater. Based on these "facts" the individual proposed that none of these composted waste products be applied to farmland, or other land in New Jersey.

A second item to remember is that emotion makes law. Facts and reality only initiate an emotional response which results in laws and regulations The classic example for our area has to do with the gypsy moth program, where the pesticide carbaryl (Sevin: LD50 (female rat) = 246 mg/kg; male = 283 mg/kg) received enough bad press that it was removed from the spectrum of recommended pesticides for the state spray program Allegations were later proven to be false A replacement pesticide, trichlorfon (Dylox· LD5O (rat) = 250 mg/kg) has toxicity levels equal to carbaryl, but does not have the name recognition, and is therefore acceptable

A final note involves the mass media — newspapers, radio, and TV. These are the primary sources of information to the public. In its' present format, the news is highly editorialized by somewhat liberal personalities. News today must quickly catch the attention of those reading, listening, or watching, or it does not sell. This can lead to sensationalism, and less than accurate reporting. Catch words are used frequently, and result in incorrect interpretations. In our business we have words such as pesticides, which indicates poison (not pest control). Meanwhile disinfectant (which is used in the home and is a pesticide) means clean. Other dichotomies include nutrient runoff which equates to pollution, while fertilizer at the home equals green or beauty.

WHAT AND WHY ARE WE TRYING TO PROTECT?

Aside from the public perception issue then, why should we even consider runoff as something we should address? Our future and the cost thereof is one of the situations we should look into. We have two natural sources of potable water in this country. Surface water has problems with phosphorus. Specifically, aquatic growth is limited by the phosphorus content of the water. Eutrophication of a surface body of water will begin at a 2 ppm concentration level of phosphorus. The quality of the water source will decline once eutrophication proceeds.

Groundwater is the other natural source of potable water. The Environmental Protection Agency has set the legal limit of nitrate-nitrogen (NO_3-N) in potable water at 10 ppm. While there have been few cases of methemoglobonemia (blue baby syndrome), justification for this standard is not just motherhood and apple pie. The only possible discussion may be on the margin of safety, which is great.

Let's look at the history of methemoglobonemia. It can be stated in the United States, there has never been a recorded case in adults. The most recent infant fatality occurred in 1989. It was the first in 25 years, and in that case, the infant was fed formula which was prepared with water containing 70 to 80 ppm NO_3-N. There are sub-lethal problems which may affect individuals also. It should be noted that the information is from large animal studies. Included in the list of potential problems are. vitamin A deficiency (pink eye in cattle), thyroid disorders (iodine deficiency), reproductive problems, oxygen deficiency (methemoglobonemia), and general undiagnosed maladies. It was also noted however, that animals tend to build a tolerance to the nitrates when given low level doses

Standards, no matter how good or bad they are perceived by us can always be acceptable, as long as they are uniformly administered. In New Jersey, there was a proposal to reduce the standard for potable water from 10 to 3 ppm NO_3-N This would make us unable to compete because of regulation.

THE LAW

What is happening nationally with regard to water regulation? By 1988, eight states already had groundwater legislation on the books. They included Arizona, California, Illinois, Iowa, Mississippi, Missouri, Nebraska, and Wisconsin. Debate on pending legislation was scheduled during 1989 in Georgia, Hawaii, Kansas, Louisiana, Massachusetts, Minnesota, Montana, New York, Ohio, Oregon, South Dakota, Tennessee, and West Virginia.

Can we survive with our heads in the sand? It is my belief that we must be pro-active rather than reactive. We must conduct the research necessary and institute changes in our production schemes which will reduce potential problem areas. We, as producers of nursery stock, should always keep our image in mind. We must know how we want to be viewed by those around us. I believe we are protectors of the environment. We produce shrubs, trees, flowers, and above all, beauty. If public relations is objectionable, look at it as public education. We must get the message out of the good we are doing for our environment.

SOURCES OF AQUIFER AND SURFACE WATER CONTAMINATION

The question of where nitrate contamination of groundwater and phosphorus contamination of surface water come from is always an issue for agricultural producers. "Non-point source pollution" is a term which has come from the federal government. Farming can fall into this category when runoff from production areas leaves the property. Whether we like it or not, agriculture does contribute to both groundwater and surface water contamination with nitrates and phosphorus respectively.

Now the other half of the story. We are not the only ones causing problems Organic disposal systems can produce contamination. Old landfills, or those without a liner will leach any type of compound—from nitrates to toxic compounds. Septic systems are designed to satisfy clean water standard by dilution. The design is to result in a dilution which does not exceed the federal standard of 10 ppm. Obviously, this type system is designed to contaminate only to a certain level. Industrial disposal has also provided contamination. Even processors of food products can add to the nitrate load, when field applying waste water

INFORMATION FROM THREE YEARS OF CONTAINER RUNOFF MONITORING

Over the last three years, a total of seven states have been involved in monitoring runoff water from container nurseries. This was a cooperative projects in the Eastern part of the United States. The results are being compiled, but I can give you some basic information and trends which I saw in New Jersey. First, I must give you some information about the experimental design.

Water was monitored during peak runoff (in the late mid-period of the irrigation cycle) for nitrate-nitrogen and phosphorus Samples were not to be taken immediately after fertilization nor immediately after rain Samples were taken from nurseries which used only liquid fertilization, those which used only slow release fertilization, and those which used a combination of those two fertilizers.

The results were consistently inconsistent. High and low levels came from nurseries using each type of fertilization. Part of the answer may lie in the fact that samples were not taken close to the times of fertilization for liquid fertilization nurseries. It was typical for all nurseries that the concentration of nutrients peaked at the production site for nitrates, and declined as one proceeded toward the impoundment. For phosphorus, the trend was to peak at the impoundment, and decline toward the production site. Impoundment water peaked at about 20 ppm nitrates late in the season, while the phosphorus peaked at about 1.7 ppm Early in the season, nitrates were, in several cases, actually lower in the impoundment than from the wells. Conversion, volatilization, and sedimentation are all apparently involved Ammonia will volatilize, while nitrates will experience denitrification. Phosphorus is not lost, and can probably be found in the sediment portion of an impoundment.

WHAT CAN WE DO AS PRODUCERS?

No matter what the solutions, they must be cost-effective and commercially feasible. Look at fertilizer efficiency. There are many ways to manage efficiency A change to slow release fertilization from liquid is the most obvious. Maximizing space utilization is another way of making better use of the fertilizer applied. Timing fertilization can also help Some information on episodic growth of certain types of plant material was conducted in California. Theoretically, plants exhibiting this type of growth could be fertilized only when the plants will actually use the nutrients Changes in container design to more effectively use water should be realistic under proper management also.

Use of an impoundment to maintain runoff water on-site is a technique used by an increasingly large percentage of growers in our area Additional modifications could result in filter strips being incorporated into the system. Work has indicated that filter strips will clean water that passes through it There is some discussion as to the proper design size, and there are also questions as to the method of "cleaning" the water. Much of the "cleaning" may come from precipitation of the particulate matter in the water. Some may also come from uptake of the nutrients in the water.

The use of a wetland filter has been used effectively. It should be noted that wetlands are ecosystems. We are not speaking of just poorly drained soils. Wetlands tie-up nitrates by denitrification. One of the earliest marshes used to "clean" water is at Brookhaven, here on Long Island. While it may seem that this type cleaning system may require more space than an impoundment, an accelerated cleansing time will lead to a probable reduction in potential size differentials.

NPURG - A Computer Program to Assess Risk of Pesticides to Ground and Surface Water

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A priority of society today is the protection of water resources including prevention of ground and surface water contamination by pesticides. Yet, the Environmental Protection Agency (EPA) has reported finding as many as 74 pesticides in ground water in 38 states with 46 of these linked to agricultural uses (Williams, 1988).

Frequent and prominent media attention to such studies has prompted public outcry to limit or ban the use of pesticides. This in turn has spurred an increasing number of state and federal regulations regarding what, where and how pesticides are used.

Consequently, agricultural producers are required to be more informed about the pesticides they apply and the potential risks those chemicals pose to ground and surface water supplies. Determining potential risks involves evaluation of pesticide and soil properties, site conditions and management practices.

PROPERTIES OF PESTICIDES

The ability of an applied pesticide to reach ground or surface water sources is determined in large part by its chemical and physical properties. The principal factors influencing the fate of applied pesticides are solubility, adsorption and degradation rate.

Solubility is the capacity of a pesticide to dissolve in water. The more readily a chemical goes into solution the more likely it is to leach or move through soil. Solubility is measured in terms of milligrams of chemical that will dissolve in one liter of water. It may also be expressed as parts per million (ppm).

Adsorption is the ability of a chemical pesticide to attach itself to the surface of a soil particle. The proportion of chemical dissolved in soil water compared to the amount bound to soil is expressed as a coefficient, K_d. However, since adsorption is most affected by the amount of organic matter in soil, the expression K_{oc}, which factors in the percent organic carbon in soil, is more commonly used to measure adsorption.

Degradation rate determines how long a pesticide persists once applied. The slower the rate of degradation the longer a chemical will remain in the environment and be subject to leaching or surface runoff. Degradation is measured in terms of half life, that is, the number of days it takes for an applied chemical to be reduced to 50% of its original amount.

Knowing the quantitative values for each of these pesticide characteristics does not in itself indicate the actual risks of ground and surface water contamination. However, when compared against a set of criteria, qualitative judgements can be made. According to EPA established criteria for groundwater contamination potential, pesticides with solubility greater than 30 ppm, K_{oc} value less than 500 and *a half life greater than 20 days are considered to pose a significant risk of leaching.*

SOIL AND SITE CHARACTERISTICS

An evaluation of potential for leaching or surface loss of applied pesticides would not be complete without consideration given to soil characteristics. Soil texture, structure, permeability and percent organic matter are characteristics which determine vulnerabilities of a given soil to leaching or runoff.

Obviously coarse textured soils are more permeable and therefore more vulnerable to leaching than fine textured soils. However, surface runoff probabilities will be less. Soils with high organic matter content will retard the movement of chemical pesticides not only because of their capacity to absorb water but also the tendency of the electrically charged pesticide molecules to adsorb to surfaces of organic particles.

Site features influencing the potential for pesticide leaching or surface runoff include depth to the water table and slope. High water tables are vulnerable to pesticide contamination simply due to their proximity to surfaces where pesticides are applied. Shallow water tables also mean shorter time intervals for leachate to reach subsurface water and therefore less time for chemical and biological factors to degrade the pesticides.

Generally slopes greater than 15% increase the chances of surface runoff although the potential for pesticide leaching may be reduced. Soil texture and permeability will influence these processes to some extent.

NPURG

Clearly, there is a considerable amount of information that must be processed in order to predict probability of water contamination from applied pesticides. Since all of these factors can be represented quantitatively, it has been possible to develop algorithms to express the interaction of these factors However, it is at best a formidable task for the pesticide user to find all pertinent data on pesticides and soils, much less the equations involved in calculating potentials for water contamination.

In 1988, specialists from University of Massachusetts Cooperative Extension and the Soil Conservation Service (SCS) developed a computerized information delivery system to synthesis pesticide and soil data, and predict the potential for applied pesticides to move by leaching and surface runoff (Jenkins and Lyons, 1988). The program is called NPURG, an acronym for National Pesticide/Soils Database and User Support System for Risk Assessment of Ground and Surface Water Contamination.

NPURG consists of two databases. The first is a pesticides properties database which includes information on over 230 pesticides. The other is the Soil Conservation Service State Soil Survey Database.

From these databases, the user can select pesticides and soil types As each selection is made, pesticide and soil properties data are displayed via windows. NPURG can compare pesticide and soils and display relative ranking of leaching and surface runoff potentials for each pesticide/soil combination.

This analysis is based on the SCS Soil-Pesticide Interaction Screening procedure developed by Dr Don Goss, SCS Research Soil Scientist (Goss, 1988). A simple three part rating system is used to indicate relative potential for pesticide loss on the given soil through leaching or surface runoff. A rating of "Potential 1" indicates high probability of pesticide movement, "Potential 3" indicates a low probability while

"Potential 2" rating is intermediate. Detailed explanations of the rating system and the "Potentials" are provided through pull down menus and HELP screens within the NPURG program.

NPURG also allows for selection of more than one pesticide and soil type at a time, and will display and print a matrix of leaching and surface loss ratings for each pesticide/soil combination. The matrix permits easy comparison of pesticides when alternative products are under consideration. Printout of the matrix is in the form of a worksheet so that the information can be customized (Fig. 1).

The NPURG program permits the user to modify the soils database when site specific soils information can be collected. This can mean more accurate analyses of a given situation but also allows the user to evaluate how soil modifications such as increasing organic matter content may influence the potential for pesticide leaching. The chemical database may also be modified by adding new chemicals or the editing of the chemical database as new data become available.

Another feature of NPURG is the inclusion of extensive educational information available through the use of pull down menus and windows. Information regarding data sources, definition of terms and concepts, calculations used to determine ratings, and interpretations of ratings is available.

NPURG APPLICATIONS

As a pest management tool, NPURG can function as a quick-retrieval source of information on specific pesticides and soils. But its primary value is to "red flag" pesticide use situations that could be troublesome It is in this capacity that we have been using NPURG in Massachusetts when working with nursery producers and other growers. We use NPURG analyses as a beginning point in the development of comprehensive pest management strategies which are sensitive to environmental vulnerabilities, specifically ground and surface water contamination. This also presents an opportunity to discuss alternative approaches to pest control including chemical, biological and cultural. In this capacity, NPURG can be a useful tool in further development of IPM (Integrated Pest Management) programs for growers

This latter application of NPURG will be more practical with impending development by University of Massachusetts Extension specialists of a third database for inclusion in the computer program. This database will interject information on application methods and alternative pest control strategies by crop whenever analyses of a specific pesticide/soil interaction yields a high potential risk rating.

AVAILABILITY

NPURG is currently available only in the New England states through SCS and Cooperative Extension agents who are using it in consultations with growers to arrive at best pest management practices.

NPURG

Pesticide/Soil Interaction Ratings for Ground and Surface Water Protection

Chemical database name USDA2-03 DBF Date of issue Tue Aug 13 11 54 58 1991

Soil database name MASOILS DBF Date of issue Tue Aug 13 10·03:36 1991

Pesticide User ____________ Date Thu Dec 05 10 00 12 1991

Address· ____________ Crop ____________

Location· ____________ Target Pest· ____________

% of field for Soil Type #1 ______ % #2 ______ % #3. ______ %

Ave Slope ______ % pH ______ Drained/Undrained

Water Resource Ground/Surface Type ______ Distance ______

______ Soil/Pesticide Leaching Potential (SPLP) ______

NPURG 9 500	Soil			
Database 2.031	Series.	ADAMS	PITTSFIELD	WINOOSKI
	Texture	LFS	L	SIL
Pesticide:		**Hydro - A**	**Hydro - B**	**Hydro - B**
ALACHLOR		1 *	2 *	2 &
BENEFIN (BENFLURALIN)		2 *	3 *	3 &
BENSULIDE		1 * E	2 * E	2 & E
DCPA (CHLORTHAL-DIMETHYL)		2 *	3 *	3 &
METOLACHLOR		1 *	1 *	1 &
NAPROPAMIDE		1 *	2 *	2 &
ORYZALIN		2 *	3 *	3 &
OXADIAZON		2 *	3 *	3 &

*max slope is > 15%, & depth to seasonal high water table < 6 ft , + ponded G (guessed) / E (estimated) database values used in the computations.

These ratings are first tier relative rankings of pesticide/soil interactions They are intended for use by SCS and CES personnel as one component of an environmental risk analysis Please see attachment NPURG RATING SUPPLEMENT to help evaluate these ratings

Planner ____________ Agency ______ Phone ( ) -

Figure 1. Printout of NPURG leaching potential analysis for several preemergent herbicide/soil combinations Worksheet format allows inclusion of site-specific information.

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Jenkins, J.J. and **J.P. Lyons.** 1988 Use of an expert system to derive pesticide groundwater contamination recommendations. Proc of Workshop. Integration of Expert Systems with Conventional Problem Solving Techniques Agriculture San Antonio, TX. Aug 10-12,1988.

Goss, D. 1988 Pesticide-Soil Interaction: Potentials For Loss USDA-SCS National Bulletin No 430-9-3, National Soil Survey Center, Lincoln, NE

Williams, W.M. 1988. Pesticide in Ground Water Data Base 1988 Interim Report. USEPA-OPP Environmental Fate and Effects Division, Washington D.C

MONDAY AFTERNOON 9 DECEMBER 1991

The afternoon session was convened at 1:45 p.m. with Dale Deppe serving as moderator.

Environment-Friendly Plant Production System: The Closed, Insulated Pallet

Bruce A. Briggs and Dr. James A. Robbins
Briggs Nursery, Inc , 4407 Henderson Blvd, Washington 98501

James L. Green
Horticulture Department, Oregon State University, Corvallis, Oregon 97331

Editor's Note: This paper was also presented in the Southern Region and can be found on page 304.

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Use of Spunbonded Fabric Grow Covers in Deciduous Seedling Production

Richard E. Watson
Watson's Nursery, 6140 Bond Road,West Valley, New York 14171

During 15 years of deciduous seedling production my greatest obstacle to good germination and survivability has been our spring weather that is typified by prolonged cool wet spells followed by sunny days with many frosty nights. The frosts rarely killed outright, but rather seedlings appeared to get progressively weaker with each frost making them more susceptible to damping-off Surviving plants usually grew slowly until the warmer weather of June.

After many trials over several years with different covers and supports I settled on the following system. In early spring prior to germination we cover individual seedbeds with 10 ft wide freeze covers weighing 1.5 ounces per yard and later with grow covers of 0.6 ounces per yard. These tarps, manufactured by Kimberly Farms, are made of UV-stable, white-polypropylene, spunbonded fabric and are porous to water and self-ventilating.

The tarps are supported on 1/2 in. PVC pipe hoops fitted on 18 in. steel stakes which have been driven halfway into the ground, 48 in. apart over our 36 in. wide beds Hoops every 4 ft down the length of the bed provides a tunnel support for the tarps with a clearance of 18 to 24 in. at bed center. The sides of the tarps are secured down with boards and concrete blocks.

On frosty nights and during cool, wet weather tarp ends are closed down, otherwise they are left rolled up. We maintain 5 to 12°F warmer temperatures under these closed covers. After danger of frost has passed and with warmer weather we ventilate more as each species dictates by switching to the lighter tarps or by opening short sections of tarps in the middle of beds

I have found not only better germination with less damping-off, but also much larger and more vigorous seedlings. For example, without fabric covers 1-0 *Cornus mas* ranged 2 to 9 in. tall, with fabric they are 6 to 24 in. tall.

Though porous to water, penetration is not uniform, particularly with brand new tarps. The heavier fabric especially sheds much water. Actually during the spring I believe this is of benefit keeping the beds drier and warmer, hence less prone to damping-off.

When seedlings are 2 to 6 in. tall the beds are uncovered for weeding, fertilizing and a thorough irrigation as well as for disease and insect control. Insect populations have been down considerably with a few exceptions. Irrigation also continues over covered beds as needed through the summer.

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Lack of uniform water penetration has not noticeably affected germination or growth except when attempting to germinate surface sown seed like *Betula* where consistent, even moisture is critical We solved this problem this year by running an irrigation line with 4 ft square pattern micro-nozzles hung under the tarps from the hoops.

Another use that looks promising in early trials is for autumn frost protection of late tender growth of species, such as *Parthenocissus tricuspidata,* which is prone to such damage.

Almost all materials in these cover systems are reusable many times. Still being used are some of the heavy tarps first used in 1988 The light tarps are usually used two or three times.

I feel these fabrics are giving me the opportunity to stay competitive with the many nurseries that have milder spring weather and longer growing seasons because the "greenhouse effect" of these fabrics is providing us better frost protection and greatly enhanced growth.

Liner Shipping

Dale G. Deppe
Spring Meadow Nursery, Inc , 12601 120th Ave , Grand Haven, Michigan 49417-9621

What a customer sees when opening the shipping container is what's important. The customer doesn't care how good a grower you are The customer doesn't care how good the plants looked when you packed them. The customer doesn't care about the shipper's problems or the kind of box you buy or the cost of the freight or the price of the plants or your reputation for making things right.

What the customer wants is "perfection". They may not say it that way but it's true The first impression when seeing your plant material is the one remembered. The better the plant material looks when it's received the better off the liner grower is going to be If there is a problem growing the plant material at a later date, customers will look inward at their own company, and what their employees may have done or what else may have happened during the growing cycle. If the plant material looks smashed or jumbled, has broken branches, dead leaves, isn't in the pots anymore, or what ever, you can bet everyone will remember, and your poor quality liner will get the blame for every problem known to mankind.

We have been successful with a few different shipping methods for potted liners.

RACKED DELIVERY TRAILERS

Racked delivery trailers are nothing really new in the industry but very successful in delivering plant material that looks good when delivered The number one problem is that small orders cost more to deliver than their worth and you can't get to everyone everywhere if you sell in a large market. Either everyone wants it the same day or everyone wants it a different day and you won't be able to do either

ROLLING CARTS

Rolling carts are being used successfully in Europe and now in the USA in the bedding plant industry. Carts can be loaded right in your greenhouse and then rolled onto a semi trailer for delivery. Carts breakdown for backhalls or for ease in unloading at delivery. They also take up less storage space during the off season. Rolling carts work well for us when delivering large orders for longer distances.

PALLET SHIPMENTS

Pallet shipments are now the standard for liner shipping The pallet shipment for potted liners was developed at Spring Meadow Nursery Inc. about 5 years ago. With each flat individually boxed in an upright position the boxes are stacked on pallets and stretched wrapped together to ship as one unit. The trucking industry has changed dramatically in the years since deregulation and service is continuing to improve. We receive next day delivery service in 6 states and 2 day service in 12 states with the whole USA in 4 days, shipping Monday with delivery on Friday. Our customers are very pleased.

UPS DELIVERY

UPS delivery at Spring Meadow Nursery, Inc. is a box with cardboard "partitions" that keep the plant material from shifting around in the box. Plants are shipped upright in the growing tray, 3 trays, 96 plants per box. By holding down the pots and tray with cardboard partitions the box can ship in any position without damage to the plants. When unpacking, the partitions pull up out of the box easily leaving the plant material looking like it just left the nursery. Our feeling is that this new level of excellence in UPS shipping will also become an industry standard.

So remember that whatever method you use to ship your plant material, it's only as good as your customer's perception.

Cornus kousa var. *chinensis* 'Milky Way' and Name Recognition in the Nursery Industry

Elwin R. Orton, Jr.
Rutgers, The State University, Department of Horticulture, Cook College, Box 231, New Brunswick, New Jersey 08903

During the past 25 years, the debilitating effects of the common dogwood borer, *Synanthedon scitula*, on plants of *Cornus florida* and, more recently, the severe effects of "dogwood decline", have resulted in a reduced demand for plants of this species At the same time, there has been a marked increase in the demand for the Asiatic dogwood, *C. kousa,* since plants of this species were known to be highly resistant to the dogwood borer and, in recent years, were found to be highly resistant to *Discula*, the incitant of dogwood anthracnose and a factor in "dogwood decline".

Foremost among the listings of *C. kousa* in many nursery catalogs has been *C. kousa* var. *chinensis* 'Milky Way', an introduction of Wayside Gardens in the 1960s. Apparently the demand for plants of 'Milky Way' outstripped the production capacity of growers as listings of "Seedlings of 'Milky Way'" appeared in various nursery catalogs during the last decade. To this day, it is not uncommon to see such listings in nursery catalogs.

In 1969, I ordered two plants of *C. kousa* var. *chinensis* 'Milky Way' from Wayside Gardens for inclusion in the performance trial of plants of *C. florida, C. kousa,* and *C nuttallii* being assembled at Rutgers University as the first step in a program of intra- and inter-specific hybridization among these large-bracted dogwoods. It became evident after a number of years, that the two plants of 'Milky Way' were dissimilar, suggesting that the plants being sold as 'Milky Way' represented more than one clone. Later, as I saw listings for "Seedlings of 'Milky Way'" in nursery catalogs, my interest in the history, or origin, of 'Milky Way' increased.

With 25 years experience in hybridizing large-bracted dogwoods, I found it difficult to explain the apparent surge of interest in *C. kousa* var. *chinensis* 'Milky Way' and, more specifically, the reason for listing "Seedlings of 'Milky Way'". All the plants of *C. kousa* that I had experience with were self-sterile, seed being produced only as a result of cross fertilization, and the resultant seedlings were genetically highly variable. Thus, I decided to seek out what information might be available concerning both the origin and the genetic makeup of the plants Wayside Gardens marketed under the name *C. kousa* var. *chinensis* 'Milky Way'.

At the time 'Milky Way' was introduced, the headquarters of Wayside Gardens was located right across the road from the nursery of the late Paul Bosley in Mentor, Ohio His son, Richard Bosley, a former president of the Eastern Region of I P.P.S. was able to put me in contact with the person who was president of Wayside Gardens in the final years of operation in Ohio. That gentleman forwarded my inquiry to Mr Richard Silvieus, who was the production manager at Wayside Gardens during the 1960s and early 1970s He very generously provided quite detailed information concerning the origin of 'Milky Way'

In the 1960s, Wayside Gardens had a field of several thousand seedlings of C.

kousa which were grown from seed obtained from many different plants The seedlings in this field were evaluated for floral characteristics, with primary emphasis on large floral bracts and precocious flowering. About 15 plants that Mr. Silvieus said were truly outstanding in these characteristics were selected and transplanted to the corner of a field at the 100 acre production nursery, Wayside Gardens maintained at Perry, Ohio. These selected plants constituted the "stock block" from which scionwood was taken for use in propagating plants of 'Milky Way' by budding.

Thus, an "original" 'Milky Way' plant traces to any one of approximately fifteen different seedlings resulting from seed collected from many open pollinated plants. Present day "Seedlings of 'Milky Way'" would thus be open pollinated seedlings of propagules of any one of those approximately 15 original open-pollinated (self-sterile) seedlings, and one would expect them to be highly variable.

So, what is the purpose of this story? Two conclusions are worthy of note. First, the original plant material distributed under the name *C kousa* var. *chinensis* 'Milky Way' was not a cultivar, rather, it was a mixture of approximately 15 different clones, the parent plants of which were selected on the basis of floral traits.

Second, even a listing of "Seedlings of 'Milky Way'" apparently has market appeal today. This is strong testimony to the power, or value, of name recognition. Clearly, this is why many plant introductions have been patented in recent years with an absurd, or nonsensical, cultivar name and trademarked under a second, and more potentially appealing, name A registered trademark, if properly used, can be renewed every 10 years; this allows the plant originator (inventor) to earn revenue as a result of name recognition long after the 17 years of protection provided by a plant patent runs out 'Milky Way' was not patented or trademarked, but the fact that open-pollinated seedlings of the original mixture of approximately 15 different clones have sales appeal clearly illustrates the importance of name recognition of plant material within the nursery industry.

Use of Paints and Preservatives in the Greenhouse

Daniel Gilrein
39 Sound Ave , Riverhead NY 11901

Paints and wood preservatives, designed to maintain the appearance and integrity of the greenhouse, must he able to withstand and protect surfaces from sunlight and extremes of temperature and humidity They should he safe for use around plants and workers, resist mildew, and in the case of wood preservatives, protect against insect and fungal attack

All surfaces should be clean and dry before application. Test for mildew with a 1:1 bleach:water spray If mildew is present it will turn a light grey color. Mildew can be scrubbed off 30 minutes after spraying with a mixture of 3 oz trisodium phosphate (Oakite, Soilax, Spic & Span), 1 qt household bleach, and 3 qt warm water.

GREENHOUSE PAINTS

Paints to he used in the greenhouse should he explicitly labeled for this purpose. Since plants are particularly sensitive to fumes from xylene and toluene solvents, formulations with these ingredients should never be used in or near where plants are or will be grown Other volatile materials are known to cause growth regulator effects on certain plants, therefore paints, stains and other coatings not labeled for greenhouse use are best avoided. Apply paints only when the greenhouse can be ventilated until the paint has thoroughly dried. Do not use metallic (such as aluminum) paint on heating pipes.

WOOD PRESERVATIVES

A wood preservative, as defined in New York State, is a coating "formulated to protect wood from decay or insect attack and which is registered as a pesticide product with the United States Environmental Protection Agency " Probably the most common coating material used in greenhouses is copper naphthenate (e.g green Cuprinol No 10™, CNS™), for above- or below-ground uses. It increases resistance to insect attack (termites, powder post beetles, carpenter ants), fungal decay and algal growth and is usually sprayed or brushed on or used as a dip A brush treatment may add one to three years of life, while dipping (with 1/10 to 1/8 in. penetration) may add 5 to 10 years. The green color may bleed through paints applied over the treatment. Some formulations of zinc naphthenate (e.g. ZNS™) may he available for interior surfaces to he painted Never use the restricted materials pentachlorophenol or creosote in or near greenhouses. They give off volatiles that are extremely phytotoxic for a long period of time Two coats of either B·I·N™ primer-sealer or a two-phase epoxy paint have been reported effective in sealing in pentachlorophenol fumes, but **ALL** surfaces must he treated.

Chromic copper arsenate (CCA) is one material used for pressure treating (Wolmanizing) lumber. CCA may he the most practical option where long-term preservation is desirable and retreatment impractical. CCA salts bind with wood fibers and leaching has not been a problem For greenhouses, the 0.40 rating (lb of CCA retained per cu ft of wood) is recommended for above and below ground,

Table 1. Comparison of prices for clear retail 1 × 8 in. lumber per linear foot

Western red cedar	Redwood	Cypress	CCA (.40)
$1.69	$1.68	$2.60	0.66

which should last from 30 to 40 years. Treat new cut lumber ends with a copper naphthenate preservative.

Avoid breathing dust from saw cuts and never burn CCA-treated wood, since toxic fumes may be produced. Wash hands after working with CCA, and wash work clothes that have contacted CCA separately.

CCA-treated lumber or copper naphthenate-coated wood should be rinsed at least six times and then thoroughly dried for a week before use. Be sure rinse water can entirely drain off and not collect and concentrate salts on the wood surface. Place spacers between stacks of wood for aeration while rinsing and drying.

Certain heartwoods are naturally resistant to decay and can last 20 to 30 years or more, but availability and price make CCA a more desirable option. Table 1 compares recent (12/91) prices for clear retail 1 × 8 in. lumber, per linear foot.

Effect of Mixes on Seed Germination

Ralph Freeman
Cornell Cooperative Extension, 246 Griffing Avenue, Riverhead, New York 11901

Over the years many bedding plant growers have experienced difficulties immediately following the germination of the seed of numerous plants. Immediately following germination the emerging shoot appeared to be infected with *Pythium* or *Rhizoctonia*. Frequently, the shoots would be severed from the seeds, falling onto the mix, sometimes rooting, then continuing to grow. The problems were blamed on poor quality seed, non-viable seed, disease problems, etc

Investigations were conducted in commercial grower operations and the following germination conditions were found: germination medium, Peat-lite mix; germinating environment, 70 to 75°F ambient; media temperatures, 70°F; relative humidity, 60 to 100%, light levels, 4000 to 6000 ft-c, and moisture of the mix was uniform and adequate.

Numerous investigations were conducted to determine the cause of these losses. It was found that the presence of surfactants and/or fungicides in mixes influenced these effects. Under controlled conditions in the laboratory the symptoms seen under grower conditions could be duplicated with any of the surfactants or fungicides available to the trade. Thus, further investigations led to modifying the Peat-lite mix (Table 1) that would successfully germinate seed without any losses. Table 1 also shows the conventional growing mix commonly used in plant production. These and other studies have led the author to believe the surfactants per se are not the causal factor but may trigger a series of organic chemical reactions to occur to stimulate these effects. Further studies need to be completed to understand the reasons for these occurrences.

Fungicides should not be applied until the seedlings are established.

Table 1. Peat-lite mix for growing plants and germinating seed

	Amt/cu yard	
Materials	Growing mix	Seeding mix
Peat moss	13bu	13bu
Vermiculite	13bu	13bu
Dolomitic limestone	5 lb	5 lb
Treble superphosphate (0-46-0)	1/2 lb	1/2 lb
Gypsum	2 lb	2 lb
Potassium nitrate (12-0-44)	1/2 lb	1/2 lb
Calcium nitrate (15-0-0)	1/2 lb	1/2 lb
Trace elements (use one only)		
Esmigram	5 lb	--
Perk	5 lb	--
Micromax	1 5 lb	--
AquaGro granular	1 lb	--

All materials must be uniformly blended together for best results

Treble superphosphate, gypsum, and dolomitic limestone should be in a powdered form before inclusion into the mix

There are 26 bushels per cubic yard (this allows for shrinkage of the mix when the peat and vermiculite are mixed together) To make a one bushel measure the inside dimensions should be 13 in x 13 ft x 13 in

Controlling Melon Aphid in Greenhouses

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Scott Clark
Cornell University, Long Island Horticultural Research Laboratory, 39 Sound Ave., Riverhead, NY 11901

Aphids are one of the insect pests frequently encountered in greenhouse crop production. Aphids damage plants by removing plant sap, excreting honeydew on the plant surfaces, transmitting disease organisms, and by reducing the aesthetic value of the plant. Although the most common aphid in the greenhouse is the green peach aphid, *Myzus persicae*, the melon aphid, *Aphis gossypii*, is also a frequent greenhouse problem as well as on various crops in the field.

The melon aphid can be very difficult to control, partly due to insecticide resistance, and its even distribution throughout the plant makes pesticide penetration to the lower portion of the canopy very important.

Horticultural oils and insecticidal soap are gaining wide acceptance in pest management programs due to their environmental and plant safety along with their effectiveness in controlling a wide range of pests. Using them in combination with traditional pesticides has shown increased activity and the potential for reducing the necessary concentration for effective control

In a recent demonstration conducted in a woody propagation greenhouse on Long Island, several insecticides and combinations were evaluated for melon aphid control Plots were 3 x 5 ft and replicated four times in a randomized complete block design. Two applications for each treatment were made nine days apart. Aphids were counted on 3 apical leaves of 10 plants per plot before the first application and again 2 days after both application dates. Treatments were applied using a CO_2 backpack sprayer with a #4 hollow cone nozzle. The first application took place on March 20 using a spray volume of 120 gal per acre and pressure of 45 psi. The second application took place on March 29 with a spray volume at 240 gal per acre and 60 psi. Treatments, rates, and results are presented in Table 1.

Table 1. Control at melon aphid in a commercial greenhouse, 1991

		Aphids per 10 plants[1]		
Treatment	Rate/ 100 gal	Pretreatment March 20	TRMT[1] March 22	TRMT[2] March 29
Orthene 75S	0.75 lb	39 a	31 ab	15 ab
Mavrik 2F	10 oz	45 a	34 ab	43 c
Safer Soap	2 gal	35 a	23 a	7 ab
Ultra fine oil	2 gal	52 a	44 bc	31 bc
Orthene 755	0.75 lb			
+ Soap	1 gal	49 a	17 a	0.5 a
Mavrik 3F	10 oz			
+ Soap	1 gal	27 a	14 a	4.5 a
Check	unsprayed	40 a	56 c	73 d

[1]Means within a column followed by the same letter not significantly different (P=0.05, Fisher protected LSD)

Pretreatment counts varied but were not significantly different. Control with the first application ranged from 0 to 62%. As with any pesticide application thorough coverage is essential and it was felt that the spray volume and pressure used in the first application was inadequate When both pressure and spray volume were increased, control was improved considerably. A combination of Orthene plus soap gave the best control followed by Mavrik plus soap and soap alone. It should be noted that sampling for control took place on the tips of the plants. As previously noted melon aphid is distributed evenly throughout the plant canopy making penetration to the lower canopy necessary for efficient control. Results indicate two applications may be beneficial in obtaining satisfactory control.

Effect of Quaternary Ammonium Compound Dips on Rooting of *Rhododendron catawbiense* 'Boursault'

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Local nurserymen have expressed interest in using anti-microbial treatments on woody cuttings prior to mist propagation, in order to control pathogens inadvertently introduced to the propagation area on cuttings collected from outdoor-grown stock Few fungicides are registered for dip treatment, and those available often do not control a broad spectrum of pathogens. Before pursuing efficacy studies, we thought it important to determine whether anti-microbial substances used as dips were non-phytotoxic. A previous study examined the effect of different concentrations of Physan 20 (now Whitmire's PT 2000 Green-Shield), Phyton 27 and Banrot 40WP on the rooting of azalea and rhododendron (Clark and Daughtrey, 1990). In that study, we observed a tremendous amount of natural variation in root development among cuttings in a population. Therefore, in our 1991 study, we increased the number of replications, and were careful to block against variation in cutting diameter.

Cuttings of *Rhododendron catawbiense* 'Boursault' harvested 9/25/91 were sorted into size categories to maximize uniformity within replications, and wounded on both sides of the base. Groups of 20 cuttings were then given a 1-min dip treatment before the ends were touched to 3% IBA powder. The dip treatment solutions were various concentrations of Green Shield (Whitmire Research Laboratories, Inc., St. Louis, MO), which contains two quaternary ammonium compounds as active ingredients. Cuttings were stuck into 70% peat-30% perlite medium in #50 Pro-tray flats, and arranged in a randomized complete block on one greenhouse bench. There were 10 replications of each treatment. Cuttings were rooted under intermittent mist; temperatures ranged from 18 to 27°C (65 to 80°F). The rooting category (stage of root development) was recorded for all cuttings on 12/1/91.

RESULTS

None of the treatments had a significant effect on the proportion of the cuttings which initiated roots (Category 3) or developed small root systems not yet filling the container (Category 4) (Table 1) within two months. Treatment at the 400 ppm rate did appear to be conducive to the development of a large root system (Category 5) in a small percentage of the population. There was a great deal of individual variability in root development, even in the control treatment.

Table 1. Effect of Green Shield treatments on root development in *Rhododendron catawbiense* 'Boursault' cuttings

Ammonium chloride conc. (ppm)	Root development categories[1]					
	1	2	3	4	5	Sum of 3, 4,& 5
0	1.6a[2]	9.2a	4.5a	3.7a	0.8a	9.0a
50	0.9a	8.4a	4.4a	4.1a	1.7ab	10.2a
100	1.0a	8.3a	3.9a	4.3a	2.1ab	10.3a
200	1.7a	7.6a	4.9a	4.5a	1.1ab	10.5a
400	1.6a	9.4a	3.5a	2.9a	2.3b	8.7a

[1] Root development categories: 1=no callus, 2=callus only, 3=5 or-less roots initiated, 4=more than 5 roots initiated plus secondary root development, 5=root system extensive, filling the plug.

[2] Values represent mean number of cuttings (out of a possible 20) in each developmental stage for 10 replications of each treatment; values followed by the same letter are not significantly different (Fishers Protected LSD, p=.05)

CONCLUSION

Green-Shield cutting dips did not inhibit rooting of *R. catawbiense* 'Boursault' within the concentration range tested. Although Green-Shield is not labeled for direct application to plants, it is labeled for use on hard, inanimate surfaces in the greenhouse. Disinfecting flats, benches, and work surfaces with Green-Shield should not have any negative effects during plant propagation.

LITERATURE CITED

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Specimen Conifer Production

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MARKET NEEDS

Dwarf and unusual forms of conifers have been recognized since the 1800s. Ten dwarf forms were first listed in 1938, and by 1966 over 1000 forms were available. Now the cultivars available are abundant. In developing a market for these specimens, we need to consider today's economy and the time available to home owners for work in their landscape. Building lots are becoming increasingly smaller in size as real estate prices soar. Funds required for care of massive plantings has led to a serious look at the benefits of smaller, compact plantings in this day of economic stress. A new home owner must consider time and effort, as well as expense, when planting a harmonious landscape. Dwarf and unusual conifers in a landscape will provide years of beauty, balance and growing interest to the space limited gardener, as well as eliminating yearly garden chores that are a must for massive plantings. Limited space and great expectations support the need for various forms of dwarf or unusual specimen conifers, therefore creating a market need.

STOCK PLANTS

The most important factor besides market need is the availability of quality stock plants. Without healthy and vigorous stock plants, it is impossible for production to advance. We began purchasing stock plants in 1975 when we acquired the last plants propagated by Henry J. Hohman of Kingsville Nursery. At that time, we had approximately 100 taxa, and today we have over 1000 taxa in production. Several criteria must be met before buying in stock plants. The most important is that the plant is true-to-name. We feel it is important to know the history of the plant and the supplier before we commit to purchasing any particular stock plant. The plant must be healthy, have good vigor, be true-to-name and adaptable to our zone and climate conditions. We may not always purchase mature stock plants and may resort to buying in liners; however, the liners must meet the same criteria as the more mature forms. If the stock plant source is in a liner form, we will grow it on for a period of two years in a one-gal container and then plant it in our field. If the stock plant is of a mature size, it will be incorporated into one of our display gardens. Many times, we will plant stock plants into our regular field production or container production area and then harvest them every 4 to 6 years, depending on quantity of cuttings or scions needed. During this period of time, we are also able to evaluate the plant for its growth, maintenance requirements and special characteristics. All stock plants are under our regular growing program that includes fertilization, pesticide control and irrigation.

PROPAGATION

The two basic methods for producing specimen conifers are by grafting or by cuttings. Our grafted conifers are propagated from December through March, and our conifers from cuttings are stuck from October through April.

The introduction of disinfestation procedures into our production system is the most important factor in our successful propagation of these plants. All of our scions and cuttings are emersed in a 10% bleach solution immediately after preparation. We also wash our propagation houses with bleach and sterilize all tools, flats and pots.

GRAFTING

Understock is potted into 2 3/8 x 5 in. pots in February and March. We feel that the deep band pot has increased our percentage of take incredibly. The pot size of the understock is critical to the success of grafting. Our potting soil is basically a mixture of 70% composted pine bark, 20% coarse sand, 10% peat moss, lime (7 lb per yard), and Sierra Blend + minors 17-6-10 (10 pounds per cubic yard).

The understock is maintained under regular growing conditions with water, fertilizer and pesticide control. When it is time to graft, the understock is brought into the head house as needed for grafting preparation and actual grafting. We use a standard modified side graft, making certain that scions are of good size and vigor and that rubber strips are not too tight. The plants are then plunged into palite with 72°F bottom heat. They remain in the grafting houses until April and then are removed to a shade frame where they will remain until summer potting. Prior to potting, grading takes place and inferior plants are discarded. All plants are potted into a trade 1-gal container using the same soil mix as in the understock. It is important that grafts are hardened off prior to potting. If potting takes place during June or July, the plants are placed under 47% shade. However, if they are potted in August or later, shade is not necessary. These plants will remain in the one-gal container for 2 years or 3 to 4 growing seasons. At that time, they are ready for field planting.

CUTTINGS

We usually use cuttings for various cultivars of *Chamaecyparis, Cryptomeria, Juniperus, Picea abies, Taxus, Thuja* and *Tsuga*. Cuttings are taken in advance of propagation and are kept in cold storage where they are kept moist until preparation time. They are then removed from cold storage and taken to the head house where they are prepared and stuck. Our media consists of various ingredients such as 75% palite and 25% peat moss as one mix; another would be 50% sand and 50% peat moss. All cuttings are dipped into a 2% IBA talc or into a liquid quick dip at a ratio of 1:5 or 1:10 respectively. Flats of cuttings are carried by conveyer to the cutting house and placed on bottom heat at approximately 72°F with ambient air temperature maintained in the low 50s depending on sunlight and heat buildup.

Low profile plastic tunnels are placed over the flats to increase rooting and to save heating energy. Cuttings are rooted within a 6 to 10 week period and then potted into a 2 1/4 in. rose pot, 1 1/2 quart pots or 1-gal containers. This would depend on the cultivar, production time and scheduling. A 2 1/4 in. rose pot plant would go into a 1 gal after 1 1/2 years of growth and a 1 1/2 qt would go into a 2-gal can, also after 1 1/2 years of growth. These plants are then grown on for a period of 2 to 3 years or until field ready for lining out.

GROWING-ON

Fields are prepared one year in advance of planting out. If we are going into a new piece of farm ground that has been planted in alfalfa or some other crop, we will perform soil tests and prepare the soil accordingly. If the field has been planted in corn, wheat or other nursery stock, a triazine test for herbicides is in order, along with routine soil testing. An attempt is made to prepare the ground in late fall for planting the following spring. An application of liquid cow manure is applied at the rate of 15,000 gal per acre and then subsoiled to a depth of 18-20 in. The ground will remain in this condition until spring planting. It has been our experience that fall subsoiling greatly increases the survival rate of plants the following year. This is probably due to better moisture, friability and aeration in the soil. Once the ground is ready for planting, the fields are laid out according to blocks and topography. Plants are tagged, removed from their containers, and the root balls are broken up entirely. They are then loaded into field planting boxes and delivered to the fields. There the plants are unloaded onto the planter and planted out. Our spacing depends on the cultivar of plant and at what size we plan to harvest it. The standard spacing is 6 ft in the rows and 18 ft between rows. The columnar conifers are more tightly spaced. If we are going to harvest plants at a 7 to 9 year schedule, we will block these plants into three rows per block, with grass strips in between. Fertilization is done in March and September, and pesticide control is on an IPM basis. Our herbicide program is still under testing and evaluation. Herbicides can be a problem, especially if you plan to use your field stock as a propagation source. We clean cultivate where possible and in late summer drill in oats for- a winter cover crop. This helps soil erosion control and protecting the root surface. All plants remain in the field until they reach landscape size of specimen quality.

HARVESTING

Plants are harvested yearlong depending on the market. We will trench and water in before digging if we are digging in summer. Most plants are dug with a mechanical digger, with the exception of the larger or specimen conifers which are hand dug. After they have been loaded by forklift, plants are brought out of the field and taken to the holding yard by wagon. Conifers, such as *Picea* and *Pinus*, are not dug between bud break and hardening off.

SALES

We contribute the majority of our sales to the Foxhorough product itself and also to word-of-mouth sales. Advertising occupies only a small portion of our budget, and our sales staff is inhouse. Our first public listing was included in a national sources guide 14 years ago, and from there we built our clientele base.

Pricing is a somewhat difficult area because of the inability to extensively compare pricing of our specimen conifers with those of other nurseries. Our basic criterion is to test the market with pricing and to develop our base from there. Pricing on specimens is done on an individual basis.

In summary, the cultivation of conifer specimens is an area that many mainstream nursery businesses bypass. Specimens require extra field space, years to harvest, patience and marketing ability. To become an innovative grower in this day and age, we must take time, make space and he creative for each specimen conifer has its own characteristics.

Seedling Production at Bailey Nurseries

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Bailey Nurseries, Inc. is a large wholesale production nursery headquartered just south of St. Paul, Minnesota. Over 2500 acres, split between Minnesota and west coast growing areas, are dedicated to the production of nursery stock. In Minnesota, deciduous seedling production of almost 4 million plants is accomplished on approximately 25 acres of fine loamy soil located in the Mississippi River valley. We have a Zone 4A rating by the U.S.D.A. system. The propagation of trees and shrubs from seed has often been relegated second-class status in the nursery business. Indeed, it is a rather inexpensive and low-tech undertaking, but quite important because high quality seedlings are often not available on the market. Our goal is to produce an adequately sized, vigorous seedling in one year. To help actualize this goal, a comprehensive mix of soil building, collecting of hardy local seeds, pest control, watering and fertilization practices is imperative.

Currently we are growing about 110 species of trees and shrubs from seed. We make every effort to collect seed locally to insure hardiness, trueness-to-type, and a proper stage of maturity. An ambitious reevaluation of our seed sources is presently underway at Bailey's. We hope to improve our seedlings in the areas of hardiness, form, fall color, vigor, pest resistance, etc. through the evaluation and selection of superior "mother plants" and controlling these plants in seed producing orchards.

Following an annual chronology of seed maturation, seeds are collected as the species ripen. Our seed picking crews invade the Minnesota Landscape Arboretum, local golf courses, boulevard plantings, nursery seed orchards, public parks, wild areas and homeowner landscapes in search of seeds from needed species. Crews can hand pick, sweep or rake up, shake onto traps or vacuum up the seeds or fruits as the various species dictate. With most species there is an extended period during which the seed will be mature and can be collected successfully. Birds, rodents, wind and other natural agents can disrupt the collection process and their effects must be dealt with. Some species (e.g. *Tilia americana* and *Ostrya virginiana*) will germinate much better if collected on the green side. This requires the propagator to be knowledgeable of the eccentricities of each species to be successful. Fruits are kept in a refrigerated room and cleaned as quickly as possible. A Dybvig-type seed cleaner is employed and the clean seed is dried to the desired moisture content on screens. Cleaned seed is then stored in a freezer with low relative humidity and a constant 32°F temperature.

We promote soil improvement as an integral part of producing good seedlings. To this end an annual application of cattle manure is used, at the rate of 30 tons per acre, on all land scheduled for seedling production. In late spring a crop of sudan grass is sown, then chopped and plowed under at maturity. A high nitrogen complete fertilizer is utilized as needed and followed by subsoiling and other ground preparation. Raised beds are formed by use of a Fobro bedmaker. Vapam, a soil fumigant, is then applied to the beds through a tractor mounted spray boom at a rate of 90-gal per acre. Overhead irrigation is supplied to drive and hold the fumigant in the soil. After two to three weeks to allow for dispersal of the chemical the beds are fit to be seeded.

Deciduous tree and shrub seeds often exhibit involved dormancies that can be perplexing to overcome. Regarding dormancy requirements, the seeds we deal with fall into one of these four categories:

1) Seeds which need little or no pretreatment to allow germination (e.g. *Betula, Catalpa*, and *Caragana*).

2) Seeds needing an extended cold period to break dormancy. (i.e. 60 to 120 days at 32 to 40°F.) Genera needing this cold period include *Malus, Pyrus* and *Sorbus*.

3) Seeds which benefit from 90 to 120 days of warm stratification (50 to 70°F) followed by 90 to 120 days of cold stratification at 32 to 40°F. These types, including the genera *Cotoneaster*, *Cornus* and *Rosa*, generally exhibit a tough impermeable seed coat and require the warm stratification period to sufficiently degrade their seed coats to allow the seed to become fully imbibed with water. Then the cold stratification period will be effective.

4) Seeds that require scarification of the seed coat by concentrated sulfuric acid or boiling water to break down the seed coat and permit germination (e.g. *Gleditsia, Gymnocladus,* and *Rhus*). These types have very formidable seed coats requiring these radical treatments to facilitate adequate and timely germination.

Knowing these requirements individual species are treated as needed to fulfill their needs. About 66% of our seeds are sown in early fall as they require only the cold period to germinate. About 20% of our species are sown in early July to fulfill the warm-cold stratification requirements. The remaining species are either scarified and spring sown or spring sown with no pretreatment.

Seedling density within the seedbed is arguably the single most important factor in producing useable seedlings. By starting with fresh viable seed and knowing the number of seeds per pound and average germination probability of a given species one can usually determine a sowing rate that will result in an acceptable seedbed population. We sow most of our seed by hand broadcasting onto the bed with the remainder sown with a lawn fertilizer spreader. A tractor drawn drum is pulled over the seed to insure good soil contact and a sand layer is applied. One-fourth to one-half inch of sand is applied depending on the size of the seed sown. A final mulch of about three inches of chopped sudan grass is applied on the beds and thoroughly watered.

All seedbeds having been labeled and plotted can be found easily in the spring to begin removing the hay mulch. Seeds are checked for progressing germination and when a particular species has its roots down about one-half inch the hay is promptly removed and placed into the aisle. This hay can then be used to recover the seedlings should they be threatened by nighttime radiational frosts that frequently occur at this time of year.

About two weeks after all seedlings have emerged, soil samples are taken and tested for nutrient levels. Beds are then fortified with an application of Scott's Pro Grow (24-7-8) fertilizer as needed. Supplemental irrigation is available and applied at the rate of one inch per week as needed. The bulk of our weed control is done with hand labor. Six to eight weeders are employed during the summer to keep the weeds under control. Poast herbicide has been invaluable in the control of grasses. Leafhoppers and aphids can be a real problem for us. A weekly spraying of malathion or orthene keeps the insect damage at a tolerable level. During the summer, inventories and evaluations are done on the seedbeds to help determine if any practices, seed sources, sowing rates, etc. can be improved. Results are looked at to conclude what worked and what did not and what species need new trials to improve standards and or growth. In the St. Paul area we can commence digging seedbeds in mid to late October. We have normally had several killing frosts by then and seedlings are beginning to defoliate. We presently use a Fobro HD bed digger powered by a 60 h.p. tractor. We require about fifteen people for approximately twenty days to finish the harvesting in a timely manner. Generally we like to be finished digging by November 10th as winter freeze up can occur on any date thereafter. The harvested seedlings are loaded into pallets on a wagon and transported quickly to our humidified cold storage area. The coolers are maintained at approximately 34°F. and the relative humidity in storage is held at over 90% by use of a timed air-over-water mist system.

Grading takes place in a room heated to 55°F for the workers comfort. There is a timed humidity control system used to maintain a high relative humidity in the room. Pallets of seedlings are brought into the grading room by forklift. Two men grade from each pallet, placing the graded plants on a table in front of them. Grading is done by height with most shrub species, or by caliper on the shade tree and rootstock species. Each grader has one man that counts the plants into bundles and ties them. Great care is taken to align the root lines of the seedlings within the bundle so bundles can be root pruned on a band saw and still maintain uniformity in root length. After bundling, the plants are packed in pallets with moist shingle-tow placed on the roots to help maintain root viability during storage. Some harder to store genera including; *Betula, Celtis, Crataegus* and *Quercus*, are sealed in the pallets by what we call shrink-wrap, a cellophane film, that is wrapped around the pallet. This increases and maintains the relative humidity within the pallet and minimizes the "hardened buds" which often won't break when the seedlings are lined out in the spring. We required about 6,500 man hours to complete the grading, tying and packing away of roughly 3 1/2 million seedlings last winter.

Does IBA Inhibit Shoot Growth in Rooted Cuttings?

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Single-node 'Royalty' rose cuttings were utilized to examine the relationship between adventitious root formation, bud break, and ethylene synthesis of cuttings following IBA treatment. IBA application increased rooting and inhibited the bud break of cuttings. IBA≥ 600 mg·liter^{-1} almost completely inhibited bud break of cuttings during four weeks of rooting. IBA treatment stimulated ethylene synthesis, which was inversely correlated with bud break of cuttings. Ethephon also significantly inhibited bud break. Bud break of rose cuttings was completely prevented by repeated ethephon sprays used to maintain high endogenous ethylene levels during the first 10 days. Treatment with STS, and ethylene action inhibitor, improved bud break.

REVIEW OF LITERATURE

Synthetic auxins, such as indole-3-butyric acid (IBA) and naphthaleneacetic acid (NAA), are commercially used to promote adventitious root formation of cuttings. They are more effective than indole-3-acetic acid (IAA) because of their greater stability within tissue and during storage (Hartmann et al., 1990). However, application of synthetic auxins to stem cuttings was found to inhibit bud development of cuttings in several species (Christense et al., 1980; DeVries and Dubois, 1988). Auxins applied at high concentrations even prevent shoot growth or shoot abscission after bud break, although root formation was adequate (Hartmann, 1990). For example, IBA at 1000 to 2500 mg·liter^{-1} caused almost complete bud abscission of 'Ennis' and 'Cassina' hazelnut softwood cuttings (Bassil et al., 1991).

After rooting, the buds of cuttings of many species enter a period of dormancy before they are able to resume shoot growth (Goodman and Stimart, 1987; Hartmann et al., 1990; Smalley and Dirr, 1986). Early bud break and shoot growth are considered important factors regulating the overwinter survival of newly propagated cuttings of *Acer, Cornus, Hamamelis, Magnolia, Prunus, Rhododendron* and *Viburnum* (Goodman and Stimart, 1987; Smalley and Dirr, 1986). Many actions of auxin are mediated by the synthesis of ethylene (Burg and Burg, 1968). Our hypothesis concerning the auxin inhibition of bud break in cuttings is that auxins applied to cutting bases increase ethylene synthesis in the upper part of the cutting, and as a result of the high endogenous ethylene concentration, bud break of cuttings is inhibited or bud dormancy is induced. In the present study, we used single-node 'Royalty' rose cuttings as a model system.

MATERIALS AND METHODS

Five to six-year-old stock plants of 'Royalty' rose were grown in benches or containers in a medium of 1 perlite : 1 peat : 1 soil (by volume). The greenhouse was at 21/16°C (day/night) in spring and winter, and with 16 h photoperiod achieved by high intensity discharge lamps hanging 2 m apart and 1.5 m above plants. Fertilization with 20N-20P-20K was applied weekly at 200 mg·liter^{-1}. Rose shoots were excised for use when flower buds grew to 1.5 to 2.0 cm in diameter. Single-node cuttings with 4 leaflets were taken only from node 4 to 8 (distal to proximal) in order to obtain uniform cutting materials. For STS application, entire cuttings were held 20 min in a 0.5 mM (Ag+) STS solution prepared according to Reid et al, (1980) and then washed with tap water to remove superficial STS residue. Ethephon was applied at 300 to 500 mg·liter^{-1} by foliar spray until runoff.

Cuttings were rooted in a medium of 3 perlite : 2 peat moss (by volume) under intermittent mist operated for 5 sec every 4 min from 6:00 a.m. to 10:00 p.m. Temperature of the rooting medium was 20 to 23°C in spring and winter. Percent bud break of cuttings was recorded at intervals from 2 to 5 days. A lateral bud 0.7 cm in length was counted as broken. Cuttings were harvested after 20 to 30 days. All cuttings with roots ≥ 1 mm were considered as rooted.

For endogenous ethylene determination, three samples of four cuttings were randomly taken at each sampling date, except for one experiment in which eight cuttings were used. Ethylene gas in cuttings was extracted by placing cuttings in de-gassed water in a vacuum desiccator and reducing air pressure to a range of 91 to 95 Kpa (50 to 80 mm Hg height) for 4 min. An inverted funnel sealed with a rubber stopper was placed over the cuttings to collect gas bubbles. With this method, 1 to 1.5 ml gas could be collected from four cuttings and 0.8 to 1.0 ml was injected for gas chromatographic analysis. To avoid the interference of stress-induced ethylene due to sampling disturbances, all samples taken at the same time were completed within 45 to 50 min.

A completely randomized design was used in this study with 4 to 5 replications of 10 to 24 cuttings in each replication. The experiment of bud break response to IBA concentrations, however, had only two replications of 16 to 18 cuttings.

RESULTS

The number of roots per cutting increased for IBA concentrations up to 600 mg·liter^{-1} but did not increase there after (Fig. 1). IBA treatment remarkably reduced percent bud break of cuttings, even at a concentration as low as 100 mg·liter^{-1}. IBA ≥ 600 mg·liter^{-1} almost completely inhibited bud break of cuttings during the first four weeks. Percent bud break and the number of roots per cutting were negatively correlated ($r = -0.807$, $P = 0.0002$).

IBA significantly stimulated ethylene synthesis in rose cuttings. Endogenous ethylene concentration peaked after 2 or 3 days following IBA treatment (Fig. 3). During this period, ethylene concentration of cuttings treated with 500 and 1000 mg·liter^{-1} IBA was 4 and 10 times that of the control cuttings, respectively. Significant differences in ethylene production of cuttings were between three treatments still observed even after 20 days. Ethylene levels were well correlated with bud break of cuttings. The control cuttings had lowest ethylene level and highest percent bud break. IBA treatment at 1000 mg·liter^{-1} stimulated more ethylene production and more seriously delayed bud break of cuttings than did the 500 mg·liter^{-1} IBA treatment (Fig. 2).

A timely correlation was also observed between ethylene concentration and bud break of cuttings. The course of bud break for the control cuttings could be divided into three distinct periods, from 0 to 13 days, 13 to 25 days and 25 to 43 days. The rate of bud break was a constant within each period (Fig. 2). The regression-estimated slopes were 3.6, 0.8 and 2.4 for the three periods, respectively. Bud break in the second period was significantly slower than those of the other two periods (P=0.0001). Such a rate change was preceded with a high endogenous ethylene concentration in the cuttings (Fig. 3).

When ethephon solution at 500 mg·liter^{-1} was sprayed once daily on leaves of cuttings to maintain high endogenous ethylene levels during the first 10 days of

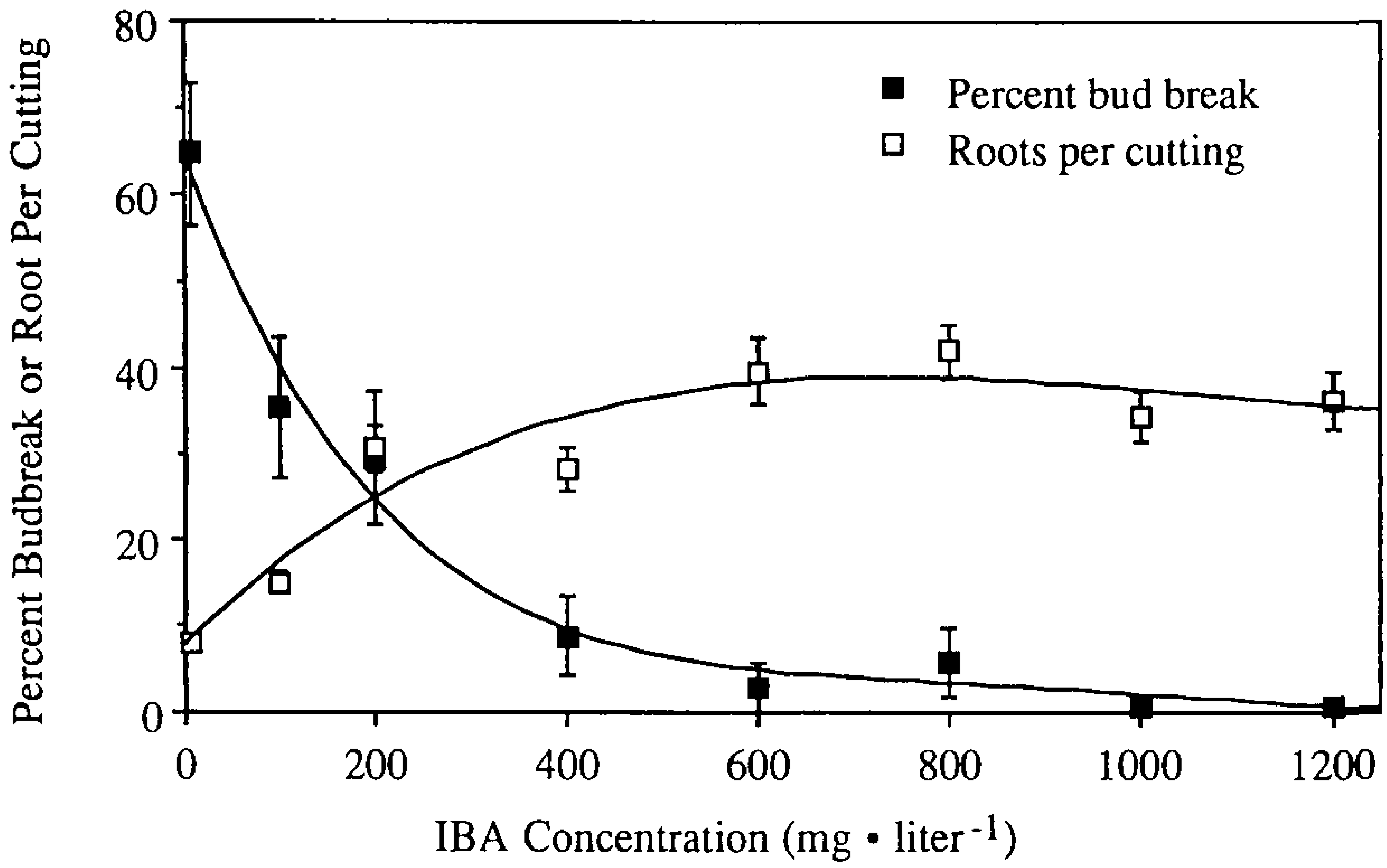

Figure 1. Rooting and bud break of 'Royalty' rose single-node cuttings following IBA treatment before rooting. Each treatment used 33 to 35 cuttings, which were harvested after 28 days. Bars denote the SE of the mean.

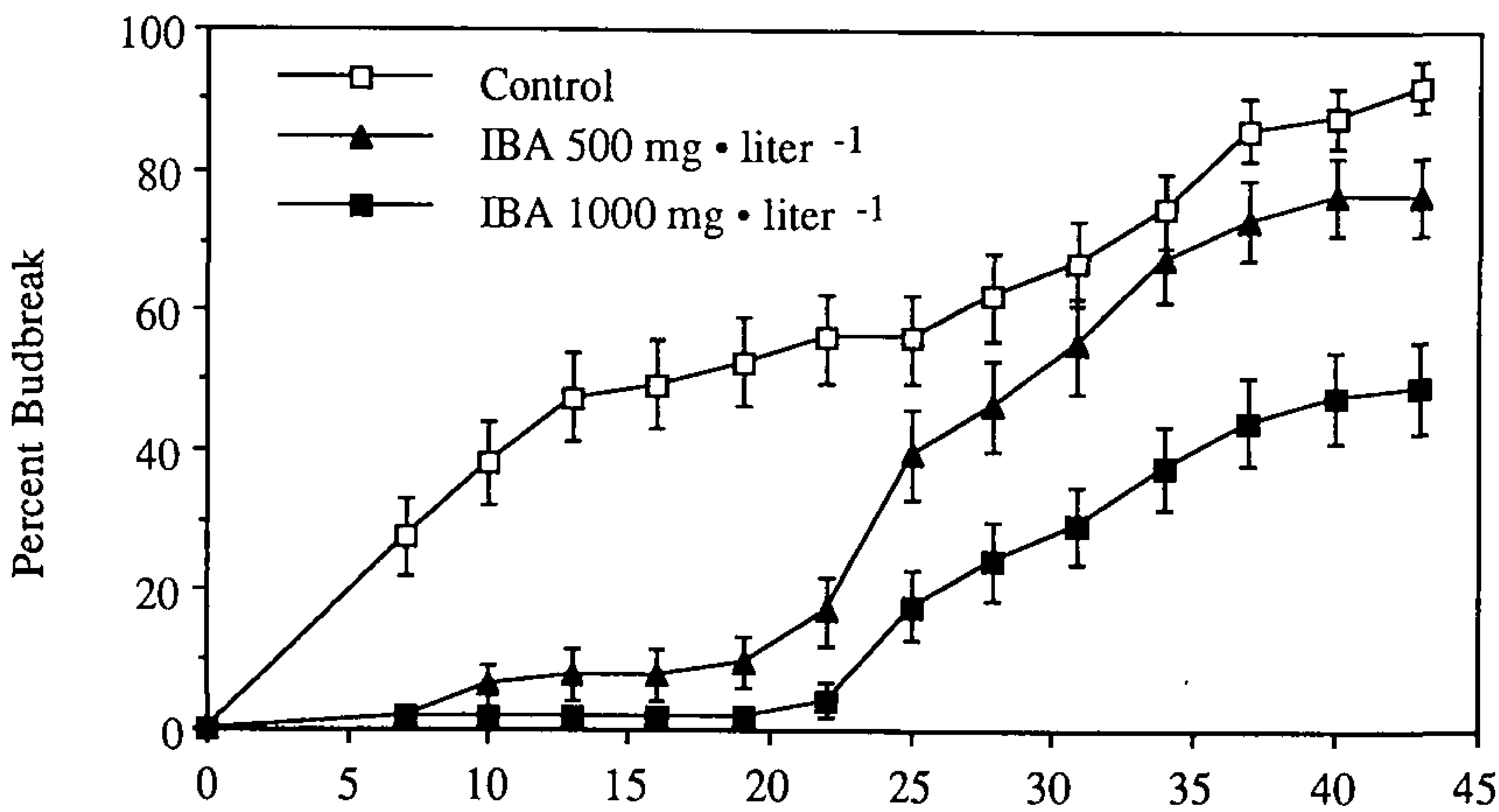

Figure 2. Bud break of 'Royalty' rose single-node cuttings following IBA treatment before rooting. Each point is the average value of four replications with 14 to 18 cuttings in one replication. Bars denote SE of the mean.

rooting, ethephon completely inhibited bud break as did the IBA treatment (Fig. 4).

More than 90% of STS-immersed cuttings broke their buds during the first 12 days of rooting, while IBA-treated cuttings showed <40% bud break even after 60 days (Fig. 5).

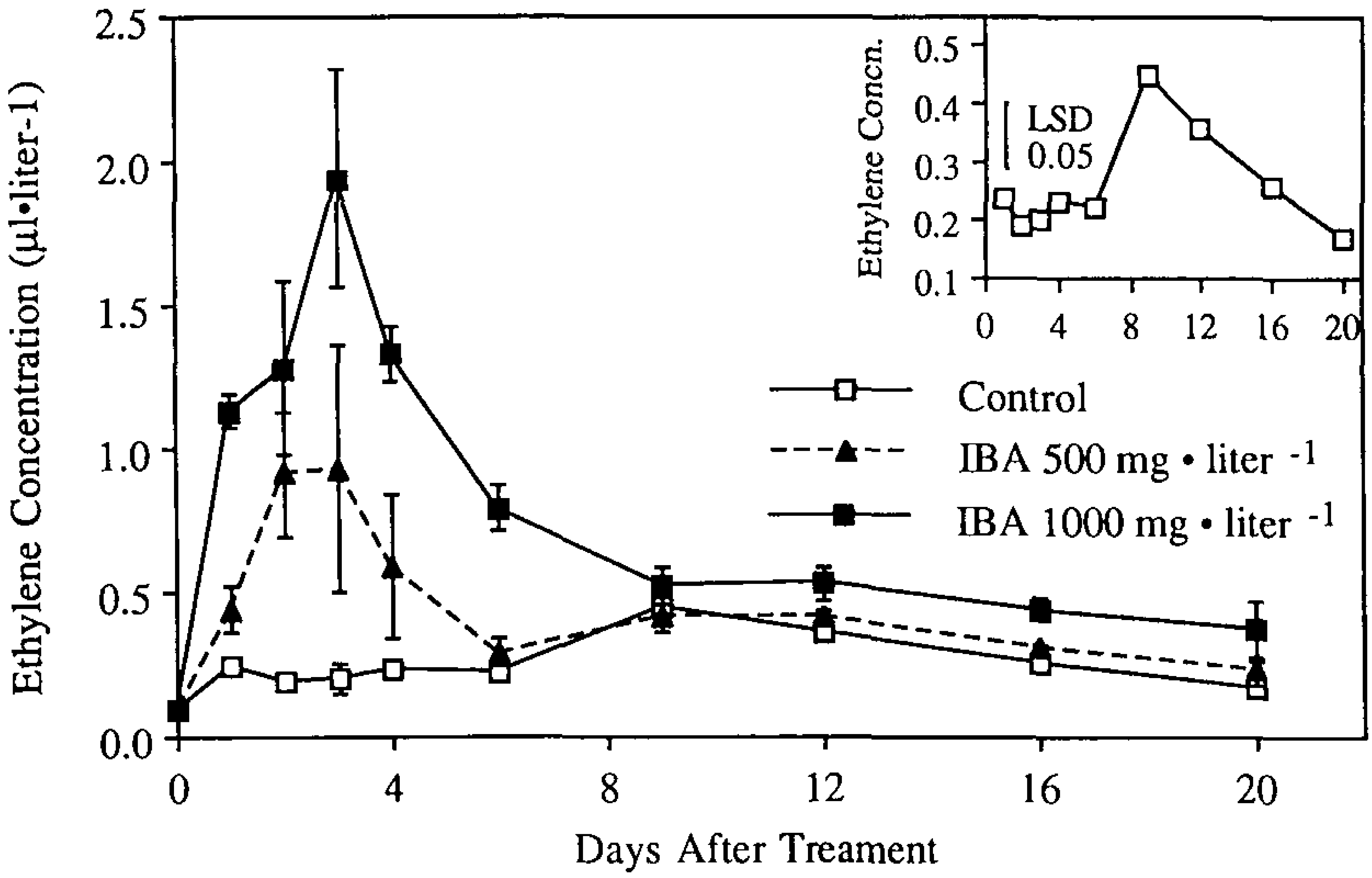

Figure 3. Endogenous ethylene concentration of 'Royalty' rose single-node cuttings following IBA treatment before rooting. The upper-right graph shows the change of ethylene concentration of the control cuttings over the time (day). Three samples of four cuttings were taken for ethylene determination. Bars denote SE of the mean.

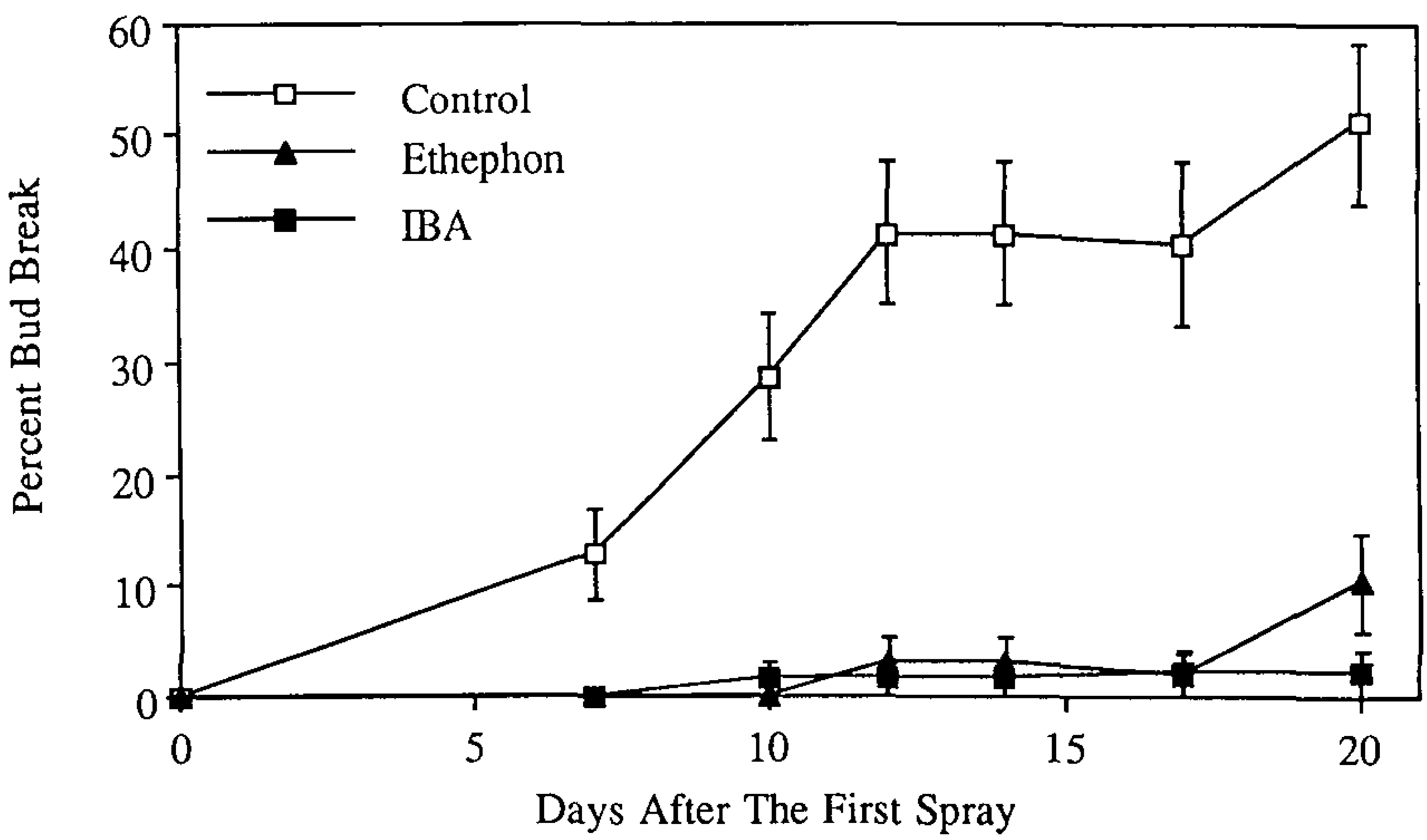

Figure 4. Bud break of 'Royalty' rose cuttings following IBA and ethephon application. IBA at 600 mg·liter^{-1} was applied through 10 sec dip before rooting, and ethephon at 500 mg·liter^{-1} was sprayed on leaves of cuttings daily at 10:00 a.m. at the first 10 days. Data are means of four replications of 15 to 16 cuttings. Bars denote SE of the mean.

DISCUSSION

IBA-induced root formation in rose cuttings was accompanied with increased ethylene levels. Ethylene levels were always inversely correlated with bud break (Fig. 1, 2, 4). STS, an ethylene action inhibitor, stimulated bud break of cuttings in absence of IBA, and increased the early bud break of IBA-treated cuttings (Fig. 5).

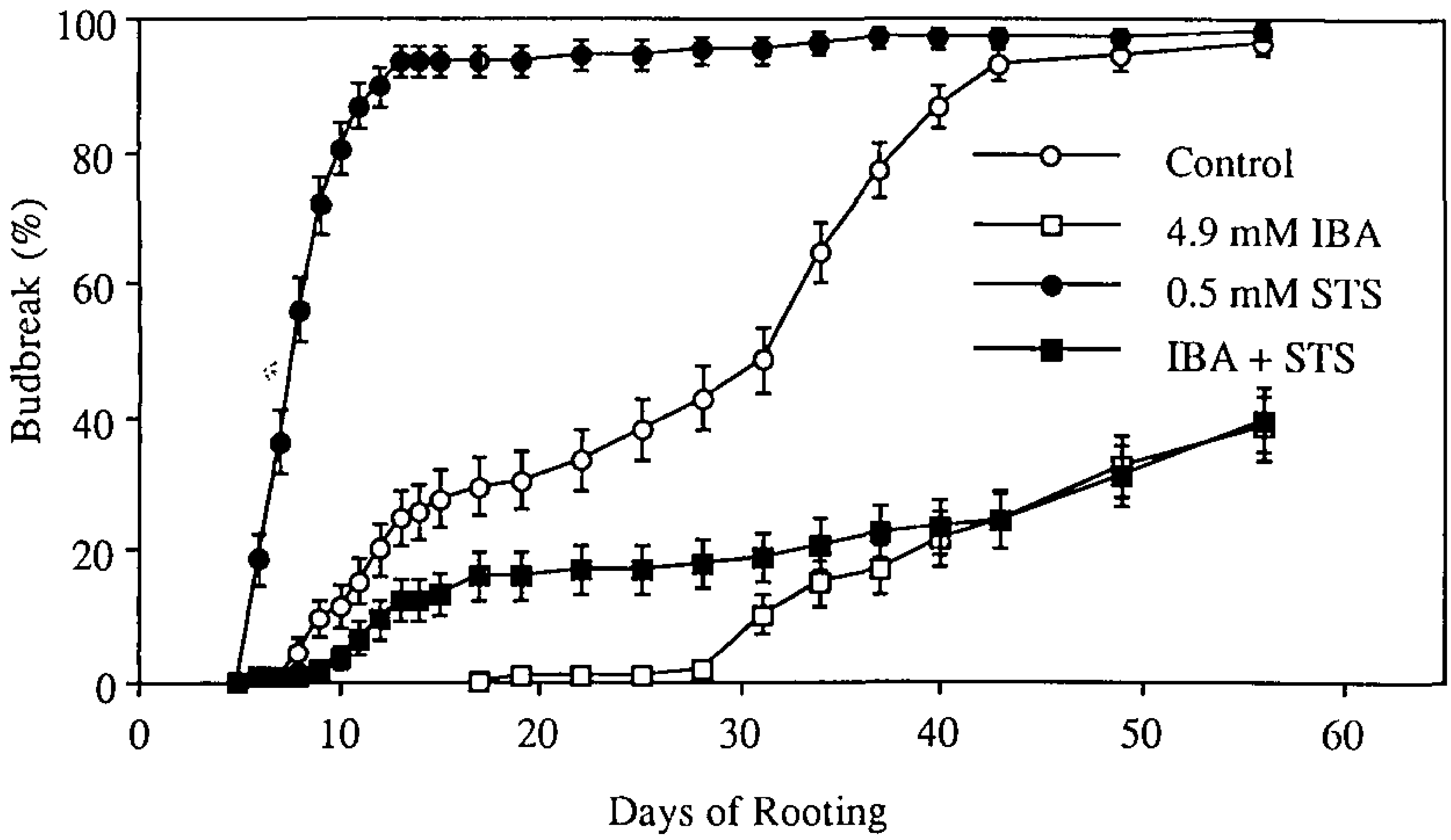

Figure 5. Bud break in 'Royalty' rose cuttings after STS and IBA treatments (Experiment A). Bars indicate SE of the mean (N = 120).

In prior work, ethylene applied to pea nodal sections and decapitated stem cuttings effectively retarded axillary bud development. Buds lost their ability of further development when ethylene treatment lasted more than 3 days (Burg and Burg, 1986). IBA treatment dramatically increased ethylene production of rose cuttings over the first week (Fig. 3). Significant differences in ethylene levels between the control and IBA-treated cuttings was still apparent even after 20 days. In pea plants, stem ethylene concentration decreased after decapitation which stimulated the outgrowth of lateral buds. Ethephon suppressed axillary bud development when it was applied to nodes, axillary buds or the cuts of decapitated plants (Yeang and Hillman, 1982).

Recent work conducted in two laboratories provided further support for our hypothesis. Wiesmen et al. (Wiesman et al., 1989; Wiesman et al, 1989) showed that IBA applied at the cutting base was more likely to be transported to the upper part of the cutting and rapidly metabolized into IBA conjugates, which were even superior to free IBA in serving as the auxin source during the later stages of rooting. Moreover, Riov and Yang (1989) observed that IBA-treated mung bean cuttings had higher levels of ethylene precursors and ethylene in the upper part of the cutting during rooting. These studies, together with our present results, suggest that applied auxin was transported to the upper part of the cutting, increased ethylene production, and as a result, inhibited bud break of cuttings. Auxin-induced ethylene synthesis is primarily responsible for the bud break inhibition of auxin-treated cuttings.

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FRASER HANCOCK: Is the leaf drop that occurs with *Ilex* during cutting propagation related to ethylene?

NINA BASSUK: It could very well be that your increasing the ethylene level which may be increasing the senescence of the leaves.

STEVE MCCULLOCH: Did you notice any carrier effect differences.

NINA BASSUK: No.

Development of Double Flowering (Petaloid) Lepidote Rhododendrons

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Lepidote rhododendrons in the landscape are generally perceived by the casual observer as different from large leaf rhododendrons. Because their foliage and growth is normally only about half the size of the large leaf rhododendrons, lepidotes often appear to more closely resemble evergreen azaleas. This creates an intriguing situation. Evergreen azaleas thrive in non-stressful planting locations and are well suited for gardens where winters are moderate, but they generally perform inconsistently in northern landscapes. In USDA Zone 5 and colder, many of the so-called evergreen azaleas retain few leaves over the winter, and those that remain often suffer unsightly burning from sun and wind. Flower buds on many evergreen azalea cultivars are less able to tolerate sharply variable and low winter temperatures, often opening unpredictably in northern gardens.

Because of this winter hardiness deficiency there is a need for more reliability in evergreen-azalea-type plants in northern landscapes. The lepidote rhododendrons have the potential to fulfill this need even though most of today's lepidotes are more vigorous and upright growing than a typical evergreen azalea. In fact, their superior tolerance of winter wind and sun may help improve garden appearance if a few of their shortcomings can be corrected. The development of double flowering lepidotes serves to further enhance their potential, and may create an opportunity for better looking gardens.

The term "double flowering" can be confusing and is ambiguous in nursery industry usage. Some of the hybrids I will describe have completely double flowers (all of their stamens have been transformed into petals), some are only semi-double (some of the stamens are partially or fully transformed into petals), others are "hose-in-hose" (one set of petals within the other), and still others are combinations of double and hose-in-hose. There is often variation among individual flowers on the same plant as well. A more appropriate term for "double flowering" might be "petaloid", implying any modification of stamens into petals. I am also aware that other breeders have done work with double flowering lepidotes, but this presentation will focus upon only those developed at Weston Nurseries.

Edmund V. Mezitt grew up immersed in horticulture and worked with his parents, Peter J. and Anna, at their nursery in Weston, MA. He and his dad had often lamented the dearth of winter hardy colorful rhododendrons suitable for New England. They had worked to improve the selection over the years by recognizing, selecting and vegetatively propagating plants with superior characteristics from seed grown populations. They had also begun to try some of the new cultivars becoming available from other sources. However, after graduating from Cornell in 1937, Ed came to realize that real improvement would only occur with more direct hybridization and selection efforts.

Ed's very first attempt at hybridizing in 1939 was extremely fortuitous. It resulted in the now familiar *Rhododendron* 'P.J.M.' hybrids which, in addition to being superior plants in their own right, have become parents for many new hybrids, including all of our petaloid hybrids. The pollen parent of this hybrid was an unidentified species (later recognized as *R. dauricum* var. *sempervirens*) which Ed and his dad, Peter J. Mezitt, had received from a missionary who collected plants in China. The seed parent was a selected plant of *R. carolinianum*, a common New England landscape choice, from Peter Mezitt's home landscape. It seems probable that the petaloid characteristics that occur in later hybrids are carried in the genes of the *R. dauricum* because we have observed no doubles in crosses of *R. carolinianum* alone. It is still unclear whether petaloid-prone genes are unique to the specific individual *R. dauricum* that was the 'P.J.M.' parent.

Although Ed performed additional crosses after the 'P.J.M.' cross, no records exist until 1950 and 1958 when he documented 33 and 37 crosses respectively. Most of his 1950 attempts were between different species of rhododendrons/azaleas and intended to generally expand the season of color. By 1958 he had begun to focus upon specific characteristics within the groups; those crosses performed with lepidotes attempted to develop an early blooming white similar to 'P.J.M.' Several lepidote cultivars that we grow today resulted from those 1958 crosses: cross #33 ('P.J.M.' on *R. carolinianum* 'Album') produced *R.* 'Balta' and *R.* 'Laurie'; cross #36 (*R. mucronulatum* 'Cornell Pink' on *R. carolinianum* 'Album') produced the "Shrimp Pink" series from which he selected 'Caronella', 'Llenroc' and 'Vallya'.

In 1963 Ed Mezitt recorded 129 crosses and began a hybridizing/selection program that continued every year (excepting 1965) until his death in 1986. About one third of his 1963 crosses involved lepidotes. From his records and in my frequent conversations with him regarding hybridizing goals, it is evident that he recognized substantial potential for the lepidote rhododendrons in the New England landscape. Even though to my knowledge he never expressed the desire to replace the evergreen azalea with lepidotes, he was well aware of their superior characteristics for this climate. Superior winter hardiness, wider choices of color, attractive foliage year-round, expanding the season of color, and generally to maximize the ability to thrive in the climate and soils of central and northern New England were his prime breeding objectives.

It was in 1963 that he documented his first attempt to create double flowering plants by using a 'P.J.M.' that occasionally exhibited an extra petal (he called it "double P.J.M.") as a parent. Cross #66 [his "evergreen pink *R. mucronulatum*" (probably a selected pink *R. dauricum var. sempervirens*) on "double P.J.M."] was the first one to actually produce truly double flowers. Cross #90 (pink *R. mucronulatum* on 'P.J.M.') produced two seedlings that, while not double themselves, each produced a petaloid plant (*R.*'Counterpoint' and *R.* 'Staccato') when self-pollinated.

A major breakthrough occurred in his 1964 cross (#201) between a *R.* 'P.J.M.' and *R. mucronulatum* 'Cornell Pink'. This was one of 146 crosses he performed that year, and it resulted in one remarkable fully-double pink plant which he named 'Weston's Pink Diamond'. These first four petaloid hybrids expanded Ed's awareness of the possibilities for new hybrids and formed the basis for all the petaloid rhododendrons we grow today.

Many of the features of petaloid lepidote rhododendrons can help to increase the appeal of New England landscape plantings. The ones we've developed are extremely early blooming plants, among the first woody plants to welcome the spring. Most of the ones we grow flower consistently earlier than *R.* 'P.J.M.'

cultivars. They have tested winter hardy throughout most of southern New England (USDA Zone 5), and seem to thrive in open, exposed planting locations normally considered unsuitable for rhododendrons and azaleas. All have a propensity to blossom at a very young age, often when only inches tall. Because of their precocious tendency to set flower buds after only a few weeks growth, they tolerate shearing without sacrificing the next spring's bloom. All seem to be easy to propagate conventionally or by micropropagation. Since their stamens have been modified to form additional petals, they produce very little pollen and tend to be sterile; by setting no seed heads they require no deadheading to maintain clean appearance and vigor. Colors currently range from pure white to pink, and provide a welcome supplement to the familiar lavender rhododendrons (*R. mucronulatum* and *R. dauricum*) that bloom at the same season.

These new hybrids also have disadvantages. Because they are so very early to bloom in the spring, they are susceptible to damage from late frosts and freezes. Choosing a planting location with adequate air drainage is important because damaged flower heads are unsightly and can linger on the plant until new growth covers them. Most of these hybrids tend to be more upright growing than spreading. Most are rather vigorous and require periodic shearing, particularly when young, to maintain shape. Additionally, most retain relatively few leaves in winter. While most are not entirely deciduous, their winter foliage (although often colorful) is not one of their best features. A major problem, which they share with most other lepidotes, is their susceptibility to root diseases such as *Phytophthora*; this is best prevented by planting healthy plants in well-drained soil and maintaining plant vigor with proper cultural practices,

A major objective in our current breeding programs is to improve winter foliage retention so that the plant presents an attractive appearance in the landscape all year. We are also working on enhancing the flowering characteristics to include a wider range of colors, more intense flower colors and increased frost resistance. Breeding to move the flowering season later would avoid the frost danger and would also help make them look more like an evergreen azalea to the ultimate consumer.

We've found that a significant challenge in introducing a new plant is the vast amount of time necessary to overcome skepticism and induce the consumer to change from current preferences. This situation is exacerbated when potentially important features of the plant are disappointing or when the long term performance of the new plant is not proven. With the lepidote rhododendrons, thanks largely to the success of *R.* 'P.J.M.', many people are already familiar with some of the attributes of lepidotes. While this helps overcome some apprehension, much testing must still be done to truly evaluate their value to the landscape.

Whether or not these new hybrids ultimately prove to be appropriate alternatives to the evergreen azaleas remains to be seen. But these petaloid lepidote rhododendrons are already, on their own merits, important assets in Zone 5 gardens. And as we achieve the improvements I've described, it seems inevitable that they will become an essential component of tomorrow's gardens.

Rooting Double White French Hybrid Lilacs—Power vs. Liquid IBA

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INTRODUCTION

Because of difficulty in rooting double white lilacs at the Royal Botanical Gardens (R.B.G.) using our conventional method of 8000 ppm IBA in talc, we decided to treat cuttings of seven double-white, French-hybrid cultivars with 5000 ppm IBA in alcohol and compare the results with our conventional method. The results showed there may be a minimal advantage towards using alcohol over the talcum powder and that *Syringa vulgaris* 'Krasavitsa Muskovy' was by far the best double white lilac to be rooted from softwood cuttings.

Lilac propagation has been a leading priority of R.B.G. for some time. A concern has been to make sure lilacs are on their own roots to help insure trueness- to-name and to help avoid incompatibility problems, hence the reason for rooting lilacs from softwood cuttings.

MATERIALS AND METHODS

Double-white, French hybrid lilacs used in this study included (Rogers, 1976):

'Krasavitsa Muskovy'	Kolesnikov, USSR, 1963
'Madame Lemoine'	Lemoine, France, 1890
'Professor E. H. Wilson',	Havemeyer, New York, 1943
'Oakes' Double White'	Meader, New Hampshire, 1963
'Rochester'	Grant, New York, 1971
'McMaster Centennial'	Brown/Pearson, Ontario, 1987
'Saint Joan'	Blacklock, Ontario, 1953

Lilac propagation is done in an unheated, quonset-style, fiberglass-covered greenhouse measuring 10 x 30 ft (Graham, 1986). There is an exhaust fan at one end and during the summer months the house is covered to provide 50% shade inside. There are two benches, one on each side with an aisle down the middle. The benches are filled with sharp sand and thermostatically controlled electric heating cables are buried within to provide constant bottom heat of approximately 70°F. Humidity and irrigation are provided by an intermittent mist system. The mist nozzles used are 'Pate B1O' which are brass, have a 1-mm orifice and a discharge of 0.9 liters per minute at 25 psi. The nozzles are spaced at 36-in. centers on a 1/2-inch copper line suspended about 18 in. above the cuttings. Water to the line is controlled by an electric solenoid valve. Preceeding the solenoid valve in the water line is a 1/2 in. line strainer to remove any debris which might clog the nozzles. The solenoid valve is activated by 2 time clocks wired in sequence. The first clock runs a standard 24 hour cycle. During its "on" period, it activates a 30 min time clock with 30 sec calibrations. The on periods for both of these clocks are manually altered based on prevailing weather conditions. Typically on a sunny July day 30 seconds of mist would be applied every 15 minutes between 8:00 a.m. and 7:00 p.m. The water used is city water with a pH of about 7.4.

All lilac cuttings are rooted in wooden boxes with inside dimensions measuring 22 x 10 x 3.5 in. The rooting medium is a homogeneous mixture of 4 parts sharp sand to 1 part screened sphagnum peat moss. The medium is suitably moistened prior to sticking the cuttings. The pH of the medium is not monitored on a regular basis, but is decidedly alkaline.

Maturity of the wood is a key factor in softwood cutting propagation. If taken too early, cuttings are soft and very perishable; if taken too late, they become woody and difficult to root. In Hamilton, harvesting of cuttings is done after flowering during the first two weeks of June, when the softwood shows a dappled brown colour.

Early morning or rainy days are the best time to collect the cuttings. Generally, the cuttings collected are 4 to 7 in. long and have 4 to 6 pairs of leaves. Poor growth, diseased material and rank or sucker-like growth should be avoided. After being severed from the plant the cuttings are dipped in water and stored in plastic bags in the shade until needed.

All cuttings are prepared individually in a shaded area. The lower one or two pairs of leaves are removed and a fresh basal cut just below a node is made leaving 2 or 3 pairs of leaves. The leaf area may be reduced by half to permit greater density of cuttings while still maintaining adequate air circulation. A 1/2 in. wound is made on one side of the cutting above the basal node.

All the cuttings were collected and stuck in one day. We took as many cuttings as we could from each cultivar. Half were dusted with 8000 ppm IBA in talc (0.8% IBA Stim-Root No. 3) and the other half were dipped in 5000 ppm IBA in alcohol (0.5% IBA Stim-Root Liquid 5000).

Due to the lack of cuttings we did not stick a control group of cuttings. The cuttings were then inserted into prefilled boxes of rooting medium on 1.5 to 2 in. centers. Filled boxes were then moved to the mist house and closely monitored. The average time for lilacs to root is 7 to 10 weeks. We did not have time to tally the results until the first of October.

RESULTS

First we counted the number of roots on each cutting and tabulated the results (which we have but are not shown here). We then added all the cuttings that rooted and presented them as a percent of cuttings rooted (See Table 1).

Secondly each cutting was rated on a scale of 0 to 5 according to the quality of roots:

0 = Cutting is dead
1 = Cutting is alive, no callus or roots
2 = Cutting is alive with one root, survival is doubtful
3 = Cutting is alive with several roots, little branching, survival is questionable
4 = Cutting is alive with several roots, all with some branching, survival is likely
5 = Cutting is alive with abundant vigorous branching roots, survival is very good.

The cuttings which were most likely to survive (ratings 4 and 5) were then added together and presented as a "Percent of cuttings likely to live."

The findings show that using 5000 ppm IBA in alcohol is slightly better than using 8000 ppm IBA in talc. 'Krasavitsa Muskovy', 'Madame Lemoine', 'Professor E. H.

Wilson', and 'Oakes' Double White' all had high percentages of rooting. On viewing the column of Percent of Cuttings Likely to Live only 'Krasavitsa Muskovy' had a high total making it the preferred cultivar to root.

Table 1. The effects of IBA concentration and application method on lilac cutting rooting.

Cultivars	Number of cuttings	IBA concentration (ppm)	Cuttings rooted (%)	Cuttings likely to live (%)
Krasavitsa Muskovy	100	8000 talc	96.0[1]	82.0[2]
	100	5000 alcohol	92.0	79.0
Madame Lemoine	100	8000 talc	83.0	51.0
	100	5000 alcohol	94.0	63.0
Professor E.H. Wilson	75	8000 talc	76.0	40.0
	75	5000 alcohol	78.7	46.6
Oakes' Double White	100	8000 talc	78.0	42.0
	100	5000 alcohol	61.0	39.0
Rochester	75	8000 talc	34.7	17.3
	75	5000 alcohol	44.0	20.0
McMaster Centennial	40	8000 talc	10.0	0.0
	40	5000 alcohol	15.0	0.0
Saint Joan	100	8000 talc	6.0	0.0
	100	5000 alcohol	4.0	1.0

[1]Any cutting that had just one root was recorded as rooting.
[2]Numbers 4 and 5 from the scale to measure the quality of roots were added together to make the column "Cuttings likely to live".

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Propagation of New Japanese Maples Cultivars

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How do we come by the selection of new and distinctively different cultivars of Japanese maples? More importantly, how do we test these new cultivars to be absolutely certain that they are winter hardy, heat or drought resistant before we name and introduce to commercial propagators. Let us take a close look at some of these answers.

THE SELECTION PROCESS

Our Nursery in Media, Pennsylvania has dozens of rare and unusual Japanese maples covering about one acre with another one-half acre of rare and unusual trees in our private arboretum. Most of these trees are 20 to 30 years old. As you may or may not know, Japanese maples have very small flowers ranging from 1/8 to 1/16 in. An abundance of flowers can be found on most trees in the spring and in years of stress. With active insect and honey bee activity (we keep honey bees for this purpose), all of these older trees are cross pollinated. In the fall, thousands of seeds fall to the ground and by the next spring, they become sturdy little volunteers with a great proliferation of leaf sizes, shapes and colors.

It has been a yearly enjoyment of my wife, Carolyn, and myself to study this carpet of thousands and thousands of tiny volunteers. We use little wire marker flags to put alongside the most unusual plants that exhibit spectacular leaf color and vigorous growth habit. This marking is done in early June with lifting and potting completed by the end of June.

Usually 300 to 500 trees are lifted and tagged using the following code: series 168, year 91, tree number 25. Tagging is done with aluminum tags and logged into a log book for future observation. Periodic evaluation and recording takes place. This process is extremely time consuming but equally important in tracking a potential new cultivar.

The weeding out process now takes place and over the next two years, we may retain only 5 to 10 trees out of the original 500. You may have observed that summer high temperatures of over 90 to 100°F coupled with a prolonged drought, have a marked tendency to cause most Japanese maples to lose there lovely spring color. Under the above conditions, they soon exhibit a marked tendency to green.

We here at Red Maple Nurseries have searched for a tree that would hold its red color regardless of heat or drought. Thus, the cultivar Moonfire was discovered, tested and released to the commercial market. We estimate that over 500 growers are growing 'Moonfire' here in USA, Holland, Canada and England.

'Moonfire' is a splendid color addition for Japanese maple growers. 'Moonfire' is, however, a slow grower and lacks the strong growth of 'Bloodgood'.

Our search for a more vigorous plant that would hold its red color regardless of heat or drought intensified. We built six aluminum frames under high shade and in the fall, scattered and planted many thousands of seed taken from a variety of our large red *Acer palmatum* trees.

In spring, these seeds germinated and a profusion of color resulted. We will now pay particular attention to the red leaf color under shade. How long would this intense red color hold up? Would it fade out in high temperatures and drought conditions of 90 to 100°F?

After several years of testing and many great disappointments, finally a new little tree emerged that showed great promise. The color seemed to increase under high temperatures. Placed side by side with 'Bloodgood', the new cultivar showed no fading or greening. We have named this tree 'Emperor One'.

TECHNICAL ASPECTS OF PROPAGATION

Acer palmatum 'Emperor One' was a seedling selection found by my father, Donald G. Wolff. This tree has been under close observation and experimental testing for the last 30 years. Color is a high-intensity dark red with little or no color fade out in extremely high temperatures. This year's summer temperatures with many, many days ranging from 90 to 100°F and considerable drought, proved conclusively the value of this new fade proof Japanese maple. It is drought resistant and exhibits excellent growth characteristics which are superior to 'Bloodgood' that has been the standard of the trade for many years. This cultivar winter grafts very well and is being produced in quantity by summer cuttings. I am a firm believer that a new cultivar should be thoroughly tested 8 to 10 years before release. 'Emperor One' should be released this coming year.

Acer palmatum 'Hubb's Red Willow', named for Elwood Hubbs, an outstanding grower from Riverton, N.J. A delightful tree with long, red willow-like leaves which holds its color well into the season. Color retention is equal to that of 'Bloodgood'. 'Hubbs Red Willow' has a fastigate quality but can be easily pruned (in the winter) to present a fuller profile.

'Hubb's Red Willow' is relatively easy to propagate both by winter grafting and summer cuttings. It is drought resistant and quite winter hardy in the New England states and Great Lakes region. Being quite heat tolerant, it can be grown as far south as the Carolinas. This cultivar has been on test at our Snowdenville Nursery for 10 years.

Acer palmatum 'Green Mist' a seedling selection found in 1949 by my uncle, Prof. William H. Wolff, a professor of horticulture. Over 500 nurseries are growing 'Green Mist'. As the name implies, it has a beautiful light green color in spring with a pleasing green canopy somewhat resembling the cultivar Waterfall. The outstanding characteristic of 'Green Mist' is its beautiful fall coloration of bright chrome yellow leaves mixed with intense red leaves and some green leaves on the underside. Growth habit is sturdy, developing pendulous branching to the ground. This tree is winter hardy in the New England states and Great Lakes region. It is drought resistant and heat resistant and can be grown as far south as the Carolinas. 'Green Mist' can be rooted, but it is more desirable to graft the tree 6 to 10 in. high on the rootstock for better appearance.

PROPAGATION BY GRAFTING

Propagation of 'Red Willow', 'Emperor One' and 'Green Mist' by winter grafting is easily accomplished using the same rootstock for the three cultivars and dozens of other cultivars we produce. Rootstocks are seed grown *A. palmatum* (small seed) or referred to as "littleleaf". We have gone to a 4 to 5 in. deep square plastic pot for larger and stronger understock. Our findings show that you can get the grafted tree off to a superior start by using a larger rootstock. Rootstocks are of extreme importance for the economics of production with fewer losses on the bench and earlier line-out time.

It seems there are as many potting mixes as there are growers. Basically, we use *1/3 fine ground pine bark, 1/3 good garden loam pH 6.5, and 1/3 mix consisting of* sand and perlite to which is added some dolomitic limestone to adjust the pH.

Rootstocks are lifted and potted ideally in March which gives the entire spring and summer for growing and adjusting to the pot. Rootstocks should be placed in partial shade (30%) and attention should be given to proper watering and fertilizing. A balanced liquid fertilizer such as Peters 20-20-20 is used. We fertilize four times a year being careful to discontinue all fertilizing after August 15th. This prevents the trees from pushing new growth too late in the season and prevents winter damage or possible death.

Rootstocks should be dormant by mid-November when they are brought into the propagating house which has a constant temperature of 60°F maintained both day and night. By January 1st, the trees are breaking dormancy and new white roots have formed on the root system. This should signal that it is time to graft. All tools and the entire grafting area must be frequently sterilized using a disinfectant, sanitizer and fungicide, such as Physan 20. A grafter's hands must be kept clean to prevent pathogens from entering the graft union. This is a common error by new and inexperienced grafters. Consider your grafting room as a hospital operating room with maximum sanitary conditions and plenty of good, diffused lighting. Grafting knives must be razor sharp. They are sharpened by using a good stone and leather strap for final sharpening. We use a goodyear rubber strip to bind the scion to the rootstock. We find a side approach graft is the best. A tip on binding— not too tight—not too loose, but firm and keep the rubber strip flat while binding. We use a small cut-down paper clip to aid in locking up the binding strip by pulling it through and under the last binding. Grafted stocks can be dipped in wax at 140°F or the union plunged under perlite or even sand as some European grafters do. New foliage will appear in 30 days and now attention must be given to watering. We remove all grafts from the greenhouse by the first of June— putting them in about 40% shade and later in full sun. Light liquid fertilizing (using Peters 20-20-20) is given when taken out of the propagating house and again in June and July. No fertilizer should be given after August 15th as mentioned in growing understocks.

By mid-November, we bring the trees into an underground storage cell such as a root cellar. Winter protection requirements include adequate ventilation and watering as needed; light is not necessary. Weekly inspections for fungus and mice are necessary. We use Ropel for mice and Captan for fungus—other good fungicidal drenches are equally as good. Plants are removed by late April or early May. Trees are either planted out as field liners or preferably grown on for one year (in the original grafting pot) and lined out the following year. Early frost can be dangerous so use constant vigilance for temperature changes.

PROPAGATION BY CUTTINGS

Our experience with rooting cuttings goes back some 30 years. We had many failures before analysis of failures produced success. Cutting wood is always taken from a well hydrated tree. You are wasting your time to take wood from a dehydrated tree. We gather our large cutting wood very early in the morning (5:00 a.m. to 10:00 a.m.) and place it in a large styrofoam container in layers of ice.

Cutting wood collection in eastern Pennsylvania starts on June 10th. Our potting mix is pine bark, peat moss, perlite mix or commercial pro-mix and the pots should be filled in advance and watered with a surfactant such as Aqua Gro to be certain they are wet.

Hormone liquid dip treatment using one of several commercial root inducing substances containing indolebutyric acid and naphthaleneacetic acid, such as in Dip-N-Grow. Our dip treatment consists of one part hormone to six parts of water. It is important to have a tiny amount of surfactant in the dip to assure good coverage of the cutting when dipping for 3 to 5 sec. Flats of cuttings go immediately to the cutting propagation room were a temperature of 70 to 85°F is maintained with good air circulation. A high pressure fog system is good, but you must avoid too much water going into the pot. Try to maintain 95 to 100% humidity in your rooting room.

Humidity is reduced when the cuttings are well rooted and moved to the outside. Rooted cuttings must be in 50% shade for the balance of the summer. As with new grafts, they are moved into our underground winter storage cell and treated identically as the new grafts with the same precautions. Rooted cuttings are fertilized with a dilute solution of Peters 20-20-20 three times after coming from the rooting house but no fertilizer later than august 15th as with the grafted trees. In May of the second year cuttings are lined out, fertilized and cultivated. Ronstar, Surflan and Devrinol can be used as pre-emergence weed killers but consult and read the label for concentrations.

PROPAGATION BY SEED

Seed is picked in early October or before the nocturnal gales blow it away. It is usually planted in specially prepared seed beds and covered 1/4 in. with bed mix and 1-1/2 in. with white pine needles to firm it in. Beds are in 70% shade. Before sowing seed, it is dipped in ropel to prevent mice, birds and squirrels from eating it. The seed bed mix is 50% fine pine bark, 25% good loam, 13% sand and 12% perlite. We pick only *A. palmatum* "Littleleaf" (small seeded) for rootstock. After 2 years in the seed bed the rootstock is ready for potting as previously outlined.

MONDAY EVENING 9 DECEMBER 1991

The Forty-First Annual Banquet was held in Salon E of the Marriott Wind Watch Hotel & Golf Club, Hauppauge, New York.

1991 RESEARCH GRANT AWARD

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DR. PAUL L. SMEAL made the following Fellow Award an Qward of Merit presentations.

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he published a bulletin on chemical weed control in grapes.

In 1951 he returned to Perry, Ohio, to join with his brother Charles and partner Paul Brockway in the operation of the family nursery that had its beginning 1919. He became president of the firm upon it's incorporation in 1956. He retired from active participation in the nursery in 1980.

His dedication to and participation in horticultural interests extends from 1953 when he was elected president of the Lake County Nurserymen's Association until the present. Among his many unselfish and diligent services are: President, Lake County Soil and Water Conservation District; member, Lake County Agricultural Extension Advisory Board; President, The Ohio State Floricultural Alumni Association; member, Area Extension Planning Committee; President, The Ohio Nurserymen's Association (1971); member, Legislative Committee The Ohio Nurserymen's Association; Chairman, The Ohio State University Horticulture Council that was active in procuring the new horticultural building, Howlett Hall and greenhouses; Charter member and one of the founders of the I.P.P.S. in 1951; President (1969) of our own Eastern Region of the I.P.P.S, member, Board of Directors of the Ohio State College of Agriculture and Home Economics Alumni Associations; member, Commission on the Study of Insectides for the American Association of Nurserymen; Chairman, Pesticide Committee for the American Association of Nurserymen; Chairman, Black Vine Weevil Research Fund, Lake County Nurserymen's Association; member, Ohio Governor James Rhodes Governor's Committee on Migrant Labor; member, Support Council of the Ohio Agricultural Research and Development Center of The Ohio State University; Horticultural advisor to the Cleveland Home and Flower Show.

Our recipient has received numerous awards including: in 1964 our recipient was awarded the honorary title of "Mr. O.N.A." by the Ohio Nurserymen's Association for his years of service and dedication; elected to Gamma Sigma Delta, Honor Society of Agriculture and elected to Phi Alpha Xi, National Floriculture Honorary Fraternity, in recognition of his out-standing achievements and contributions in the field of ornamental horticulture in the United States, recipient of the Centennial Alumni Award from The Ohio State College of Agriculture for distinguished service in 1982, again in 1991 "Distinguished Alumni Award" by The Ohio State College of Agriculture.

In his "free" time he was able to devote considerable time and talent to the Lake County Planning Commission, Lake County Farm Bureau, Perry United Methodist Church, Perry Zoning Board of Appeal, and the Judson Retirement Community.

It gives me great pleasure to present to you, Mr. **David (Dave) Dugan**, the 1991 recipient of the Eastern Region Award of Merit.

TUESDAY MORNING 10 DECEMBER 1991

The morning session was convened at 8:00 a.m. with Clayton Fuller serving as moderator.

Taxol Update

Ralph Shugert
Zelenka Nursery, Inc., 16127 Winans Street, Grand Haven, Michigan 49417

For as long as man has inhabited the earth, his medicine has been derived from plant parts—roots, stems, leaves, flowers and fruits. I do not propose to present an exhaustive list of plants, worldwide, and their remedy, but a few examples: hemlock (powdered), controls headlice; hemlock (chewed), stops bleeding; salmonberry bark, numbs toothaches; thimbleberry leaves, strengthens blood; and *Artemisia,* anti-malarial. Obviously, the list of plants is endless and many of the world's museums have displays relative to this topic, such as seen in the marvelous museum in Sydney, Australia. Many scientists, including my good friend, Dr. Ed Croom, have spent time with various native people observing the time-honored practice of healing by the use of plant parts. Some of these studies included a monkey searching a specific plant to cure a particular malady. The scientist would then identify the genus/species with the assistance of a competent botanist.

On 17 April 1991 as a part of the I.P.P.S. International Board Pre-Tour, I visited Thursday Plantation, Ballina, New South Wales, Australia. This nursery, founded in 1979, is producing plants of *Melaleuca alternifolia* not for the landscape trade, but for the pharmaceutical market. They market Australian tea tree oil for virtually any body rash or itch known to man! Their annual production is one million seedlings, transplanted to their plantations. Their return from the extracted medicine for 1990 was one million dollars.

In July of this year, many of us read with great interest, the excellent discourse written by fellow member, Peter Del Tredici (Del Tredici, 1991), entitled, "*Ginkgo* and People—A Thousand Years of Interaction". Peter described a 1,000 acre nursery in Sumter, South Carolina, which harvests, dries, bales and ships *Ginkgo* leaves to Europe for extraction. Gross sales in 1988 amounted to about $500 million. This *Ginkgo* leaf extract has demonstrated a positive effect in increasing vasodilation and peripheral blood-flow rate in the capillaries of patients suffering from a variety of circulatory disfunctions. It has also proven effective in a number of other maladies, including arthritis.

I mentioned the above two examples, *Melaleuca alternifolia* and *Ginkgo*, as a prelude for discussion of another plant genus, *Taxus*. I first heard the word taxol, which is a derivative of taxane, in 1988. In 1989, I initiated R&D project 89-2 for our nursery. Since that date, I have accumulated reams of data. Our sister and brother I.P.P.S. members have been very kind in sending me copies of magazine and newspaper articles relative to this topic. I am very proud to have had comments sent to me from all six of our I.P.P.S. regions. These contributions to my files range from International President Bunker to our own Paul Smeal, whose most recent communication was two weeks ago.

I propose, at this point, to briefly explain the origin of taxol, where the plant propagator fits into this puzzle today and what my crystal ball sees for the future.

In the mid 1950s, a chance discovery by researchers at Eli Lilly Company, prompted the National Cancer Institute (NCI) to implement a major program to discover anti-cancer substances from natural sources—plants! In the late 1960s, preparations from *Taxus*, especially extracts of *T. brevifolia* bark, were shown to be quite cytotoxic. Then, in 1971, a group at Research Triangle Institute isolated pure taxol. Due to the scarcity of the drug, only a few cancer types have been investigated to date. Nonetheless, excellent response has been demonstrated for advanced refractory ovarian cancer. This result has been verified in more extensive human cancer treatment studies. NCI has announced that the efficacy of taxol in ovarian cancer warrants full clinical development. Once available commercially, it is estimated approximately 10,000 to 12,000 ovarian cancer patients each year would receive treatment, creating a need for roughly 50 pounds of taxol each year —just for the United States. As the potential of taxol to treat other cancer types is realized, and early results in breast cancer are very promising, even greater quantities of the drug will be required to meet the clinical need. At this point, I want to note that the pure taxol produced to date has only been produced from the bark of *T. brevifolia*, not from needles and twigs of a cultivated plant source. This leads us into developments initiated in 1988 and continuing to date.

In October 1989, Ken Cochran, curator of Secrest Arboretum and Ed Croom, Research Institute of Pharmaceutical Science, University of Mississippi, visited with me at Zelenka Nursery, Inc. Due primarily to the efforts of Cochran and Croom, an organization named, The Alliance of Growers and Universities for *Taxus*, was formed.

In November of 1989, I was invited to Washington, D.C. to attend a USDA sponsored meeting. This meeting generated much verbiage, very little positive action and my introduction into bureaucracy! Truly incredible!

In March of 1991 representatives from Rhode Island Nurseries, Studebaker Nurseries and Zelenka Nursery, along with Ken Cochran, met with representatives from the Natural Products Institute, University of Mississippi at the OARDC in Wooster, Ohio. The name of the organization was changed to The Alliance for the Production of Taxol. Among positive actions this meeting generated a letter sent to some 70 plus *Taxus* producers asking them to sign a commitment agreement which, among other things, will inventory *Taxus* species/cultivars by age and availablity for potential drug extraction.

The first drying of *Taxus* clippings took place at Zelenka Nursery on 6 April 1991. I hasten to add that the biomass for a potential multi-billion dollar drug is being dried in a 45 year old corn dryer! Sounds incredulous, but it is true. Drying took place through May and early June, 1991, and on 12 June 1991, NCI denied a proposal from the alliance (through USDA) to produce taxol from needles/twigs of *Taxus* cultivars. It is ironic that at about this time the Forest Service was given permission to allow the harvest of 750,000 pounds of bark from *T. brevifolia* for 1991. These 100 year old, plus trees (supposedly the slowest growing conifer in North America) are admired by many environmentalists and also, are the habitat of the spotted owl. It is reported that three to six trees yield enough bark to produce taxol to treat one lady. The alliance has constantly maintained that the nursery community has a sustainable source of supply with our cultivated *Taxus* plants, rather than the rape of our native western yew.

Zelenka started drying again in September with biomass received from Rhode Island Nurseries, and clippings received from Fairview Nurseries in October. November, December and January drying activities involved whole plants received from Gardner Nursery. Other than a few cultivars for clinical testing, all drying has consisted of *T.* x *media* 'Hicksii'. On 16 September 1991 Zelenka Nursery received a cooperative agreement from USDA to produce (and dry) 100,000 lb of *T.* x *media* 'Hicksii' for the cancer treating drug, taxol. The first shipment, after much delay, is scheduled to ship next week. Time will tell!

Now, where does the nursery community, and particularly the plant propagator, fit into the taxol program?

First of all, anyone growing *Taxus* can join the alliance. Your contact is Ken Cochran, Secrest Arboretum, who can advise you as to the questionnaire, contract, etc. If I can help, please ask me. Second, is there a potential for a *Taxus* second market, one for drug production? The answer is definitely affirmative! The vast majority of nurseries are more comfortable in supplying biomass from clippings, cull plants, and propagation waste rather than gamble with dedicated acres without a contract. In my view, contracts will be on the horizon, probably offered by someone outside our nursery community. I urge you to carefully review any contract extended to you!

I have celebrated 69 birthdays on this planet and am probably more naive today than I was as a child. I can recall, in 1989, how great this Research and Development project was going to be. First, and foremost, the humanitarian feature of my nursery community saving ladies' lives with normally discarded clippings from pruning, propagation waste and culled plants. We would gather the waste from our *Taxus* plants, send the material off to some magical facility for drying, extraction and purification, and quickly the drug taxol would appear! How naive can one be?

My friends, I have learned that the pharmaceutical industry does not subscribe to our motto of "To seek and share". I don't understand, nor do I adhere to a mentality of confidentiality. This has been very difficult for me, to say the least. I can contact the University of Wisconsin and discuss taxol with Brent McCown or Dave Ellis, who are conducting taxol intercellular research, quite comfortably because we are I.P.P.S. brothers.

I am not allowed to enjoy that type of dialogue with pharmaceutical companies around the world. It is apparent, one view is first, to save lives and the other view is, profit foremost.

The Alliance is viable because most growers in the Alliance have propagators and production people who are I.P.P.S. members. As plant propagators, we once again have the opportunity to utilize the plant parts of *Taxus* to save lives, in addition to beautifying the world. All of us have a tremendous challenge and by seeking and sharing, we definitely will meet and accept and conquer the challenge.

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An Update on Trademarks and Cultivar Names

Richard H. Munson
The Botanic Garden of Smith College, Northampton, Massachusetts 01063

When I last spoke to this group in December 1988 my purpose was to bring to your attention a situation which was just beginning to become a problem (Munson, 1989). I wish that I was able to report to you that the problem had been solved or even lessened. However, the opposite appears to be the case. My goal in presenting this paper is to update you on the continuing problem and to inform you of some communication from the Office of Patents and Trademarks regarding the trademark issue and what it may mean to our industry.

The issuance of plant patents to clones with trademarked fancy names and nonsensical cultivar names continues without apparent abatement. During the past three years I have encountered numerous examples of this practice in our trade publications, nursery catalogs, and popular horticultural magazines. It is important to understand the basic rationale for assigning a nonsensical cultivar name to a patented clone while at the same time obtaining a "fancy" trademarked name. The underlying fact is that clones are sold on the basis of a single name with which the horticultural public has become accustomed. If somehow that one well-known name can be monopolized the name owner can effectively control the sales of that particular clone. As you know, plant patents are in force for 17 years, the same as for any patent. Since breeder's rights or patent owner's rights are protected during the period the patent is in force, the situation really becomes a problem at or near the time the patent expires. Let me give you an example of a common scenario. The plant illustrated is intended to be fictitious. An apple tree clone has been patented with the cultivar name Cinnamon Spice listed as the name of the clone on the patent. Nearly seventeen years later, the original patent owner, realizing that he is about to lose his exclusive production of the highly successful cultivar Cinnamon Spice, applies for a trademark for the name 'Cinnamon Spice', and gives, as the cultivar name for the clone, the unpleasant name 'Bulhaw' (a code name combining the originator's initials with those of his partner). Upon expiration of the patent, other nurseries are able to propagate and sell the clone without paying royalties. However, they are unable to sell the plant by its widely known fancy name Cinnamon Spice, which is now the sole property of the trademark owner. They are quite unlikely to be able to sell the clone under its "new" cultivar name, 'Bulhaw', either. At this point the only real option left is to give another name to this clone, whether trademarked or not, and hope that a demand can be created for this "new" cultivar. The end result is not desirable.

Another variation on this theme is that a licensed grower of a patented clone obtains a trademark on the cultivar name and gives a new cultivar name for the clone on the trademark application. This is sometimes done without the knowledge or permission of the patent owner. Instead of the clone with a well-known name passing to the public domain, it is now essentially the private property of the trademark owner. How can this happen? What has happened to the system of cultivar registration? Can anything be done to stop these practices?

As Chairman of the Plant Nomenclature and Registration Committee of the American Association of Botanical Gardens and Arboreta it fell to me to attempt to obtain some clarification of the practices of the Patent and Trademark Office of the U.S. Department of Commerce with regard to trademarks for plant names. Past attempts by myself and others had not been successful. This time, however, I was successful in receiving a reply which shed some light, and some ambiguity, on the practices of the Patent and Trademark Office (PTO).

My original letter gave several examples of the problem of which my committee was aware. The letter also explained the system of cultivar registration set forth by the International Code of Nomenclature for Cultivated Plants. Although the Cultivated Code was effective in the proper naming of cultivars in the past, it is now essentially passe since it has no force of law. Indeed, one of the main problems with our system of naming cultivars is that registering a name with a National or International Registration Authority is totally voluntary. Many nurseries simply ignore or bypass the registration process in favor of trademarking.

What follows is a summary and paraphrasing of the reply as they relate to specific questions. *What about the confusion of consumers who may not be aware that the same plant may exist in the trade under two or more names as a result of the trademarking of a well-known cultivar name and the subsequent re-naming of the clone by other growers?* The laws pertaining to registration and protection of trademarks are not intended to allow deliberate confusion for consumers. However, the PTO is not charged with the responsibility to seek out and eradicate trade practices that might result in consumers making purchasing decisions without the full understanding of what is available to them in the marketplace. Only if a new proposed trademark is too similar to an existing mark would it likely be denied. "It is neither the right nor the responsibility of the PTO to educate consumers that identical plants may be available under two different trademarks. Similarly, in the situation where the new producer of a formerly-patented plant utilizes the cultivar name for that plant, it is neither the right nor the responsibility of the PTO to educate consumers that a plant designated by a relatively unknown cultivar name is identical to a plant sold under a well-known trademark." In both cases, although consumers may not be buying formerly-patented plants with the full knowledge of the situation they are not being "confused" in any way which the PTO has the power to prevent (Samuels, 1990)

What about the "extension" of patent monopolies by the use of trademarks? "It has long been a theoretical underpinning of trademark law, and a judicially recognized principle, that the trademark laws should not be used to extend the limited monopolies granted by the patent laws." However definitive this statement sounds, the situation is tempered, and perhaps confused, by the question of whether or not "a formerly patented product has become generic, as used by the public......", and, if so, "then the trademark laws will not preclude generic use or fair use of the designation" (Samuels, 1990). Aspirin is used as an example of a formerly trademarked pain reliever with a little used chemical name. Since the public never became familiar with the chemical name the trademarked name became, by common usage, generic. The same phenomenon may occur in the cultivar plant trade which *may* allow new propagators of a formerly patented plant the right to use a name originally adopted as a trademark. However, one must weigh the cost of likely court challenges compared to the cost of a normal licensing agreement with the trademark holder. "You may consider this scenario to constitute extension of the patent holder's monopoly, but it cannot be viewed as a government authorized extension or even one that the government ought to prevent. The mechanisms of the marketplace determine whether a term continues to function as a mark or whether it has become generic (Samuels, 1990)." The burden of showing that a mark has become generic falls to the prospective new user, which also implies financial risk.

Why not require patent applicants to use cultivar names which meet the requirements of the Cultivated Code? (This would at least prevent the use of a "fancy" trademark and a nonsensical cultivar name.) This recommended amelioration of the problem may not be possible, not only because the Cultivated Code has no force of law, but also because, according to the PTO, "commercial consequences caused by the use or lack of use of a variety denomination in the market place cannot, and should not, be addressed by the patent system (Samuels, 1990)." In addition, Article 13 of the International Convention for the Protection of New Varieties of Plants (UPOV) does not require that cultivar names be in a modern language, but only that the designations not mislead or cause confusion concerning characteristics. The Cultivated Code approach seems to be possible if, and only if, there is complete voluntary adherence by all involved. This scenario is unlikely to be even a remote possibility.

Can anything be done to prevent the trademarking of cultivar names which have long-standing use in the trade? According to the PTO, whenever anyone makes application for a trademark designation for a plant the current policies of the Trademark Examining Operation (TMEO) require the examining attorney to consult with the USDA to determine if the designation sought has been registered or used as a cultivar before. If it is found to be so used, then registration of the mark will be refused. Likewise, the USDA may check with the PTO to determine if a proposed cultivar name has been previously registered as a trademark. This cross-cooperation has resulted in the denial of trademark applications when it was shown that the name already existed as a cultivar name. It is obvious, however, that this system can work only if the USDA has access to complete and up-to-date records. Unfortunately, these do not exist. It would take the establishment of a national database to enable this system to work effectively. One of the barriers to effective control of registration of improper trademarks is the limited means available to both the PTO and the USDA to monitor all trademark applications.

Can blanket trademarks be prevented? The PTO cannot arbitrarily decide to deny trademark applications that meet all legal requirements even if the mark is likely to be used as a "blanket" trademark, i.e., a single name that applies to plants in various genera. They do, however, promise to continue to strictly apply trademarking rules in accordance with existing regulations.

Conclusion. It appears that the trademarking of "fancy" names will continue. However, the trademarking of cultivar names of formerly patented clones may be prevented by proving that the cultivar names have become generic as a result of usage. This does, nevertheless, imply certain financial and legal risk which may cost more than normal licensing agreements. The only other "solution" may be legislative.

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New Breeders' Rights Legislation in Canada

Peggy Walsh Craig
Canadian Ornamental Plant Foundation, 652 Aberdeen Avenue, North Bay. Ontario, Canada P1B 7H9

Canadian plant breeders, at long last, can enjoy what most industrialized nations have had for many years: Plant Breeders' Rights. Bill C-15, written into law in August of 1990, is designed to stimulate plant breeding in Canada and encourage foreign breeders to introduce protected plants into the Canadian market.

Similar, but not identical, to the protection a US plant patent offers, the new legislation grants Canadian breeders exclusive rights over their cultivars' reproductive material. If growers wish to grow or sell the cultivars, they must obtain the breeders' permission and pay royalties.

Eugene Whelan, Minister of Agriculture for many years in the Trudeau cabinet, is reported to have said that he'd seen more rubbish written on plant breeders' rights than on any other subject. The Plant Breeders' Rights Act is one of the most publicized, persistent, and controversial pieces of legislation ever to be passed by Canada's Parliament. The debate leading to its enactment lasted for more than a decade. Plant breeders' rights was an agricultural issue that received just as much ink in consumer magazines as in farm journals. Legal advisors from the Department of Justice started drafting the legislation in July, 1977. It was the patience and persistence of at least two individuals that enabled this law to be passed. Keith Laver of Springwood Consultants, and chairman of the Plant Breeders' Rights Committee for the Canadian Ornamental Plant Foundation (C.O.P. F.) worked at least 20 years on this legislation. Wilf Bradnock, head of the Seeds Division for Agriculture Canada, continued to push for the legislation through three different administrations over a 13-year period.

A Plant Breeders' Rights Office is now set up in Ottawa to establish regulations and register plants. The address is:

Plant Breeders' Rights Office
Agriculture Canada, Plant Products Division
K.W. Neatby Building
960 Carling Avenue
Ottawa, Ontario K1A 0C6
Phone: 613-995-7900
FAX: 613-992-5219

They will publish a plant varieties journal listing applications received, rights that have been granted, and other important notices. The first issue describes guidelines for registration and is available free of charge from the above address. Collection of royalties and enforcement of the regulations will be left up to the individual breeders and organizations such as C.O.P.F.

In addition, a Plant Advisory Committee with 16 members representing interested parties, has been established to meet with the Minister of Agriculture. Standing on the Committee for the ornamentals industry are Bruce Macdonald, *Director of the University of British Columbia Botanical Gardens, representing the* Canadian Nursery Trades Association; Herb VanderEnde, of Burnaby Lake

Greenhouses representing Flowers Canada, and Keith Laver, representing C.O.P.F Recently Jim Garrett from Mori Nurseries has been named as Keith's alternate.

Different plant groups will require somewhat different regulations, so each group will be dealt with separately. At the October, 1990 meeting, priorities were set for the various plant groups Chrysanthemums and roses are in the first priority group, along with canola, potatoes, soybeans, and wheat. Crabapples, *Prunus* spp., herbaceous perennials, ornamental conifers, and woody ornamentals (genera to be determined) are on the secondary list. After that comes annual flowers, begonia, bulbs and corms, bush and cane fruits, cranberry, creeping red fescue, forest trees, gladioli, grape, Kentucky bluegrass, shade trees, tree fruits, and vegetables. This last list is in alphabetical order (not according to priority) and is not all-inclusive. To date, applications are available only for those species that are covered by regulation, which are roses and chrysanthemums in the ornamentals area.

In addition, it was decided that applications for protection will be accepted if sales have taken place after the date of the legislation (1 August 1990). This means that once the regulations for a particular plant group have been set, a breeder can apply for protection if initial sales of the plant did not begin in Canada before 1 August 1990. Cultivars which have already been introduced abroad, will be eligible for protection in Canada provided they were not introduced abroad prior to August 1, 1986 or 1 August 1984 for slower growing plants such as trees. The implication of this decision is that hybridizers can go ahead and introduce new plants after 1 August 1990 and then be able to apply for protection when the regulations cover that category. Introducers would be wise to advise growers that they intend to protect the cultivar legally and that the growers should undertake to agree to paying royalties before receiving stock. It should also be noted that protection is not retroactive. Rights are in effect once the right is granted, or, if a provisional directive has been applied for, rights are in effect from the date of that application.

Enforcement is a big question in many peoples' minds. As you might expect, Canadian laws do not have jurisdiction in other countries, so a Canadian nurseryman with a hot new item will still have to apply for a patent in the U.S. to protect it here. Likewise, a U.S. breeder will need to have an agent, who is a resident of Canada, register the new plant in Ottawa to receive protection there Now that this protection is finally available in Canada, C.O.P. F. hopes that breeders from the U.S. and other countries will be more willing to introduce new plants into the Canadian market. Furthermore, there is the possibility that C.O.P.F. might act as an agent for foreign breeders. The Board of Directors presently has this under discussion, with a decision expected early next year.

Also, the Plant Breeders' Rights Office does not intend to be involved with enforcement of royalty collection. If you develop a new plant and someone is propagating it without paying you a royalty, it is up to you to take legal action. In some countries, there are independent agents who look after this for a number of plant breeders. Before the legislation was passed, C.O.P.F. was not able to do much enforcement. However, this is a service that both grower and breeder members of C.O.P.F. are now requesting.

There are some profound differences between the U.S. plant patent system and the new Canadian law In the United States, all horticultural plants propagated asexually (except tuberous ones) can be covered by a plant patent.

Seed crops in the U.S. are covered by the more stringent Plant Variety Protection Act of 1970 This Act is reasonably restrictive and coverage costs a great deal more than protection of ornamentals under the Patent Act.

In Canada, all crops come under the one Act. This follows the trend set by most countries with PBR legislation, which passed their legislation more recently than the U.S Plant Patent Act.

Another distinction that can be drawn between the U.S. and Canadian systems is that in the in U.S., plants and unauthorized propagation of plants are covered by patents, but not necessarily the propagation of **parts** of those plants. In Canada, the rights granted are more encompassing

Finally, the right granted in Canada is not a patent. As a breeder, you can license anyone you like to grow the plant for you. However, if you deny someone access to your cultivar, they may file a request for a compulsory license. If it is determined that, for example, unreasonable licensing conditions were demanded, i e. excessive royalties, a compulsory license may be granted. This would compel the holder of the right to make the variety available to that person at a set royalty rate.

The reason C.O P.F is not so enthusiastic about the new legislation is because the costs of registration are much higher than expected. In general, it will cost $1,800 to register in the first year, and $300 every year after that.

The most important goal of all this effort is to see the establishment of a new profession in Canada: private plant breeding. There are growing conditions in Canada which beg for unique, hardy plants and there is talent and skill in breeding that deserve recognition. Plant Breeders' Rights Legislation lays the groundwork for this vital enterprise.

NEW PLANT FORUM

Compiled and Moderated by Jack Alexander

PRESENTERS:

Kathy Freeland .... Midwest Groundcovers, St. Charles, Il
1) *Vinca minor* 'Ralph Shugert'

Christopher Rogers .... Weston Nurseries, Hopkinton, MA.
1) *Halesia monticola* 'Rosea'
2) *Halesia tetrapetera* (syn. *H. carolina*) - hybrid

Dan Studebaker .... Studebaker Nursery, New Carlisle, OH
1) *Betula nigra* 'Tecumseh Compact'
2) *Taxus* × *media* 'Amherst'

Nancy Vermeulen .... John Vermeulen and Son , Inc. Neshanic Station,NJ
1).*Rhododendron* 'Peter Vermeulen'

Dick Brooks .... Kalmia Woods Nursery, Concord, MA
1) *Rhododendron* 'Aviva Ann'

Gary Koller .... Arnold Arboretum, Jamaica Plain, MA
1) Acer *heldreichii*
2) *Securinega suffruticosa*

Vinca minor 'Ralph Shugert'

I volunteered to present this plant with a great deal of pleasure. The person for whom it is named is very special to me and through the years has been a pillar of knowledge and strength to many of us. Having a plant named for oneself is like being given a bit of immortality and I cannot think of a better person to have his name in perpetuity!!!!!

A new and distinct cultivar of *Vinca minor* has been patented by Hortech of Spring Lake, Michigan and is being grown by Midwest Groundcovers, St. Charles, IL; Wayside Gardens of South Carolina; and Shadow Nursery of Tennessee.

This plant, *V. minor* 'Ralph Shugert' originated as a sport of *V minor* 'Bowles Variety' and was first propagated by David Mackenzie using intermittent mist and root inducing substances during 1986. The plant is characterized by foliage which is the same shape and size as 'Bowles Variety'. It has leaves that are colored deep glossy green, edged with a thin margin of white. Flowers are typical of the parent plant. 'Ralph Shugert' is a vigorous grower, has great commercial potential, and good ornamental value

The registration as a woody plant cultivar was applied for an received in 1987.

The plant was named "to commemorate the most enthusiastic and sharing horticulturist that I have had the pleasure of knowing".

Halesia monticola 'Rosea'

This medium sized tree in the north blooms in mid-May with 3/4 to 1 in. light pink bell-shaped flowers. Its light green four winged fruit turns light brown in September and persists into the fall The original tree is 50 ft tall and pyramidal in outline. Cuttings were obtained from the Arnold Arboretum's Case Estate

Halesia tetraptera Hybrid

This tree is from a group of seedlings originating from Weston Nurseries. The original tree is 20 ft tall and 30 ft wide Its pure white bell-shaped flowers are slightly larger and showier than the species. It blooms in mid-May. The 1 1/2- to 2-in., light green, four-winged fruit turns light brown in September; it persists through the fall Both these *Halesia* selections root readily from softwood cuttings taken in June.

Taxus × *media* 'Amherst'

This taxus is another selection from seed of Hatfield origin done by Laddie Matiska, a student of L.C. Chadwick. He named this plant after the city in Ohio in which his nursery was located. The bright green, stiff needles have a very characteristic curl, curved to show the lighter undersides of this coarser *Taxus* × *media* type. It is a striking unique-looking, low-spreading shrub while young, becoming hemispherical shaped with age with most branches ascending. It exhibits excellent winter color, hardiness drought tolerance and a good growth rate. Large specimens may be viewed at Secrest Arboretum Living Herbarium of *Taxus* in Wooster, Ohio.

Betula nigra 'Tecumseh Compact'™

This plant was discovered at Studebaker Nursery about seven years ago as a chance seedling purchased in as *Betula nigra*. The plant was half the size of the species with dense, compact branching much of it extending at 45 degrees to a nearly horizontal plane from the main stem Progeny taken as stem cuttings produced the same effect; the oldest outplanting is about 5 to 6 ft tall as a 6-year-old plant and about as wide. Unpruned specimens, 5-years old, are wider than tall, about 6 to7 ft across and 4-ft tall Some single-stemmed plants are staked and side branches are allowed to create a weeping effect. The cinnamon-exfoliating bark is well displayed for specimen use. The compact clump form can be used for screening in residential and size-restricted landscapes. This plant appears to exhibit more overall prostrate or horizontal branching then *B. nigra* 'Fox Valley'. Growth rate is fairly vigorous as rooted cuttings grow to 2 ft the first year in liner beds. The 'Tecumseh Compact' name has been trademarked by Studebaker Nurseries, Inc.

Rhododendron 'Peter Vermeulen'

This outstanding rhododendron was selected from a group of plants believed to originate from a cross of *Rhododendron* 'America' with *R.* 'Scintillation'.

Flower color is a bright iridescent pink with shades from dark (Pantone 239u) to light (Pantone 217u) Buds hold the dark shade with florets opening dark and graduating to dark and light. The semi-prominant blotch is golden yellow (Pantone 121u). Florets spread from 2 to 3 in and form 5 to 7 in. trusses that are firm and symmetrical.

Foliage is dark green (Pantone 350u), broad, flat, slightly rounded at leaf edges, prominently ribbed and blessed with an eye-catching sheen or shine depending on the season.

Plant habit is broad, rounded, and full, with strong, sturdy growth.

It cultures well in micropropagation and responds nicely in subsequent transplanting, growing soon to produce a well budded saleable plants.

Rhododendron 'Aviva Ann'

This rhododendron is a hybrid of *R. yakushimanum* and the old Waterer cultivar 'Mars'. It forms a densely-branched rounded plant, 4 1/2 ft high by 7 1/2 feet wide in 17 years. The leaves, which are held by the plant for 4 to 5 years, are 3 1/2 to 5 in. long, stiff and leathery, with a thin, tan-colored indumentum covering the lower surface. The foliage has sustained no damage during 18 New England winters

In Concord, Massachusetts, 'Aviva Ann' blooms during the last week in May to the first week in June, depending on the season. The inflorescence is composed of 15 to 19 flowers in a truss 6 to 7 in. in diameter; individual flowers are 3 in. in diameter, of heavy substance, and when newly open are an intense clear pink, turning paler as the flower ages, but retaining the deeper pink coloration on the edges and reverse of the flower.

The plant has bloomed freely (no damaged buds) after a low winter temperature of -17°F (-27°C).

Acer heldreichii—Balkan maple

Maples are a strong component of the landscape because of their proven adaptability, dependability, availability, cost effectiveness and name recognition by the public. The quest goes on to find new selections among a relatively narrow species range which also limits genetic diversity should unforseen pests and diseases become problematic.

A maple deserving greater consideration by growers is *Acer heldreichii* native to Yugoslavia, Albania and Greece but which remains rare elsewhere. The Arnold Arboretum first acquired this plant in 1902 (AA 12498) from the Spath Nursery Company in Berlin, Germany. A second shipment was received from Spath Nursery in 1912 (AA 12490). This plant remains in good condition with a height of 64 ft, a spread of 38 ft and a DBH of 5 ft 8 in., recorded in 1990. The tallest specimen recorder by S.J Bean in Trees and Shrubs Hardy in the British Isles is at Hergest Croft, Hereford, 75 ft tall with a circumference of 9 ft recorded in 1985.

Balkan maple is quite similar to *A pseudoplatanus* but seems to vary in the following ways: According to Alfred Rehder in the Manual of Cultivated trees and Shrubs on *A. pseudoplatanus* the yellowish green flowers are borne in narrow, pendulous panicles while those of *A. heldreichii* are yellow in upright ovoid long-stalked panicles. At maturity *A. heldreichii* becomes a less massive tree making it more appropriate to smaller landscape spaces. At the Arnold Arboretum our mature trees have all grown taller than wide which might prove to be a useful characteristic along urban streets. The bark of the tree is much different in that our specimens do not exhibit the exfoliating bark typical of *A. pseudoplatanus*. Instead the bark on young trees is a medium brown with a faint undercolor of salmon. Young trees have terminal buds which are plump and bright green, reminding me of the terminal buds of *Syringa vulgaris*. Trees grafted in 1985, and now 6 years old, stand approximately 15 feet tall and are full and bushy with multiple branches. On mature trees the bark remains relatively smooth interrupted by low profile plates of the same color and the salmon color highlights are retained.

The foliage on the typical species is similar to *A pseudoplatanus*. What is different is that in the autumn *A heldreichii* turns a clear butter yellow, occasionally marked with brown veins before falling away. At the Arnold Arboretum the variety *Acer heldreichii* var *macropterum* (Syn. *A. heldreichii* subsp. *visianii*) has among the most beautiful foliage of all the large leaved European maples. The leaves are deeply divided into narrow lobes to create a shape reminiscent of the foliage of Virginia creeper Again, the autumn foliage is bright yellow The variety *macropterum* also varies by having fewer, but thicker branches which gives the plant a more open character.

All the Arnold's mature trees of Balkan maple have grass growing right up to the trunk indicating that the root system is not so shallow nor the branching so dense as to retard those plants growing at or near the base. A question which needs to be answered is that of the trees resistance to salt spray. Will it be equally tolerant of ocean and maritime environmental conditions as *A pseudoplatanus*? If it proves to be, this characteristic along with it smaller size and good autumn color would make it a desired plant for the seacoast, along highways and other locations where environmental salts are a problem.

The seeds being distributed today come from Arnold Arboretum number 12490 and result from open pollination among the extensive collection of maple species nearby. Optimum germination results from one month of cold stratification prior to sowing the seeds.

Securinega suffruticosa—fountain hardhack

Changes in landscape style require that nurserymen and landscape designers seek desirable characteristics from little known plants. This allows new planting combinations and a move away from the standard and sometimes boring palette usually employed in the field of planting design.

One shrub in which I find desirable characteristics is *Securinega suffruticosa* in the *Euphorbiaceae*. Native to north east Asia it was first introduced to cultivation in North America by the Arnold Arboretum in 1881. The primary feature which I admire is the habit. It matures to a plant bearing branches which first take an upright character gradually arching outward and down creating a cascade like effect. This cascade is enhanced in the autumn when the foliage becomes a clear, bright butter yellow. This saturated color combines with a delicate airy texture to give the effect of a golden waterfall Winter also captures a pleasing effect for the plant tends to be a colony of twiggy stems appearing like a miniature woodland. Current season stems are a bright green all summer long. In the fall they turn a light tan brown providing a visual winter contrast against the darker browns and blacks of nearby shrubs and trees.

The habit of the plant varies with age and vigor. At the Arboretum a planting approximately 5-years old grows in full sun at the top of a dry bank. Here the plants range in height from 5 to 8 ft tall and an overall upright habit At another location a planting approximately 10-years old standing in dappled shade have grown 3 to 4 ft tall with a strongly arching habit. Much older plantings also share this size and shape.

The foliage is alternate, with a simple, entire, elliptic to ovate shape. The summer color is a bright yellowish green which allows it to be mixed with other plants to create compositions of shape, texture and form.

Flowering occurs in late summer. The plant bears a multitude of small greenish yellow flowers borne in the leaf axils and the blossoms will be missed by all but the most observant. The fruit is the size of a small peppercorn which ripens from pale green to brown at maturity. Fruits are divided into three sections, bearing three to six seeds. I have discovered that at some point of ripeness or dryness the capsules burst open and fling out their contents, reaching distances of 3 to 5 ft or more. Germination trials shows that optimum results occur after 3 months of cold stratification.

As a wild plant we have the following record from a recent collection, Arnold Arboretum #625-85, provided us by the Research Institute of Ecology and Botany in Vacratot, Hungary Seeds were collected from the wild in north Korea during autumn 1984 from "a mixed, rocky, broad-leaved forest and pinewood on hills West from Pyongyang City at 300 meters altitude on granite." The Flora of Japan by Jisaburo Ohwi says that plants grow in thickets and grassy slopes in lowlands of Honshu, Shikoku and Kyushu where it is a common native plant.

At the Arnold Arboretum these plants thrive in full sun to light shade and they seem to be exceptionally tolerant of dry to droughty soils To my knowledge we have never had any dieback resulting from winter damage or summer heat and drought The plant grows at The University of Massachusetts in Amherst, which is in USDA Zone 5. It appears that plants will not tolerate heavy or poorly drained soils nor an exposure of more than moderate shade. Spontaneous seedlings occur occasionally suggesting that it has the potential to become invasive.

From a design viewpoint I believe that the plants would make excellent thickets for border plantings in parks or smaller scale residential landscapes especially for autumn and winter viewing. From their graceful habit, drought tolerance and toughness I wonder if they might not make ideal subjects for large landscape containers, rooftops or as delicate barriers for median strips of highways. I can imagine how lovely a mass of this would be standing behind a stone wall and faced down to the wall with a bold sweep of *Pennisetum alopecuroides*

Securinega suffruticosa is a shrub deserving wider landscape trials to learn of its full potential and adaptability. Help learn more about it by taking seeds home, grown plants and conduct your own evaluation!

EASTERN REGION QUESTION BOX SESSION

The Question Box Session was convened at 9:30 a.m. 10 December 1991 with Ralph Shugert and Bruce Briggs serving as moderators.

MODERATOR BRIGGS: Question for Deb McCown. You have in tissue culture *Cornus kousa* 'Milky Way Select'. What is the source of this plant?
DEB MCCOWN: Origins of Milky Way Select. Original plant from old Lake County Nursery Exchange (L C.N.E.), now Lake County Nursery, who were growing dogwood from seed of original 'Milky Way' plant. L.C.N.E. said seed was pretty "true" to original clonal plant. We brought in seedlings and selected one that was particularly nice. We could not call our microcuttings 'Milky Way' but wanted to indicate that our plants would be similar to original 'Milky Way' clone—hence 'Milky Way Select'. We have carefully explained this in our catalogue.

MODERATOR SHUGERT: Question for Elwin Orton. How about telling us about *Cornus kousa* 'Summer Stars'. Is it a clone?
ELWIN ORTON: To the best of my knowledge it is a clone that was patented and the rights are owned by Princeton Nurseries It was found on Long Island.

MODERATOR SHUGERT: Question for Dick Wolff. Anything new on verticillium wilt on Japanese maples or other *Acer* species?
DICK WOLFF: No one has found a cure for the disease We did an experiment with bark known to be infected with verticillium By three years we lost all the plants mulched with bark containing verticillium wilt We came to the conclusion that we would not allow any hardwood bark to be associated with Japanese maples

MODERATOR SHUGERT: Question for Dick Wolff With our latest knowledge of disease, etc., when is the best time to prune Japanese maples?
DICK WOLFF: We start our pruning about this time of year and continue all winter.

MODERATOR SHUGERT: Question for Dick Wolff. When preparing cuttings or scions what is best disinfectant these days for knives, etc.?
DICK WOLFF: We are using Physan. We had previously used isopropyl alcohol. We even have our grafters rinse their hands in a little alcohol.

MODERATOR SHUGERT: Questions for Dick Wolff. Do you get any new growth on *Acer palmatum* rooted cuttings before they go dormant? Why is it important to use small-seeded *A. palmatum* for understock?
DICK WOLFF: A few of them will break bud but most do not We tried lights but discontinued them. Rooting is not the problem—getting them through the winter is the problem. We do not give them nitrogen fertilizer in the late summer. We overwinter them in an underground storage pit where we can store 15 to 20 thousand plants. Fungus can be a problem so spray and watch ventilation to control. Rodent control is also necessary.

At one time we collected all the different understocks we could and we found that a number of them were not winter hardy. We found that small seeded *A palmatum* was reliably hardy and have never had any problems with it.

MODERATOR BRIGGS: Is anyone using an electrically heated, slotted pipe (callusing tube) for grafting? I have plans for one heated with water, but am interested in one using a heat cable.
BRUCE BRIGGS: I would suggest that you contact Harry Lagerstedt, Lisa Buchholz, and Verl Holden who have done it in the west Their names can be found in the new Membership Directory. You need to experiment yourself because timing is very critical.

MARK SUTCLIFFE: You might contact Dick Jaynes in Connecticut who is doing it on a lot of different plants.
DAVE THOMPSON: You might also contact Frank Gouin at the University of Maryland who is doing it with forced hot air.

MODERATOR SHUGERT: We have a golden yew in production for 30 years under the name *Taxus cuspidata* 'Aurescens'. The habit holds the middle between 'Hicks' and Densa yew for lack of anything better to compare it to. It grows at the typical speed of *T. cuspidata*, does well in containers but burns in the field at a young age. I would like to know if anyone knows the plant and why so few people produce the plant?
FRASER HANCOCK: I believe we have the same plant and we are propagating it at Sheridan Nurseries as *T. cuspidata* 'Aurea'; they have called it 'Aurescens' as well There appears to be two forms, a broad grower and upright type.
DAVE THOMPSON: We brought in *T cuspidata* 'Aurescens', 'Aurea', 'Aurescens Nana', and *T. baccata* 'Aurea' and planted them out in a hedge. We could not tell the difference between any of them. It roots very easily with 0.8% IBA.

MODERATOR SHUGERT: I have heard a few times this week about seed propagation of cultivars. Doesn't this violate the definition of a cultivar being genetically identical?
ELWIN ORTON: Cultivars are not limited to asexual propagation methods by International Code of Nomenclature.

MODERATOR BRIGGS: How much reversion is in flower color do propagators find in *Syringa* 'Sensation' propagated by softwood cuttings? Is there a difference if propagated by tissue culture.
STEVE MCCULLOCH: 'Sensation' is a chimera an it will sport to a white type. You can do a good job of separating out the off types because white lilacs tend to have paler leaves.

MODERATOR BRIGGS: This person would like to know if anyone has experienced the problem of *Hydrangea* 'Annebelle' not flowering or flowering with a reproductive flower: We have seen this in our field. The plants have been propagated by shoot sections taken off dormant plants.
STEVE MCCULLOCH: I have heard that there is variability with *Hydrangea* 'Annebelle' but do not know why.

DICK BIR: It flowers the first year from cuttings for us. Don't fertilize is the secret

MODERATOR BRIGGS: What are the cost factors in the CIPS system?
BRUCE BRIGGS: Based on work at OSU and what I have seen in Europe it could be competitive.

MODERATOR BRIGGS: Has any work been done on how plants do in a landscape after being grown with a constant supply of moisture as in the closed watering system discussed by Bruce Briggs?
BRUCE BRIGGS: We grew some on, including magnolias and *Cedrus deodora*, and they seemed to respond as well as if not better in some cases.

MODERATOR BRIGGS: What plants can we plant in our discharge water ways to absorb nitrogen, etc.? If we can contain the water at time of discharge could we treat it?
PEGGY CRAIG: I am interested in this because our land fill and swamp filtration with species, such as cattails, has been used.
VOICE: I think that the Soil Conservation Service would be the people to contact for information.

MODERATOR BRIGGS: What are the ingredients in successful grafting of *Picea pungens*? Please discuss understock, timing, post graft storage, water and any other factors
DAVE THOMPSON: We use *P. abies* understock. A strong healthy understock is all important We are grafting now and in January, February and March. We are also experimenting with August grafting. You do not have to plunge them but can use high humidity. We watch for the first swelling if the scion bud and start the two stage cut back process. The first cut back is to the length of the scion and that remaining understock is used as a support for the scion until planted out

MODERATOR BRIGGS: Is anyone using up to 50% municipal leaf compost with pine bark as a container medium?
TOM KIMMEL: We have been told that you can not use more than 20% as a peat replacement because of burn from the high nutrient content.
PETER ORUM: You need to get an analysis before using it because you can burn your plants badly. Run an E C. test at the least.
ED LOSLEY: I would caution about the use of yard waste that contains grass clippings because of the potential pesticide problem.
WAYNE MEZITT: Everyone I have asked about the pesticide residue with lawn waste says it is not there. I think we need a study on this.

MODERATOR SHUGERT: Can anyone provide information on the rooting of *Prunus glandulosa*? Please address timing, cutting type and length, type of medium, rooting hormone and after care
MARK RICHEY: The first flush is the best and goes down hill after that. Run the medium and the tops a little on the dry side.

MODERATOR SHUGERT: Does anyone reuse media in a greenhouse bench for later crops? What is most successful method for regaining good sanitary conditions for next crop?
ED LOSLEY: Take it out, it's good insurance.

MODERATOR BRIGGS: Is anyone using household soap for insect control:
RALPH FREEMAN: Ivory Snow flakes controls spider mites. However it is not labelled for pesticide use Ivory Soap (flakes) used at 1.6 oz/gal will control 85% of two-spotted spider mites in one day If Vendex is included at label rates. . nearly 100% control wil be attained. This work was done at Cornell several years ago.

MODERATOR SHUGERT: Question for Dave Thompson. Do you recommend leaving a piece of the understock on the grafted scion that has taken in order to feed the scion better or do you cut the understock top off right after the scion has taken?
DAVE THOMPSON: You have heard my comment on *Picea pungens* With *Tsuga canadensis* and *T. caroliniana* the faster we cut the root stock back the faster we will force the scion; the same thing with *Cedrus*. With the pines we are a little more skeptical and take our time cutting them back.

MODERATOR SHUGERT: Question for Dave Thompson. Where do you collect scions for *Chamaecyparis noothatensis* 'Pendula', *Picea breweriana*, an other conifers with pendulous branchlets? From branch tips or branchlets?
DAVE THOMPSON: We have found that with pendulous forms such as prostrate *P. pungens* that if we take a strong leader off the stock plant we don't seem to have the prostrate characteristic. We use lateral shoots with that type of plant. With *P. abies* 'Pendula' it depends on how fast we want to get it to market. For fast results we look for the strongest and straightest terminal. With *Tsuga* we have no preference.

MODERATOR SHUGERT: Question for Dave Thompson. Do you dip *P. pungens* scions in Clorox?
DAVE THOMPSON: Everything gets dipped in 5% dilution as a quick dip. We take 4 crops a year out of our houses and them we go in and scrub down with a 10% Clorox solution After that we go in and spray with 100% Clorox solution. We have eliminated our fungus problems.

Effects of Water Quality and Water Management on the Growth of Container Nursery Stock [1]

Carl E. Whitcomb, Ph.D.
Lacebark Research, P O Box 2383, Stillwater, Oklahoma 74076

EXPERIMENTAL LAYOUT

This study was conducted in six central Florida nurseries beginning April. The test plants were Fashion azalea, Hetzi Japanese holly, and blue Pacific shore juniper The fertilizer sources were an 18-6-13 experimental Osmocote, 24-4-0 High N,

Table 1. Water analysis at six container nurseries in Florida

	Nursery location					
Elements/Salts	A[x]	B	C	D	E	F
Sodium	25 ppm	5	10	32	112	5
Calcium	60	31	42	104	62	80
Magnesium	17	10	13	10	14	2
Potassium	2	2	2	1	4	0
Carbonates	0	0	1	1	1	0
Bicarbonates	120	140	162	351	176	294
Chlorides	10	10	17	66	201	10
Sulfates	6	3	7	1	8	0
Nitrates	2	0.1	3	0.1	0.1	1
Boron	0.01	0	0.03	0.01	0.03	0
EC	-- [Y]	0.2	0.3	0.6	0.9	--
SAR	--	0.2	0.3	0.8	3.3	--
Adj SAR	--	0.3	0.5	1.8	5.5	--
% Sodium	18	8	12	19	53	5
pH	7.5	7.6	7.7	7.9	7.6	7.1

[x] A,B,C are nurseries that contain good water (moderate to low levels of calcium, sodium, bicarbonates, chlorides, sulfates, and boron D,E,F have marginal water (one or more of the following were high, calcium, sodium, bicarbonates, chlorides, sulfates and boron) For example, water D had high calcium and bicarbonates, and other elements were acceptable. Water F had high bicarbonates and others were acceptable

[y] EC, SAR, and Adj SAR for Nurseries A and F are not available All six water samples were done at a lab and these two were omitted without explanation

[1] **Ed. Note** This paper was presented at The Southern Region Meeting but was not able to be included among that Region's papers

17-7-12 Osmocote, 16-10-10 Nutricote, and 20-4-10 Woodace. Rates were 2.0, 2.7, and 3.2 pounds of nitrogen per cubic yard. All plants received 4 pounds of dolomite and 1.5 pounds of Micromax per cubic yard. After all mixing of chemicals and planting was done with 36 single-plant replications, six reps of all treatment (270), plants were transported to six different nurseries Three nurseries had water of good quality and three had marginal water (Table 1). Good water was defined as water containing moderate to low levels of calcium, sodium, bicarbonates, chlorides, sulfates, and boron (Table 2).

Marginal water contained one or more of the following at high levels: calcium, sodium, bicarbonates, chlorides, sulfates and boron. The plants were placed on container beds among other newly planted stock in one-gallon containers. A rain gauge was placed in each block of plants, and the owner/manager was asked to record rainfall weekly. All plants were evaluated for number of branches and were pruned in July and September. In addition, all plants were spaced in September and given a second application of herbicide. In early December, the plants were evaluated and top weight was determined. The water received by the plants at the six nurseries was 50, 63, 70, 108, 116, and 126 inches during the eight month period

RESULTS AND DISCUSSION

Because of the complexity of the study and space limitation, only the conclusion highlights are included here. All plants were of good color with no visual deficiencies of any kind, except most of the azaleas at Nursery C (50 inches water) died from insufficient water and at the end of the study the plants with Woodace were somewhat off-color at all nurseries indicating nitrogen deficiency.

Table 2. Total water received by plants over the eight month study and five key water analysis factors and three soil mix analysis factors at the end of the study

	Nursery locations						
	A	B	C	D	E	F	
	70	126	50	116	108	63	rainfall and irrigation (in)
Water	60	31	42	104	62	80	calcium (ppm)
	25	5	10	32	112	5	sodium (ppm)
	120	140	162	351	176	294	bicarbonates (ppm)
	102	41	65	146	188	87	total bases (Ca, Na, Mg, K) (ppm)
	222	181	222	497	367	381	bases and bicarbonates (ppm)
Soil mix	2180	2501	1626	4397	2691	4393	calcium (ppm)
	25	21	25	33	150	19	sodium (ppm)
	5 8	6 6	5 5	7 6	6 4	6 9	pH of mix at end of study
	1 (best)	3	4	6 (worst)	5	2	overall plant growth and quality assessment

Water Effects

1) Water application varied 150% among nurseries. This is an astounding variation for the same basic plants in a similar geographic region

2) Relative to plant growth at the various locations, it is important to note the Nursery A had excellent plants and applied moderate quantities of water. Nurseries C and B had nearly identical water quality, but Nursery C applied less water (50 inches) while Nursery B applied much more water (126 inches). To the azaleas this meant death at Nursery C and a full two-point reduction in visual quality (on a 1 to 10 scale) at Nursery B when compared to Nursery A. Juniper and holly were also affected by the limited watering at Nursery C. Junipers and hollies at Nursery B showed fewer adverse effects from the heavy watering than the azaleas in terms of top weight, but visual grade was somewhat lower because the plants tended to be more loose and open.

3) The plants of all three species with the highest visual quality (most salable) were at nurseries A and F (Table 3). These nurseries applied 70 and 63 inches of water, respectively, and applied small quantities of water frequently vs. the more widely accepted practice of allowing the plants to dry, then water thoroughly

4) Nursery F had marginal water, yet with good water management, grew excellent plants, nearly as good as nursery A that had good water (Table 2). On the other hand, Nursery C had good water but did not apply enough or allowed the plants to dry too far before re-applying, and quality was low Nursery B had good

Table 3. Main effects of nursery location on growth of three species in containers (These values are averages for all five fertilizer sources at all three rates for a specific species and location

	Nursery Location					
	A	B	C	D	E	F
Azalea						
Top wt (g)	91 a[1]	79 c	--[2]	45 e	68 d	83 b
Visual grade (1-10)	8 8 a	6 7 c	--	5 3 d	6 4 c	8 3 b
Branches/plant	21 b	18 c	--	16 c	17 c	25 a
Holly						
Top wt (g)	60 b	58 b	52 c	45 d	51 c	74 a
Visual grade (1-10)	7 6 a	7 1 b	5 7 c	5 5 c	5 9 c	7 8 a
Branches/plant	48 a	34 d	38 c	33 d	34 d	41 b
Juniper						
Top wt (g)	73 b	70 b	47 c	48 c	48 c	80 a
Visual grade (1-10)	7 9 a	6 5 b	5 7 c	5 5 c	4 1 d	6 7 b
Branches/plant	12 b	11 b	12 b	8 c	11 b	16 a

[1]Values followed by the same letter going across (left to right) are not significantly different at the 5% level (5% = less than 1 chance in 20 of being incorrect)

[2]Nearly all azaleas died

water, but applied far too much, which caused more open plant growth (leggy appearance) and a lower visual quality Also, because of the "extra" water applied, the calcium in the mix was high at the end of the study having increased with each watering.

5) The plants at Nursery E showed no visual symptoms reflecting injury from the high sodium, yet the plants in general were substantially smaller and of lower visual quality. The extent of the injury was probably compounded by the relatively high amount of water applied (108 inches) High chlorides, on the other hand, did not appear to be a factor affecting growth.

6) Calcium, magnesium and sodium in the irrigation water accumulated in the soil mix. The level of calcium in the mix was accurately projected, based on the amount of dolomite added, calcium level in the water supply, and quantity of water applied Bases (calcium, magnesium, sodium) do not leach from the container mix (or do so very slowly), thus the more water applied, the more they accumulate (Table 2).

Fertilizer Effects

1) In general, the experimental Osmocote 18-6-13 produced plants with the most branches. Plants grown with this fertilizer generally had a higher visual rating than their respective top weights would suggest because of the increased branching.

2) The most consistent performing fertilizer and rate overall for the three species at all six nurseries was 16 pounds of 17-7-12 Osmocote.

3) High-N 24-4-10 excelled only at Nursery E where sodium was high in the water, performing marginally at the other five nurseries.

4) Nutricote (16-10-10, five parts 270-day and one part 70-day) produced good growth of azaleas and holly but only at the 21-pound rate compared to the 16-pound rate of either Osmocote. Growth of junipers was not favored by Nutricote.

5) Woodace 20-4-10 grew plants of good quality for the first four to five months of the study. However, by September foliage color suggested that available nitrogen was low, especially at the nurseries that watered heavily.

6) All of the fertilizers at the high rate at Nursery B produced reasonably good plants even though an excessive amount of water was applied If fertilizer rate was low or medium; plant quality was only fair to poor

7) Where water was the limiting factor, Nursery C, none of the fertilizers appreciably improved plant growth over the other, and high rates were generally detrimental.

8) At Nurseries E and D, where water quality was marginal, there was no advantage to using more than the 12-pound rate of any fertilizer.

CONCLUSIONS

1) The best plants were from Nursery A with good quality water and good water management (70 inches). However, careful water management with marginal quality water can result in good container nursery stock as found with Nursery F

2) Poor water management, even with good water, can result in limited growth or loss of size and quality

3) Small amounts of water applied frequently provided better plant growth than heavier applications less frequently

4) Water quality and water management DO influence how a slow-release fertilizer performs Some of the variation of slow-release fertilizer influence on

plant growth observed throughout the container nursery industry can be attributed to water quality and water management.

5) Most minerals in the irrigation water do not leach, but rather accumulate in the soil mix The more water applied, the greater the accumulation.

6) All of the slow-release fertilizers in the study resisted leaching of nitrogen even at very high water rates. The only exception was plants with Woodace which began to yellow sooner at Nursery B (126 inches) vs. Nursery A (70 inches). This suggests leaching