FURTHER EXPERIENCES WITH PROPAGATION OF PISTACIA

LLOYD E. JOLEY and KARL W. OPITZ

Agricultural Research Service,
U.S. Department of Agriculture, Chico, California and
University of California San Joaquin Valley
Agricultural Research and Extension Center,
Parlier, California.

INTRODUCTION

In 1960 the senior author presented a report (8) to the Plant Propagators' Society describing experiences in propagating trees of the genus *Pistacia,* especially the fall-coloring shade tree *Pistacia chinensis* Bunge. Since then, there has been an upsurge of interest in California in the propagation, planting and growing of the pistachio nut of commerce, *Pistacia vera* L. Because of its timeliness, this paper will bring the subject of *Pistacia* propagation up-to-date.

PROPAGATION BY CUTTINGS

All *Pistacia* cultivars are topworked onto seedling rootstocks. The question is often asked, "Can they be propagated by rooting cuttings of mature trees?" Attempts to root cuttings fail so consistently that the subject is seldom mentioned in the literature. Of the hundreds of cuttings started at Chico and Davis no more than 5 percent have rooted, regardless of the time of year the cuttings were taken or the rooting compounds and treatments used. This unfavorable outlook should not, however, deter nurserymen and research workers from trying new techniques for rooting *Pistacia.*

On the other hand, and in common with other tree species, cuttings of *Pistacia* seedlings often root easily if taken during their first year of growth Some nurserymen have wondered if they could use young, vigorous seedlings to develop clonal rootstocks of uniform vigor and fast growth. Commercial pistachio producers certainly need more uniform rootstocks. But it is not known if, similar to other plant species (2, 7, 13), young *Pistacia* trees can be kept in the juvenile condition in order to produce large numbers of cuttings. Before they are utilized, however, such clones must be evaluated for growth compatibility with the cultivars to be topworked on them as well as for their ability to produce satisfactory crops. Repeatedly, it has been observed that not all select seedlings make superior rootstocks. Furthermore, comparisons should be made between seedling and cutting rootstocks. With certain plants cuttings produce inferior trees.

SPECIES USED FOR ROOTSTOCKS

Seedlings of several *Pistacia* species have been tested as rootstocks for the pistachio nut, but mostly *P. atlantica* Desf., and *P. terebinthus* L. are used commercially in this country. Since all *Pistacia* cultivars are topworked onto seedling roots the selection of these rootstocks and the methods used in producing them economically are important to nurserymen and growers. Thus far, the industry is based largely on seeds supplied from trees growing at Chico, California. Because these trees can no longer supply the demand for seed, other sources are sought. Any new sources that are discovered will represent untried species or hybrids. It is important, then, that these new sources be capable of producing thrifty, fast growing rootstocks compatible with the cultivars used for topworking them. The rootstock's ability to produce heavy crops can only be determined by long term trials. Hopefully, some will be found that prove superior to those now available.

Fortunately, 'Kerman' (pistillate) appears to be compatible with a wide range of rootstocks but 'Peters' (staminate) is variable. Other selections, including 'Lassen' (8) are known to make poor growth on some rootstocks so the value of any new *Pistacia* rootstock can never be taken for granted until it has been evaluated.

POLLINATION AND SEED PRODUCTION

Except for an occasional tree (12) all *Pistacia* are dioecious. That is, the sexes are on separate plants. They are wind pollinated. Furthermore, all species cross-pollinate easily so it is difficult to find pure species. In fact, there is so much doubt about a truly valid *Pistacia* species, except the pistachio nut *P. vera,* that it is better to identify elite seed-producing clones by an identifying source or location number and name rather than species name alone.

Pistacia are known to be pollinated by pollen drifting as much as half a mile and it may occur at greater distances. To produce seed of known parentage it is necessary that seed trees be isolated from all but the desirable pollinators or else bag the female flower clusters with pollen-tight covers and pollinate by hand. For natural pollination both sexes must bloom together. *P. atlantica* trees usually bloom in late March, ahead of *P. terebinthus*. Occasionally the two may overlap slightly and hybridize, though their hybrids are not easily distinguished. Likewise, later-blooming *P. chinensis* pollen-producing trees may overlap *P. atlantica* seed trees. Where this happens vigorous variants appear among *P. atlantica* progeny that are probably hybrids of these two species. Occasionally early blooming *P. vera* pollen trees may pollinate late *P. terebinthus* flowers.

Seeds of most *Pistacia* ripen in September and October. Ripe, fertile fruit of *P. atlantica* and *P. terebinthus* turn blue or blue-green.

They are harvested by knocking with poles or mechanical shakers onto sheets or collecting frames. Removal of the epicarps or hulls immediately after harvest is preferable while they are soft and easily scrubbed off. If dried on the seeds they attract storage insects and act as a germination inhibitor. Small quantities can be cleaned by scrubbing on a coarse screen but larger amounts are best cleaned mechanically. A vegetable peeler works well if modified so that clearance between the revolving disk and cylinder wall prevents the small seeds from escaping. To produce the best quality, freshly harvested and cleaned seeds must be dried as rapidly as possible to prevent molding and spoilage, preferably at temperatures below 100° F. Seeds spread thinly on screened bottom trays with air blowing over and through the trays will usually dry in three to four days. Seed is stored, dry, in plastic bags or other moisture tight containers at 35-40° F.

SEED PLANTING AND GERMINATION

Pistacia seeds can be planted almost any time but it is normally done in the spring. Seeds planted in November or December and subjected to winter conditions germinate better than seeds planted in March and April. However, starting *Pistacia* seedlings under glass or plastic during November and December is not recommended. Damping-off diseases are most prevalent at this time and are difficult to control.

Long time observations and research (unpublished) at Chico indicates that best germination of *Pistacia* seeds occurs when germination is initiated at 70° F. or lower, and that at 80° F. germination can be very poor and nonexistent at 90° F. or higher. Most growers and nurseries report a similar experience but a few in Arizona and California claim better results at 80° F. or higher, particularly with *P. terebinthus*. The reasons for this difference are not clear and are being studied. In the meantime, however, growers are advised to germinate their seed at the lower temperatures. (Caution: It requires very little direct sunlight on soil to warm it to 80° F. or higher at seed planting depth.)

Most *P. atlantica* seeds sprout without pregermination treatment other than soaking in water 1 to 2 hours before sowing. On the other hand, *P. terebinthus* seeds vary in their response and are more difficult to germinate. Normally, good results follow damp seed storage at 40° F. for 6 weeks and by germination at 70° F. or lower. Total germination following this cool storage occurs rapidly and uniformly within a few weeks. If seeds are germinated in "rag dolls" they should be checked daily and transferred to peat pots as the roots appear.

For growers who may wish to grow and fruit *P. vera* seedlings, an effective way to stimulate rapid germination is to soak the seeds in water at 40° F., changed every few days, for 2 weeks prior to planting.

CONTAINERS AND CONTAINER MEDIA

With a few exceptions, all *Pistacia* rootstocks are now grown in containers prior to transplanting to permanent field locations Many growers and nurserymen use manufactured pulp containers about 16 inches tall and 6 inches in diameter. Those preferring to make their own containers can form them by folding an 18 inch square of felt sheathing or tar paper into a cylinder held together at the edges by stapling to a lath. Equally satisfactory, though not usually employed, are heavy plastic bottom perforated bags of similar length and diameter Container grown seedlings help prevent high losses that frequently occur when nursery-grown *Pistacia* trees are bare-rooted prior to transplanting. Felt paper containers will disintegrate after 5 or 6 months in the nursery yard but, carefully handled, they can still be transplanted, intact, without disturbing the roots. Manufactured containers usually hold up to a year or more but must be removed at transplanting time because they are slow to break down.

Container growing media vary with the grower or nursery. Some use one of the University of California mixes (10); others buy commercial mixes, while still others prepare their own. Most mixes contain sand, ground bark, or peat in various proportions. Generally, a nutrient mixture containing nitrogen and other essential elements is added to give the young plants a quick boost and get them off to a good start. Some may add small amounts of a loamy soil to give the mix more adhesive properties so the ball of soil will hold around the roots when transplanted. For best results the soil in the containers should not differ greatly from the soil in which the tree will grow. All potting mixes should be clean and, preferably, sterilized by fumigation with methyl bromide or steam (11) to reduce damping-off fungi and other diseases, nematodes, and weed problems In fact, all plants grown for sale in California must be grown in soils that meet the requirements of the Plant Quarantine and Nursery Service for plants free of pests. To avoid soil-borne pests and diseases this practice should be universally adopted.

GROWING AND CARE OF PLANTS IN CONTAINERS

There are several methods for starting young plants in containers Each has advantages and disadvantages. One of the more promising was first suggested by Dwight Long as a result of work he started at Modesto (9), and continued at the Saratoga Horticultural Foundation (3), to prevent bending and circling roots in container-grown ornamental trees Later this work was elaborated upon by Harris, Long and Davis (4) and others (5, 6), establishing principles for effective production of high quality container-grown plants through good transplanting and root pruning techniques. The young seedlings are started in organic pots (usually 3 inch peat pots) since *Pistacia* roots can easily penetrate this type of container. Seeds or sprouted seeds can be planted directly into the pots, or young seedlings may be transplanted into them before the roots develop extensively. For very young plants with short roots the terminal portion can be cut off to force branch rooting at an early stage. Seedlings with long roots require pruning to stimulate even distribution throughout the pot without detrimental bending (4).

The young plants should develop many lateral roots before transplanting into the large containers. Allowing the roots to grow through the peat pots half an inch or more and then rubbing them off to the pot before transplanting them will accomplish this. Also, seedlings in peat pots set over wire screen will "burn off" terminal roots and induce lateral rooting. Gallon containers are not tall enough to prevent root curling. The 16-inch and taller containers usually do well for one growing season.

Starting the young seedlings in, or transplanting them first into smaller containers have other advantages. If seeds do not germinate or grow well, only a small container is discarded. For transplanted seedlings only those that produce a thrifty, well-grown top and root system in the small peat pots need be transplanted, discarding the weak, slow-growing plants. Similar and further culling can occur when transplanting into the large containers. This culling can produce a uniform, high quality product. In selecting and culling for quality the evidence we have indicates that vigorous, well-grown *Pistacia* trees are produced on rootstocks with strong root systems.

A less satisfactory method is to plant seeds directly into large containers. This eliminates the necessity for transplanting and handling before being moved to the orchard. However, such plants usually produce a long taproot, with little or no side branching, that reaches bottom in 3 or 4 months Furthermore, this technique does not promote sufficient cullage and the top may be short for field planting.

Young *Pistacia* seedlings are quite succulent during the first 5 to 6 weeks of growth and sensitive to over-watering and damping-off diseases. Experienced growers and nurserymen are finding that optimum growth is best achieved in a soil kept continuously near field capacity for moisture and well supplied with nutrients. Opinions vary about the frequency of application and amounts of nutrients to apply to plants growing in containers, but it is generally considered better to apply small amounts at frequent intervals rather than large amounts at long intervals. Nurseries using University of California or commercial mixes, with balanced nutrients added, produce superior early growth. Without a doubt, nitrogen is the single most important element. Also important are calcium, potassium, phosphorus, magnesium and probably other lesser, but essential, elements. Blood meal or sewage sludge can be used to supplement inorganic mineral sources.

TOPWORKING THE SEEDLING ROOTSTOCKS

With close attention to detail, container-grown seedlings with sufficient caliper (3/8 inch or larger) at 6 inches above the ground level may be budded the first summer. Very unsatisfactory results have been obtained in trying to topwork *Pistacia* seedlings in containers. Standard practice is to transplant seedlings to their permanent orchard location before topworking. For growers preferring to topwork 2 feet or more above ground, a longer period of growth is necessary in order to attain enough height and diameter. There are indications that trees topworked at 2 feet or more produce less overgrowth at the bud union than those topworked near or below ground level, as has been demonstrated with citrus (1).

Although *Pistacia* trees are propagated by both budding and grafting, most propagators prefer the ordinary T-bud, either upright or inverted. It is faster and generally more successful than a scion graft and makes more economical use of scarce budwood. A few grafters report good success with whip grafts, and bark grafts, but others report results varying from fair to mostly total failure. One nurseryman successfully whip-grafted scions with terminal buds attached Another set 1 to 2 inch terminal scions as side grafts near the base of container-grown seedlings. Take of these scions was good but cost in time was a major disadvantage against this method. In 1953 we saved a valued *P. chinensis* tree at Chico by setting all available terminal and lateral buds. Few lateral buds survived but a high percentage of the terminal buds grew. These were cut with a moderately slanting cut immediately below the terminal bud similar to a side or bark graft with the bud inserted under the bark, the same as a T-bud. Other budding techniques that some propagators use successfully include the chip bud, ring bud and patch bud. Any one or all may be more successful at one time or another than the T-bud, but require more time to set.

Wherever *Pistacia* are grown and propagated opinions vary regarding the best time of the year to insert their buds. Some people believe April and May are the best months. Others believe these buds take better when set in late summer or early fall. There are proponents of both viewpoints in California. Most propagators, however, get the best results in September and early October if the rootstocks are in active growth and the bark slips well. At Chico (14) buds placed in March or April take poorly, if at all, with a marked increase as the time of budding is extended through the summer and fall. Failures in spring budding occur more often during rainy or cloudy, cool periods; but good bud take can occur during periods of warm, sunny weather in late April and May.

Opinions vary about the effect of temperature on bud take. Some propagators prefer to stop budding when temperatures go above 95 to 100° F feeling that bud-take decreases above these temperatures.

Others feel that temperature has little effect. There are only observational data to support either contention. Nevertheless it appears that with orchards on well established rootstocks, adequately irrigated and fertilized, temperature at time of budding is not of much importance.

Experience indicates it is important to use well grown budwood, produced either as water sprouts or strong terminal growth. Good budwood can be produced by cutting back branches on trees in early spring, forcing out new growth. This insures a greater supply of vegetative buds, for many of the lateral buds on the previous season's growth of mature trees are flower buds and only vegetative buds can produce new trees. Flower buds are distinguished by their larger size and plumpness.

Both rubber budding strips and non-adhesive vinyl nursery tape are used for tying *Pistacia* buds. Vinyl tape has the disadvantage that it does not disintegrate in sunlight and, therefore, must be cut away. One nurseryman reported better results using the clear form of this tape rather than the green colored form. Both ties are effective and work equally well.

Variability is still one of the facts of life in propagating *Pistacia* today. We know this plant to be as variable as the walnut in its behavior but very little is known about its basic physiology. There is much need for research in the laboratory and field on basic physiological, growth, and histological problems. One nursery ran a series of tests using several budders and budding techniques, varying the time of day the buds were set, using different sources and qualities of buds as well as location of buds on the scion. In no case was it possible to associate the variable results obtained with any one factor.

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MODERATOR MAIRE: Any questions on pistachio propagation?

ANDY LEISER: A question on transplant problems—have you tried mechanical diggers to transplant nursery trees so that you could grow them in nursery rows then transplant to the field? We have had fairly good success with a few Chinese pistacia up to 4 or 5 inches in diameter.

KARL OPITZ: Well, Chinese pistacia are easier to handle than *P. terebinthus.*

ANDY LEISER: They're hard, too, but we have handled them up to 4 or 5 inches—transplanting with mechanical diggers.

STEVE FAZIO: My question is directed to Mr. Joley, not so much on the propagation but adaptability. Can we use *Pistacia chinensis*—its production—as an indicator that *P. vera* will be adapted to that area?

LLOYD JOLEY: Let's say this. Back in 1954 I saw some *Pistacia chinensis* trees growing there at the University of Arizona in Tucson that were suffering somewhat from chlorosis. Whether *P. vera* will behave like that, I do not know for I did not see any *P. vera* trees then in that area. I did, however, see some *P. vera* trees in the Cochise Stronghold at the same time that appeared to be quite normal in leaf color though they were small for lack of water.

RALPH SHUGERT: What's the economic dollar value given to the pistachio in California annually?

LLOYD JOLEY: It is low at the present time. I imagine if there are 500 tons produced this year it will be a large quantity, but this will be increasing each year from now on.

RALPH SHUGERT: What dollar value?

LLOYD JOLEY: Some of the growers have been getting as high as $1.00 to $1.10 a pound, some around 75 or 80 cents, depending on the quality.

KARL OPITZ: And there is a tremendous difference in the quality of these nuts, depending on how they are harvested and how they are handled thereafter, no matter what variety is involved.

JOE HALL: Are there any disease or insect problems that have been prevalent with pistachios?

LLOYD JOLEY: We have not seen any particular disease problems with the tree itself, other than the roots. Verticillium wilt can be a very serious disease. Oak root fungus also can be serious But as far as the tree top is concerned—no. In Texas, they have septoria leaf spot, but we have not had it here.

KARL OPITZ: Under other California conditions, that is, in areas where they should be grown — in the central San Joaquin and Sacramento Valleys—we have an excellent climatic situation and do not anticipate any problems with the top. The root problems can be serious, however.

HUDSON HARTMANN: What about germinating seeds of *Pistacia chinensis?* You described procedures for the other two. Is there any special treatment to promote germination of *P. chinensis* seeds?

LLOYD JOLEY: We have had all sorts of reports on *Pistacia chinensis* seeds and, I am beginning to believe, the problem is as variable as the reports In general, most *P. chinensis* seeds will germinate well without any treatment other than soaking them in water for an hour or two before sowing. But sometimes they will not germinate, no matter what you do; perhaps cold treatment would be useful in such cases. Yet we have used cold treatment and it did not seem to make any difference. I suspect that, in some cases, there is a failure somewhere in the germination process, especially failure to keep the germination medium sufficiently damp. Germination media can often appear damp on the surface yet be too dry at seed depth. Likewise temperatures above 75° F. can be detrimental. If there is some other answer we do not know about it.

MODERATOR MAIRE: Thank you very much, Karl Opitz and Lloyd Joley, for that very interesting presentation on propagation of pistachio

Now, to continue; Bob Gonderman is here from the Los Angeles State and County Arboretum. He has been doing some experimental work with certain rather difficult-to-root plants and we are lucky to have him. I am sure that Bob will have some interesting things to report. So, here is Dr. Bob Gonderman from the Los Angeles State and County Arboretum in Arcadia:

STUDIES WITH CUTTINGS OF DIFFICULT-TO-ROOT PLANTS

ROBERT L. GONDERMAN
Los Angeles State and County Arboretum
Arcadia, California

In attempts to root cuttings of difficult-to-root plants, a number of variations of lesser-known methods have been tried. I have had some moderate success in rooting cuttings of pines, oaks, and eucalyptus, and perhaps our methods may enable propagators to produce better landscape plants more easily and cheaply.

Vegetative propagation of desirable clones is becoming more and more practical as we apply our present knowledge to old rooting problems and learn to benefit from past experiences, such as we may learn at this meeting. Our mission-oriented research has permitted a few publications, so some of you already know of some of my work.

We may think of rooting as the result of expression of the interaction of root promoting and inhibiting factors metabolized within the plant itself. Production and concentration of such factors may be investigated by taking cuttings at various growth stages—before, during, or after a flush of growth. With the assistance of my class members, we have rooted several reportedly difficult plants during their spring flush of growth. Usually these have been single experiments; they are not reported until enough repetitions have been made.

It is conceivable that rooting inhibitors may be leached from the plants if they are easily soluble. My early trials in this regard have yielded only promises so far. While leaching, we could at the same time infuse the cuttings with phenolic or proteinaceous substances for possible promotion of endogenous auxin production.

Another approach is to gather cuttings when the root promoting effects are highest. One of the physiologically favorable times appears to be during the spring growth season. Our class members taking

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Another approach is to gather cuttings when the root promoting effects are highest. One of the physiologically favorable times appears to be during the spring growth season. Our class members taking cuttings at this time have obtained rooting with the following plants within a five week period. *Rhapiolepis, Ilex cornuta,* jujuba, loquat, *Templetonia, Abutilon, Metasequoia,* sun azalea, crape myrtle, *Carissa,* and *Bauhinia. Platanus, Ceanothus,* avocado and *Eucalyptus* took longer. These were mostly one time trials, with some repetitions carried on each year since 1969. None of this work has been reported up to this time

Timing of obtaining cutting material of various species may be of vital importance. With *Osmanthus fragrans aurantiacus* we found cuttings rooted only in spring and fall with no rooting in summer or winter. Trials with *Hymenosporum flavum* showed rooting to peak in early spring with few cuttings rooting the rest of the year. Interestingly, when endogenous auxin activity is highest, these often root best without exogenous hormones, and high concentrations of added auxin have decreased rooting.

Juvenility has been clearly recognized as a major factor in difficult-to-root plants We are attempting an approach in this area. We are working with 100 year old pine trees that are smog resistant. These are not only hard to find but it is difficult to obtain adequate satisfactory cutting wood. We are retaining the few cuttings that rooted and using them as "juvenile" stock plants and are hoping to obtain ease of rooting from cuttings taken from these due to the juvenility factor.

Also the position on conifer trees from which cuttings are taken suggests some juvenile effect. Reportedly cuttings taken from lateral ramets of lower ortets root more readily.

An important consideration is the great variation in Douglas fir trees Here the propagator needs to maintain records of parent trees and then use only the best rooters among them.

Several ideas which may have a beneficial influence on rooting will be briefly suggested. While I have used them, no specific data has been extracted on their overall value.

(1) Use of a penetrant carrier as dimethyl sulfoxide to carry rooting hormones into the vascular system of the cutting. This material has been useful in waxy, resinous, woody types of cuttings but has been of little value in other cases.

(2) Give cuttings as much light as they can use without inducing wilting. My own mist system is in full sun with natural photoperiod.

(3) Relatively high bottom heat and low foliar temperature seems to be worth consideration. After various trials and accidents, no ill effects have been seen, but rather an apparent enhancement of rooting has been obtained with several varieties and species.

(4) The pH of the rooting medium is reportedly optimum at about 5 to 6. Perlite has little buffering capacity and its prolonged use may cause a salt accumulation. Peat is usually added in summer. In

winter, less water is required and peat is omitted. With a small mist flow to carry salts away, we have had no appreciable problems with perlite.

(5) Lastly, propagation by tissue culture is an approaching possibility, though there is yet much to be known. Most of you know the merits of dividing promeristems under aseptic conditions to obtain propagules of desirable clones in large numbers. A variation of this method which may be faster and easier for some of you is the use of sterile sections of twig tips. Which medium and which hormone, and their concentrations, are problems which will be worked out with time. Probably one should start with a simple nutrient solution but complex media, as that of Murashige and Skoog, should yield response from a wider range of species.

Using the above techniques, I have been able to root cuttings of *Pinus pinea, P. palustris, P. roxburghii, Quercus agrifolia, Q. leucotricha, Eucalyptus ficifolia, E. gunnii* and a few others.

Not all attempts to achieve rooting of difficult plants have resulted in success, but trials which are evaluated lead the way to increased rooting percentages with less time and effort involved. It is hoped that some of these suggestions will work for you in the interests of producing better plants for more people to use.

MODERATOR MAIRE: We have a few minutes before coffee break for a couple of questions for Dr. Gonderman.

HAROLD ELZINGA: Who is the distributor for DMSO?

BOB GONDERMAN: You can get it from Van Waters and Rogers, Baker Chemical—chemical suppliers of that sort. It is not expensive.

HAROLD ELZINGA: What concentrations?

BOB GONDERMAN: I use a range—sometimes 100 parts per million, sometimes 1000 ppm— with the quick-dip method, normally.

MODERATOR MAIRE: Thank you very much, Bob Gonderman. We appreciate your being with us and giving us a most interesting talk. This will end this part of the morning session.

MODERATOR BRIGGS: Now, first on our propagation panel we have Ted Frolich, Dept. of Agricultural Sciences, University of California at Los Angeles. Ted has been on our program many times before. He has worked with citrus and other sub-tropicals. Ted is going to talk on the use of screens in the bottom of flats. This can involve two things: drainage, or modifying the growth of the root system. Next on our panel will be Dieter Lodder who originally came from Germany. He started with Monrovia Nursery; now he is at Armstrong Nursery He is the supervisor of propagation there and will be talking on propagation of lilacs. Ken Inose is with K & Y Nursery, Gardena, California. He will be talking on pumice as a rooting media. Then from Canada we planned to have with us Walt Van Vloten, but Walt didn't make it; he did send along his propagator, Harold Elzinga, again from Canada. And then Bob King from California Propagation Co. at Sepulveda. He again will be talking on something that we're all concerned about—the relationship in propagation between light, temperature, aand humidity. So, basically, this is what we will have this morning on our panel Ted, would you take over from here and talk on the screen bottom flats? Thank you.

THE USE OF SCREEN BOTTOM FLATS FOR SEEDLING PRODUCTION

EDWARD F. FROLICH

Department of Agricultural Sciences
University of California
Los Angeles, California

Seedlings of many plants produce pronounced tap roots in their initial stage. This is especially characteristic of materials from arid and semi-arid areas such as the southwest of the United States and parts of Australia, South Africa, and the Mediterranean region. When transplanting from the seed flat to pots, it is necessary with these materials to drastically reduce the size of the root system in order to avoid bending of the roots. This very often results in loss of the seedling

One way to overcome this problem is by root pruning the seedlings prior to the transplanting operation. In the past this was sometimes done by using a material toxic to roots in the bottom of the flat. Copper was most commonly used, either as a screen laid in the bottom of the flat, or by coating the flat heavily with copper naphthenate. This is effective in killing the growing point of the taproot, but there is a danger of getting an excess of copper into the seedlings, which could lead to various nutritional disturbances.

In the College of Agriculture at UCLA, screen bottom flats are used for starting seedlings of plants native to the Nevada desert. These flats are built of one-inch thick redwood for the sides and discarded Saran screen for the bottoms. This screen is the grade usually used to give about 50% shade. To support the Saran a piece of 2" x 4" mesh turkey wire is used. The depth of the flat is determined by the size of the container to be used in the transplanting. A flat 1¼" deep is about right for transplanting to 2¼" peat pots. The flats are raised above many. He started with Monrovia Nursery; now he is at Armstrong Nursery He is the supervisor of propagation there and will be talking on propagation of lilacs. Ken Inose is with K & Y Nursery, Gardena, California. He will be talking on pumice as a rooting media. Then from Canada we planned to have with us Walt Van Vloten, but Walt didn't make it; he did send along his propagator, Harold Elzinga, again from Canada. And then Bob King from California Propagation Co. at Sepulveda. He again will be talking on something that we're all concerned about—the relationship in propagation between light, temperature, aand humidity. So, basically, this is what we will have this morning on our panel Ted, would you take over from here and talk on the screen bottom flats? Thank you.

THE USE OF SCREEN BOTTOM FLATS FOR SEEDLING PRODUCTION

EDWARD F. FROLICH

Department of Agricultural Sciences
University of California
Los Angeles, California

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The medium used is industrial #3 grade vermiculite. This material is easy to water, holds moisture moderately well, and has good aeration With many larger seed it is not necessary to supply nutrients in order to get the seedlings large enough for transplanting. With some species, especially those with very small seed, it is necessary to fertilize One-half strength of a complete nutrient solution, such as Hoagland's, is used when needed.

When planting in a medium such as vermiculite, and feeding when necessary, it is possible to obtain close control of the growth. It is desirable to have the seedlings on a nutrition program lower than that which would give maximum growth. A low-nutrient level, especially with nitrogen, results in a higher root to top ratio.

Several advantages have been found with this system. The seedlings can be transplanted to pots or cans with virtually no loss of the root system, resulting in less mortality. By keeping the nutrition low, the seedlings are sturdy and easily handled. Plants can be held longer in the seed flats if necessary and still be usable.

MODERATOR BRIGGS· Our next speaker now will be Dieter Lodder:

PROPAGATION OF SYRINGA VULGARIS 'LAVENDER LADY' FROM CUTTINGS

DIETER W. LODDER

Armstrong Nurseries
Ontario, California

Syringa vulgaris 'Lavender Lady' is one of the few cultivars of this species which performs reasonably well under Southern California conditions and is, therefore, of economical importance to nurserymen in this area.

Unlike the French lilacs which are budded or grafted, *S. vulgaris* 'Lavender Lady' is normally propagated by softwood cuttings. This plant is not incompatible with the commonly used understocks such as *Syringa vulgaris, Ligustrum,* or *Forsythia,* but it is raised from cuttings because its growth is slower than that of these understocks and, if grafted, would result in extremely heavy suckering from the understock.

Success with the rooting of softwood cuttings of *S. vulgaris* 'Lavender Lady' at Armstrong Nurseries was unpredictable. Through experiments, a successful method was found which is described as follows:

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Softwood cuttings are taken as soon as new spring growth was available which is in mid-March in Southern California. Nodal cuttings are taken and stuck into flats filled with a rooting medium of five parts No. 3 Sponge Rok and one part, regular grind, Canadian peat moss. The flats are placed under intermittent mist. Four to 5 weeks later, all cuttings are taken from the flats while still under intermittent mist but without going through the usual hardening-off period prior to potting.

In our experiments, close to 50% of the cuttings rooted heavily. They were potted and placed into a greenhouse where high humidity was provided. The humidity was gradually reduced over the next 3 weeks, during which the plants continued growth with rapid root formation.

When the cuttings were dug from the flats most of those without roots had produced a heavy callus which probably developed during the first weeks in the greenhouse. Some heavily callused cuttings were found with a single, heavy root which had emerged from an area around the base of the cutting, not blocked by callus.

All callus was removed and the cuttings were re-stuck into new flats. This time Hormex #3 was used. At the start we used Hormex #1. While being processed during potting and resticking, the plant material must be kept moist, as the cuttings were not hardened off prior to the first pulling.

Six weeks later, about 70% of the reset cuttings were rooted, potted, and left under humid greenhouse conditions until sufficiently established.

Syringa plants produce heaviest growth during early spring, which means, with reference to rooted cuttings, that little or no new growth can be expected during the first year. In order to force growth on our newly potted plants we moved several flats to cold storage where they were kept for two months at 40° F. and then returned to a shade house. Two to 3 inches of growth developed within the first month; however growth stopped when, during a few days this summer, temperatures rose over 110° F. We plan to conduct additional experiments in forcing growth during the first year.

We found that cuttings of *S. vulgaris* 'Lavender Lady' must be taken when they are quite soft. The tissues will become hard and woody during the rooting process. Cuttings made from mature spring growth were of wood that was too hard and they failed to root. To obtain highest rooting percentages, rooted cuttings must be pulled after 6 weeks. Callused cuttings should be treated as described above and returned to the cutting flats until rooted.

MODERATOR BRIGGS: Would Ken Inose come forward? Ken will now talk on pumice as a rooting medium.

PUMICE AS A ROOTING MEDIUM

KEN INOSE

K & Y Nursery, Inc.
Gardena, California

The source from which we get our pumice is on the Eastern slopes of the High Sierras near Bishop, California. It is mined, screened and graded at the mine and delivered to our nursery in bulk. It is not heat treated and is chemically inert with a neutral reaction. The chemical composition of pumice is as follows:

Silica (SiO_2)	67.98%
Aluminum oxide (Al_2O_3)	16.98%
Iron oxide (Fe_2O_3)	0.24%
Titanium oxide (TiO_2)	0.06%
Calcium oxide (CaO)	0.64%
Magnesium oxide (MgO)	2.90%
Sodium oxide (Na_2O)	2.84%
Potassium oxide (K_2O)	0.09%
Loss on ignition	7.95%
Sulfuric anhydride (SO_3)	none
	99.66%
Water soluble potassium oxide (K_2O)	Trace

We buy the ⅛ to ¼ inch grade in 40 cu. yd. loads weighing approximately 25 tons. The cost is about $25 a ton delivered.

Some of the advantages of this material are that it is sterile and it also has very good drainage when used with a mist system. Because of the latter characteristic we are able to use, to our advantage, a non-clogging, high volume mist head, manufactured by Spraying Systems Co., Chicago. (It is a 160° parasol head No. ¼ E 5.8 with each head covering about 36 sq. ft. at 60 pounds pressure).

We root all our conifers and our hard-to-root broad-leaved evergreens in straight pumice under mist. In rooting hard-to-root cuttings, we feel that pumice has advantages over other materials in lower water retention and good bottom drainage. We also feel that the slight additional cost of pumice is offset by the increased rooting percentage and the quality of the root systems formed.

In conclusion I will add that no matter what rooting medium is used the following conditions are necessary for success. Clean mother stock, proper sanitation practices, proper relationship between air movement, light, temperature, and something that is very important in southern California, good quality water.

REFERENCE

Hartmann, H. T. and D. E. Kester. 1968. Plant Propagation: Principles and Practices, 2nd Edition. Prentice-Hall, Englewood Cliffs, New Jersey.

MODERATOR BRIGGS: Thank you, Ken. I know there'll be a lot of questions after a bit on that because many people are concerned about using pumice. I know we've looked at it many times.

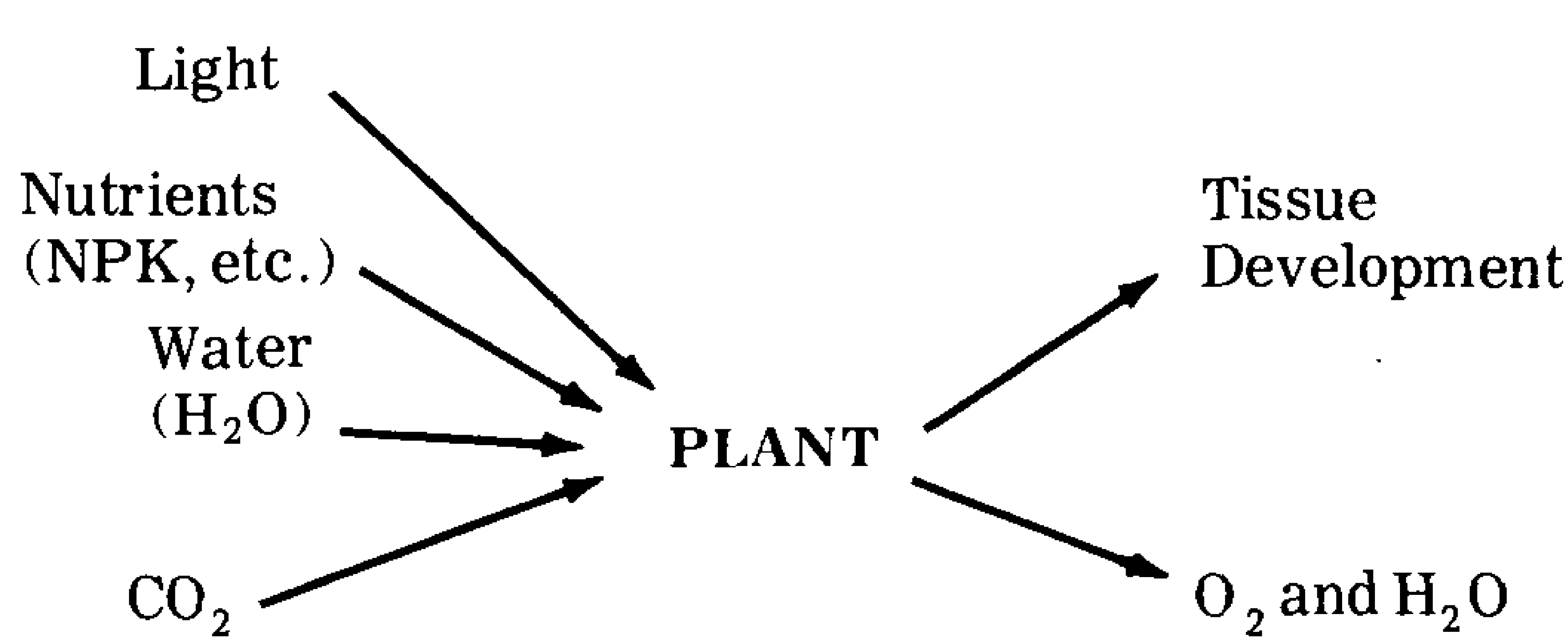
Bob King is now going to talk on the relation of light, temperature, and humidity as it affects plant propagation. Bob, it's all yours:

THE BALANCE OF LIGHT, HUMIDITY AND TEMPERATURE AS RELATED TO CUTTING LEAF DROP

ROBERT W. KING

California Propagation Company
Sepulveda, California

The very complex chemical mechanisms involved in plant development and growth can be summed up simply as follows:



the reactants (materials at left) entering into the plant system and being transformed into the products (materials at right).

Horticulturists have learned by experience that by increasing the amount of the reactants, the amount of products also increases. (chemists call this Le Chateliers' principle). Thus a well-watered and stock, proper sanitation practices, proper relationship between air movement, light, temperature, and something that is very important in southern California, good quality water.

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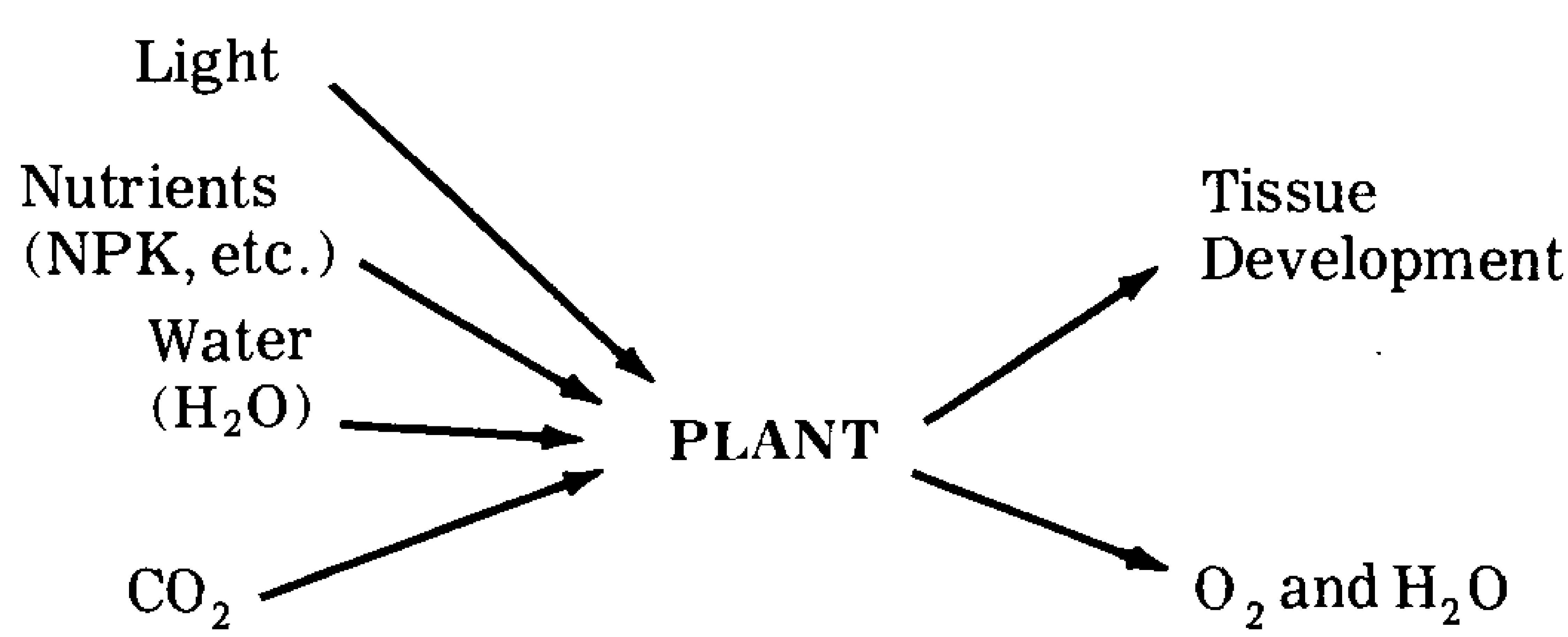

the reactants (materials at left) entering into the plant system and being transformed into the products (materials at right).

Horticulturists have learned by experience that by increasing the amount of the reactants, the amount of products also increases. (chemists call this Le Chateliers' principle). Thus a well-watered and fertilized plant in a lighted location will grow vigorously. We know from experience, however, that there are limits to the amount we may increase these reactants. Overwatering, over fertilization, sunburn, can all result in collapse of the system (plant death). Furthermore the tolerance to increasing these reactants varies from plant to plant so that each species has its own particular optimum values. Also these reactants can only be utilized by the plant in certain ratios; fertilization without ample light and water will not increase development. It is this critical balance of the reactants—light, humidity and heat—and their relation to cutting viability that will be discussed further.

Light and Humidity. Light being an essential ingredient in plant development, the energy source for the reactions in the photosynthetic process, the practical problem for the propagator is to provide ample light without burning or drying out the cuttings. High humidity ($>90\%$) in the cuttings' atmosphere greatly reduces transpiration, as does a water film on the leaf surface; but often cuttings must be protected further by shading. In our propagation operation all cutting beds are shaded with polypropylite shade cloth. The particular cloth selected provides about 50% shade, or a maximum day light intensity of about 1,200 foot-candles.

Heat. It is general knowledge that increasing the temperature in the rooting zone of a developing cutting speeds the initiation and growth of roots. The basis for this is, of course, that Q_{10} of the chemical processes in root development must be somewhere between 2 and 3. In other words, for each 10° C that the temperature is increased, the process doubles or triples in rate. There are of course limits, and temperatures in the range 65° F to 75° F are most often selected as optimum for root initiation and growth. Practically, this is accomplished in our facilities by hot water circulating through pipes beneath the cutting beds, the flow of the water being thermostatically controlled.

The Balance. Despite our careful efforts to provide the optimum conditions of ample light and moderate heat in the rooting zone, we have found that during periods of extended cloudy weather (over two days duration) there was significant leaf drop and cutting deterioration. This condition was especially pronounced in crops of *Xylosma congestum (X. senticosa)*, *Pittosporum tobira* 'Varigata', *Ficus benjamina,* and *Ficus retusa* var. *nitida*.

The maximum daylight intensity at cutting level was measured during one such cloud-cover period and found to be only 125 foot-candles. Apparently the drop in light intensity, combined with the warmth of the bottom heat, had shifted conditions more in favor of fungal growth and cutting deterioration than plant development, fungi being Thallophytes and not requiring light for growth. The problem confronting us was how to best return the balance of heat, humidity, and light to a point more favorable to plant growth. Two solutions seemed evident.

1. To increase light intensity and thus spur plant development. This could be done by installation of artificial light sources or by removal of all shade fabric during cloudy weather but replacing it on clear days.
2. Decrease bottom heat and thus retard the growth of fungi and the rate of plant deterioration due to high respiration.

Solution No. 1 was ruled out as financially unfeasible. Artificial light (fluorescent) installation would be expensive and of doubtful benefit. Removal of the fabric cover from greenhouses and hotbeds, with subsequent replacement each time there was several days of overcast would require a great deal of labor and introduce the danger of burning the cuttings if shade was not applied promptly after clouds dissipated.

Conclusion. We then tried Solution No.2 by reducing the bottom heat, thus the temperature of the rooting zone area to 50-55° F., each time a cloud cover prevailed for more than one day. The following results were obtained as shown in Table 1.

Table 1. Effect of reduced bottom heat during cloudy weather on rooting.

	Rooting without bottom heat reduction	Rooting with bottom heat reduction	Elapsed rooting time
Pittosporium tobira 'Varigata'	58% ± 1%	88% ± 1%	49 days
Xylosma congestum (*X. senticosa*)	63 ± 1	92 ± 1	35

The ability of cuttings to retain leaves in good condition under reduced bottom heat, even through overcast periods of two weeks and longer, was most striking. Speed of root development was retarded slightly. Rooting periods averaged about 10% longer, depending upon number of overcast days occurring during cutting development.

This practice of lowering bottom heat in cloudy weather has now been adopted as standard procedure in our nursery and results have been favorable both in hotbeds and greenhouses. Graphically what we are accomplishing can be seen in Figure 1.

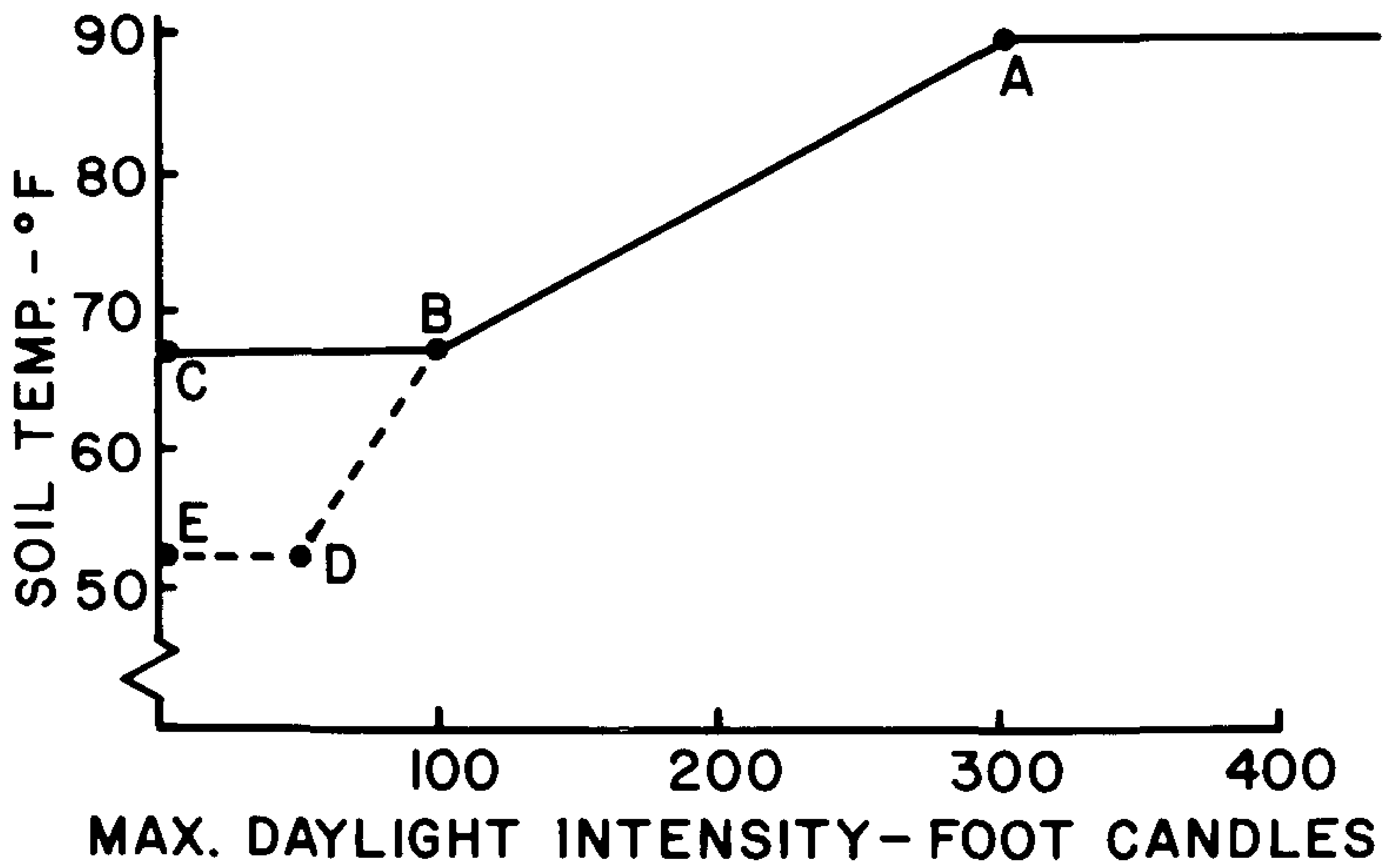

Fig. 1. Bottom heat levels as maintained according to the maximum day light intensity levels.

On clear sunny days, as light intensity drops in evening hours from point A to B, the heater goes on at 70°-65° F., maintaining plants in that temperature range throughout the night hours (B to C). On overcast days, with low light intensity, the temperature is allowed to drift lower, to the broken line B to D, and the plants are kept in this lower range (50°-55° F.) for the duration of the cloudy period.

MODERATOR BRIGGS: Thank you very much. In fact, while Bob was talking I realized that we do this and we never understood why we did it. We have some plants that root very poorly in the greenhouse under heat in the winter, but if we take them out, put them in the lath house, where it is nice and cool, they root like weeds. Maybe we've got the same problem, I'm not sure; we do have low light in the winter up in Washington.

Dick, would you introduce our last speaker?

RICHARD MAIRE: Now on our Propagation Panel we will have a talk by Richard Puffer, Farm Advisor in San Bernardino, giving information on Christmas tree propagation, developed mainly by Mr. Fred Dorman. Dick:

ROOTING MONTEREY PINE CUTTINGS

RICHARD E. PUFFER

University of California Agricultural Extension Service
San Bernardino, California

Monterey pine (*Pinus radiata*) is used to a considerable extent in landscaping and for Christmas tree farms in Southern California.

One of the biggest problems has been the effect of air pollution on the trees. Monterey pine trees vary considerably in their susceptibility to air pollution, ranging all the way from no damage to, in a few cases, death of the tree. Most of the susceptible trees show a yellow mottling of the needles and, occasionally, will turn brown immediately after a heavy attack. This problem led to the study of the rooting of cuttings from resistant trees to see if clones could be developed that would be resistant to air pollution. As we studied the variability among Monterey pine seedlings, we discovered that an occasional tree would grow into an almost perfect Christmas tree shape with very little pruning. Some of these trees also had desirable color and needle characteristics that made them very desirable for Christmas trees. We visited farms that had planted thousands of Monterey pine seedlings and searched for the few "perfect" trees. Cuttings were taken from these trees and rooted in sand with mist sprays. We soon discovered that cuttings from one tree did not root at all, while cuttings from another tree would root quite satisfactorily, showing that the seedlings not only vary in the aspects described above, but also in their ability to root. This is shown in Table 1.

Table 1. Variability in rooting ability of cuttings taken from individual Monterey pine trees.

Number of trees	Percent of cuttings rooted
1	60
2	20
2	13
1	10
4	1
2	0.3
3	0

Fred Dorman, who has a Christmas tree farm in Highland, Calif., has been working on rooting cuttings of Monterey pine since 1968. He has shown rather conclusively that cuttings taken from trees resistant to air pollution are also resistant to air pollution and, conversely, cuttings taken from susceptible trees are also susceptible to air pollution.

Mr. Dorman has grown rooted cuttings to fairly large trees and then took cuttings from these trees and found that they also rooted satisfactorily.

Table 2 shows the results of Mr. Dorman's trials over the past two years. To simplify the data, the percent of the cuttings that rooted from each tree were put in one of ten classifications. Each classification has a range of 10%. If a certain trial had 35% of the cuttings from one tree that rooted, that tree would be listed in the fourth classification identified as 31-40%. The mid-points of rooting in each trial for the trees are indicated. The last trial did not do as well as the previous ones because it was done in the summer; it is much easier to root cuttings in the winter in San Bernardino County.

It can be seen from this table that, as the trials continued, there was an increasingly higher percentage of cuttings rooted. This is because the techniques for rooting were continually being improved and the trees producing cuttings with a high rooting percentage were kept for retrial, while the trees giving poor rooting cuttings were discarded. In each trial, new trees were introduced to test their rooting capabilities.

It is evident from Mr. Dorman's work that we can find so-called "perfect" trees that will root satisfactorily on a commercial basis. This could be very important to the landscaping and Christmas tree industries.

MODERATOR BRIGGS: Thank you, Dick. Jolly, do you have a question?

JOLLY BATCHELLER: Were these cuttings placed in flats or in the ground?

DICK PUFFER: All of Fred's cuttings are in beds—raised beds. He uses sand as his rooting medium; bottom heat with mist. The sand is about 4" deep.

JOLLY BATCHELLER: In Rotarura, New Zealand, I saw a bed of 5,000 Monterey pine cuttings placed in the ground in June (the equivalent of our December). They were to be dug the following June. Out of the 5,000 I saw, five were counted as dead.

DICK PUFFER: Yes, I didn't want to get into that much detail, but thank you for bringing it up. Dr. Libby has been able to do the same thing at Berkeley, but we can't do it in southern California. It think it

Table 2. Results from seven trials in rooting Monterey pine cuttings.

Period of taking cuttings	Number of trees per trial	Number of stock trees whose cuttings rooted in the indicated percentages.									
		0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	81-90%	91-100%
2/69-5/69	11	2	2	1	[a]4	0	1	0	1	0	0
5/69-8/69	12	4	[a]4	1	1	1	1	0	0	0	0
8/69-11/69	22	2	5	[a]5	3	1	5	1	0	0	0
2/70-5/70	45	7	10	[a]10	9	3	3	1	2	0	0
1/71-5/71	25	0	1	6	4	[a]2	4	2	4	2	0
2/71-5/71	16	4	2	0	0	2	[a]1	3	2	1	1
5/71-9/71	8	1	3	[a]3	0	0	0	0	1	0	0
Total	139	20	27	26	21	9	15	7	10	3	1

[a]Mid-point in each trial for rooting percentages obtained.

has to do with the dormancy of the tree, perhaps at the time the cuttings are selected. In southern California the tree never really goes dormant. You know, you go and choose a tree at a tree lot at Christmas time, and you're quite apt to see new young growth coming out. This is one of the problems they have next to smog, which is their biggest problem—and tree variability. But in the Berkeley area, the trees do become more dormant.

RALPH SHUGERT: I would like to direct this to Dieter on his lilac propagation. I'm not familiar with the cultivar he discussed. He said that he has had no success in budding this particular cultivar. I'm wondering have you ever tried budding it on *Syringa villosa* rather than *Syringa vulgaris?*

DIETER LODDER: No, we haven't. We haven't tried budding or grafting. I have seen grafted plants in large containers but there was a lot of suckering from the understock, which happened to be a *Ligustrum* variety. These plants were suckering heavily. We did not attempt to bud or graft but it is quite possible that it works.

RALPH SHUGERT: I just bring it up because I have had some experience with some lilac cultivars in the Midwest. We have had very poor bud take, down as low as 15 to 20% on *Syringa vulgaris,* but using *Syringa villosa* as the understock we have increased, sometimes doubled, our percentage of takes with those cultivars that are tough to graft on *S. vulgaris.*

DIETER LODDER: No, we haven't tried this yet. Maybe we should and see what happens. But I think the fact that the understock will sucker too heavily will probably prohibit this sort of thing.

RALPH SHUGERT: That's the only point in bringing this up. You will not find the suckering with *S. villosa* that you have with *S. vulgaris.*

ANDY LEISER: Another question for Dieter. On your difficulty in breaking dormancy of lilac buds, have you tried gibberellic acid treatments? We used it on a number of other things—I haven't worked on lilacs with this. In certain deciduous plants that we root, we want to break bud dormancy. The rooted cuttings go dormant during the summer but we can force them into growth with GA treatments.

DIETER LODDER: No, we haven't tried GA. The experiment in forcing growth in the first year was only done this year on a very small scale. We had four flats which were moved into cold storage; they were not treated in any other way. As a matter of fact, they were almost neglected. We brought them out of cold storage and placed them in the lathhouse, and watered them well. A few days later, the buds started to break. I was afraid of this hot spell we have just had; the plants actually stopped growing but I looked at them yesterday again to see if I had some additional information and they had started to grow again. The ones that were propagated this spring, potted and not moved to cold storage have not shown any activity up to now. But we might try GA and see if we get better results.

MODERATOR BRIGGS: Did I understand you right that cold storage did help break dormancy?

DIETER LODDER: Right.

MODERATOR BRIGGS: Now, what is the time we are talking about—a week, two weeks, a month, two months—what length of time is necessary in cold storage to do this?

DIETER LODDER: Well, with this experiment we used two months. We put them in cold storage for two months and took them back out again. We took them out about six weeks ago (mid-August). They were barely established in the pot. The cuttings taken earlier this spring were potted—we moved them into a greenhouse to get a fairly heavy root system developed in the pot—then we moved them straight to cold storage. They started to grow immediately after they were taken out of cold storage.

MODERATOR BRIGGS: Thank you. Andy, if someone wants to play around with gibberellic acid, what would you say would be the concentration to try, in parts per million, to try to break dormancy?

ANDY LEISER: We work with a fairly wide variety of plants, sometimes in small quantities and often, with the deciduous plants they do go dormant, we can't get them into a flush of growth before fall. By spring they're pretty well debilitated. We usually use 1000 parts per million. Cold storage may be fine, but when you can spray a little gibberellic acid on the buds and in a week or two have them pushing vigorously, it might be a real economic advantage.

MODERATOR BRIGGS: Thank you. I believe on rhododendrons to break dormancy, they went up as high as 1% (10,000 ppm) when it was put on with an eye dropper on the buds. So that would be a good range—1000 to 10,000 ppm—this might be something to work around.

ANDY LEISER: It can be quite variable and we've had to repeat—certain species don't respond to one application. We go back ten days later and apply it again. The second time around we get good results—sometimes.

MODERATOR BRIGGS: Any other questions? I have one on pumice. How do you get the fine particles out of pumice, or do you even care about the fine particles?

KEN INOSE: The grade we buy is screened quite well and most of the dust is eliminated.

MODERATOR BRIGGS: That is an important point; we have found this to be a problem in our area. Most pumice we buy has too many fine particles; it packs and there is poor drainage. I was curious to see how you got around this problem.

HOWARD BROWN: How many times can you re-use pumice?

KEN INOSE: We can re-use our pumice, but we steam sterilize it after the first time. But I find it works well in our soil mix so we just throw it into our soil mix. Usually we only use it once, but it can be used twice—but before the second time it must be sterilized.

MODERATOR BRIGGS: When you re-use it, do you find that you have lost something from the pumice that helped, that you didn't have when using new pumice? Did you ever encounter this?

KEN INOSE: Last year, early in the year, the source from which I was getting my pumice was unable to supply me so I had to re-use my pumice for a while until I found a second source. I found that it worked well after we sterilized it—it gave as good results as the first time.

ANDY LEISER: I have a question for you, Dick, or possibly Jolly can fill in. I'm fascinated about this pine rooting; we have located a very fine pine in a place from which it is difficult to get seed. I've been writing for almost a year trying to get seed; we think it might be amenable to this type of cutting propagation. I have a two or three-part question: What hormones are used and at what levels? In your mist propagation, what time of year is this done? And, Jolly, in New Zealand, do they use bottom heat under their beds, wounding, hormone treatments, or anything?

JOLLY BATCHELLER: As I recall it right now, they take 8 to 10 inch cuttings, unwounded, untreated, line them out about 4-6'' apart in beds in rows about 10'' apart, directly in the ground, open sun, no mist. Then, along about 6 to 8 months after they've been placed they get callusing and rooting started. Then they run a vertical disc or a cutter down through the bed about every two weeks. At the end of one year they have a compact mass of roots and transplanting is no problem at all; the plants go directly into the field where they grow them to mature timber size in 20 years.

ANDY LEISER: What kind of soil mix?

JOLLY BATCHELLER: It is a sandy loam.

ANDY LEISER: And where is this in New Zealand—so we can guess as to climate.

JOLLY BATCHELLER: Rotarura is near Auckland in the north island of New Zealand.

MODERATOR BRIGGS: Now, Jolly, is this the wet season over there—in weather where there is no dehydration of the top?

JOLLY BATCHELLER: Well, Rotarura is, I believe, at an elevation of about 2,000 feet. New Zealand's temperature and range of rainy seasons would be like that of southern Oregon. There is no place more than 60 miles from the ocean—they have the influence of the ocean. The rains come throughout the season; they don't have a long dry period.

MODERATOR BRIGGS: They do get morning fog from the ocean then, maybe?

JOLLY BATCHELLER: No, Rotarura is about 30 to 40 miles from the ocean; they don't have morning fog but I wasn't there all year, however.

VOICE: Do they remove the needles from that part they put in the ground?

JOLLY BATCHELLER: I wasn't there but the propagator said, "we just stick them in the ground."

VOICE: Do they use hormones?

JOLLY BATCHELLER: No hormones.

GORDON WATTS: I heard a report on this and it mentioned the mixture of sawdust and dirt in the Australian and New Zealand propagation of their trees; and they did remove the bottom needles from cuttings before they stuck them in the ground.

MODERATOR BRIGGS: Going along with this—three or four years ago we had two Japanese exchange students that were with us some 18 months. We had a language barrier, but we could find out enough between us to learn that in Japan—in southern Japan—they take cuttings in the same manner, except they stick the cuttings in the river for about four or five days. This actually removes something from the cuttings—possibly a rooting inhibitor. Then they do the same thing—they line them out in an open field. But this is their monsoon period which is real wet—they do get rooting and do it very nicely. We tried this method in western Washington but we had nearly 100% dehydration and loss going through the winter—it wouldn't work. That's why I'm curious—how they get by without mist on such large pine cuttings outside.

ROBERT WARNER: Can you use root cuttings to start Douglas fir?

MODERATOR BRIGGS: Has anyone used root cuttings for Douglas fir? I don't know of any literature on this. When you dig a Douglas fir seedling you never see a root that shoots a sprout and grows. I presume the percentage take of root cuttings would be pretty small, if any. I've never seen a Douglas fir in the woods or a Douglas fir in the nursery that ever had any root sprouts. Would anyone like to make a comment—root cuttings of Douglas fir?

ROBERT WARNER: Root cuttings are almost the only way you can propagate breadfruit—but I'm sure not many people are doing that.

MODERATOR BRIGGS: There are a lot of trees that could be propagated from root cuttings, but we don't think enough about this, perhaps. We have tried quite a few trees that do sucker but even then we have a problem of getting the root cuttings to grow. Maybe again, this is a matter of technique.

WEDNESDAY AFTERNOON SESSION

October 6, 1971

MODERATOR RAY HASEK: It gives me great pleasure to introduce a colleague of mine for a good many years, Dr. Tok Furuta, Extension Ornamental Horticulturist, at the University of California, Riverside. And he will talk to us about controlled environment seed propagation. Tok:

THE PHYTOTRONIC ENTERPRISE

TOKUJI FURUTA

University of California
Riverside, California

The room was gleaming white and seemingly sterile. Occasionally a door opened and music from a transistor radio entered from somewhere outside. Otherwise, there was an air of hushed expectation.

The only sound was a gentle hiss as air passed through the adjustable louvers into the room, combined with a faint hum from the lights. This was all the sound that could be heard as women robed in white moved about silently inspecting the rows and rows of white plastic trays. From time to time they would stop to more closely inspect and manipulate one of the living creatures on the white trays.

The room was divided into two parts by a lightproof curtain. Half of the room was brilliantly lit from overhead lights. On the basis of the glow from each lamp one determines that at least two types were used. The other half of the room was dimly lit for part of the time, in darkness the remainder. Every 12 hours, the curtains automatically parted and the lights moved to the dark side.

Through special tubes attached to the trays, water and nutrients reached the tiny creatures. There was no waste, the floor remained spotless. The workers inspected the controls and monitoring devices to be certain the composition of gases and the temperature and relative humidity were within acceptable limits for the creatures to grow vigorously.

Reached through large sliding doors at one end of the room was a smaller room whose walls were lined with shelf after shelf. Over each shelf were fluorescent lights. On the shelves were more of the white trays seen in the larger room.

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At the far end, through more sliding doors, was a clean preparation room. Here the trays were prepared before being placed on the shelves in the small room.

Would this be a description of the propagation facilities for seedlings at some nursery in the future? Would there be advantages for the nurseryman, and for the consumer? Can seedlings be propagated this way and still be of high quality?

This description is not of the future. Essentially, it is based on facilities already in operation. At the 1970 meeting of the American Society of Agricultural Engineers, James A. Buck (4) of the General Electric Company presented a paper, "High Intensity Discharge Lamps for Plant Growth Applications," in which the facilities above, a part of a commercial greenhouse vegetable operation, were essentially described.

Some thoughts on terminology: The terminology that has developed to describe facilities for plants is confusing. The following descriptions may be helpful.

> **Phytotrons** are combinations of greenhouses and growing rooms for plants.
>
> **Controlled environment** has been used to designate the system of growing plants in rooms or chambers under artificial lights when temperature, composition of the gases, and relative humidity as well as soil moisture and nutrition are controlled. This is usually contrasted to *greenhouse* culture where natural light is used—perhaps supplemented with artificial light, but still natural light is the primary source. In the greenhouse the soil moisture, nutrition, humidity, atmospheric gases and temperature may also be controlled so the environment of the plant is controlled.
>
> **Growing rooms** are temperature-controlled, artificially-lighted rooms for growing plants. These rooms are large enough to permit people to enter. Composition of the air may also be regulated.
>
> **Growing cabinets** are smaller than growing rooms and the operator cannot enter.
>
> **Germinators** are rooms or cabinets designed especially to germinate seeds—usually high humidity and rather precise temperature controls are needed.

Focus on the problem. To fully comprehend the subject of germinating seeds and growing plants under controlled conditions, it is necessary to seek answers to the following questions. First, can plants of the desired characteristics and quality be grown in these facilities? Second, what are the phases of plant growth and development that are involved in the system? Third, why would one consider using such facilities? Lastly, what are the benefits and the costs?

When evaluating all data to decide whether these systems are worthwhile, one must remember that different systems of production are being compared. Each individual has somewhat different requirements for the system. Each must of necessity make the analysis because the right system for one may not be right for another.

Can it grow plants? To study plants under controlled conditions, or to be able to rapidly evaluate some conditions, such as the number of seeds that germinate, laboratory workers and research scientists have for many years used cabinets and growing rooms. These have been used to grow plants but generally were too expensive or complicated for practical use. Because the idea worked, adaption to field use followed.

Researchers, nurserymen and greenhouse vegetable growers in Britain and the European continent have studied the use of growing rooms for a number of years (5, 9, 16, 17). Concurrently, procedures were being developed (3), in the U.S. to grow seedlings under fluorescent lights.

There is no question but that seeds may be germinated and high quality young seedlings grown in growing rooms under artificial lights. But what about the benefits to the grower, and to the consumer?

Phases of plant growth. While plant development and growth from the onset of germination of the seed until transplanting to the field is a continuous process, taking the viewpoint that three distinct phases of plant development are involved would help to evaluate systems—procedures, equipment, etc.—developed for the culture of plants in growing rooms. These phases are as follows: (1) Germination of the seed, (2) Growth of the small seedling until transplanting, and (3) Growth of the small transplant. Demarcation between these developmental phases is not sharp. Duration of each phase is dependent upon the species and the environmental conditions that prevail.

Each phase has distinct optimum environmental conditions and space requirements. These may vary with plant species and even variety.

In a series of articles in 1969, Cathey (7) reported on the response of seeds of 112 species of plants to different regimes of temperature and light. He divided the responses into nine groups. He found that light inhibited the germination of seeds of some species such as *Vinca rosea* and *Limonium suworowii* (*Statice suworowii*). On the other hand the presence of red light on imbibed seeds was essential or enhanced the germination of many species such as *Petunia* 'Maytime;' *Kalanchoe* 'Tom Thumb;' *Begonia* 'Snowbank' and *Primula* 'Fasbender's Red.' Light intensity of 200 foot candles or less was sufficient; many plants responded to as low as 0.2 foot candles of light energy.

Temperature acted to modify the response to light. Optimum temperatures varied from 55° F. (lupine, *Myosotis*, sweetpea) to 80° F. (mimosa, *Grevillea robusta*).

The optimum environmental conditions for small plants before and following transplanting might be considered to be the same. Obviously, higher light energies are needed than those needed for seed germination. Early research in the U. S. reported minimum light intensities of 500 to 600 foot candles were needed to produce acceptable plants. Following transplanting to small pots, or spaced in flats, British scientists have been working with light intensities of 500 to 1000 foot candles on the plants.

The major difference between the last two phases would be the space needed for the plants. The space requirements for seed germination and growth of the small seedlings would be the same.

These requirements suggest that at least two separate cabinets or rooms would result in the most optimum conditions, efficiency and costs. A small room or cabinet for seed germination could be used. Several cabinets could be used to obtain the best condition for germination of each species. Low light intensity (200 fc), high humidity (65% and over) and temperature varying from 55° F. to 80° F. would be needed. Shelves may be close together. A second and larger room would be used to grow the small plants before or following transplanting to small pots. Higher light intensities (over 500fc) and lower humidity would be a consideration. The necessity of water and fertilization must also be added to the system.

Reasons for commercial usage. Around many nurseries may be rooms not fully utilized, or are used for only part of the year. Converting these to growing rooms would not only more fully utilize them but permit more efficient use of capital. This is a principal reason for commercial usage of growing rooms. Cellars, common storage and refrigerated storages are examples of facilities that can be more fully utilized. If there would be a corresponding release of greenhouse space for crop production, greater benefits would accrue as the released space is put into income-producing crops (4).

Another reason often expressed for use of growing rooms is that plants develop more rapidly and uniformly under these conditions than under greenhouse conditions. This generally is true because of a constant uniform environment and one suited for rapid plant growth. For example, air temperatures are more constant in growing rooms than in greenhouses. And due to the uniform intensity of light while the lamps are on, plants in growing rooms often receive more total light energy during the day than they would in greenhouses under natural conditions.

A third reason advanced for the use of growing rooms for small plants is earlier production, such as flowering or yield of vegetables, or more total production. Again there seems to be general agreement that this is true.

Faster growth. It would be surprising indeed if plants did not grow faster under growing room conditions than under greenhouse conditions. The total concept of using growing rooms is to be able to provide optimum environmental conditions whatever the whims of mother nature.

All factors in a plant's environment—water, nutrients, temperature, light energy, etc.—function together as a subsystem to influence the rate and amount of plant growth. Research scientists at the USDA have found that plant growth can be speeded tremendously by increasing the intensity of all environmental factors. Some of the fastest growth was obtained when the following environment prevailed: air temperature of 85° F. days and 75° F. nights, 16 hours of light at 4000 foot candles of intensity, relative humidity of 65%, 2000 ppm of CO in the air, air movement around the plants constant and four to six applications of water and fertilizer each day. This should be contrasted to research in Great Britain where ambient CO_2 levels were used, temperatures of 70° F. day, 65° F. night, 16 hours of light at 1000 foot candles intensity and air movement at 60 feet per minute.

It appears that plant growth can be speeded tremendously. The cost of providing the escalating environment must be balanced against income to determine practicality.

Early imprinting. Environmental influences on young seedlings can persist for many weeks, even when the plant has been removed from that environment. This effect has been shown a number of times (6, 8, 10, 11, 12, 14, 18). The effect may be larger plants, earlier flowering, earlier yield, and more yield. Adverse effects may also be noted.

Often, the nature of the crop determines whether the effect may be adverse or not. For example, Hopkins (10) reported that brief periods of water stress with small tobacco plants delayed flowering (flowering at a higher node). Actually this effect was beneficial because yield was increased due to a change in distribution of leaf surface and the delay of flowering at a higher node.

Where the grower is interested in faster growth and earlier yield, or more total yield, or both, early imprinting could be used to advantage However, where the grower sells plants, the value of early imprinting for faster growth and earlier yield may be open to question. True, the crop will be ready for market in a short period of time. However, if adverse weather caused delays in selling or delivering the plants, would they become overgrown and of poor quality too rapidly? Would the faster growth shorten the shelf life of plants at retail outlets? Both of these are possibilities based on the evidence and must be considered.

Benefits and costs. The benefits of using growing rooms may be listed as follows: (1) faster plant growth, (2) earlier yield or more total yield or both, (3) more uniform plant growth, (4) utilization of under-used or waste space, (5) more predictable plant growth.

To a businessman that starts seedlings and matures a crop—be it flowering or vegetables—these benefits could mean more precise regulation of the crop and an improved income picture. To the businessman that sells small plants, some of these benefits may mean shorter shelf life of the small plants.

The cost of providing these facilities vary with location and environment. In England, some data indicate that the cost per tomato plant was from 4% to 110% more depending upon the system of growing room culture used (15). On the other hand, Buck (4) quotes the vegetable grower as stating that he saved money—"Our anticipated savings...should amount to 0.008 cents for each of two million lettuce seedlings and 0.04 cents for each of 75,000 tomato plants started. We also expect to save over 1,200 man hours of labor..." Both of these facilities did not report the use of elevated levels of CO_2. Because the last facility was utilizing underused refrigerator space already on the premises, it is not clear what costs of building or depreciation of structures was involved. The report by Lingard considered depreciation of the structures as a cost of operation.

The environment to maintain. If you were to construct facilities for germinating seeds and growing young plants, what should be the level of each environmental factor over which control could be exercised? In 1969, a representative of George Ball, Inc. (2) wrote that they were recommending the following conditions for the germination and early culture of bedding plants: (1) Constant day and night temperatures of 65° F. to 70° F.; (2) Minimum light intensity of 500 to 800 foot candles at plant level, using warm white fluorescent tubes as a light source; (3) Lights on for 18 hours per day. No mention was made of CO_2 levels, relative humidity or air movement. Presumably these factors fluctuated naturally.

Scientists working at the USDA (13) suggested that the optimum environmental system had the following characteristics: (1) air movement of 100 feet per minute; (2) day temperatures of 80° F. to 85° F. and night temperatures of 70° F. to 75° F.; (3) relative humidity of 65 per cent; (4) light intensity of 100 foot candles for germination and 2000 foot candles for growing; (5) light duration of 16 hours; (6) light source of cool white fluorescent tubes and incandescent bulbs (10% of wattage); (7) CO_2 levels of 400-500 ppm for germination and 1000-2000 ppm for growing.

In the facilities described by Buck (4) the following conditions prevailed: (1) Constant air movement, velocity not stated; (2) constant temperature of 70° $\pm$ 5° F.; (3) light intensity of 4000 foot candles; (4) light duration of 12 hours; 5) light source a combination of high pressure sodium and metal halid lamps.

As previously mentioned, growing rooms in Britain have from 500 to 1000 foot candles of light at a temperature of about 70° F. Light duration was generally 16 hours. Fluorescent tubes are the most common light source.

Several considerations should be kept in mind for these facilities. First, germination rooms require less light than growing rooms. A maximum of 200 foot candles would be sufficient for germination while growing rooms should have a minimum of 500 to 1000 foot candles of light at plant level.

Second, germination rooms require higher humidities than growing rooms. A level of 60-65% should be sufficient for growing rooms.

Third, maximum effect of elevated CO_2 levels is obtained only under high light intensities—over 1500 or 2000 foot candles of light. Elevated temperatures during the light hours are important.

Fourth, the length of lighting for best growth is somewhat dependent on light intensity. Buck (4) stated that they found as good growth with 12 hours of light at 4000 foot candles as 16 hours of light at 2000 foot candles. Other reports indicate the same. Light intensity high enough to make 12 hours of lighting sufficient has some practical advantages in efficient use of lights.

Fifth, light source is relatively unimportant to plants as long as the proper color balance is maintained. Light source does influence cost of installation and operation.

In the final analysis, each situation must be analyzed on its own merits depending on the desires of the manager. Guidelines for minimum conditions might be drawn up, but these may not be the most efficient for the particular situation.

Some engineering considerations. Buck (4) presented the ideas that went towards designing and building a growing room for commercial conditions Only one level of plants were to be grown, and a light intensity of 4000 foot candles was desired. High intensity gas discharge lamps were used. Use of fluorescent lights would require many lamps and mounting them close together. Also some difficult lamp temperature requirements were imposed, requiring a complicated air handling system. Still, the fluorescent lights would have been less expensive to install.

Passing the air over the lamps and exhausting at the bottom of the room help to cool the lamps, and to heat the air. Outside air can be used to cool the room whenever outside air is below growing room temperature. However, this would complicate the task of maintaining elevated CO_2 levels. Excess heat from the lighted growing room might be used to heat other facilities such as the germination room.

Burning the lights constantly and moving them from one room to another each 12 hours would make maximum use of this expensive facility—and increase the life of the bulbs in the process. Control of photoperiod may be by means of low intensity lights in the dark room.

British research workers have developed ideas to have more than one layer of plants in a growing room. Tiered mobile benches are placed between banks of lights. The concept seems to hold much promise.

Separate seed germination rooms should be provided. Ideally, three rooms are needed—a germination room, a growing room for small plants in the seed flats and a growing room for the plants in small pots or packs. The latter two rooms may be combined without serious difficulty.

In conclusion. The widespread use of separate germination and growing rooms for seedlings will depend upon the costs and benefits that accrue to the producer. There is no question on the ability of producing quality plants, of obtaining faster growth and of the effects of early imprinting. Recent technological developments make these facilities practical.

Whether greenhouses will be completely replaced by these facilities is questionable. Under some conditions, greenhouses will be replaced. More likely these facilities will be part of a well organized system of production for plants that include greenhouses and outdoor facilities as well as growing rooms and germination rooms.

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MODERATOR HASEK: Thank you, Tok. Any questions?

RALPH SHUGERT: Tok, I was wondering, in researching this did you run across anything in the use of lights for breaking double dormancy in seeds? I'm thinking of genera like *Vibernum* and *Tilia,* which, for a commercial man, seed dormancy presents quite a problem. Has anyone done any experimental work in lighting to break double dormancy?

TOK FURUTA Well, frankly, no because I wasn't looking for that aspect. I don't recall any information I've seen on this particular aspect. Seed is generally responsive to light only after it has imbibed water and is getting ready to germinate This is just removing one block of germination. Now, when you're talking about double dormancy—this may be caused by inhibitors or something else like this. I don't know. It's questionable in my mind whether light would have any effect on both aspects of double dormancy.

MODERATOR HASEK: We are to have a panel on our next segment, which is on seed handling. We will start with Gene Baciu.

PROLONGING SEED LIFE

EUGENE BACIU

Mistletoe Sales, Wholesale Seeds
Santa Barbara, California

Seeds of short life have presented problems for the nurseryman for centuries. In the days of the sailing ships, expeditions were made to gather plants from all over the world. Many of these plants had to be grown in containers on the ships and, in most instances, it took years to transport these plants to Europe and other countries. The steamship helped tremendously in transporting the plants that bear short-lived seeds. Then came the airplane and now we have jets that can transport the seeds from any place in the world to the grower in a few hours. Of course, at times it has taken up to six weeks to get them out of Customs. I have had seed received from Thailand by Customs on August 2 which were not released until September 16, resulting in very poor germination. I was unable to get a reason from Customs for their refusal to release my shipment. Perhaps some work could be done with Customs to shorten this period of time.

Resulting from our changing habits of living, we have developed a desire for small plants to be available at any time of the year. Now the problem is a method of prolonging the life of seeds so that we may reach this goal.

During the past several years, I have been working with moisture and temperature control methods and have had some success with the following seeds. *Dizygotheca elegantissima* seed viability is usually 8 to 10 days. With the right amount of moisture and temperature control, (35° F.), the viability has been increased to 6 months with 90% germination *Syzygium paniculatum* (*Eugenia myrtifolia*) retains its viability for about one week; now with refrigeration the seed can be kept about two months. At the end of this time, remove the seed from cold storage and germinate them, just enough for the seed to crack. Then return them to the refrigerator at a temperature of 34° to 38° F. By doing this we have added 6 more months to the life of *Syzygium paniculatum*, for a total of 8 months. *Magnolia grandiflora* has been a mancy—this may be caused by inhibitors or something else like this. I don't know. It's questionable in my mind whether light would have any effect on both aspects of double dormancy.

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During the past several years, I have been working with moisture and temperature control methods and have had some success with the following seeds. *Dizygotheca elegantissima* seed viability is usually 8 to 10 days. With the right amount of moisture and temperature control, (35° F.), the viability has been increased to 6 months with 90% germination *Syzygium paniculatum* (*Eugenia myrtifolia*) retains its viability for about one week; now with refrigeration the seed can be kept about two months. At the end of this time, remove the seed from cold storage and germinate them, just enough for the seed to crack. Then return them to the refrigerator at a temperature of 34° to 38° F. By doing this we have added 6 more months to the life of *Syzygium paniculatum*, for a total of 8 months. *Magnolia grandiflora* has been a real problem for the propagator who is unable to harvest his own seed. *Magnolia* will lose its viability in 10 to 15 minutes, if exposed to direct sunlight. With a temperature of 32° to 35° F., *Magnolia* seed has been stored for 5 months with over 4,000 plants obtained from 1 lb. of seed. California native *Quercus* seed must be kept at a moisture content of not less than 65% and under cold storage at 35° F. In California, *Quercus agrifolia* seed is harvested in October; with proper storage we have had seed showing 85% germination one year later.

Seeds of other species that may be stored for many months in the same manner are: *Rhaphiolepis, Fatsia, Philodendron* and *Eriobotrya. Philodendron* seed after being cleaned, has kept its viability for over two years. *Eriobotrya* seed has been kept for over a year with 95% germination. If the seed shows dryness, the best way to add moisture is to wash the seed and let it drain, then return it to cold storage. With more study along these lines, we will be able to have seed available for germination during any time of the year.

MODERATOR HASEK: Thank you very much, Gene. Now we will hear from Dr Will Bitell, Dept. of Biological Sciences, University of California, Santa Barbara. Dr. Bitell[1]

MODERATOR HASEK: Last in this session will be a talk by Betty Atwater of the Ransom Seed Laboratory here in Santa Barbara. Betty:

SEED DORMANCY AND GERMINATION

BETTY RANSOM ATWATER

Ransom Seed Laboratory
747 Knapp Drive
Santa Barbara, California

Our knowledge concerning the nature of the germination process in seeds constantly progresses and we are gradually beginning to understand some of the complex physical and chemical mechanisms which control a seed and determine when germination will occur. The preservation of the species has been assured by the incorporation of various delays in the growth so that all of the seeds will not germinate at once. This unevenness of germination is especially noticeable in perennials and in native and ornamental plants. Most of our common vegetables and flower annuals have been selected over so many years that fast and complete seed germination is normally expected of them.

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Before planting, or when a poor stand is realized from a lot of seed, it is possible, in the laboratory, to examine the seed and determine whether it is dead or dormant. Various standard techniques may be used: the excised embryo test; or the seed can be allowed to fully imbibe water, then it can be cut and put into a tetrazolium solution which, in a few hours, will stain a live embryo red. The dead tissue either doesn't stain at all or injured areas may be a muddy color.

If the seed is dormant there are a number of factors that may be preventing germination:

(1) A hard or impermeable covering may prevent the imbibition of water by the embryo or endosperm.

(2) Imbibition may be complete but inner or outer membranes may be impermeable to essential gasses such as oxygen.

(3) Imbibition may be complete but the presence or development of inhibitors may prevent embryo development.

Important current research on these problems was recently reviewed and discussed by international delegates to the International Seed Testing Association Congress in Washington, D.C. in June, 1971, during a Seed Quality Research Symposium (3).

These discussions reviewed the mechanism of germination. To obtain the maximum germination in a given lot of seed it should be *stored advantageously* from time of harvest to time of planting. For many seeds this would involve a seed moisture content of not less than 4% or more than 12% and cool to low storage temperature.

Vigor will pretty much parallel freshness, full maturity, and seed size, providing germination conditions are favorable. Genetic factors play an important part in vigor expression.

Favorable germination conditions are:

Optimum temperature—this differs with the species. (2)

Maximum imbibition—special treatment to insure water imbibition may be necessary such as scarification, hot water treatment, sharp temperature alternation, acid treatment, percussion. The most significant point may be the strophiole rather than the seed coat as a whole, or the inner membranes may need to be pierced or treated.

Optimum aeration — the accessibility to oxygen and other gasses is essential to the activation of developmental hormones. This involves a more subtle permeability which more often involves the inner membranes and cell walls and may be stimulated by certain light intensities, low temperature or sharp temperature alternation, high CO_2 or oxygen pressures.

Elimination of Inhibitors—this may be done by leaching or washing the seed, using chemical neutralizers, overcoming the effect of the inhibitors by adding the necessary hormones such as kinetin or gibberellin, and by elimination of soil-borne inhibitors or harmful salt concentrations in the water supply.

Seed of each species shows individual anatomical devices which largely govern its behavior. A familiarity with seed structure will help as much as anything in deciding the best route to follow in overcoming dormancy in any particular species (1).

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2. Rules for Testing Seeds—Assoc. of Official Seed Analysts, 1965. Proceedings of the Assoc. of Official Seed Analysts, Vol. 54 No. 2. Secy., W.N. Rice, State Seed Lab., Univ. of Mass. West Experiment Station, Amherst, Mass. 01002
3. Seed Quality Research Symposium—16th Congress of the International Seed Testing Association. June 7-8, 1971. U.S. State Dept., Washington, D.C. To be published as the first number of a new ISTA publication, "Science and Technology of Seeds", Editor Mr. D. B. MacKay, Cambridge, England.

   Papers were given in four main Technical Sections as follows:

   I. Seed Vigor—Chairman: Dr. Walter Heydecker, Univ. of Nottingham, Nottingham, England
   II. Biochemical and Pathological Techniques in Seed Testing—
   A. Variety testing—Chairman: Dr. C. S. Garrison, Plant Industry Station, Beltsville, Maryland, USA
   B. Pathological testing—Chairman: Dr. V. R. Wallen, Plant Research Institute, Central Exp. Farm, Ottawa, Ontario, Canada
   III. Mechanisms of Seed Germination Control—Chairman Dr. S. B. Hendricks, Chief Scientist, Mineral Nutrition Lab. ARS, Beltsville, Md. USA
   IV. Seed Storage—Chairman: Dr. O. L. Justice, ARS, Hyattsville, Maryland, USA

MODERATOR HASEK: Thank you very much. Now, if there are any questions we'd be glad to entertain them at this time. Please direct them to whomever you want. Any questions?

JOLLY BATCHELLER: In airmailing seed, does the temperature in the storage compartments of the plane affect them? It generally gets pretty cold at 10,000 to 40,000 feet.

WILL BITELL: It's very possible. I never thought of that—possibly, yes.

JOLLY BATCHELLER: Whereas with surface shipment by boat, the seeds would, most likely, be in the hold where it would be hot and humid. This could affect them, too.

WILL BITELL: Yes, also the way they're handled. There are many, many factors that could become involved. You're not sure about what has happened to the seed. That is what I mean about trying again and again because from the time they're collected, through the time they are handled until planting there are so many factors that enter into the picture, that you can't be sure whether the seeds will germinate or not. For instance, many of you may know Dr. Franchesci who, repeatedly, tried to grow the Montezuma cypress and finally, I think on the fourth or fifth try, the seed that he got was viable. In those times, of course, shipment was always by freight. You might be interested to know why we have so many different plants here in the Santa Barbara area. In 1895, Dr. Franchesci obtained over a thousand different species of seed from all over the world and exchanged about fourteen or fifteen hundred packets from here. So there is no wonder why we have such a varied flora in this area. But it was due to his persistency and interest in establishing these species.

HUDSON HARTMANN: Gene, I'd like to ask—on the low temperature seed storage you were describing—do you treat your seeds with any fungicide during this period?

GENE BACIU: No, I haven't been treating the seeds. But I watch them carefully and if there is any sign of mold showing or any such problems, I immediately take the seed out and wash them and add a small amount of vinegar or a drop or two of Clorox in water, then wash it out thoroughly. This treatment is usually good for two or three months. That is about all I do to hold mold in check. I have been afraid of using mercury compounds because it seems to me 2 or 3 months after treatment, the seed loses all its viability. I think possibly from the gases, but I'm not sure.

ANDY LEISER: Gene, I'm going to ask you a loaded question. I know you know the answer but I think it's something that wasn't covered here. You do a lot of seed collecting—put a lot of seed in storage. But don't you take a precaution between the time you walk up to the plant to collect the seeds—and you go to storage—to decide whether even to put it in storage? This refers mainly to the wild collected seed that comes in from exchanges overseas that have been collected by botanists. I think you know what I'm driving at, if not...

GENE BACIU: Well yes, Andy, I have had this happen to me several times, one particular acacia tree was very nice—a good color to it—a real nice purple one. I went up to the tree and examined quite a few of the pods and their fullest seeds, but over a period of time, I became careless. I picked all the tree into the tarp, shook all the pods off and wrapped it up, threw it in a truck and came on home. I told the man to clean it out and he said, "What do you mean clean it? There's nothing inside to clean." So all the pods were sterile. I don't think there were ten seeds in about ten bushels of pods.

ANDY LEISER: What about the seed itself, though? The same thing could happen with the seed itself.

GENE BACIU: Yes, the seed itself can be sterile. You have to know what you're looking for when you cut the seeds open; a good example of this is *Cedrus deodora*. Early in the season, you can take a cone, break it open and there'll be a nice plump seed, all very watery. A month later you come back and off the same tree, take cones, break them open and probably 90% of the seeds are dried up and empty. But they look nice and full and if you don't cut them open maybe you will bring back a lot of empty seeds. If you're picking seeds off a lot of shrubs, or certain species of ground covers, California native ground covers, as we're using now, as you go along—every 4 or 5 plants—you should stop and examine the seeds and make sure that you're not going to run out of viable seed and pick a lot of emptys. Sometimes you can't help but pick empty seeds but in the process of cleaning you can get rid of most of them. Often, however, they're all about the same weight, size, and there is no way to separate them out. We store our dried seeds in an insulated building. On the top, where the sun shines most, we have 12" of insulation so it stays nice and cool; and then we have circulation of air in the room which keeps it quite dry. Some seeds—especially on the coast here—if you don't have a method for keeping them dry, they'll absorb moisture from the fog and, even if you put them in when they are real dry, in a month or two you have lost a few hundred pounds of seed, which represents a lot of work in collecting.

RALPH SHUGERT: Gene, I don't know if you do much seed stratification here in California. Assuming you do some—do you have any stratification media that you prefer over another?

GENE BACIU: I use peat moss, a small amount, just enough to hold the moisture around the seed. But for magnolia, we just turn our seeds over once a week, we do not add anything to them—just keep the seeds as we bring them out of the wash. On this same line of stratification—but a little different—on palm seeds, I find that most palm seeds have sufficient moisture in the seed itself to germinate. A little tip here for the growers. Some of the nurseries are using this method now. When the seeds are cleaned and washed off and the excess moisture drained away—when they are just on the verge of drying—bag them up and throw them on your bench; there is sufficient moisture inside the seed to cause them to germinate. I notice that seeds of the Queen palm, *Arecastrum romanzoffianum* (*Cocos plumosa*) germinate much better that way than if you put them in a flat and keep them wet. I think they get too wet and the germination percentage is low. Another one with which we've had problems for quite a few years is *Jubaea chilensis,* the Chilean wine palm. If you take the seed fresh, before the milk dries out, and just put them in plastic bags, seal them up and, in about six months, there will be close to 100% germination. No added moisture whatsoever. I know nurseries that have been trying to grow it—some have success with it—some don't. But this way they will have just about 100% germination.

HOWARD BROWN: In commenting on Ralph's question about stratification, we do quite a bit of this in the winter quarter class in plant propagation at California Polytechnic Institute, San Luis Obispo. We find a very nice way of handling this is to use a rather coarse grade of sawdust, moistened, and mixed with the seeds. We have a 3 mil polyethylene tube, which we buy in rolls. We put the seed-sawdust mixture in it, wrap it at both ends, with a label inside and outside, then put it in the refrigerator at 32-41° F. It does a wonderful job. There seems to be an antibiotic factor in the sawdust that reduces the growth of mold.

RICHARD MAIRE: I was going to ask Gene if he would like to comment on the success he has had with some of the native plants in hydromulching We got involved in this together and it might be interesting to bring up at this time.

GENE BACIU: Yes. A few years ago I gave a little talk on hydromulching of native seeds along California highways and in subdivisions and so forth. Since then we have done a lot more work and I have been back to check most of the plantings that we have done so far. The people in southern California might see, down towards San Diego, a planting of natives on the Torrey Pine Road just outside of La Jolla. I would say the bank is maybe 500-700 feet high—a big cut; the soil is very sterile. Some plants we used were *Atriplex semibaccata, Mimulus longiflorus,* the red *Mimulus* from San Diego, *Cistus villosus,* and *Eriogonum giganteum.* Well, this has been under irrigation and within two weeks after seeding we had 3½ *Mimulus* plants per square foot on the average. I might add there were two pounds of the *Mimulus* seed—the red and yellow—a pound of each sown on 10½ acres. *Cistus* seed was sown one pound to the acre; they planted about 7 acres with *Cistus* in it, and the other 3½ acres they didn't use any. The *Cistus* seed produced almost 3 plants per square foot. With *Atriplex* sown at the rate of 5 pounds to the acre—we had approximately 8 plants per square foot. The *Eriogonum gigantea* didn't show up until this year but now it's getting very thick. Some of them are even blooming but there is a tremendous number of plants showing up. The people in the surrounding area got very excited at first because there was not a quick showing, so they reseeded it with a Birdsfoot trefoil and right away they got a lot of green color; they put 80 pounds (that would be 8 pounds to the acre) and by fall it had grown two feet high but then, of course, it all died off. There were not many of the native plants left and they were watering every day, sometimes 3 or 4 times a day. But during the winter, a lot more *Atriplex* came up, and by spring it had given about 95% coverage. Today there is just maybe 3 or 4 small areas, a foot here and there that are not completely covered with *Atriplex semibaccata; Mimulus* is coming up there very nicely, too, and it's thick enough to show good color. Watering it once a month would be plenty of water. But it does give a color on that bank all the year round of red and yellow flowers.

MODERATOR HASEK: Thank you very much, Gene, for a most delightful discussion of your interesting work with seeds. Next on the program we will hear from Mr. Otto Martens of Deigaard Nursery, a world authority on palms, speaking on—"Palms—Propagation, Production, and Uses" Otto Martens:

PALMS—PROPAGATION, PRODUCTION AND USES

OTTO MARTENS

Deigaard Nurseries, Inc.
Santa Barbara, California

When we think, read or dream of the tropics, nothing comes into mind faster than soft balmy air, blue lagoons with white beaches, palms swaying in the breeze, and glorious sunsets as inviting background for the silhouettes of majestic graceful *Cocos nucifera*.

The International Airport in Los Angeles has taken advantage ot this "tropical" thought association for commercial reasons: The winter traveller from Canada, from the blizzardy plains of the middle-west, or the snowbound eastern states, is made to believe that he landed right in the tropics on stepping out of the plane into all the palms that wise and skillful landscape architects placed in and around the air terminal in groups and in groves.

Limitation of palm habitats and uses makes familiarity with this plant group non-existent to some and restricted to those of you from winter-cold and desert-dry areas. So, to understand our topic easier a few remarks on physiology and ecology may be in order. Palms are the plants most valued and indispensable to millions of people over the world. When Linnaeus, the Swedish botanist who lived during the first half of the 18th century, was asked by his students which plant family he considered the most important, he answered in Latin, the language of the scientists: "Palmae sunt principes"—(palms are the first ones). From his answer was taken the title of the quarterly magazine of the Palm Society: "Principes". The Palm Society has members in 32 countries besides the U. S. (incl. Alaska).

Indeed, when some 25 years ago, Deigaard Nurseries began to think of reintroducing palms into Southern California landscape and they were watering every day, sometimes 3 or 4 times a day. But during the winter, a lot more *Atriplex* came up, and by spring it had given about 95% coverage. Today there is just maybe 3 or 4 small areas, a foot here and there that are not completely covered with *Atriplex semibaccata; Mimulus* is coming up there very nicely, too, and it's thick enough to show good color. Watering it once a month would be plenty of water. But it does give a color on that bank all the year round of red and yellow flowers.

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Indeed, when some 25 years ago, Deigaard Nurseries began to think of reintroducing palms into Southern California landscape and we began to study the history, botany and nursery practice of palms, a whole new world opened up before our eyes, a wonderfully exciting experience, a strange driving enthusiasm took possession of us which to this day still has not left us totally.

Let us share some of the wonders of this plant family, a family of some 2600 species, better than 230 genera, so diversified in every respect, and of such importance as to food and shelter, household goods, utensils, cosmetics, furniture, hats, dresses, buttons and ornamentals, that millions of people not only depend on them, but without them would not be able to survive. Perhaps even the nurserymen of 50 years ago might not have survived. They used raffia for tying and grafting. Raffia comes from the palm, *Raphia ruffia*.

In thought association to most people, palms and tropics are analogous. So it seems to be anomalous that a number of palm species will not tolerate the humid, hot climate of the tropical belt too well. The geographical lines of palm growing are roughly 40 degrees north latitude to 40 degrees south latitude—the northern part of Japan, Spain, Azores, central California in the northern hemisphere, to New Zealand, Cape of Good Hope in Africa, and the center of Argentina in the southern hemisphere. However, the tenderline for the palms (*Cocos nucifera*) is from 20 degrees north to 20 degrees south, much more restricted; the real maximum palm vegetation of the tropics confines itself into a strip of 5 degrees north to 5 degrees south, just narrowly on each side of the equator. For our consideration we omit the latter two belts, because *Cocos nucifera* is beyond the cold and dry heat tolerances, even in the warmest moderate part of California.

Amongst the species needing a cool climate for optimum development, therefore for good use in subtropical areas, is the American needle palm, *Rhapidophyllum hystrix,* native from the Carolinas to northern Florida. This dwarf, full and compact, very pretty palmate clump palm can stand 0° F. It is reported to have survived —9° F. Very slow growing, it is, unfortunately, little known and rarely found in cultivation. In landscape it would make an excellent combination with *Chamaerops*.

Better known is the Chilean wine palm, *Jubaea spectabilis*. We have not seen more miserable specimens than those in the hot humid climate of Southern Florida. But they will grow to perfection in the coolness of the Chilean mountain climate, a feather palm tree with the most enormous trunk in thickness of all palms, 4 to 5 feet in diameter. We will see some marvelous groups of this species during the Society's Lotusland* tour. In their native habitats this extraordinary palm is on the nearly-extinct list, because their craving for alcohol makes the natives cut the trees down mercilessly. The massive trunks, after being cut, yield from 75 to 100 gallons of sap; fermented into toddy, this

* Lotusland, Montecito, California

means a few gay hours for a few people. The one and only palm indigenous to Chile is a sacrifice to human appetite. It is possible that man became infatuated with drink, when in prehistoric times monkeys fought for a place on broken peduncles of palm influorescences, where sap oozed out of the wounds and, in the humid heat of the tropics, quickly fermented. The monkey's tongues lapped it up as fast as they could get to it. Not a joke, but the truth and, in any case, a sinless way of becoming an alcoholic.

Other palms needing a cool climate are:

(1) *Trachycarpus fortunei,* which grows as far north as in the parks of Vancouver, British Columbia, in England as rare specimens, and as tub plants at the Alster Pavillion in Hamburg. Also I had correspondence with a man in Idaho where he grew one outside in open ground, sheltered, for a number of years.

(2) *Chamaerops humilis,* the dwarf palm of the Mediterranean area and much used as accent, where palms will grow in cooler and more arid sections.

(3) *Nannorrhops ritchieana,* very hardy but seldom seen in home plantings, which is found as a small creeping palm on the high plateau of Afghanistan in altitudes up to 9000 feet and often under a cover of snow

(4) *Rhapis excelsa* and *Rhapis humilis,* lady palms from South China are hardy and are jewels used as tub plants in house and patio.

(5) *Rhopalostylis sapida,* the shaving brush palm named so because of its featherduster like crown of leaves, grows to perfection in our Southern California climate so similar to its native country, New Zealand, especially along the cool coast. Again a fine stand of two species may be seen at Lotusland.

(6) The most fascinating of all hardy palms, in fact one of the most fascinating of all palms is a native of Columbia and Equador—not of their steaming jungles in the lowlands, but of their high elevations in snow and frost: *Ceroxylon andicola,* the Andean Waxpalm. At altitudes of 10,000 feet they are found in magnificent stands, glistening white trunks up to the unbelievable height of 200 feet—200 feet of straight white trunk, 1 to 1½ feet in diameter—truly an engineering wonder, with a crown of only 8-10 leaves, but each leaf 20' long, silvery white underneath. Alexander von Humboldt saw them first, but it was the German botanist Engel, enthralled by their beauty as he was camped underneath them, the starry heavens above, who heard in those inspirational moments, the white leaves on the alabaster trunks rustling in the night wind, eternal symphonies of Beethoven in his mind. He called the palms *Beethovenia,* a name which later was preempted because of earlier nomenclature. Once thought to be the tallest trees in the world, they are certainly some of the most inaccessible, and can be reached only by mule trail. Seeds

lose their viability on the long transport back. Although botanists tell us that *Ceroxylon* would grow in the mountain areas of Oregon and Washington, perhaps in the Coast Range of California, no effort has been made so far to do this. The only Andean Waxpalm now in California, to my knowledge, of promising size, is grown by a veterinarian in Vista.

Lastly, No. 7 on the cool list is *Howeia*, alias *Kentia*, raised and used for decoration in quantities limited only by the short supply of seeds, with two species: *H. forsteriana* and *H. belmoreana*. They are indigenous to the small Lord Howe Island between New Zealand and Australia, growing right from the waterline in belts halfway up the two mountains which top the island. The upper half is occupied by two species of Arecoid palms, similar to *Howeia*, as well as the aristocrats in the Southern California landscape, *Hedescepe canterburyana* and *Clinostigma mooreanum*. Look for specimens of all four in perfection at the estate of Mme. Ganna Walska (Lotusland). *Howeia* trees in young stages freeze at 28° to 30° F. They are outdoor landscape material only in protected areas; on the other hand, they do not thrive under excessive humid heat; only very few *Howeia* palms were seen on visits to tropical Hawaii and Florida.

Certain species of the following genera are hardy enough to find their place in the California landscape: *Archontophoenix, Arecastrum, Arenga, Butia, Erythea, Livistona, Paurotis (Acoelorrhape), Phoenix, Sabal, Trithrinax, Washingtonia.*

Palms are divided by their leaf structure into pinnate and palmate palms. They are also distinguished by their differentiation of ultimate size: dwarf, medium, tall, climbing, creeping, branching. In landscaping, the architect more often searches for dwarfness and middle size; tall palms, massive palms, there are many. Unfortunately, often we find *Phoenix canariensis*, enormous of size, bulky in appearance adorning a residence with a 60 foot front yard, entirely out of place; often we find an 80 foot *Washingtonia*, singly or in a group, in front of a window planted on a same size lot. Surely, *Washingtonias* and *Phoenix* trees have their places—on roads, in parks, on freeways.

It is lamentable that the ultimate in dwarfness—*Syagrus liliputiana* and *Iguanura pedunculata*, each 4 inches high only, their maximum rarely surpassing 12 inches, their trunk as thin as a goose quill, may not be used here because their cold tolerance is beyond California's natural environment. This is true for most of the climbers with the exception of one, *Chamaedorea elatior*. It climbs by way of bending its leaves backward in an angle and thus hooking itself to tree limbs

Out of our reach in every respect is the fastest and longest growing of all climbing palms, *Calamus* or Rattan, known for its use in furniture making. A maximum growth of 556 feet in length has been measured by the Forestry Department of Malaya, amazing and truly phenomenal.

Palms are monocotyledons. Their age, historically, is known to be about 150 million years. Fossils have been found as trunks, roots, leaves, pollen, seeds. I have brought a few to this meeting to look at, 40 million years old; the necktie trinket is supposed to be 150 million years. Note the vascular bundles appearing as dots. The physical structure of the palm trunk shows that it consists of vascular bundles—tubes—no cambium layers for expansion sidewise. The tubes can go only two ways: up or down. Trunk, leaves, roots all grow in one of these directions Therefore, the trunk diameter is determined in the first years of its growth.

The leaf in its top stage actually does not grow, it only unfolds; it already has finished its growth period inside the trunk apex. The astonishing fact is that there are numerically as many leaves inside the apex of the trunk as there are crown leaves on the palm trunk outside. So, if *Cocos nucifera* (we are thinking of well-grown, well-developed, well-watered, well-nourished specimens) has 26 crown leaves, that many leaves are inside in more or less developing stage. For this species it takes 25 days for a new leaf to open and, in a continuous cycle, an old leaf to die, the age of one leaf can be determined as 26 leaves x 25 days = 650 days plus same amount inside apex = 1300 days, or 3.6 years, for a complete leaf cycle. A leaf growth tabulation of 40 species is in preparation at this time. It will be of interest to evaluate rhythm and age, as all species seem to be different.

On two remote little granitic islands of the Seychelles group between Africa and India, north of Madagascar, we get acquainted with a rare and, one of the world's most fantastic palms, *Lodoicea maldivica,* the Coco de Mer, known for its double coconut-like fruit. This tree produces the largest seed in the vegetable kingdom, often weighing 40 to 50 lbs. each. A fully grown plant, 100 feet tall with a straight trunk 1 foot diameter, 100 to 300 years of age, palmate leaves 36 feet long, at its optimum, has 12 open leaves; one new leaf will unfold every 9 months = 108 months. Take the same amount inside the apex = 216 months, or 18 years, is the age of one single leaf. The *Lodoicea* seed matures after 6 years on the tree, drops off to the ground, and rolls down hill (it can't roll uphill), and sprouts after 1 year. But the question remains, "where did the *Lodoicea* palms come from growing on top of the decomposed granite ridges?"—But like so many questions in the world of palms which remain unanswered, so does this one. Speculation is that once in prehistoric ages there was a plateau running from East Africa to India and these ridges, with the palms on them, are remnants and relics.

A similar manner of growth is observed in the root system. Because of their tube system roots do not expand in diameter, but die to make room at the stem base for new and heavier roots, always developing and growing from the base. This is the reason that nurserymen may dig up palms 80 feet tall with only a small, or hardly any, ball of roots and dirt and transplant them without difficulty. Not the old roots but the newly developing roots will carry on life, while during the transition stage the plant will live on starches stored in the trunk and bole. New roots will form in the warm soil of summer readily whereas in wet, cold, winter weather a transplanted palm may not survive, as no new root growth is stimulated. Therefore summer is the best time for transplanting At the same time, reduction of foliage is compulsory, of course, to diminish water loss from the plant.

Propagation of palms is the easiest of all plant procreation and there is really not very much to tell about Let's write off, one after another, the methods that do not go: cuttings—no, grafting or budding—no, layering—no; meristem culture (we experimented with *Chamaedoreas*), but no results—still there may be a chance; suckering and division—yes, but only on certain stooling species, like *Chamaerops humilis, Rhapis, Areca, Phoenix reclinata,* and *Reinhardtia.* All date palm orchards are started this way but no emphasis has been put on this method for ornamental palms.

The simple, easy method of palm propagation is by seed. One of the principal productions in our nursery is *Howeia forsteriana.* Seeds are gathered commercially on Lord Howe Island (between New Zealand and Australia), packed in slightly moist peatmoss or similar medium and shipped by boat under Australian government rules and prices. At the port of entry the seeds are inspected and fumigated under auspices of the U. S. D A. Division of Entomology and Plant Quarantine. On arrival at the nursery the seeds are immediately planted seed-tight into electric hotbeds with thermostatic soil control at 80° F. At 85° to 95° seedlings start to show burn damage. The propagating medium consists of 50% Canadian peat (fine), 50% perlite (Sponge Rok) No. 2, thoroughly blended with "Water-in".

Previous to planting, beds are sterilized with methyl bromide. The redwood frames are treated with copper naphthanate. The embryo within the endosperm of palm seeds for most species is greatly subject to drying out, therefore seeds on long travel time may be soaked in water for one to two days prior to planting. While seeds of dicotyledonous plants can go dormant for long periods of time, e.g. seeds of native California chaparral plants, monocotyledons — like palms — cannot. They have a limited span of viability, in subtropical zones from 2 to 3 months; in tropical zones with little temperature changes, and little variance between wet and dry seasons, 2 to 3 weeks. Fresh seeds therefore are mandatory for commercial results. *Howeia* seed germination is uneven, from 4 months to 2 years — a good average, 9 to 12 months. Seeds which have not sprouted the first year are put through a water test and replanted. Before roots become large (they do very rapidly), the young seedlings are potted off into 2½" rose clay pots, plastic pots were discarded because of insufficient root aeration. Height of stem exposure is up to the bole, with seed mostly still attached. The potting medium consists of ¾ sandy loam, ¼ forest humus or mushroom compost, combined with a trace of slow release granulated fertilizer, and sludge. This method of *Howeia* seed propagation is typical of any palm species. However, germination periods vary greatly, some requiring only 3 to 4 weeks, others 1 to 2 years; also species from the tropical belt need higher germination temperatures

A great portion of our palm production is transplanted from liners or 1 gallon cans into nursery rows in the open field to mature into salable landscape specimens. Here regular nursery methods apply· periodic irrigation by an overhead Rainbird system, tractor cultivation (we want green mulch for aeration and soil conditioning), fertilization with Hi-12, commercial nitrogen plus trace elements, and strict pest and obnoxious weed control. Pests are palm scale, mealybugs, mites and rabbits, and occasionally rats. Diseases, mostly encountered under confined and shade conditions are *Penicillium vermoeseni, Rhizoctonia* and watermold. All of this is kept fairly well under control with the help of County Agricultural Inspectors, Farm Advisors and plant pathologists from the University of California.

Howeia palm and shade-loving palm production is different. From liner pots *Howeias* are shifted into 6" clay pots as triplets, established above ground, then plunged, pots and all, into sterilized open ground in the shade house until salable—after 4 to 5 years. A part of this 6 inch stock (triplets) is shifted into 2 gal. green metal containers which are readily accepted by the trade. A third part is knocked out of their pots and transplanted back into open ground to be advanced into larger specimens for later digging and establishing in wooden tubs. This procedure requires considerably more time, but since there is a ready market, even by air freight to the east coast, the investment is warranted.

Those varieties of palms, other than *Howeias,* used for indoor decoration or requiring a shady location are brought from liners to salable container size by similar growing procedures. As the plants are brought up into larger containers periodic fertilizing begins. We use a U C. soil mix together with dried blood or hoof and horn, potassium nitrate, oyster shell, dolomite lime, gypsum, single superphosphate, and potassium sulfate in regulated proportions.

Earlier we listed those hardy species of palms which have proven best for California landscaping. Species which are dwarf, or semi-dwarf, and commonly used as house or conservatory plants are: *Chamaedorea, Howeia, Phoenix roebelenii, Phoenix rupicola, Rhapis, Microcoelum weddellianum, Trachycarpus takil, Livistona, Arenga,* and *Linospadix monostachya.* Species for hedge, fence, or windbreak are: *Chamaerops humilis, Phoenix reclinata, Acoelorrhaphe wrightii, Sabal,* and *Arenga.*

Palms are playing an ever-increasing role in the landscape picture. They again have come into their own. It is false, however, to assume that palms are "low maintenance" or "no maintenance" plants. They are to a degree—they will exist under adverse conditions, even under plain neglect, when other trees would have, long ago, given up the ghost, but then, of course, they are far from looking their finest. But give them water, some fertilizer, even once in a great while, and they will respond. They will give back to you their appreciation with great beauty.

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MODERATOR HASEK: I would like to thank you very much, Otto, for such an excellent talk. We certainly appreciate your being here to give this fine presentation.

We will now go on to our next speaker, Mr. Ralph Shugert from Spring Hill Nursery in Tipp City, Ohio, and President of the IPPS. Ralph:

RALPH SHUGERT: Ladies and gentlemen, before I start my talk I would like to compliment Mr. Martens on probably one of the finest presentations on a plant group that I have ever witnessed—ever been fortunate enough to hear. A tremendous presentation.

PROGRAMMING PROPAGATION

RALPH SHUGERT

Spring Hill Nurseries Co., Inc.
Tipp City, Ohio

One day several weeks ago I had an opportunity to reread the Proceedings of the Seventh Annual Meeting of the National Association of Propagating Nurserymen which was held on June 23, 1926 in the Kentucky Hotel, Louisville, Kentucky. This was the Proceedings of the first meeting, printed and recorded for this astute organization, and showed the interest in plant propagation, as well as the comraderie of propagators some 45 years ago. There were several items of fascinating interest from this meeting and one that immediately came to mind was the adjournment at 11:00 P.M.! Apparently even in the earlier days, plant propagators just did not give up but carried meetings until the last hour. There was also comment regarding planning being relative to practicability, and a direct quote from Professor A.C. Hottes points out this fact.

> "*Asparagus sprengeri,* a common florist plant, as all of you know, was grown in a few garden conservatories for years before anyone thought it might be of value. So many things in life have value as soon as someone has brains enough to see the value in them."

And so we have planning from the viewpoint of creativity and the value of various plant items is there if it will fit into our particular scope of operation. Professor Hottes also made some interesting comments to conclude his talk and I think it is relative today in our much faster moving society and quite apropos.

> "I think it is most likely the personal contact you make in places like these meetings that gives you the emotional thrills. You go home thinking that you have had a mighty fine time in spite of everything else that has been wrong. Our lives, then, ought to be practicable, scientific, and emotional."

Perhaps these introductory comments do not pertain to specific programming for propagation, but I did think that Charles Hess might be interested in the concluding sentence of Professor P. W. Zimmerman, then of the Boyce Thompson Institute. Recall please that this was uttered in 1926:

> "When the material is properly handled, practically any plant type can be grown from cuttings."

I am sure that virtually everyone in this room today would certainly agree to Professor Zimmerman's astute comment.

So now to the topic on hand, that of Programming Propagation. In reviewing the Proceedings of the I.P.P.S., a habit I cultivate several times each year, discussion on propagation planning is strangely lacking. It is true that each of us engaged in common endeavors is directed by the uniqueness of his individual company. My brief remarks today will concern my company, Spring Hill Nurseries of Tipp City, Ohio which derives some 82 percent of its revenue from the sale of plant material through mail order and cash and carry sales. Each of us are directed in our planning by our own business philosophy. At the Ninth Annual Meeting of the Western Region in Fresno, California, Ralph Pinkus spoke of his planning operation in Texas and, while it is certainly far different than our own, the basic precepts are exactly the same. There also was a comment by another Society member who answered his own question, "How do I know how many plants to grow?" in Volume 19 of our Society Proceedings. There isn't a hard, fast rule, in my opinion, as to planning because it is going to vary with individual company objectives. The propagation planning at Spring Hill is simply predicated on three basic guidelines:

1. Previous season's sales, the history of sales information that is compiled by weekly computer reports and terminated with one final sales season report.
2. The so-called new plant; this would include recent plant introductions or plants new to our mail order catalog although they may have been introduced many years ago.

and finally,

3. A listing of plants used in other previous catalogs, but omitted for one reason or another due to lack of sales, shortage of supply, and many other factors.

In a nursery community operation handling many varieties of plants, in many sizes, the computer report is almost mandatory. It is certainly expensive, but the immediacy of data information is extremely vital. For example, at Spring Hill our very capable propagator, Mr. Andrew Brumbaugh, can look at a Sales Analysis Report from the previous season, either spring or fall, and determine the propagation scheduling for the coming season. Our reports are set up to give us the following information: catalog number, name of variety, size, sales for the previous week, to-date sales, projected sales (based on the factor that we feed into the computer), last year's sales, the projection of sales from the previous week, wholesale sales, purchased inventory, stocked inventory, and then the last two columns give us again the projected sales and an end balance. The end balance column is merely the difference between the purchased and stock inventory, less projected sales and wholesale sales. This enables us to know if we are going to have enough items of a variety and size for shipment. It is merely a plus or minus showing a surplus or a deficit in a certain plant. While this is not pertaining necessarily to planning, we also receive vital information on a report given at the conclusion of each season, spring and fall, which enables us to review the replacements and shortages in every item and in every size in the catalog. We enclose a form in every shipment allowing a client to make comment on plants received. These topics cover such things as poor quality, dead on arrival, dry roots, shipped late, etc. We feel that this enables a customer who is not happy upon receipt of shipment to take immediate action and this enables us then to promptly satisfy a customer and bring them back into the fold. The only reason I mention this replacement report is that this enables the plant propagator to carefully study those items which have high replacement percentages. In our particular mail order catalog, reviewing some 1,200 plants and sizes (for example, a particular plant listed in five sizes would be counted individually), our over-all replacement percentage, reported, was 3.01%. If this figure is used as a norm and we find a plant such as Cherokee Dogwood with a replacement percentage of 10% or 12%, then we must take some steps to reduce this unprofitable percentage factor. This can be done with improved packing techniques, or perhaps a better hardening off process, prior to the ultimate distribution of this plant It is a valuable tool for the propagator, because if he is planning to stick 1,000 cuttings to bring off 400 saleable plants, and if his replacement percentage is 10%, then he will naturally, of course, increase his initial sticking. The various reports also enable the propagator to schedule one, two, and three year's production. For example, there could well be several mail order items that would be of sufficient size, if held two years in a mist bed, being hardened off the last six months The harvest would then be from the mist bed rather than from the rooted cutting lined to the field for a two or three year period

Unquestionably at this time there are, no doubt, several of you in the audience saying that this is all well and good to have computer reports, but my operation does not warrant an overhead investment of this nature. I would be the first to agree! The computer fits any business only to the extent of its logic in cost and the data that one wishes to derive from it. It is an old saying, but certainly very true, that the computer is only as good as the data that is fed to it. The only thing the previous comments have pointed out, or at least attempted to point out, is the importance of record keeping. There are very, very few plant propagators who do a sufficient job in keeping records. I think it is vital and, in fact, almost mandatory that we keep careful,

careful records from the time we take the cutting until the time that plant is harvested for sale. We all have been exposed to the individual who invariably receives a 100% stand on any batch of cuttings he sticks, any grafts he might make, or any buds in the field. All of us in this room know, of course, that a 100% catch across the board is an impossibility. We must know the shrinkage from the time the cuttings are stuck in the bench until the time that block of plants is ready for harvest. These are the percentage figures that are vital, so I urge all of you in planning propagation to put record keeping at the top of the list. Experiment, inquire, and investigate the techniques and procedures that are used at other nurseries. There is also a good possibility of borrowing an idea or two on record keeping from concerns outside our own nursery community. The mere fact that we have a so-called perishable item, and that we might be anywhere from two to ten years away from harvest is immaterial. We must, good friends, and I cannot stress this strong enough, have ample data to support us when we plan next year's propagation. If we have a good history of past performances of particular plant varieties we are headed on the right track. I cannot accept the negative attitude, which I have heard, in that there is no need of keeping records because something could happen to that particular block of plants and the records would be meaningless. It is true that so-called "Acts of God" can occur, but it certainly is not an economic nor a reasonable approach to a very scientific industry. There was a sentence that struck my eye in a recent newsletter which said, "Drowning problems in an ocean of information is not the same as solving them", and I think that this quotation is certainly applicable in this regard. No one can stand at this lectern and tell each of you how to plan your propagation. As I mentioned earlier, it is going to vary with each individual company, dependent upon management's goals. But each of us, as plant propagators, whether we are employee or employer, have an obligation to our parent organization to fulfill their production requirements. Some of us will do a better job of this than others, but the ones who are reasonably successful will be those individuals who have labored hard to do the best job possible, and at the same time do a better job in record keeping and, in the interpolation of the data, which these records afford them.

And now to sum up the brief remarks that have been uttered, I am quite aware that I have outlined nothing particularly specific for anyone to take home from this meeting. But I do hope that I have been able to at least motivate some thinking to the extent that we all must do a better job in reducing costs, and trying to grow the finest plant humanly possible. Some of the words uttered by Samuel Taylor Coleridge, one of the great gifted poets of the English romantic movement in the early 1800's, echoed some philosophy that has always been quite interesting to me.

"As a fruit-tree is more valuable than anyone of its fruits singly, or even than all its fruits of a single season, so the noblest object of reflection is the mind itself, by which we reflect. And as the blossoms, the green and ripe fruit of an orange tree are more beautiful to behold when on the tree, and seen as one with it, than the same growth detached and seen successfully, after their importation into other country and different climate, so it is with the manifold objects of reflection, when they are considered principally in reference to the reflective power, and as part and parcel of the same."

What Mr. Coleridge is saying here in his philosophic treatise is, of course, that we need a connection between the various facets of our life and, in this same light, we need the communication and, most certainly, the connection between production and sales. This can be manifested only by strong communication channels between the production and sales department of any company whether it have two employees or 2,000.

This is what we are on the face of the earth for — to communicate, to understand, and to love one another. When we accomplish this goal, we truthfully will have become a full and complete human being. It could be finally summated with one sentence: Let the states of equilibrium and harmony exist in perfection, and the happy order will prevail throughout heaven and earth, and all things will be nourished and flourish.

WEDNESDAY EVENING SESSION

October 6, 1971

NEW IDEAS AND INNOVATIONS—

William J. Curtis, Moderator

MODERATOR CURTIS: Who will be the first one to present an idea or an innovation? Who would like to come forward and present it to this group?

JOLLY BATCHELLER: Bill, I saw something just last week that I think is most interesting. At the California nursery convention in Palm Springs I saw a new type of pot which I think is excellent. I'm not boosting a product but it answers questions that some of us have. Many of us use a "spaghetti" system for watering and there are many different ways to attach the end of the tube to the container. They vary from a little lead weight you drop in—to a spike that you put the tubing over; and these cost money. The tubing itself isn't too expensive but the little plugs are. Someone has come up with a better idea. I think it's real good. They have taken a plastic pot and they have made a bulge on the side of it. My perspective in drawing these is a little bit difficult, but taking a view from the top, here is a normal pot and on the edge

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MR. PERRY: We run into the problem every once in a while of having a small area—say 10 feet square—that we want to fumigate with methyl bromide. If you don't happen to have an applicator, here's a little stunt that we pulled and I'm using it right along. Simply take a piece of 1" board, and get about a ten penny nail—it has to be a good stout one. Put a ten penny nail through that, put a cat food can on here, set your methyl bromide can on the nail and then go ahead and spread the tarp, put the soil around the tarp, get it all sealed in real well, then go over and step on the methyl bromide can and you've got it made.

MODERATOR CURTIS: That's what we want. Fine idea. That's what we're after. Who's got the next idea? Real good—come forward.

VOICE: We had to fumigate about three acres with methyl bromide and we didn't have the proper machine, you know, the one with the tubes and the tines to go down in the soil, etc. So Neil McClain came to our rescue and brought us out one of these outfits—well, the type they use for strawberry fumigation. What we did, it's kind of a simple idea, is to use a blower. Right at the exhaust section was a tube that came out You just take your 50 pound cylinder of methyl bromide and hook your polyethylene tube into this blower. Before this, of course, you take the polyethylene plastic sheeting and dig the trenches and put the soil over the edges of the poly in the trench. But before you put it all down you want to take an intake tube and then a blower tube that goes the entire length to the other end. Then you just crank up this blower and you blow this thing up like a tent and then put your intake back underneath the plastic and then start injecting the methyl bromide. It does a beautiful job. Strawberry growers have been using it for years and yet I've never seen it used in nurseries We did quite an acreage and had real good results. We used just a plain type of compression blower, a very simple device. But if you do this quite often I imagine it would pay to own one.

MODERATOR CURTIS: Who has the next idea or innovation to bring forward?

GENE BACIU: There are a couple of things I've observed—one is growing plants in poly bags. I don't know if any of the nurseries here have tried it, but I observed this in Hawaii this year. There are full gallon sizes as well as 2 gallon sizes. The gallon size is delivered from Hong Kong to Hawaii for less than ¼ cent per bag. This particular nursery was planting directly from the seed flat into the poly bag and, as the roots spread out—the bags were perforated—quite a few holes in them—the roots would grow out and the tap root went through the bottom. When they would pick them up to plant into the yards, they would prune the roots. We cut a couple open and there was very little root curl or anything like that. You could take a tree by the trunk and throw it across the room and the root mass stays intact. Of course, they can't be stacked vertically but they lay them down in a truck when they move them; they stack them in there like cord wood trees. For small containers I think it's something to look into.

Another thing I read about the other day, and I've been trying to tell a few nurserymen about it, is on rooting cuttings of eucalyptus. Now when the eucalyptus seedling gets up to about 4 to 6 inches high, you make a tip cutting and it will root very readily. What rooting hormones they require, I don't recall. But then if you want a flowering eucalyptus you would have to take the original plant in the liner and then grow it on up until you see what color you have. But by taking new cuttings of this first cutting that you took, you can root these tender cuttings very easily. However, if you take a large tree and try to root the cuttings from it, there is a real problem. But using these small, young, tender cuttings and keeping them this way until you find your color, you get about 90% take on the cuttings all the time. So if anybody wants to get a nice red eucalyptus and grow it continuously like that, I think it would be worth looking into.

JOLLY BATCHELLER: Gene, do you know who is doing that in Hawaii?

GENE BACIU: The cuttings are being rooted here in California, at La Canada—Descanso Gardens. And now, on foliage plants, you know you can get a eucalyptus like *E. perriniana* or *E. pulverulenta* from which you can pick out very good foliage in a young stage and get your cuttings started from that; then you have a very uniform growth of trees from which to make foliage cuttings. They do root well when young and tender but when the plants get a little larger they are quite difficult to root.

MODERATOR CURTIS: We will now hear, as an added bonus in our evening program, a talk by Bob Warner describing some of the work he has been doing in Hawaii with citrus rootstocks. Bob Warner:

VEGETATIVE RESPONSE OF CITRUS ROOTSTOCKS TO PHOTOPERIOD

ROBERT M. WARNER

Department of Horticulture
University of Hawaii
Honolulu, Hawaii

This report will describe a technique which is widely used by nurserymen in flower crops but, as far as I know, is little used for woody plants such as citrus. I refer to the use of photoperiod control which could reduce the time requred to bring young trees to marketable size.

Until very recently most citrus varieties in Hawaii were grafted on Rough lemon rootstocks or were "air layered." Only very recently the citranges, Cleopatra mandarin, and sweet oranges have come into use as rootstocks. Trifoliate orange has not been used by nurserymen; it was believed to be too slow in growing, taking 3 or 4 years to reach grafting size. When lined out in the field it made almost no growth from September until the following April or May. The common explanation was that it needed winter chilling. Temperatures near sea level in Hawaii are seldom lower than 65° F. and average in the high 70's which is considered unlikely to be a limiting growth factor for citrus.

We subjected rootstocks to three photoperiod treatments: 8 hour, 16 hour, and normal day lengths.

The 16 hour treatment was produced by a normal day plus a 4-hour light break in the night with 100 watt incandescent lamps. Shoot growth was greatly increased by such long day treatments as shown in Table 1. Cleopatra mandarin shows a smaller but highly significant response to long days than Trifoliate orange or Troyer citrange. Growth under normal day lengths (10 hr. 50 min. to 13 hrs. 10 min. in Hawaii) was intermediate, between that obtained under long days and short days

Oranges and tangerines grafted on these rootstocks also responded to photoperiod treatment producing in some cases up to 4 or 5 times the shoot growth obtained under long day treatments. This is shown in Table 2.

It is evident that temperature is not a limiting factor in growth of citrus in the tropics. All the citrus species investigated responded to some extent to long day (short night) treatment. In temperate climates, citrus plants should make extra growth in heated glasshouses with long day photoperiod treatments given during winter.

Table 1. Shoot growth of citrus rootstock seedlings under 3 photoperiod treatments (after 17 weeks)

	Rootstock shoot growth—cm.[a]		
Photoperiod	Trifoliate orange	Troyer citrange	Cleopatra mandarin
Short (8)	23.5 a	54.0 d	44.5 c
Normal (12 ± 1 hr. 10 min.) (Hawaii)	30.7 b	64.4 e	51.0 c
Long (16)	47.2 c	100.4 f	57.4 d

[a] Means followed by different letters are significantly different (P > 0 01)

Table 2. Degree of increase in shoot length of grafted citrus under long days compared to short days (after 28 weeks)

	Rootstocks		
Scion variety	Trifoliate orange	Troyer citrange	Cleopatra mandarin
Frost Washington	5.1[a] * *	2.0	2.3
Clementine	3.9 *	1.2	3.7
Dancy	1.5	4.1 * *	3.7
Minneola	3.3	1.4	2.3
Owari		4.4 *	2.6

[a] i.e., growth under long days (16 hrs.) was 5.1 times greater than under short days (8 hrs)

* Difference significant (P = > 0.05)

* * (P = > 0.01)

MODERATOR CURTIS: Any questions of Dr. Warner?

VOICE: Was that a photoperiodic light response or a photosynthetic response?

BOB WARNER: The long day treatment was with 100 watt incandescent lamps which do not give enough light to make any photosynthetic difference. It is believed to be a triggering of the phytochrome pigment, changing it from a far-red to a red receptive form so that it promotes vegetative growth instead of permitting the buds to go dormant. These trees, especially the trifoliate orange and the Troyer citrange seem to go almost dormant, not quite; but they quit growing about the first or middle of September, when the days get around 12 hours in length. In Hawaii we only get about an hour and 10 minutes difference each side of 12 hours either in the summer or the winter. But I think we have to go to a 14 hour day length to get good vegetative response from citrus. Of the citrus we've worked with, including a number of tangerines and a number of citranges, they have all responded to some extent; but the rough lemon rootstock, which I didn't show here, gave less difference in response to the long day, compared to the short day, than some of the others. This was true also of the tangerines. This is probably the explanation why tangerines are well adapted to the tropics. We can get them to grow right through the winter in Honolulu by giving them long day treatments. I don't know what happened to this chilling requirement.

MODERATOR CURTIS: Thank you very much, Dr. Warner. I understand we have two more groups of slides for tonight. Percy Everett, one of the charter members of this organization, has something for us. Percy:

PERCY EVERETT: Thank you, Bill. At the meeting at Los Gatos several years back, I showed a few slides, gave a little talk on some new developments at the Rancho Santa Ana Botanic Garden. Of course, one of the best, I think, that created the most interest and also got us into a little trouble was the *Berberis* or *Mahonia,* as you might know it—"Golden Abundance". This went out and then somebody found the plant in Bill Curtis' nursery supposed to have gone to Canada; and we had a stop order from the U.S.D.A. Since then the plants have gone through all the tests for wheat rust resistance. Not only did the U.S.D.A. pass the original clone but the seedlings from the clone, because they were afraid somebody might start growing seedlings from the original clone. We have thought the clone is so good, after consulting with many nurserymen, that the Botanic Garden is now in the process of patenting it. Since I left the Garden three years ago, I don't know exactly what its status is now; however, I know that the papers are now at Washington and you who have had experience with patenting know about how long it takes. However, what the Garden plans to do is to sell a little tag with the plant. They cannot be sold unless that tag is on them. The tags will be very inexpensive. I don't know what the Board of Trustees has decided upon, but it will probably be in the neighborhood of 10 or 15 cents a tag. So I thought I'd bring along three slides that I took at the Botanic Garden this year to show you the appearance of the plant. This picture shows you the real meaning of the words, "golden abundance". I have learned that one or two of the nurseries that have taken cuttings of this have had complete failure. I am not prepared to say what percentage of cuttings we have rooted, but we have done a great deal better than that. In fact, we have rooted them so well that we figured that it certainly is commercially possible after you once get on to the technique. This plant is a true hybrid between *Mahonia aquifolium* and *M. amplectens*. The seed was collected from one plant of *M. amplectens* which was growing not too far away from a *M. aquifolium* plant. After planting these seedlings, I discovered this one plant and thought it was so good that I watched it for about two years. After that I called it to the attention of the director of the Garden and he, too, thought it was good and he said let's call it "Golden Abundance". We have since had Dr. Robert Thorne, the Garden botanist, look at it for its technical description; he said it is a complete hybrid in that every botanical feature shows the effects of both parents. So it seems to be split right down the line. It's a very vigorous plant. I've been growing it in my own yard for the past 6 or 7 years and it does very well under garden care

MODERATOR CURTIS: Any questions for Percy?

VOICE: I would like to know if those plants are growing out in the full sun and where?

PERCY EVERETT: Yes, they are in full sun. They're growing in the Indian Hill Mesa area of Claremont, California, where we had temperatures this last summer up to 115° F. It behaves beautifully; I cannot say that it is free from the leaf miner but this pest can be easily controlled by systemic insecticides. I have found in my own personal garden that if it is given good air circulation, there is very little leaf miner present. If it's in an area where the air circulation is not very good, then it is highly susceptible. The original clonal plant has, to my knowledge, never shown any leaf problems.

LES CLAY: How is it for hardiness?

PERCY EVERETT: The plants were tested by the U.S.D.A. at the University of Minnesota for wheat rust susceptibility. I don't know whether they plant them outside or not. Maybe someone knows more than I do as to how they test them back there. I have no fear of its hardiness. I think *M. aquifolium* has been grown fairly far eastward and I know that *M. amplectens* grows at an elevation that certainly does get down well below freezing. I don't have any definite figures at the present time; this is one characteristic we need to test out a little more.

VOICE: How long does the flowering period last?

PERCY EVERETT: I suppose 3 weeks or more. It is equal to any of the *Mahonias* that are on the market. In fact, it is so superior that I don't see how anyone can grow any other *Mahonia*, except if they wanted a compact dwarf type, which often doesn't even flower. When 'Golden Abundance' is in fruit, it's equally beautiful. I was just too lazy to go down to the Botanic Garden and get a slide of it in fruit. I had some taken and showed them to the group here several years ago; but it's magnificent. The clusters of hanging fruit are long and those who have seen the clone have said it has two stages of beauty, or three, perhaps—the plant, flowering, and the huge fruit clusters.

BILL CURTIS: While we're speaking of *Mahonias*, on the way down, Bob Ticknor, Warren Ferris and I stopped at Bob Boddy's Nursery at Fort Bragg, California. Bob has gone over part of one row of his stock plants of *Mahonia aquifolium* with a circular lawn mower. He cut the plants off close to the ground and now he has tripled or quadrupled the amount of cuttings that he gets, and they're nice, lush cuttings. So if any of you have a stock block of *Mahonia compacta*, and they are getting a little bit late, I suggest that you go over them with some mechanism or other and cut them off right close to the ground. I've been tempted to do that to mine. I was a little bit hesitant about doing it but when I get home, I'm going to cut them off as close to the ground as the circular mower will do it. I think this will result in getting a lot more cuttings.

THURSDAY MORNING SESSION

October 7, 1971

MODERATOR FURUTA: Dr. Charles E. Hess, who wears many hats, is from the New Jersey Agricultural Experiment Station at Rutgers University. He is Director of the Experiment Station, also Dean of the College of Agriculture, and as if he doesn't have enough to do with those two jobs, he is in the process of setting up a new College of Environmental Sciences. So it is a great pleasure for me to introduce to you this morning, Dr. Charles Hess:

THE STATUS OF THE ART AND SCIENCE OF ROOT INITIATION

CHARLES E. HESS, Dean

College of Agriculture and Environmental Science
Rutgers University
New Brunswick, New Jersey

Since man recognized the needs and benefits of reproducing plants asexually and, more specifically, propagating them by means of cuttings there have been many significant advances which have made the technique more efficient and have extended the range of plants which may be propagated by cuttings. I would like to review the techniques and advances, pointing out some of the major contributions, showing the blend between art and science, and finally demonstrating that there still remain areas in which answers are still wanting and opportunities for research abound.

Early propagators quickly realized that one of the major problems which must be solved when propagating plants by cuttings is to control water loss. The bell jar provided one solution. It provided a restricted volume of air which could become quickly saturated with moisture, either from evaporation from the media, or from water vapor transpired by the cuttings. When the water vapor in the air surrounding the cuttings reached the concentration of water vapor within the leaves an equilibrium was established and the net loss of water from the cuttings was essentially eliminated. The bell jar, however, was inefficient because of its small size and the fact that it had to be watched carefully to ensure that it was not exposed to direct sunlight. Not only did the small volume of air allow a rapid accumulation of moisture, it also acted as a heat trap and, if exposed to direct sunlight, would accumulate sufficient heat so as to severely damage the cuttings.

Grafting cases, or Wardian cases, were developed which facilitated handling larger numbers of cuttings and also increased the efficiency of operation in terms of shading and ventilation. This system was continuously used for many years with only slight modifications.

A specialized system developed for the propagation of rhododendrons was developed by Guy Nearing. The Nearing frame was essentially a cold frame with a fixed reflector. The reflector was designed to be open to the north and the frame was only exposed to reflected light. In this way the rhododendron cuttings would receive sufficient light by reflection and not be exposed to direct sunlight which would cause an undesirable buildup of heat within the frame.

The introduction of plastic film, or polyethylene, provided opportunities for new advances in efficiency and flexibility. The plastic could be used to replace glass, which reduced the weight of the sash, and thereby facilitated handling. In many cases the conventional grafting case was substituted by a polyethylene tent, sometimes referred to as the vapor-proof case. Cuttings could be placed in the polyethylene tents, watered well and covered with the polyethylene, and essentially be left undisturbed until rooting had been completed. Up to this point, however, although there were changes in the mechanics of controlling water loss, the basic principle remained unchanged. That is—water loss was controlled by building up the humidity surrounding the cuttings.

In the early 1950's a new technique was introduced called, "mist propagation." Although some propagators had used a similar technique many years earlier by mechanically syringing the cuttings every few hours, mist propagation brought a degree of mechanization that was unique to the propagation operation. It also added a new parameter in the control of water loss from cuttings. That is, rather than just depending upon increasing the humidity around cuttings, the leaf temperature was decreased thereby reducing the tendency for water vapor to be lost from the leaves. This new dimension in moisture control also allowed propagation in higher light intensities and did not require a restricted air space. As a result, a wider range of plant materials could be propagated by cuttings, particularly when very soft cuttings were used; that is, cuttings from the new growth of plants. It had not been possible to use these cuttings previously because the soft nature of the tissues, coupled with a low initial reserve of carbohydrates, resulted in their quick decline and decay in the grafting case. But the new environment of mist with its cooler temperatures and higher light intensity facilitated both rooting and photosynthesis. Since the cutting tissues are highly active in the early spring flushes of growth, rooting took place in many cuttings formerly considered impossible to root. Mist propagation truly represented a major contribution to the vegetative propagation of plants. Since the introduction of mist propagation there have been changes and refinements. Initially mist was applied continuously and it was quickly found that an intermittent form of mist was superior. Intermittent mist reduced the leaching and water-logging problems that were associated with constant mist. Also intermittent mist did not reduce the medium temperature below optimum levels. Since the application of any water to cuttings will lead to some leaching, the concept of adding some nutrients to mist was introduced. Although in some cases nutrient mist has accelerated rooting, the greatest benefits appear to be realized in the subsequent growth of the cuttings once they are rooted. In addition to applying nutrients to the mist some researchers have incorporated slow-release fertilizers in the media. Materials, such as Osmocote and MagAmp, have had some beneficial effects on root initiation but again the greatest benefit is realized once the cuttings are rooted.

During the time propagators were concerning themselves with different ways of controlling water loss from cuttings another highly significant discovery was made. That was that plants contain growth regulators or hormones which can regulate or accelerate the process of root initiation. The isolation and identification of indoleacetic acid as the naturally occurring plant hormone led to the development of many synthetic growth regulators which were tested for their root promoting ability. Materials such as indolebutyric acid and naphthaleneacetic acid are now used routinely to facilitate the rooting of cuttings. Once again the range of plants which could be propagated by cuttings was enlarged and the efficiency of the technique was greatly improved. Again there have been some refinements and adjustments in the use of the plant growth regulators. They may be applied in talcum powder or in liquid, either as a concentrated dip or as a dilute soak. In most cases the concentrated dip provides efficiency of application and generally the largest response, since the growth regulator is already in solution and more rapidly penetrates the cuttings' tissues. Additives such as DMSO have been tried to facilitate the uptake and movement of the root promoting substances in the cuttings. Other materials, such as catechol, which appears to protect the plant growth regulators within the tissues of the cuttings, have been used. More recently a new group of plant regulators, commonly used for retarding the growth of plants, have been shown to have the abliity to stimulate root initiation in some cuttings. The growth retardant, B-9, applied at a rate of 1000 to 5000 ppm has stimulated root initiation in chrysanthemum cuttings.

Although the introduction of mist propagation and the use of growth regulators have increased rooting efficiency and have extended the range of plant materials which may be propagated by cuttings, there nevertheless remains a large number of woody plants which are still considered to be nearly impossible to root.

Studies in the physiology of root initiation have been conducted to attempt to find the reasons why some cuttings are very difficult to root. It is clear that substances essential for root initiation are synthesized in the buds and leaves of cuttings and are translocated to the base of the cuttings through the phloem. The effectiveness of leaves and phloem transport in root initiation can be demonstrated by comparing the rooting of leafy and defoliated cuttings and cuttings that have been girdled compared to non-girdled cuttings. Leaf removal and girdling drastically reduce the rooting potential of a cutting. The substances which are translocated from the top of the cutting to the base include the naturally occurring auxin, indoleacetic acid, sugars, nitrogenous substances and a group of compounds which have been referred to as the "rooting cofactors." The cofactors are substances which react synergistically with indoleacetic acid to accelerate the rooting process. It has been suggested that the variation in rooting ability of cuttings is an expression of how many and how much of the rooting cofactors are present. An easy-to-root cutting would have a good supply of auxin, carbohydrates and nitrogenous materials and rooting cofactors. Difficult-to-root cuttings may lack one or more of the essential components. In addition to the mobile components regulating root initiation, there appears to be a nonmobile component. It has been suggested that the nonmobile component may be a protein such as an enzyme. Research in Bouillenne's laboratory in Belgium indicates that the polyphenol oxidase enzyme may be involved in root initiation. The enzyme can be found present in those cells which are about to divide and differentiate into a root initial. We have found that the polyphenol oxidase isozymes appear in the hypocotyl of mung bean cuttings prior to root initiation and their development is accelerated when indoleacetic acid and catechol are supplied in the incubation medium.

In addition to the internal physiology of cuttings during root initiation the external effects of the environment have also been considered. The effect of light, both in terms of quantity and quality, have been investigated. It is interesting that light can influence rooting in strikingly different ways. For example, light is essential for photosynthesis and, in the case of softwood cuttings, increased rooting can be realized by increasing the available light. However, in the area of root initiation at the base of the cuttings, light can actually be inhibitory. In fact, if the tissues in which root initials are to be formed can be grown in the absence of light, that is etiolated, the rooting potential of the tissues is greatly increased. The etiolated tissues contain more free sugar, less starch, and essentially no lignification. The thin-walled cells appear to be easily induced to rapid cell division and differentiation into root primordia. As a general rule, long days—that is, 16 hours of light or more—favor root initiation and root development, while short days—8 hours of light or less—reduce rooting potential. The carbon dioxide content of the air surrounding the cuttings also can influence rooting potential. Higher CO_2 levels in the range of 1800 to 200 ppm supplied for 12 hours per day have increased rooting. Carbonated mist has been used with similar results. Also, increasing the medium temperature by the use of hot water or electric heating cables has speeded root development and in some cases increased the range of plants propagated by cuttings.

The most recent development which may, in fact, have a substantial impact and wide-range implications in plant propagation has been the development of the technique of tissue, or meristem, culture. Cultures of tissues from carrot, tobacco and Jerusalem artichoke have been grown for a number of years. The first practical application of the technique on a wide scale has been the propagation of orchid species by excising the meristem and growing them on a defined medium. Other tissues from herbaceous and woody plants have been successfully cultured. However, one of the biggest problems with tissue culture and one which is very similar to the problems incurred in root initiation is the inability to cause the tissues to differentiate into shoots and roots from the callus stage. We are all familiar with cuttings which may produce abundant callus but yet stubbornly refuse to initiate primordia. Although in tissue culture, roots frequently do form in the callus, it is considerably more difficult to obtain shoot differentiation. One of the great problems, therefore, facing researchers in the physiology of plant propagation—and it is perhaps one of the great unsolved problems of biology—is the understanding of what regulates the differentiation of a group of cells into a recognizable plant organ. Since all cells contain the information needed to develop into a total plant, the question is: why is only a small portion of the information available at any one time, and what regulates what information will be made available to direct the development of a group of cells into a shoot or root at a particular point in time? As we learn more about the regulation of differentiation we will be better able to regulate root formation in cuttings and also expand the use of tissue culture as a commercial practice in plant propagation.

MODERATOR FURUTA: Thank you, Charlie. I think we will take one or two questions now if you have any at this time.

VOICE: Is there a method or formula for determining the minimum number of foot candles necessary for root initiation?

CHARLES HESS: Of course you can't answer that in a general way, because it varies from plant to plant. Plants such as dogwoods, for example, which are an understory plant, will tolerate less light—will reach maximum photosynthesis under less light intensity than say, a plant that grows under full light intensity. Now that I say you can't do it, let me tell you what, as a general rule, we use. Saran cloth, at about a level of 20% shade, seems to work out all right. We used to use cheese cloth, but Saran is more stable; it won't break down as readily. This use of shade has a number of advantages. It does, apparently, allow enough light through to give ample photosynthesis to a wide range of plant materials. It also reduces certain problems if you're outside, such as wind affecting the mist bed. Those are the two things that I think of right off hand. I would say, even in New Jersey, where we don't have all the sunshine that you have here, that outside it is advisable to use some degree of shade. The other advantage that I think of in using shade is to reduce the frequency of mist applications. Our goal is to try to just keep the leaf with a film of water on it. Any more than that really is probably a surplus and can cause problems, as far as lowering the rooting medium temperature, water-logging of the medium and so forth. So if you use this combination of mist and a light shade, you can, perhaps, get a little closer to the optimum set of environmental conditions.

FRANCES SPAULDING: I wonder if you have any idea where ethylene fits into the picture of root initiation.

CHARLES HESS: It had been observed for many years, before ethylene became a very fashionable thing to study in plant physiology, that ethylene did stimulate root initiation. A good example is tomatoes. If tomatoes are exposed to a low quantity of ethylene, then lots of roots form up and down the stems; there are people who are suggesting that the effect of an auxin in stimulating root initiation is in injuring the tissues a little bit so that they will produce ethylene. It's ethylene that's doing the job as far as root initiation is concerned. At this point, I'm not really prepared to agree with that — but I can't disagree with it, either.

MODERATOR FURUTA: Our next topic will be, as presented in the program, Staking, Pruning and Spacing. And with this I think the speakers have a wide latitude; you could go almost anywhere. So I should like to introduce at this time two gentlemen who need no introduction to this group, Dr. Andy Leiser and Dr. Richard Harris.

TREE TRUNK DEVELOPMENT: INFLUENCE OF STAKING AND PRUNING[1]

ANDREW T. LEISER[2], RICHARD W. HARRIS[2],
P. LANNY NEEL[2,3], DWIGHT LONG[4], NORMAN W. STICE[5]
AND RICHARD G. MAIRE[6]
Department of Environmental Horticulture
University of California
Davis, California

Abstract. Trunk development of young container-grown trees was strongly influenced by pruning and staking practices. Trees were produced which were able to stand without support when planted in the landscape This was done by eliminating stakes, leaving lateral branches on the trunk and spacing plants so their tops were free to move Even though rigidly-staked trees

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with their lower limbs removed grew taller, they developed less caliper at the trunk base, much less taper to the trunk and a smaller root system. Most of the trees staked during production were not able to stand upright when planted out.

The program topic: staking, pruning and spacing will be divided into two sections. I will discuss staking and pruning experiments conducted by Dr. Richard Harris, Richard Maire and Bill Stice, Dwight Long, Lanny Neel and me at ABC Nursery in Gardena, Oki Nursery in Sacramento and Saratoga Horticultural Foundation and at the University of California at Davis. The pruning and staking experiments were triggered in part by studies done in cooperation with Dr. John Kemper, School of Engineering at UCD, which showed that a sapling tree with a well tapered trunk had more uniform stress distribution than one with a non-tapered trunk.

But why should the development of the plant concern the plant propagator? In my remarks at the opening session I alluded to the "Compleate Propagator"—a propagator concerned with the end product as well as one just concerned with putting roots on a cutting. So we would like to share with you some ideas on how to put a trunk on a tree

With the advent of container production of trees in nurseries, changes in traditional cultural practices developed. These changes include closer spacing, removal of lower branches to facilitate watering and spraying and staking to prevent lodging. One result of these changes is that many trees so produced are unable to stand erect without long periods of staking when planted in the landscape. Such staking is costly and frequently results in severe damage to trunks and limbs unless staking is done carefully and is frequently inspected.

Environmental effects on wood formation and stem form have been reported by Larson (5, 6). Using low-light intensities for extending daylength, he demonstrated that both leaves and terminal buds exert an indirect control on wood formation in red pine in addition to the direct contribution of photosynthates. With Tamarack (*Larix laricina* (duRoi) K. Koch.), wind movement increased radial growth and tracheid development and decreased internodal growth. Bud and lateral branch removal decreased internodal and radial growth and tracheid development in both free-swaying and staked trees.

Trees growing in dense forest stands are prone to windfall when surrounding trees are cut (3). They are taller, have less trunk caliper and taper (i.e. decrease in caliper per unit of height) than similar trees growing in the open (1, 8). Jacobs reported that 16-year-old Monterey pines which were guyed for two years made less than 70% as much new caliper growth as trees not guyed. "After two years, trees that had been prevented from swaying were no longer stable in a normal environment." (8). Rigid staking of young myoporum trees in the landscape resulted in trees which were taller but which had less trunk caliper and taper than trees not staked (4).

Stress distribution is much more uniform in tapered than in non-tapered sapling trunks (4). The inability of many container-grown trees to stand upright in the landscape was thought to be aggravated by rigid staking during nursery production (9).

In nature, however, trees usually develop trunks capable of standing erect.

Young tree trunks have been strengthened and leader growth retarded by leaving lateral branches on the trunk (2, 4). This is contrary to usual California nursery and landscape practice.

This experiment was designed to study the effects of the staking and pruning on trunk development of young trees.

MATERIALS AND METHODS

Nine species of trees having varying growth habits, commonly grown in California were used. These were: *Eucalyptus sideroxylon* A. Cunn., mulga ironbark; *Fraxinus uhedei* Longelsh., Shamel ash; *Grevillea robusta* A. Cunn., silkoak; and *Schinus terebinthifolius* Raddi., Brazilian pepper at ABC Nursery, Gardena, Los Angeles County; *Betula verrucosa* Ehrh., European white birch, and *Eucalyptus sideroxylon* at Oki Nursery, Sacramento; and *Eucalyptus polyanthemos* Schauer., round-leaf eucalyptus; *Liquidambar styraciflua* L., liquidambar or sweetgum; *Pistacia chinensis* Bunge., Chinese pistache; and *Quercus ilex* L., holly oak at Saratoga Horticultural Foundation in Santa Clara County.

The four treatments were: (1) rigid staking with the laterals removed on the lower half of the trunk (conventional nursery practice), (2) rigid staking with the laterals headed to 20-25 cm on the lower half of the trunk, (3) no staking with the laterals headed to 20-25 cm on the lower half of the trunk and (4) no staking and no pruning. Heading was to be a relative soft pinch, removing 5-10 cm, but often more was removed due to the vigorous growth. Eight trees of each species were used per treatment. Treatments began in early July, 1967 just after the trees had been transplanted from 1-gallon cans to 5-gallon or egg cans. Staked trees were tied to 2½ x 2½ x 153 cm (1 x 1 x 60 in.) stakes and unstaked trees were tied to short stakes, 10 cm above the soil level until new root growth stabilized them in the larger containers. The containers were set 60 cm on center to allow free movement of the top and for sunlight to penetrate between the plants. Pruning and tying was done every 3 to 4 weeks during the growing season. The leaders of the staked trees were tied every 15-20 cm along the stake as they grew. The height to which the laterals were pruned each time was increased so that laterals on the lower half of the trees were either headed or removed

At the start of the experiment and again in December 1967, the trees were measured for height and for caliper at the can top (about 5 cm above the ground). In order to determine taper, at the second date trunk caliper also was measured at 150 cm above the can top for staked trees 170 cm or more tall. For staked trees less than 170 cm tall and for all unstaked trees the upper caliper measurement was made 20 cm below the tip. Taper, expressed as mm diameter decrease per meter of height was calculated by the formula:

$$\text{taper} = \frac{\text{diameter difference in mm}}{\text{height difference in mm}} \times 1000$$

In early 1968, the fresh weight of roots and tops were taken for each of 4 trees from each of the 4 treatments for 6 of the 9 species (Table 3).

RESULTS

By comparing lightly-pruned (laterals headed) trees, staked and unstaked; staked trees, severely- (laterals removed) and lightly-pruned; and unstaked trees, lightly-pruned and not pruned, the influences of these several cultural practices can be separated.

Effects of staking: The staked and unstaked, lightly-pruned treatments showed that staking increased height and decreased caliper growth (and hence decreased taper) markedly of 8 of the 9 species (Table 1, Fig. 1). Those staked made 25% more height growth, 15% less caliper growth and their taper was 24% less (Table 2). A number of the staked trees had greater caliper near the top of the stake than at the base, as did the staked tree in Fig. 2. The Brazilian pepper was the only exception of the 9 species to the influence of staking in that staking had little or no influence on growth.

The root systems of the staked trees (Table 3, col. 2 and 3) tended to be lighter in weight than those not staked in 5 of the 7 sets of trees measured, although differences were not significant.

At the end of the growing season, almost all of the trees that had not been staked stood upright without support while most of the staked trees could not (Fig. 2).

Table 1. **Height and caliper increases and taper of nine species of container-grown trees subjected to differential pruning and staking for 5 months.**[x]

	Staked		Unstaked	
	Pruning treatment of Laterals			
Species, location[y] response	Removed	Headed	Headed	Unpruned
Betula verrucosa — Oki				
Height increase, cm	101a[z]	104a	85a	57b
Caliper increase, mm	7.8a	8.9ab	9.9ab	10.4b
Taper, mm / m	7.8a	8.2a	9.6a	13.2b
Eucalyptus polyanthemos — Saratoga				
Height increase, cm	149a	148a	107b	81b
Caliper increase, mm	9.0a	10.7a	12.7b	14.0b
Taper, mm / m	4.0a	4.1a	6.5b	11.3c
E. sideroxylon—Oki				
Height increase, cm	126a	134a	84b	76b
Caliper increase, mm	6.8a	7.2a	9.8b	12.8b
Taper, mm / m	4.6a	5.7a	8.7b	10.3b
E. sideroxylon—ABC				
Height increase, cm	144a	136a	126a	97b
Caliper increase, mm	7.8a	8.8a	9.6a	12.0b
Taper, mm / m	4.8a	5.7a	7.0a	12.4b
Fraxinua uhedei — ABC				
Height increase, cm	158	159	140	133
Caliper increase, mm	19.3	18.2	20.5	21.2
Taper, mm / m	8.9a	9.1a	13.8b	14.1b

[x]**Treatments**

Staked — trunk tied to a 1 x 1 x 60" stake.
Unstaked — trunk not tied to a stake.
Removed — laterals on lower half of trunk removed during season.
Headed — laterals on lower half of trunk headed during season.
Unpruned — laterals on trunk not pruned.

[y]**Locations**

ABC — ABC Nursery, Gardena, Los Angeles County
Oki — Oki Nursery, Sacramento.
Saratoga — Saratoga Horticultural Foundation, Santa Clara County.

[z]Values on any line followed by different letters differ significantly at the 0.05 level or higher according to Duncan's multiple-range test.

continued	Staked		Unstaked	
	Pruning treatment of Laterals			
Species, location[y] response	Removed	Headed	Headed	Unpruned
Grevillea robusta — ABC				
Height increase, cm	135a	135a	122b	122b
Caliper increase, mm	9.5a	11.6b	14.2c	13.5bc
Taper,mm / m	7.8a	9.7b	12.5c	11.7c
Liquidambar styraciflua — Saratoga				
Height increase, cm	113a	95b	81b	60c
Caliper increase, mm	8.5a	9.3ab	10.8c	9.9bc
Taper, mm / m	6.7a	8.0ab	9.5bc	11.2c
Pistachia chinensis — Saratoga				
Height increase, cm	101a	107a	69b	58b
Caliper increase, mm	4.5a	4.3a	6.4b	4.9ab
Taper, mm / m	4.4a	3.3a	7.1b	7.5b
Quercus ilex — Saratoga				
Height increase, cm	68a	88b	71a	63a
Caliper increase, mm	3.4a	4.4b	5.4b	6.4c
Taper, mm / m	7.3a	7.1a	8.4a	10.6b
Schinus terebinthifolius — ABC				
Height increase, cm	127a	119ab	109b	95c
Caliper increase, mm	13.6	14.4	13.6	11.6
Taper, mm / m	10.1	11.7	11.6	11.0

Effects of pruning—removal vs. heading: Comparisons between the severely- and lightly-pruned staked trees showed little or no effect on height growth except with liquidambar which grew significantly taller and holly oak which grew significantly less when severely pruned (Table 1). However, lateral removal reduced caliper growth in 5 of the 10 comparisons 11% or more (significantly in silkoak and holly oak) but had little or no effect on the others. Removal of laterals also resulted in 14% or more reduction in taper in 5 of the 10 comparisons. Only Chinese pistache had substantially greater taper when severely pruned though not significantly so. These variable results may reflect inherent differences between species in branching habit and response to pruning. Shamel ash does not branch on current growth so there were no laterals to prune. Chinese pistache and holly oak had sparse and variable branching. The other species had abundant laterals.

Fig. 1. Round leaf eucalyptus 5 months after starting the staking and pruning treatments. Left to right, Staked — lower laterals removed, Staked — lower laterals headed, Unstaked — lower laterals headed and Unstaked — unpruned.

Root systems of the staked trees were smaller in 6 of the 7 sets of trees measured when the lower laterals were completely removed compared to heading but only significantly so in the mulga ironbark grown at Oki Nursery.

Heading vs. no pruning: The lightly-pruned vs. unpruned treatments (unstaked) showed greater growth differences than the severely-pruned vs. lightly-pruned treatments (staked). Heading the laterals along the lower half of the trunk produced taller trees in all species except silkoak. The mean increase of 21% for all species was significant. The response in caliper growth was variable. Caliper was significantly reduced in mulga ironbark at both locations and in holly oak. Although caliper increase in Chinese pistache and Brazilian pepper was greater than 15%, it was not significant. Heading, compared to no pruning, reduced taper 15 to 44% in 6 comparisons and had little effect in the other 4. The reduction of 16% for all species was significant.

The effects of heading vs. no pruning on root weights was also pronounced. Of the 7 sets of trees examined, 6 had larger roots in the unpruned treatment, two significantly so.

Table 2. Relative influence of staking and pruning trunk laterals for 5 months on height, caliper and taper of container-grown trees.[x]

	Staked / Unstaked[z]			Staked			Unstaked		
	Laterals Headed			laterals Removed / Headed			laterals Headed / Unpruned		
Species, location[y]	Height %	Caliper %	Taper %	Height %	Caliper %	Taper %	Height %	Caliper %	Taper %
Betula verrucosa — Oki	122	90	85	97	88	95	150 *	95	73 * *
Eucalyptus polyanthemos — SHF	138 *	84 *	63 * *	100	84	98	133	91	58 * *
E. sideroxylon—Oki	158 * *	73 * *	66 *	94	94	81	110	77 * *	84
E. sideroxylon—ABC	108	92	81	106	89	84	130 *	80 *	56 * *
Fraxinus uhedei — ABC	113	89	66 * *	99	106	98	106	97	98
Grevillea robusta—ABC	110 *	82 * *	78 * *	100	82 *	80 *	100	105	107
Liquidambar styraciflua—SHF	117	86 *	84	119 *	91	84	136 *	109	85
Pistachia chinensis—SHF	154 * *	67 *	46 * *	95	105	133	118	131	95
Quercus ilex—SHF	125 *	81	85	76 * *	77 *	103	113	84 *	79 *
Schinus terebinthifolius—ABC	109	106	101	107	94	86	115 *	117	105
Mean	125 * *	85 *	76 * *	99	91	94	121 * *	99	84 *

[x]**Treatments**

Staked — trunk tied to a 1 x 1 x 60" stake
Unstaked — trunk not tied to a stake
Removed — laterals on lower half of trunk removed during season
Headed — laterals on lower half of trunk headed during season
Unpruned — laterals on trunk not pruned

[z]Comparisons are between treatments in CAPITALS and are expressed as percentage that the first is of the second, e g $\frac{\text{staked}}{\text{unstaked}} \times 100$

[y]**Locations**

ABC — ABC Nursery, Gardena, Los Angeles County
Oki — Oki Nursery, Sacramento
SHF — Saratoga Horticultural Foundation, Santa Clara County.

* Treatments significantly different at the 0 05 level or higher

* * Treatments significantly different at the 0.01 level or higher

Table 3. Fresh weight of roots of six species of container-grown trees subjected to differential pruning and staking for 5 months.[x]

	Staked		Unstaked	
	Pruning treatment of laterals			
Species, location[y]	Removed	Headed	Headed	Unpruned
	gm	gm	gm	gm
Betula verrucosa — Oki	408	442	458	405
Eucalyptus polyanthemos — SHF	540	544	414	540
E. sideroxylon — Oki	266a[z]	573bc	356ab	741c
E. sideroxylon — ABC	87a	127a	138a	202b
Liquidambar styraciflua — SHF	624a	798ab	822b	876b
Quercus ilex — SHF	288	326	444	501
Schinus terebinthifolius — ABC	279	271	297	339
Mean	356 a	441ab	418a	515b

[x] **Treatments**

Staked — trunk tied to a 1 x 1 x 60'' stake.
Unstaked — trunk not tied to a stake.
Removed — laterals on lower half of trunk removed during season.
Headed — laterals on lower half of trunk headed during season.
Unpruned — laterals on trunk not pruned

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Fig. 2. Influence of staking for 11 months on round leaf eucalyptus. (a) Left, tree grown without stake and lower laterals on trunk headed to about 8"; tree tied to 1 x 1" stake and lower laterals removed. (b) Right, tree untied from the stake.

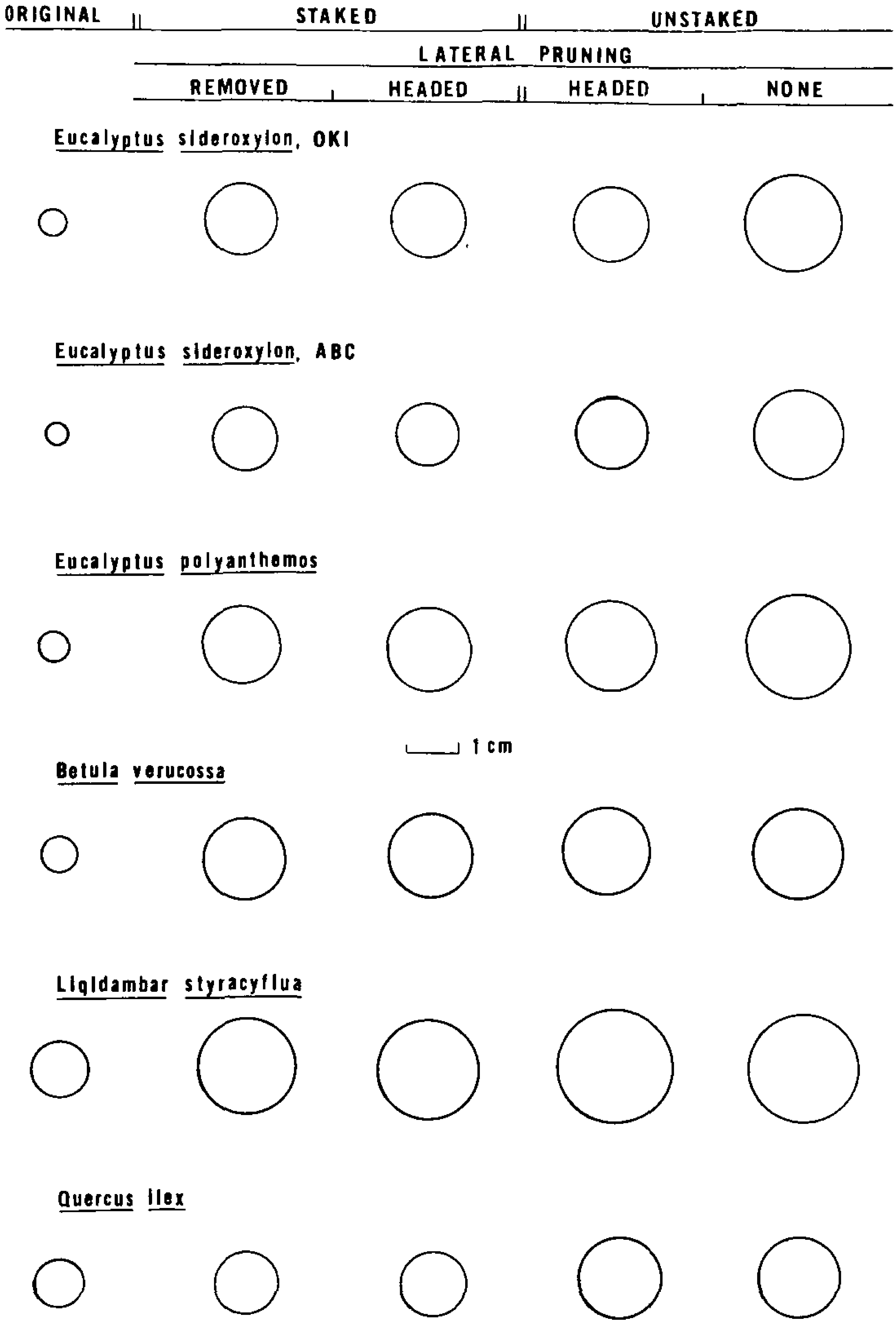

Fig. 3 **Cross sectional areas of 5 species of container-grown trees after 5 months of differential staking and pruning.**[1]

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[1]Treatments

STAKED — trunk tied to a 1 x 1 x 60" stake.
UNSTAKED — trunk not tied to a stake.
REMOVED — laterals on lower half of trunk removed durıng season
HEADED — laterals on lower half of trunk headed during season.
UNPRUNED — laterals on trunk not pruned.

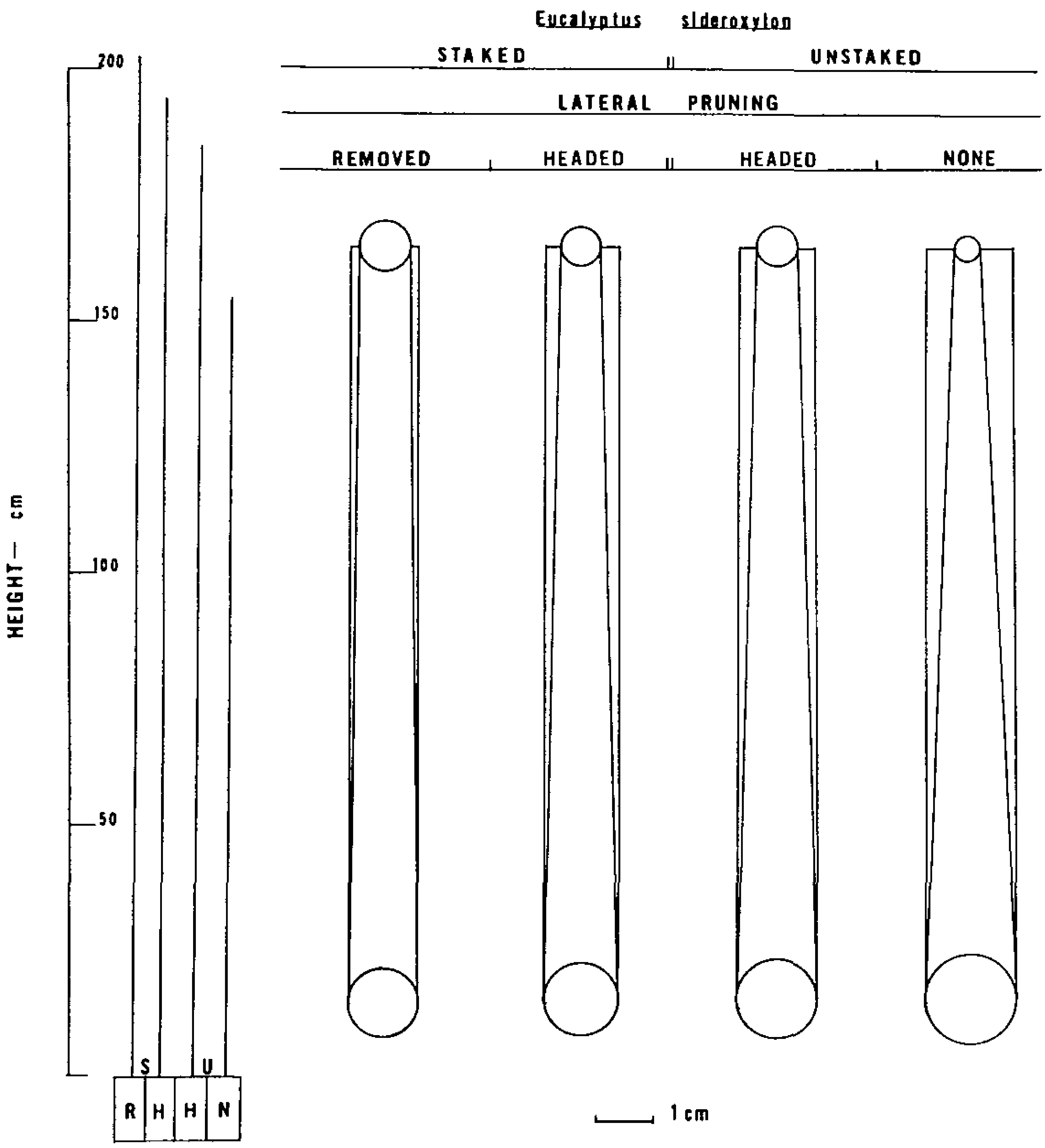

Fig. 4. **Diagrammatic representation of relative height and taper of Eucalyptus sideroxylon grown at ABC Nursery with differential pruning and staking for 5 months.**

DISCUSSION

If one assumes no interaction between staking and pruning, the influence of removing laterals compared to not pruning them can be estimated by multiplying from Table 2 the percentage for the "Headed Unpruned" by that for the "Removed Headed", and dividing by 100. For example, for mulga ironbark at ABC Nursery, the total influence of lateral removal on height would be 130 x 106 / 100 = 138 % or on caliper would be 80 x 89 / 100 = 71 %.

The magnitude of the effects of pruning and staking on trunk development are summarized in three graphic presentations. The cross sectional areas at the can top for several representative species are given in Fig. 3. The relative heights, caliper and taper for

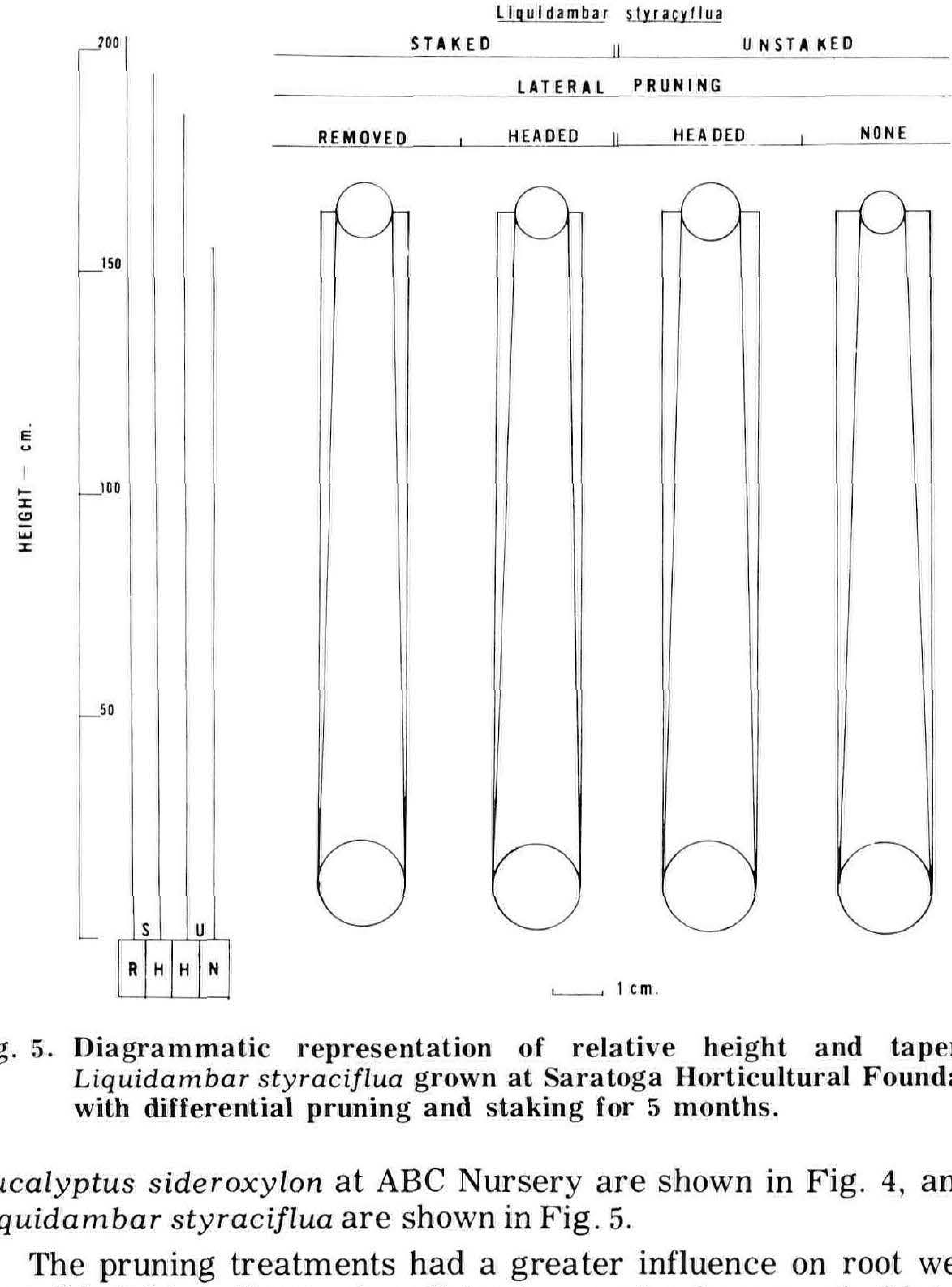

Fig. 5. Diagrammatic representation of relative height and taper of *Liquidambar styraciflua* grown at Saratoga Horticultural Foundation with differential pruning and staking for 5 months.

Eucalyptus sideroxylon at ABC Nursery are shown in Fig. 4, and of *Liquidambar styraciflua* are shown in Fig. 5.

The pruning treatments had a greater influence on root weight than did staking. Comparing all 7 sets examined, removal of laterals vs. heading and heading vs. no pruning, each increase in severity of pruning resulted in about 20% reduction in root weight. The removal of laterals decreased root weight about 30% compared to the no pruning treatment.

Refinement of cultural practices to optimize height growth and trunk development should be undertaken. Some of the variability in response may have been due to the infrequent attention (3-4 weeks) given during this experiment and therefore the rather severe heading of laterals at each pruning. Severe pruning decreases lateral growth (2). More frequent but lighter pruning might be more effective and might result in more consistent plant response.

Additional research on the effects of pruning and staking on root growth would be desirable. The root observations made were not planned originally in this research. The harvest dates were such that the more rapidly growing plants may have filled the container early in the growing season and they may have had reduced growth late in the season. The result would have been to allow the slower growing plants to catch up and reduce the differences between treatments. The differences in root growth between *Eucalyptus sideroxylon* grown at the 2 locations is an intriguing question (Table 3). Seed sources, soil mixes, fertility programs and environment varied between these nurseries.

Treatments might have been more effective if started when the plants were first moved to gallon cans. This is indicated by observations at Davis where eucalyptus and many other species have been grown successfully without stakes if they are given adequate space and are not left too long in liner pots or gallon cans.

Even though differences between certain treatments were not always significant, the consistent trends in height reduction and increased caliper growth and taper and in root weights as the severity of pruning decreased and stakes were removed give validity to the following generalization. Rigid staking and severe pruning of lower laterals of young nursery trees produces plants with greater height at the expense of caliper, taper and root development. Thus, if one is to produce young trees which can stand in the landscape without staking, the use of rigid staking should be avoided and pruning should be done in moderation.

Although the unpruned, unstaked treatment resulted in trees with the largest caliper, taper and root systems, this procedure may have limited nursery application due to reduction in height growth, additional growing space required and difficulty of maintenance. It should be emphasized that these plants were grown on 60 cm spacings.

The treatment "laterals headed, unstaked" produced trees judged to be an acceptable compromise between height growth and trunk development. Trees produced by this treatment had satisfactory height growth for the species, a full crown (good apparent size) and trunks capable of standing erect without stakes (Fig. 1 and 2).

Some species are more adapted than others to growing upright without support. Even within some species, upright growth may be quite variable depending on seed source or variation within seed source. A tree's ability to stand alone usually can be determined by the end of the liner stage. Those that can stand alone should be separated from those that cannot. The first group can be grown without support if given proper spacing. Depending on the number and their condition, the others can be grown on with minimum staking or discarded. Modifications in nursery staking practice should start with those species that easily grow upright and extended to other species as suitable cultural practices are developed.

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TREE TRUNK DEVELOPMENT: INFLUENCE OF SPACING AND MOVEMENT [1]

RICHARD W. HARRIS,[2] ANDREW T. LEISER,[2]
P. LANNY NEEL,[2,3] DWIGHT LONG,[4]
NORMAN W. STICE,[5] and RICHARD G. MAIRE[6]

Department of Environmental Horticulture
University of California,
Davis, California

Abstract. The spacing of container-grown *Betula verrucosa* Ehrh., *Eucalyptus sideroxylon* A. Cunn., *Dodonaea viscosa* 'Purpurea' Jacq., and *Liquidambar styraciflua* L was studied at two California locations in 1967 and 1968 As area per plant increased from can-to-can spacing, the plants grew

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3 Now at the Agricultural Research Center, Fort Lauderdale, Florida
4 Saratoga Horticultural Foundation, Saratoga, California
5 California Agricultural Extension Service, Sacramento
6 California Agricultural Extension Service, Los Angeles

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more in trunk caliper and taper, and in weight of roots and branches plus leaves, but less in height and weight of trunk. At the closest spacings, the lower foliage was sparse giving the trees a leggy appearance. Adequate spacing, about twice the can-to-can area, the first season gave benefits of of increased trunk caliper and fuller foliage with a minimum sacrifice in height growth

Greenhouse trials with *Liquidambar* and *Zea mays* suggest that the greater height growth of closely-spaced plants may largely be due to less movement. Height growth was reduced at least 50% by a daily, 30-second period of trunk motion

Spacing and arrangement of containers commonly used in commercial nursery production is the least area consistent with ease of providing adequate care. This usually results in placing plants can-to-can in beds of several hundred containers, particularly those in gallon cans Larger containers are usually closely spaced in 2- or 4-can rows with narrow aisles between.

Field spacing of forest (11, 12), fruit (1, 2), and vegetable (8, 9) crops has been extensively studied. Trunk diameter growth of forest and fruit trees increased as the space per plant increased. As the more closely spaced trees began to crowd, the lower foliage weakened and died (1). Tree height did not appear to be greatly affected at the spacings used (1, 11). Yield per plant, but not per acre, was increased as the space per plant increased (1, 8, 9).

Tree height and caliper growth of nursery-grown trees determines in large measure their monetary value as well as how well they will be able to stand upright in the landscape (4). Earlier observations of the lack of response of pruning treatments of close-spaced container-grown trees, raised the question of the influence of spacing on trunk development of young trees.

MATERIALS AND METHODS

The spacing study was carried out at Oki Nursery in Sacramento County and at the Saratoga Horticultural Foundation in Santa Clara County, California. Peat-pot liner seedlings of *Betula verrucosa* Ehrh., European white birch, and *Eucalyptus sideroxylon* A. Cunn., eucalyptus or mulga ironbark were supplied by Oki Nursery. *Dodonaea viscosa* 'Purpurea' Jacq., purple leaved dodonaea, and *Liquidambar styraciflua* L., liquidambar or sweetgum, were supplied by the Saratoga Horticultural Foundation.

The study was started in late June and early July of 1967. The trees were planted in gallon cans and placed in blocks having spacings of 18, 25 and 35 cm on center. These spacings gave surface areas per plant of about 300, 600 and 1200 cm^2 or area relationships of about 1 (can-to-can spacing), 2 and 4. Six plants were in a replicate at each spacing with each replicate being surrounded by guard plants at the appropriate spacing. There were 3 replicates of each treatment. If necessary, individual trees were tied loosely to a short stake that protruded about 10 cm above the soil to hold the trunk in an upright position.

In December, 1967, the plants were moved into 4-gallon (egg) cans at Sacramento and into 5-gallon cans at Saratoga (both will be referred to as 5-gallon cans). The spacings were increased to 25, 43 and 60 cm on center. These spacings gave areas of about 600, 1800 and 3600 cm^2 or area relationships of about 1 (can-to-can), 3 and 6.

To reduce the influence solar radiation might have on soil temperatures at the different can spacings, the gallon cans were surrounded with wood shavings to the can top. The 4-gallon cans had a shiny enamel finish that was considered adequate to reflect sunlight. The 5-gallon cans were painted with a white latex paint. No additional protection was given these cans. During the two growing seasons the lateral branches along the trunks were pinched several times beginning when their tips were 5-7 cm beyond the edge of the cans. Except for the lateral pinching and the elimination of staking, the plants received regular nursery care.

At the beginning of the experiments, after the first growing season and at their conclusion the second year, the trees were measured for height and for caliper at 5 and either 105 or 155 cm above the soil line. Since plants at the different 5-gallon spacings were different in caliper at the start because of their previous spacing, trunk growth is expressed on an area-increase basis. Taper, decrease in caliper with height, was determined by dividing the difference in trunk diameters by the difference in the heights at which the diameters were measured and expressed as mm / m. At the end of the experiment at Sacramento and Saratoga, the height of each node was recorded. The birch, dodonaea and liquidambar grown at Sacramento were sacrificed and partitioned into three portions; roots, trunk and laterals plus leaves. The fresh weight of each was determined.

The birch and eucalyptus trees were ready for sale or moving to larger containers at both locations in late June, 1968. These species were measured at that time and removed from the experiments. The dodonaea and liquidambar at Sacramento were removed in early July while these two species at Saratoga remained in the experiment until the end of the 1968 growing season.

RESULTS AND DISCUSSION

Height and trunk area growth was 15 to 20% greater at Sacramento than at Saratoga for the four species at the widest spacings. These differences were probably due to the high rates of fertilization and warm, sunny spring weather at Sacramento compared to that at Saratoga. The species responded similarly to the spacing treatments at the two locations. Liquidambar was the only exception as noted later.

As spacing increased, the plants increased in caliper (trunk area) and taper, improved in appearance, but made less height growth, Figs. 1 and 2. At the closest spacing, the lower foliage was heavily shaded and much of it dropped off. These trees were not as attractive as those given more space. This is shown in Fig. 2.

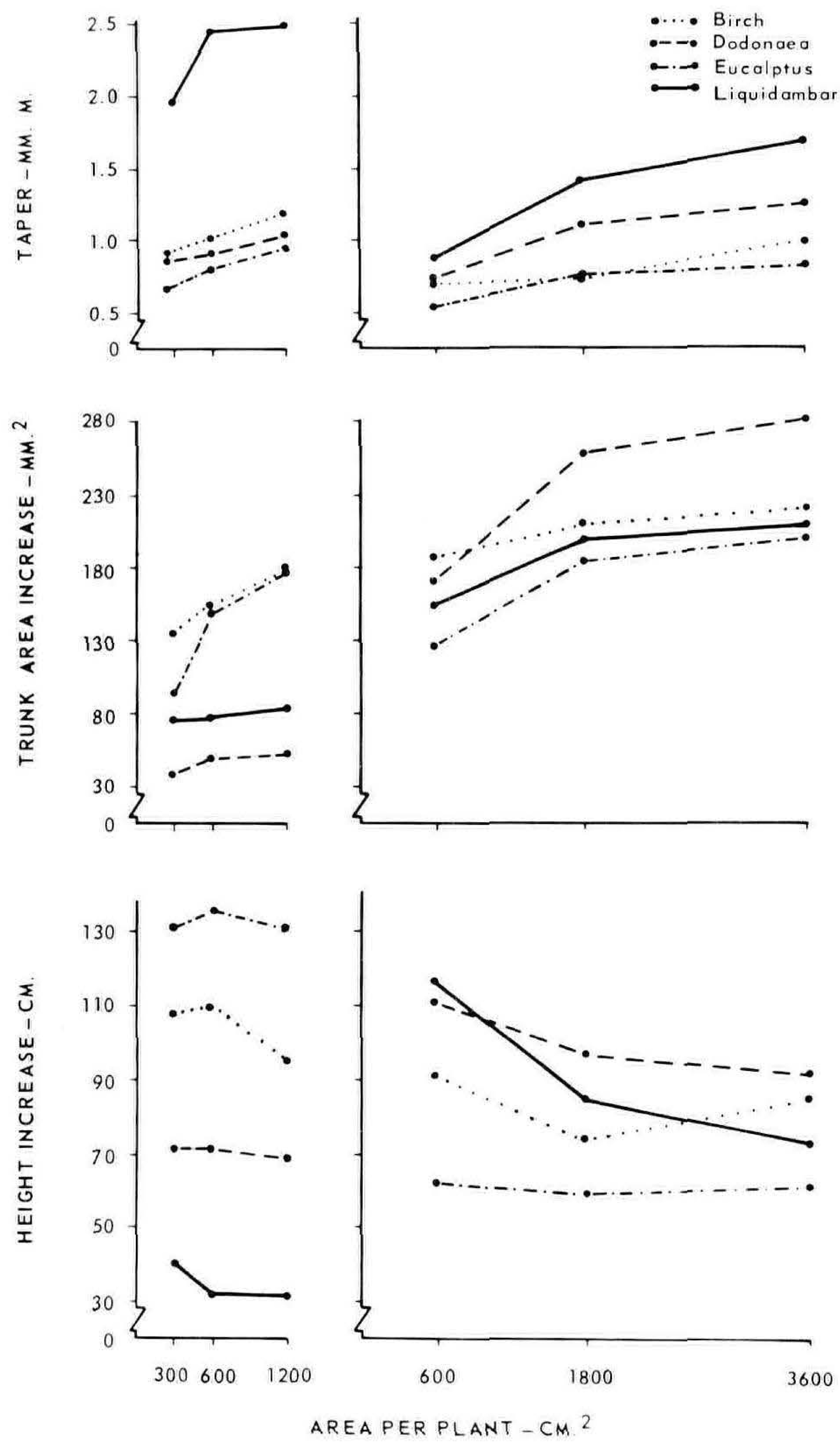

Fig. 1. **Influence of area per plant on trunk-area and height increases and the taper of four species of trees in 1-gallon (1967) and 5-gallon (1968) containers at Sacramento and Saratoga, California.**

Increasing the area per plant had less effect on the height of the trees the first season in the gallon cans than it did the second year when they were in 5-gallon cans. However, trunk area was increased on the average 30% both years when the can-to-can area per plant was increased to the intermediate spacing. Since taper is a height-caliper relation it, therefore, was more greatly influenced during the 5-gallon than during the 1-gallon stage.

The effect on height and trunk-area growth and taper was greater between the intermediate versus can-to-can spacing than was the effect between the maximum and the intermediate spacing, Fig. 1.

Fig. 2. Influence of area per plant on liquidambar at Sacramento, (left to right): 3600, 1800 and 600 cm^2 per plant, 1968.

Of the four species, liquidambar was most affected in height growth and taper by increasing area per plant. Eucalyptus and dodonaea were most affected in trunk-area growth. In the 5-gallon can, dodonaea also was markedly influenced in the degree of taper by the amount of area per plant.

Increasing the space per plant increased the weight of roots and branches plus leaves, but decreased the weight of the trunk slightly, particularly of dodonaea and liquidambar, Fig. 3. Apparently a higher proportion of tissue formed in the roots and branches of trees with greater space, while the closest-spaced trees grew taller and had less taper. This resulted in a greater volume of wood which caused the trunks of the closest-spaced trees to weigh more than the trunks of the trees grown with greater spacing.

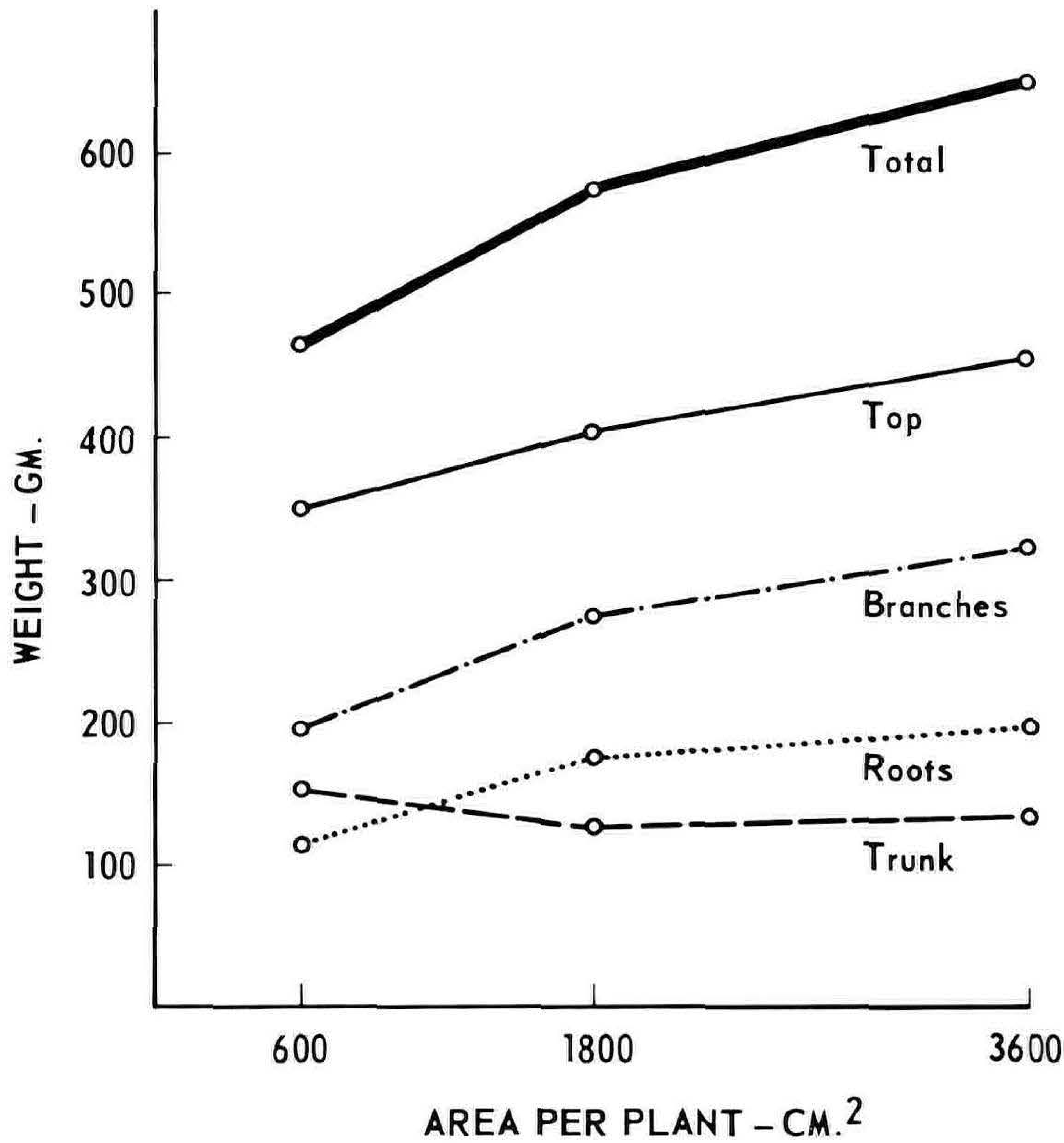

Fig. 3. Influence of area per plant on the fresh weight of different parts of liquidambar at Sacramento, 1968.

Internode length of the 1-gallon-size plants was little affected by spacing. With 5-gallon-can plants internode length of birch, dodonaea and eucalyptus was increased at the closest spacing, though not significantly. However, the closest-spaced liquidambar plants formed significantly more nodes and had longer internodes, Fig. 4.

At Saratoga, the internodes of the closest-spaced liquidambars began to be longer than those of plants with greater spacing after 6 nodes had formed in 11 cm of new growth (total tree height of 68 cm), Fig. 4. The intermediate spacing began to have an apparent effect on

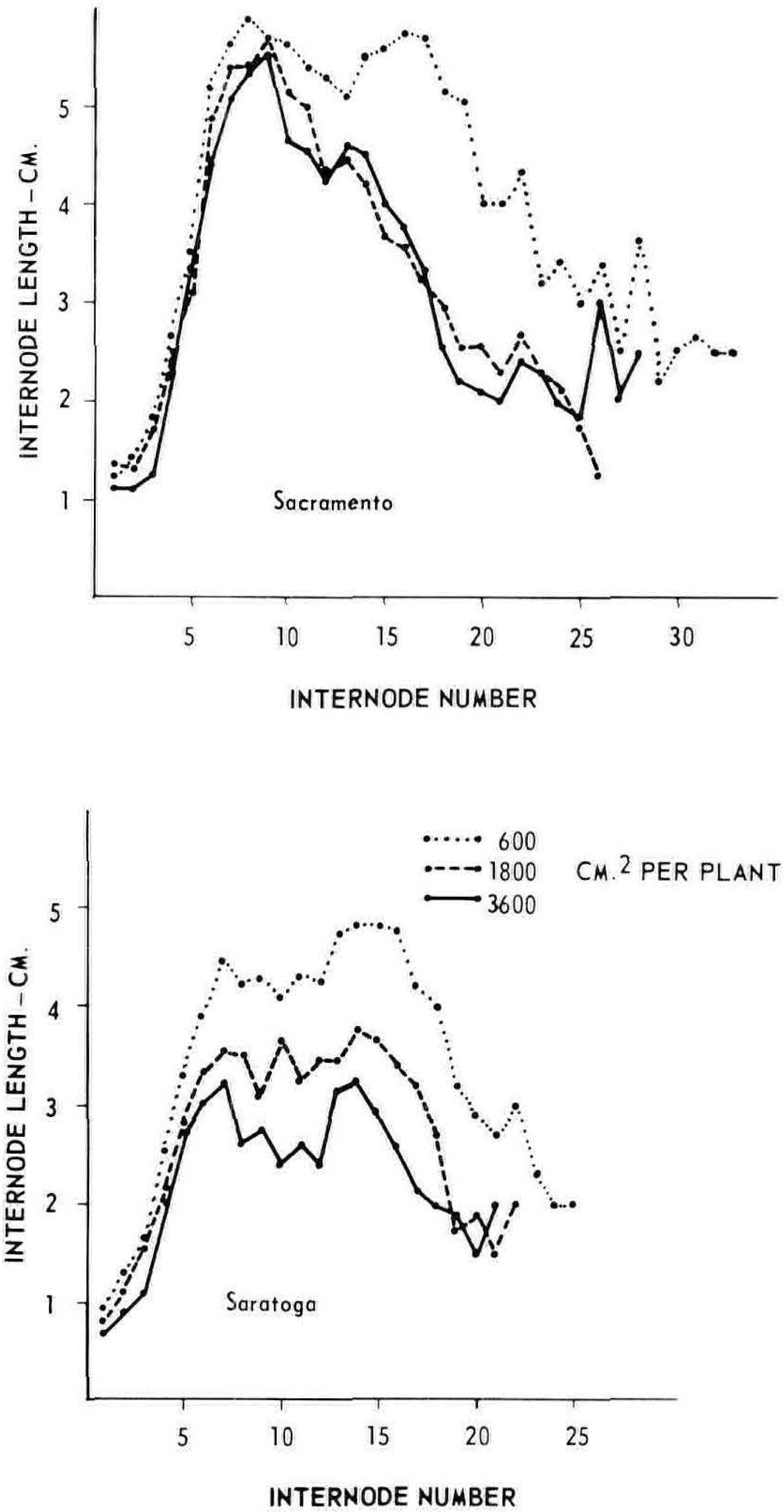

Fig. 4. **Influence of area per plant on liquidambar internode length and number at Sacramento and Saratoga, 1968.**

internode length after 8 nodes had formed in 16 cm of new growth (total height of 60 cm). At Sacramento, differences in internodal length of the closest-spaced liquidambars were not evident until 14 nodes had formed in a total of 56 cm of new growth (total tree height of 104 cm). Little or no difference in internode length occurred between plants at the intermediate and the greatest spacings at Sacramento.

The Sacramento-grown liquidambar produced a great number of leaves and made more height and trunk caliper growth by July 9 when the trees were withdrawn from the experiment than did those at Saratoga during the entire 1968 growing season. However, by July 9 at Sacramento, the growth rate had declined to 40% of its maximum, with a reduction in differences between the internodal length of trees at different spacings, Fig. 4. At Saratoga, length of newly formed internodes remained fairly uniform throughout the summer although they were shorter than at Sacramento. The initial high rate of growth at Sacramento was probably the result of high rates of fertilization, high light flux and warm spring weather. The decline in growth rate may have been due to an interaction between water stress brought on by the large leaf area per plant, an increasingly restrictive root system, and the hot, dry, summer weather. On the other hand, Saratoga is subject to morning overcast and cooler temperatures during the spring and summer. This and lower nutritional levels could account for the differences observed between the two locations.

Although these experiments demonstrated the influence of spacing on tree growth, they did not reveal which of the probable causes might be responsible. Maximum height of many plants is attained at intensities considerably below that of full summer sunlight (10). If reduced light intensity was a factor, then the stimulus must come from the lower portion of the plants, since the region of stem elongation of the plants, particularly of liquidambar, was equally exposed to light regardless of the spacing. Experiments to determine effects of light on low foliage have been inconclusive (7).

Transpiration also may affect stem elongation depending on plant spacing. Transpiration of plants at the greater spacings may be increased due to greater exposure to radiation, greater air movement and more leaves than plants closely spaced. Water deficits may be more frequent and severe on plants at greater spacings. Shoot growth of such plants would be reduced (5).

Reduced movement of the region of shoot development and elongation of closely-spaced trees may be responsible for their greater height growth. Staked trees which were less free to move, grew taller than unstaked trees (4). Liquidambar has been shown to be sensitive to brief periods of motion which caused a decrease in node production and internode length (6). Trunk motion as influenced by tree spacing could account for the differences observed at each location.

The influence of trunk motion on shoot growth is being studied further. Experiments now underway with liquidambar and corn, *Zea mays* 'Golden Bantam', confirm the marked reduction in stem elongation caused by a daily short period of stem movement, Fig. 5. Growth of liquidambar and corn in a greenhouse was reduced 50% by a daily, 30-second period to trunk motion (plants were held at about half their height (at about 50 cm) with one hand and moved back and forth about 10 cm two to three times per second).

Fig. 5. Terminal growth of liquidambar as influenced by shaking for 30 seconds daily for 40 days (left): not shaken (right): Arrows indicate height of plants when treatment started on August 18, 1971.

This may seem to be only of academic interest, but it may offer some interesting possibilities in nursery production. One problem is that seedlings are often left in the seed flat and first liner pot so long their trunks become tall and spindly. A short period of motion either by moving the flat or using air might result in sturdier plants more tolerant to transplanting. Such studies are now underway.

Further experiments will be needed to determine the mechanism responsible for greater stem elongation of closely-spaced trees.

Adequate spacing the first season gave benefits in the form of increased trunk caliper growth with a minimum sacrifice in height growth. It appears, Figs. 1 and 2, that there was little benefit in using a spacing greater than the intermediate area (600 cm^2 for gallon cans, 1800 cm^2 for 5-gallon cans). A slightly closer spacing than the intermediate might give adequate plant development with more economical use of space In these experiments, the containers were placed in a square arrangement. However, for practical nursery operations, the plants might be better arranged in double rows (preferably in a north-south direction) with greater spacing between than within rows. The spacings used by some nurseries approximate the intermediate spacings of these experiments.

Equally important as spacing, would be moving the plants to larger containers at greater spacing before the plants reach a size that would begin to adversely affect their development. Internode length at Saratoga was influenced between each of the three spacings but only between the intermediate and closest spacings at Sacramento. Therefore, it would appear that trees in the interior valleys could be spaced closer than those grown in the coastal valleys.

Container spacing and arrangement and time of transplanting to larger containers for most efficient use of land in keeping with other nursery practices need more study.

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MODERATOR FURUTA: This has been a most stimulating and thought-provoking discussion by these two gentlemen. Now, I am sure we will have several questions.

BOB WARNER: You had different growth in the two different locations. Was one more windy than the other, maybe? You would have some influence due to this.

RICHARD HARRIS: Of course, I was going under the naive assumption that light was going to be the factor involved and so we really don't have any accurate observations of what the wind conditions were. However, I think that possibly wind could have been the factor that would separate these out. But again we don't have careful observations on this. We need to get back to this.

BOB WARNER: Well, the shorter plants would be stronger, wouldn't they?

RICHARD HARRIS: We assume they will. Now again, we've only carried these trials on for 40 days or so. There is an increase in the trunk diameter from this and so again it would go back that we would feel that the shorter plant, greater taper, greater base development, would be more upright. In fact, this may have an implication in seedling production in the seed flat and in the peat pot. There is a tendency to leave them too long; they become leggy, they're not very stable. It could be that there might be a way of not shaking the plants individually, but maybe as a group—which would cause them to be shorter and make them more sturdy.

BOB WARNER: It would be interesting to determine the yield of the corn. There is a tendency now for developing shorter strains of corn and increasing the yields.

RICHARD HARRIS: Right, well this is due to genetic differences

VOICE: What would be the advantage of raising bonsai plants on a vibrating table?

RICHARD HARRIS: You've got yourself a project!

DAVID RUDÉ: Dr. Hess, please. What about the use of a complete fog system for propagation, a closed system? What is the maximum temperature you have found you can use within such a system? What are the results on the speed of rooting?

CHARLES HESS: One of the systems I didn't describe, one that was used even before mist was introduced, was the Bink's system of propagation, which essentially consisted of a source of water with a stream of air. Well, it is a sort of atomizer, which again is almost like a humidifier, providing a fog within the greenhouse. We put this sort of a system, when I was at Cornell with Bill Snyder, into a plastic tank. It was like a steam bath effect; the temperatures in there would get up to about 120° F. or so and things seemed to move along quite well. Now what the maximum temperature could be, I can't say because you have to consider air temperature and leaf temperature. Leaf temperature may be a little bit lower under these conditions than the air temperature. The Phytotektor system also would give about 120° F. air temperature inside. Under these conditions of very high water supply, a film of water on the leaves and then, as a result also a very high rooting medium temperature, the rate of root initiation on the cuttings was very, very good.

DAVID RUDÉ: In regard to the Phytotektor System and the Bink's Fog System—what was the bottom heat in each?

CHARLES HESS: In each of these two cases there was no bottom heat. You just depend upon the high temperature within the chamber itself to also raise the rooting medium temperature. Now as far as medium temperatures are concerned, we use as a working guideline, because we have the same problem that individual species will vary—about 75° F. rooting medium temperature. I would say we shoot for this as a broad spectrum figure.

I would like to ask Dick Harris a question. Since, in some of your earlier studies, you were working with the role of ethylene synthesis and so forth, do you feel that ethylene is involved in the responses that you were seeing in your experiments?

RICHARD HARRIS: I think very definitely that this is something that we need to follow up; it seems like ethylene may be involved in the mechanism here, and possibly even growth retardants may act.

I would like to go back and maybe give you a take-home message on this plant spacing; that is—what spacing should you use? This is on trunk area increase with area per plant. You notice we obtained, as I mentioned earlier, the greatest increase from the closest spacing to the intermediate and then not quite so much as we go to the greater spacing. Possibly an intermediate spacing might be reasonable to consider in spacing the plants so as to get an increase in trunk area without too much of a sacrifice in tree height. This intermediate spacing for the 5-gallon container was 17'' on centers. This was a square layout. In a nursery, of course, you'd probably want to go to a rectangular layout, which would be more efficient for the various other operations in the nursery. But something that would be at this spacing—area per plant—or just a little bit less, might be a reasonable place to start.

HERMAN SANDKUHL: Do you know why the corn or the *Liquidambar*, after shaking, had a much better green color?

RICHARD HARRIS: I don't. The first time we did this we weren't aware of the difference in color. Maybe we just didn't pick it up. It could be that actually there is not as much growth being made, so the nitrogen that is there—and these were fertilized every time that they were irrigated—is available in greater amounts to the leaves that were there. It's sort of interesting that even the old leaves that were on the plant before the shaking started, also greened up. I don't have a specific answer on that, however.

CHARLES HESS: Your analogy to the growth retardants also carries through because plants which have been exposed to B-9 or other growth retardants generally are more green than the controls.

MODERATOR FURUTA: We should go on now to the subject that has been listed on the program as "What is New in Soil Mixes for Propagation and Containers". We have three gentlemen who will address themselves to this topic for a while and then we will open it up to discussion. I want Drs. Hess and Harris and Leiser to be around then because we will direct questions to them, too, as the opportunity comes. The first speaker is Dr. Jack Paul, of the Department of Environmental Horticulture at the University of California, Davis. He has been doing considerable work in this area of soil mixes. Jack Paul:[1]

MODERATOR FURUTA: Thank you, Jack. You'll have a chance to ask questions and to continue this discussion after we hear from the other speakers. Next is a colleague of mine with the University of California Agriculture Extension Service, a soils and water specialist, Dr. Roy Branson from the University of California Riverside Campus. Roy:[2]

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[1] Ed Note Dr Paul discussed some of his studies in soil fertility.

[2] Ed Note. Dr Branson presented some of his concepts of soil mixes and plant nutrition.

MODERATOR FURUTA: Thank you Roy. Our third speaker on the panel is Mr. O. A. Matkin. He has been involved in the area of soil mixes for probably more years than he's willing to admit at this time. Matt:

SOIL MIXES TODAY

O. A. MATKIN

Soil and Plant Laboratory, Inc.
Santa Ana, California

In the last 10 years there really haven't been any new innovations. There has been a great deal of change from systems "by guess" to systems "by design." It was well over a decade ago that a "system" was proposed. The purpose at that time was to remove guesswork, chance, and frequent misfortune from the procedure of growing plants, particularly in containers. Since that time there has been a startling and worldwide change in philosophy and procedure in the preparation and handling of growing media. Although the approach has fostered the use of ingredients which contain *no* soil, its utilization has led to greater understanding and more intelligent use of "natural" soils.

Reference is made, of course, to the UC System of Producing Healthy Container Grown Plants. It is still available as *Manual 23* from Agricultural Publications, University of California, Berkeley, California

The early development of suitable growing media for containers was greatly hampered by man's inability to recognize the fundamental differences between field and container growing. Too much emphasis was placed on fertility and too little on soil structure.

The modern grower recognizes that the soil mix is comprised of both physical and chemical properties and is not the complete answer to all of his production problems. He has become increasingly aware of the influence of the many other environmental factors. The very best soil mix can still leave the door open to disaster if sanitation, for instance, is disregarded. This philosophy was the principal purpose of the UC system approach. There are many adaptations of this basic approach that are currently in popular use. These are briefly reviewed as follows:

Container nurserymen have generally leaned toward media high in low cost organic materials such as sawdust or bark, blended with sand or sandy loam. This results in a lightweight mix for economy in shipping and also has substantial advantage in ease of maintaining low salinity because of high water infiltration rates. The physical properties of these mixes are conducive to excellent root growth.

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Mixes of this type have become increasingly popular for roof deck plantings in overstructured landscape.

Pot plant growers have also altered their growing media from the prosaic "topsoil", manure, and peat to mixtures of sand, peat, and possibly wood residual. Perlite, pumice, or vermiculite are frequently substituted for part of the other ingredients. The currently popular "Cornell mix" of peat and vermiculite or peat, perlite, and vermiculite is an excellent example. Where ballast in the container is required, growers frequently substitute sand for part of the Cornell-type mix. The outstanding feature of the peat-perlite-vermiculite mixes is that they may not require decontamination before use if handled in a sanitary manner It is interesting that many Midwestern universities still recommend mixes of soil, sand, peat, and perlite composition. It is possibly a sign of progress that these recommended mixes have at least dropped the "well-composted manure" component from most of their formulas.

For **propagation**, media selected have generally been of a reliable composition as opposed to soil mixes; thus, the propagators have apparently recognized the benefits of good physical structure long before this principle was applied to container growing. Thus, we find propagators have been using sand, perlite, vermiculite, or peat moss and combinations of these for many decades. Certainly there is nothing really new in rooting media unless it be the prefabricated blocks, trays, or slabs that are attaining some popularity. The newest approach is that of direct rooting in well-aerated growing media so that transplanting is avoided. This procedure is quite popular in poinsettia and pot mum production.

In **cut flower growing**, beds of soil are generally used. These beds may be of conditioned native soil or may be completely synthetic and similar to nursery container mixes or pot plant mixes Since the soil volume is substantial, an effort is usually made to employ native soil, particularly if ground beds are used. A typical program for this type of growing medium is to add large quantities of organic matter such as peat moss, sawdust, or bark and perhaps mineral amendments such as perlite, pumice, or calcined clay. The objective is obviously one of diluting the silt and clay of native soil to such a degree that the desired physical properties are attained Perhaps the newest approach in bed growing is that of using completely inert material such as sand, pumice, or scoria as the growing medium and depending entirely upon fertilizer supplied in the irrigation water to maintain appropriate nutrition. This is neither a new approach nor a departure from the UC principle Sand and gravel culture have been tried for many decades and have been consistently used in research. The primary difference in modern use is that the leachate is discarded rather than returned for reuse. This greatly reduces the disease hazard and has been found to be quite economic. There are some obvious advantages to the inert medium system in that it is easy to decontaminate by steam or fumigation, and there are no problems from unexpected chemical or biological reactions. The greatest effort in this direction has been at Colorado State University.

An industry is developing which deals in custom soil mix preparation and perhaps this is new in that it replaces the old "topsoil" dealers It has great potential not only for nurserymen, but for landscapers Many of the wood residual producers are simplifying the process by including all fertilizers in their product so the user has only to blend sand or soil with it to attain a mix of balanced nutrition.

Finally, the use of more reliable growing media has permitted remarkable advancement in knowledge of and methods for nutrition control.

MODERATOR FURUTA: Thank you, Matt. Now we come to the portion of the program that says "Critique". Do we have questions or comments now for the soil mix panel?

BILL MORGAN: I would like to ask Mr. Matkin—has there been any work done in finding out what happens to plants which, we'll say, have been grown in a very coarse mix then are set out in the ground where they encounter an entirely different soil situation? Has any work been done on this?

O A. MATKIN: There's been a lot of experience. I'm not aware of a great deal of academic work on the subject, but this has presented, admittedly, a serious problem. Of course, when you're transplanting any container-grown plant into a natural soil, you have no choice of the natural soil and so the problem can exist whether the plant is produced in a heavy soil, a light soil, whatever, depending on what it is transplanted into So I think one has to use a little bit of good judgment when he is planting his container-grown plants into a landscape situation. The main problems that arise are those of moisture relations, in our experience. We frequently find that the artificial porous mix placed in typically loamy or clay type soil, presents a very serious problem in maintaining appropriate moisture. The biggest problem is that the root ball is covered up with the native soil and then water is applied to the native soil The plant dies, and you examine the root ball and find that it is bone dry. This is just a little lesson in the physics of moisture movement in soils—that the heavier soil, or smaller pores in the natural soil, tend to act like a blotter and, therefore, do not release water to the coarser textured root ball. We, in general, when working with landscapers, always specify that the root ball of any specimen plant shall be left exposed at the top during the establishment period; all water supplied shall be placed in a basin on that root ball only, not on the native soil. Thus the water has to flow through the root ball before it enters the native soil. This, then, insures that this root ball, which contains all of the roots the plant has, will get water; and it avoids this problem of drought in the midst of ample moisture.

JERRY MAILMAN: I would like to ask Dr. Paul the name and number of the Agricultural Extension Bulletin which he mentioned.

JACK PAUL: It is University of California Agricultural Extension AXT—113. It is a for sale publication, incidently—($2.00).

RALPH PINKUS: I want to address my comment to the people that are making up these soil mixtures. I feel that one of our duties as growers and as plantsmen is to give a plant to the public that will become a thing of beauty and not require extreme care; and we are addressing all of our efforts right now to preparing a container soil mix that we can water every day and flood the place and still have the plant grow. But when the people get it, they have a big problem. They don't water every day. They put the plant in a clay or a loamy soil and the water drains right through and they might water only once every three days. Our losses are higher than they should be from this type of plant. I think some effort should be made to give the buyer a plant in a soil mix that will hold moisture a little longer, so I would like to propose this question—what can we do or how can we work in a direction that will give us this type of soil to use and still have it to be suitable for our growers? In other words, good for the producers and good for the growers. And I'll give it back to Mr. Matkin.

O. A. MATKIN: Thanks a lot. This is a serious problem, admittedly. I think we're now seeing certain growers coping with this to a degree, particularly growers of specimen-sized plant material. They are frequently converting as they get past this critical stage of the liner, the one gallon can and maybe the 5 gallon can; they begin to phase out of our beautiful synthetic mixes and they either incorporate some native soil or they may go completely to a substitution of a clay and/or silt-containing soil for the sand in the growing medium. I believe that this is a reasonable and logical approach because when the containers become larger, the soil column depth becomes sufficiently great that we are not bothered by this water-logged situation that occurs at the bottom of the shallow container, which may encompass the entire container. So this would be, at least, one method of approach to solving this problem.

DAVID RUDÉ: In this history, this evolution of soil mixes, I see where you've taken it from the traditional focus, where it is commonly termed the "muck and magic" soil mixing and then through the U.C. System, but I feel that we've left out a very important stage here, the John Innes soil mixes, where they did incorporate and did find an all-purpose medium but utilizing soil as one of the prime ingredients. Soil—peat—and sand. Now when we're facing this interface problem of establishing plants from our containers, maybe we should look into the John Innes soil mixes as a base—as a means of standardization.

KENNETH PERRY: I'd like to direct a question to Dr. Branson. I would like to know whether there is any comparison between native peats in Northern California and the Canadian sphagnum peats, as far as nutrient holding properties are concerned.

ROY BRANSON: Sphagnum peats are considered to be superior to other types of peats for this nutrient holding ability and for other reasons as well. Some of the native peats that you see around the Sacramento—San Joaquin delta area in central California have a great deal of salinity, which is a considerable disadvantage; this does not exist in peats coming from more northern areas where they're subject to more rainfall.

BILL CURTIS: I don't think Ralph got his question answered, because for every specimen tree that's grown in a big tub or a big box, there are thousands of small plants sold. The people that buy the gallon and the two gallon sized plants are the ones who are having the problems. We are not having problems with the big plants. Well, I'd like to have an answer about what soil mix we can put in those gallon cans so that when we sell plants the buyer is not going to lose them after they are set out. How should we handle them to avoid losses?

O. A. MATKIN: Very carefully! Any small plant requires attention, and moisture must be supplied to that limited root ball. It's being moved from a condition of care—to, supposedly, a condition of reasonable care in the maintenance stage during establishment. I think that the big problem is teaching maintenance people how to take care of plants. Basically, no matter what mix they are grown in they require care. Now that's maybe not the kind of an answer you want, but the more I see it, the more I'm convinced that this is true. The more I see plantings going into a landscape, the more convinced I am that the landscaper frequently is taking overgrown root-bound plants and trying to get a finished appearance too soon. We shouldn't plant landscape materials with the idea of its being a finished landscape in a new construction. We plant with the idea of its developing into something of beauty. And personally, I would much rather plant liners than gallon cans because I think, in the end, I'll have bigger and better plants which can be taken care of better if they are planted carefully, with the top of the root ball exposed, by simple sprinkler irrigation for quite a long while.

VOICE: I think that one of the main things that we're missing here possibly is just a little bit more education in regard to the planting of these plants. Most people who are planting them should know more about it and, if they don't, we need to spend more time telling them. A great deal can be done by using a suitable buffer mix. In other words, if we are using a definite light mix in the container, and we're transplanting into a heavy soil, a larger hole can be dug and a combination of the heavier soil and the lighter mix can be applied around the root ball as a buffer zone; this will get the plant roots moving between the one condition into the other. This procedure can accomplish a great deal.

BOB WARNER: I would like to ask what place the slow-release fertilizers have with the mixes in supplying nutrients for a period of time?

ROY BRANSON: Slow-release fertilizers that contain nitrogen, I think, have a place in soil mixes which are of the modified U.C. type, those which do not have much in the way of nutrient holding ability. They're not widely used yet, but the results of some trials in California indicate that they can be useful for this purpose. When it comes to slow-release fertilizers which contain phosphorus and potassium, particularly phosphorus though, then I don't think they have a place in soil mixes because, regardless of the soil mix type, there's a pretty good retention of phosphate; but when it comes to nitrogen, slow-release materials can have some use in these mixes which tend to lose a lot of nitrogen.

BRUCE BRIGGS: I have two questions for Dr. Branson. You mentioned two ingredients that hold considerable moisture—that you considered were high level holders of moisture. Could you please inform us what two these are?

ROY BRANSON: The mix which was able to go longer without irrigation, was a mixture of peat and redwood. That was the one mix out of the dozen.

BRUCE BRIGGS: What was the proportion?

ROY BRANSON: The proportion was 60% redwood, 40% peat. Now I don't know what other proportions might give the same thing, but it was interesting to see that out of all of the dozen mixes, that was the one which had a longer moisture-release period by about twofold over the others.

BRUCE BRIGGS: After you put the mix together then and soaked it, did it again drain to become a fairly good growing medium; was the air porosity at a level so the plant could grow at a normal rate—or did you go that far?

ROY BRANSON: All of these plants were grown for months in these mixes and they grew well in that particular mix. They grew well in others too, but there was no problem with that particular mix.

BRUCE BRIGGS: My other question—maybe you would like to answer it, or maybe the others would like to—we have noticed in Washington for a couple of years, and we notice it even in California, but not as bad as up our way—that if we grow gallon cans can to can, the plants seem to respond; they grow fast. But as soon as we make the move to do the spacing we seem to have a period of maybe 30 days when the plant ceases to grow. There are always more problems with disease, more problems with the foliage not looking nice. It's also a problem when the plants are moved from a wholesale yard into the retail yard, because they also are spaced further. Is this because the plants are reacting adversely to the handling or because they are not being handled properly?

ROY BRANSON: Tok wasn't on the panel, he was a moderator, but I think he is the best person to answer this particular question. Let me turn it over to Tok.

TOK FURUTA: I was looking for Dick Harris. I think he should address himself to this question. No? Andy Leiser?

ANDY LEISER: No, I can't answer your question, Bruce, because I haven't noticed this problem with things not looking so good when you space them—unless they have been extremely crowded in the gallons. Under our hot weather in central California, when you space them, you can get some leaf scorch if all the leaves have previously been heavily shaded; just like moving something from a lathhouse out into the full sun. There is a problem, and this is one Dick Harris could discuss very well, that is the heat build-up to the root system Can to can—the cans shade each other as well as the foliage. You set them out separately and—Dick, you ought to answer this, you did the work on this, not me.

DICK HARRIS: I think, normally, when the plants are spaced further apart, you should have less of a problem with disease because air movement is better. You can get more rapid drying if moisture is contributing to a disease problem. Normally, as far as the soil temperature is concerned, in a gallon can we find that there may be temperatures, even in November in California, of 115° F., 1" from the edge of the can and 3" down from the top; half of the soil in the container would be outside of that zone. In other words, we're sort of in the middle of the volume of soil and we are getting a reduced plant growth at 90-95° F. soil temperature and killing at anywhere from 110-115° F. With a single can completely exposed, we can get soil temperatures in November, in black gallon cans, up to 120-123° F. So root injury or root death in containers can be a problem just from high soil temperatures.

ANDY LEISER: You know, Dick, maybe part of the problem that looks like disease—perhaps they think they're getting root rot or something—but it's the temperature killing the roots.

BRUCE BRIGGS: This is the point that I was wanting to make. This is mostly a care problem. When you are in warm conditions where you do have trouble with the heat burning the roots, then should we not change our water system and rather than water once a day, water three or four times a day or go into a mist system watering? Would this be a better growing condition than we are using now?

DON DILLON: Dick, in connection with your soil temperatures in containers what effect, if any, have you found in changing the color of the container to reduce temperature?

DICK HARRIS: If you either shade the side of the container with a piece of wood or tin foil, or even paint it white, you can drop the temperature 8-10° F.; this certainly could get it out of the lethal range. One of the other confusing things is that for the first few days after root killing, dead roots can absorb moisture just as well as live roots and so, initially, there shouldn't be any wilting even with killed roots.

HERMAN SANDKUHL: Has there been any noticeable problem of root suffocation with the U.C. mixes? The reason I ask is that we have had an experience with a group of dwarf apple trees that we haven't been able to figure out and I've heard of several other people having problems in developing a sour sap or root suffocation condition with the U.C. mix; I was just wondering if there's something wrong with the U.C. mix or something we might be doing or something we might have done wrong to create this situation. We noticed it in the winter months—they came out of it in the spring, but the trees just fizzled out right at this point.

MODERATOR FURUTA: I would say this—there seems to be some evidence—and I'm sure there is no reason to dispute this—that quite a few plants are sensitive in varying degrees to whatever happens to be in the type of wood product you use, be it redwood or some of the others, but particularly redwood. In one case, there has been serious losses of some of the deciduous fruit trees, such as peaches and cherries, when the trees were heeled-in or planted into a soil mix that contained redwood sawdust, but where they were put into other mixes, or just into the ground, or into sand, there were no serious losses. If there were no losses, then there were symptoms that suggested diseases, and so on. While we do use a lot of sawdust, I don't think we should overlook the fact that many plants could be sensitive to this and you may be getting some effect from this.

O. A. MATKIN: Just one point that came up here the other day that intrigued me was the fact that we do have a waterlogged zone in any container and one might ask himself—what about, say sawdust being in an anaerobic situation vs let's say, peat moss? Quite probably the peat moss is not going to do any appreciable decomposing because that's the way it was formed. But these wood residuals present something of a problem and we've been thinking seriously about this, not for containers, generally not at all in containers, but rather in landscape situations where organic amendments that have not been subject to anaerobic decomposition are placed under the root ball where they may well become waterlogged; I think there are some potential problems there. Maybe this is a part of what your problem was. I can't say.

HERMAN SANDKUHL: I think I may have figured out a possible answer to my problem and that is, when these dwarf trees were put in the containers they were not filled with the medium as much as we generally use. I think we fertilized just at the point when the new roots were coming out on the trees and possibly we had some root damage from the fertilizer.

I would like to make another comment here in reference to the U C mix and the selling of plants in it to a customer. The customer, the landscape man, as far as I'm concerned, if he hasn't got enough wits by now to do a good landscaping job and bring plants through in a U.C. system propagating medium, he should get out of the business. Basically, the home gardener is where I think we are having a lot of trouble and I think why we have the problem is because there is not enough knowledge transferred from the nurseryman to the home gardener. The nurseryman does not get this through to the customer who's buying the plants. There is a trick about it—the planting and getting proper compaction of the new soil and I just can't overemphasize the use of slow release fertilizers. I just wish there were available more of them in smaller packages so that you didn't have to sell a good customer a $15.00 sack of fertilizer to plant a half a dozen plants

TOK FURUTA: I should like to change the direction of the discussion. Someone has asked me if there was a person here who might comment briefly on the patent that now exists on the meristem culture of orchids.

CHARLIE HESS: I know a little bit about it because Wes Davidson, who is very involved with the American Orchid Society and—upon his retirement is working for them—is studying the legal aspects of a patent which an individual took out on the use of meristem or mericloning as a technique for the reproduction of plants. Now, I believe he has a patent on the meristem culture of orchids; in the initial patent request, he had also wanted to list all other plants, but I think the patent lawyers removed it because he didn't have evidence of using it for other plants. So it was specifically limited to this one case and I am sorry I can't tell you exactly what the status of this situation is now. I know that there was some consideration of either opposing this by the American Orchid Society or else the actual purchase of the patent from the individual who obtained the patent on it. So it's an interesting development in the field of plant propagation.

RALPH SHUGERT: Speaking in this regard, if someone required additional information, they could write to Ray Brush, American Association of Nurserymen, Washington, D.C. Mr. Brush stays abreast of all plant patent acts and laws, proposed and current. Ray Brush would be glad to give you this information.

TOK FURUTA: This is not a plant patent. This is a process patent. This has been granted and is valid according to the lawyers with whom I have consulted at the University. I guess it has not gone to court yet, and the only way it could be broken is by taking it to court.

THURSDAY EVENING SESSION

October 7, 1971

MODERATOR RICHARD MAIRE: We are fortunate to have tonight a presentation by Jolly Batcheller, complete with slides, on his recent trip to Australia and New Zealand to study various aspects of the nursery industry and horticulture in general in these two countries Jolly:

ORNAMENTAL HORTICULTURE IN AUSTRALIA AND NEW ZEALAND[1]

OLIVER A. BATCHELLER

Ornamental Horticulture Department
California State Polytechnic College
Pomona, California

As nearly 20% of the plants commonly used in southern California originated in the Australia-New Zealand area, I felt a study of (a) the nursery industry, (b) the plant materials they use, (c) the institutions training men for the horticultural fields and (d) arboreta, botanic gardens and municipal parks would be of particular interest and value to the Ornamental Horticulture Department and California State Polytechnic College, Pomona, California.

As I think back over the attitudes and philosophy of education as I perceived it in both Australia and in New Zealand, there is a great similarity to that found in Central Europe. It is quite distinct and different from that found in the United States, and one which I feel is better not only for the students but for the country as a whole. In both Australia and New Zealand it is recognized that all students are not college caliber and that all students do not learn either at the same rate or by the same means.

Our visit coincided with the final examinations, and we were privileged to be in on some family conversations regarding school and college exams. In several cases where the students and the parents were discussing a failure in a class, there was no shame or disgrace associated with the failure. In one case, it was apparent that the student was not ready to pass on to the higher level. Both parent and

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student accepted the facts of life that if he was not able to pass the examination this year he would be in a poor position to begin the advanced studies. A second case was where the son of a well-to-do nurseryman who had excellent grades and the mental ability to enter any college or univeristy, had decided that if he was going to be a nurseryman it would be to his advantage to go into it via the apprentice route where he would be well grounded in all of the skills and abilities, and then get what he might need as additional work in a college. A third conversation which took place in a family gathering when all children were present was the fact that the youngest child would go on to college while the older child would go the technical training route. This would make them both useful, well prepared for their life's work and happy. I think these three situations clearly show that it is the knowledge and abilities that count most with the thinking people, rather than the fact that the student had attended a prestigious college.

AUSTRALIA

I cannot start this report on Australia without indicating the warm hospitality and friendliness which was extended to us throughout this vast and challenging country. Our 30-day visit, September 20 to October 21, included Perth in Western Australia; Adelaide, South Australia; Melbourne, Victoria; Hobart, Tasmania; Canberra, the capital city; Sydney, New South Wales, and Brisbane, Queensland. All except Canberra were in the coastal areas.

The following geographical description of Australia is presented in comparison to the United States to help the readers orient themselves. Australia is practically the same size as the U.S.A. with a population of only 12,000,000 compared with 200,000,000 in the U.S.A. If we were to orient the Australian continent in the northern hemisphere, it would reach from latitude of the Panama Canal to Boston, Massachusetts. Much of Australia is desert (50%). Much of the land (95%) is below 3,000 feet elevation. Few mountains are found in the western two-thirds of the country, and in the eastern section the mountain ranges seldom exceed 8,000 feet. Water is a major limiting factor; many of the soils lack organic matter and plant nutrients. The oceans which surround Australia have a very moderating effect on an area about 60 miles in depth It is in this coastal fringe that 95% of the population is found. The coastal areas of Perth, Adelaide, Melbourne, Sydney and Brisbane grow much the same range of plant materials as are found in southern California. There is no volcanic activity in Australia

The Nursery Industry. Each state visited had an association of nurserymen which also was a part of the national body known as "The Federation of Australian Nurserymen's Association." In the major coastal cities visited there was an active, aggressive nursery industry which I felt met the expressed needs of the population. Typical of the industry in every country I have visited, there were exceptionally well-organized and well-run operations and nurseries that appeared marginal in nature I do not believe the industry has developed to its full potential.

Visible Differences. The most obvious difference, as compared to California nurseries, were:

a. Lack of planning and layout to make use of the best known merchandising and selling techniques (Examples: narrow gravel or dirt paths, no focal point, sales point and the garden center building not developed to fullest potential).
b. The use of plastic bags as containers rather than the metal gallon can.
c. The use of circular tubes instead of square pots.
d. The direct sticking of cuttings into tubes.
e. The sale of small size plants, 2-, 3-, and 4-inch tubes, to the general public.
f. The small number of 5 gallon size plants grown and sold. With rare exception, the general lack of what we call "specimen size" landscape material.
g. The neatest and best arranged nurseries were in the chain stores.

Quality of Nursery Stock. I would say, in general, that the quality of the plant materials was very comparable to that found in California nurseries. It appeared that many plants seemed to propagate more easily and grow a little faster in Australia than in the U.S.A. The uniformity of nursery stock was poor.

Pricing. Throughout most of Australia, the common practice was to mark up the green goods wholesale price only 60% The prices as related to wage structure and dollar valuation was a little lower than found in California. The mark up on hard goods varied on availability—mostly 33⅓,some 60, and a few items 100 percent, if in scarce supply.

Merchandising and Promotion. The formation of the "Trade Association Selection Committee (TASC)" and the national promotion of the "Captain Cook Bottlebrush" is a giant step in developing a promotional program for the nursery industry. One of the great difficulties of doing this on a national scale is the scarcity of people outside the few major population centers and the great distances between the major populated areas. I believe local cooperation on promotion as is done in the Sydney area would be most helpful.

Techniques and Procedures. I found the techniques and propagation procedures remarkably good in spite of the lack of available information from state and federal agencies. It was quite apparent that the most advanced operators had read a good many publications from overseas and had traveled outside of Australia. The use of the UC mix and aerated steam was nearly a "fetish" with the Australian nurserymen. The growing of seedling bedding plants at Alan Newport's nursery in Sydney was, from a technical standpoint, one of the best and most efficient operations I have seen anywhere in the world. There were other minor ingenious devices which indicated to me that the nurserymen of Australia are alert and progressive, but lack technical assistance from their state and federal governments. No bulletins or publications are available in Australia from the agriculture departments regarding ornamental horticulture, cultural practice, equipment, economics or operations.

The only state publication I found was "The Cultivation of Native Plants, published by the Western Australian Education Department.

Variety of Plants. It was quite evident that there are a good many species and varieties of Australian native plants that we should be using in southern California. This is being worked on by the arboreta and the commercial wholesale nurseries. Every nurseryman, landscape architect or park administrator who travels should keep pestering the arboreta and botanic gardens in the U.S.A. for plants which should be introduced. As an example, we do not have some of the better eucalyptus trees that are small to medium height and would serve our purpose, such as *Eucalyptus maulosa*, "White Brittle Gum," which is a tree far better than the monstrous *Eucalyptus citrodora* or *Eucalyptus viminalis*.

Educational Institutions. I was shocked to learn there is not a single chair of horticulture or a department of horticulture in any four year degree granting institution in the entire country of Australia. Degrees are available in agriculture and an individual who desires can take a few courses in horticulture. The term horticulture is all inclusive and includes vegetables, fruits, berries and citrus. The field of ornamental horticulture is practically unheard of as are college or university programs in park administration. These areas of study or courses are handled at the technical school level or in apprentice type training programs. Most arboreta and some parks have apprentice programs. I actually attended classes in two of the apprentice programs and was less than impressed as the work appeared to be below our high school level of instruction.

Waite Agricultural Research Institute in Adelaide, South Australia, had good facilities and program for research in horticulture. It provided no direct and/ or continuous help for the average nursery operator or manager. The program was pure research of a rather basic nature and not applied to the industry.

The Queensland Agricultural College, Lawes, Queensland. An all male residential college with over 3,000 acres of farmland and campus. This is a full-time in-residence course with options of (1) a two-year sub-tertiary course, (2) a three-year associate course and (3) an elective fourth year for specialization. There are 435 students in the following majors: Animal Industries, Food Technology, Poultry Technology and Plant Science. The Plant Science includes sixteen students interested in general horticulture who, in their fourth year, can take three specialized courses which deal intimately with the ornamental phase of horticulture (Course number: 402, Ornamental Horticulture; 403, Turf Management; 404, Landscape Gardening). The nursery industry of Queensland is raising money to provide facilities and to handle the cost of establishing a chair of ornamental horticulture and to increase the course offerings. Potentially, this college appears to have the greatest possibilities for a good horticulture program. The one factor which I view as limiting is that of location. Situated as the college is at Lawes (or Gatton), it is far enough away from the ocean to lack the ocean's moderating effect. It appears to me that this will limit the plant material and make the effective use of their greenhouses difficult.

Ryde School of Horticulture, West Ryde (Near Sydney), State of New South Wales. Although listed as a school rather than a college, Ryde has better facilities than Burnley (Melbourne) and it appears that a more practical applied program is presented in several areas as follows:

a. Horticultural Certificate Course, 7-8 hours per week for 3 years.

b. (Post Certificate Courses), 3 evenings per week for 2 years in the following subject areas:

(1) Park Administration
(2) Nursery Management
Additional courses are available which do not require the horticultural certificate.
(3) Greenskeeping Course, 6 hours per week, 2 years

c. Courses of shorter duration:

(1) Home Gardening	2 hours per week	36 weeks
(2) Floral Art	2 hours per week	36 weeks
(3) Bonsai I	2 hours per week	12 weeks
(4) Bonsai II	2 hours per week	24 weeks
(5) Orchid Culture	2 hours per week	6 weeks
(6) Australian Wild Flowers	2 hours per week	July to October
(7) Indoor Plants	2 hours per week	6 weeks

The Horticultural Certificate Course appears to be a well-balanced course in the subject areas, but includes no courses in Business Economics, Chemistry, Marketing or any of what we call general education including Math, English and History

Although this was the best practical school I saw in Australia, I would place it on a par with some of our junior colleges.

Burnley Horticultural College, near Melbourne, Victoria. This institution offers a two-year part-time evening course 6-8 p.m., 2 nights per week for 30 weeks. This is known as a "*part-time evening vocational course.*" It is also my understanding that students in agriculture at the University of Melbourne take some ornamental horticulture training at Burnley during the day. Located on the same campus adjacent to Burnley was the state's horticultural research facilities. Work under progress at the time of my visit was: (a) tissue culture for developing virus-free chrysanthemums and (b) a study on the virus mosaic of bulbs. Since facts are available on these subject areas and virus-free stock is readily available, this research in my opinion was a waste of hard-to-get funds and space. The facilities at Burnley as shown to me were good for show and demonstration, but I could not see how a challenging, productive program could be presented with so little student involvement in production.. The plant materials on the grounds were excellent.

College in Sydney. Although I heard a great deal about the establishment of a chair of horticulture at one of the colleges or universities in Sydney, this is still in the talking stage and I am not aware of the curriculum or facilities planned.

Apprentice Programs. There is no uniform apprentice program for nurserymen or park men throughout Australia. In some states the nursery trade is recognized as a trade and a closely regulated state apprentice program is in operation. In other states the nursery trade is not recognized as a trade and no apprentice program can be adopted or supported by the state government.

Other Sources of Training. Except for night schools which are available in some states, there are no state or national training programs by correspondence.

Educational Meetings. While in Adelaide it was my privilege to serve on a panel of educators and nurserymen discussing the need of horticultural training for nurserymen The Waite Agricultural Research Institute representative indicated their goals and objectives precluded their involvement in any such program. For the Ministry of Education, horticulture must be declared a trade before apprentice programs can be planned and courses given.

Generally, the small size of the nursery industry and the few numbers of employers who would use apprentices make it difficult to interest sufficient people to declare the nursery industry a trade and, therefore, subject to the state apprentice programs. Only in a few states is it so recognized.

Arboreta, Botanic Gardens and Municipal Parks.

Arboreta and Botanic Gardens. In the typical English tradition, horticulture was brought to Australia early in the development of the country. With it came the elms, oaks and the perennial flowers. There were arboreta in each of the major cities visited; some of them were established as early as 1814. Considering the late development of the continent, this is quite amazing. The gold rush in Australia following the one in California brought many people from California who, in turn, brought plants native to the west coast of North America (Example: *Pseudotsuga menziesii*, Douglas fir; and *Pinus radiata*, Monterey pine). Both of these trees are now of great economic importance for lumber and will mature in 25-28 years. Botanic gardens were also found in the major cities, some devoted to native Australian plants, others covered a wide range of plants from all over the world. Unfortunately, most arboreta and botanic gardens are not well financed. The directors get a fair wage, but not comparable to the pay in the U.S.A. and the worker's pay is extremely low.

Municipal Parks. No city visited was without extensive municipal parks. For example, Melbourne has 13,000 acres of parks, nearly ¼ the total area of the city. The parks generally are well-spaced and planned for the activities most needed, i.e., downtown parks are smaller and designed for passive use, suburban parks are larger and designed for active sports. Australia has strong feelings regarding physical fitness and this is quite evident by the use of athletic facilities throughout the week, month and year. Women's sports are very prominent. There are many private clubs which hold weekend competitions that keep the playing fields in constant use Here again it appears that a few of the top men in the park system get a fair wage, but the average worker has very low pay

NEW ZEALAND

A few geographical facts about New Zealand may help orient the reader. New Zealand is approximately two-thirds the size of California It consists of two major islands each 500 miles long. No spot in New Zealand is more than 70 miles from the ocean A comparison of New Zealand's latitudes with those of our West Coast would show New Zealand extending from Santa Barbara, California, to Portland, Oregon. Fifty percent of the country is over 3,000 feet elevation. The highest mountain is Mt. Cook, 12,400 feet, which is perpetually covered with snow. Water is abundant, and rain comes intermittently throughout most of the year. The west coasts of both islands are wetter than the east coast and only a few areas have low rainfall. The population is 2,900,000 with approximately 2,000,000 in the north island. This compares with 20,000,000 population in California. Both islands have volcanic activity. During my 6-week stay in New Zealand I covered most of both islands driving 4,000 miles from Auckland to Invercargil. We were in intimate contact with the country and the people. New Zealand is a lovely gentle country with beautiful scenery and the most hospitable people we have met.

The Nursery Industry. There is only one Association of Nurserymen for all of New Zealand. Most of the nurserymen are located on the north island. Despite the limited buying public as compared with California, it appears that the New Zealand nurserymen do a per capita volume of business greater than California and greater than Australia.

Visible Differences.

a. Plastic bags in gallon size were used most commonly for nursery stock.
b. Plants were sold in small sizes, 2-, 3- and 4-inch pots or tubes, but selling of such small plant sizes was not as common as in Australia.
c. Round tubes instead of square pots were used for liners.
d. Cuttings, particularly fast rooting material, were stuck directly into tubes.
e. Relatively few specimen size materials were available.

f. Nursery plants were often sold along with vegetables in the stores in small towns.
g. The best large retail nurseries were laid out as expertly as any in California. These sophisticated or modern layouts were in the most populated areas.
h. After adjustment for wage differences, the cost of quality plant material in New Zealand was higher than the cost of comparable material in Australia or California.
i. Mark-up on green goods was generally 100% of wholesale price and mark-up for hard goods was generally 33%.

Merchandising and Promotion. Here again with the small scattered population, promotion as we know and see it in southern California is not present. However, quality plant materials are available in even the smallest of towns.

Techniques and Procedures. The operation of a small general nursery does not lend itself to mechanization or extensive research in new techniques. I did find, however, that even the smaller nurseries had good, clean, neat operations and the nurserymen had made ingenious devices to increase efficiency. Soil treatments (often aerated steam) were used primarily for killing clover seed in soil mixes; however, many large nurseries did not steam soil. Clover is a basic plant in the perennial pastures. The seed is found everywhere and is a real problem. Duncan and Davies, located in New Plymouth, is the largest wholesale nursery in New Zealand. It covers 300 acres. I was impressed by the neat, orderly operation, the research department, the testing and trials given plant materials before releasing them to the public and the excellent rooting percentage obtained with the *Protaceae* by direct sticking in individual pots.

Fairs and Shows. The largest horticultural show I attended was the Auckland "Garden Week Show." It covered about 5 acres of buildings and grounds. Displays were varied and well executed. There was a cross-section of effort: the university, private garden clubs, cities, park reserves, specialty societies, and commercial nurserymen and suppliers. Speakers were scheduled throughout the week. The talks were practical, down-to-earth and well presented. The Garden Show received excellent coverage on T.V., radio and the press, and attendance was very good. Displays were not as elaborate as the horticultural display at the Los Angeles County Fair, but I felt that the people in attendance at the Auckland show carried away more usable information.

Variety of Plants. As in Australia, many of the better varieties of plants native to New Zealand are not readily available in southern California. Examples are: (1) *Tetrapanax tricolor, (T. papyriferus)* (2) the three species of *Metrosideros* and (3) several *Leptospermum scoparium* varieties. With members of the California Association of Nurserymen going to New Zealand in November 1971, I am sure some of these new varieties and clones will be brought back to California.

Educational Institutions. New Zealand is fortunate in having two institutions where horticulture is taught: Massey University located in Palmerston North in North Island and Lincoln College located near Christchurch in South Island.

Massey University. Massey University, although originally an agricultural college established in 1928, it added science in 1958 and became a full university in 1964. In 1969 graduate programs were added. There is a great similarity between Massey University and Cal Poly, Pomona, not only in its development, but in the problems it is now facing with agriculture enrollment only a small fraction of the total university enrollment. Space and money are at a premium and maintaining a meaningful, practical program is becoming difficult. Massey University offers the following horticultural curricula:

a. Diploma in Horticultural Science (2 years)
b. Degree, Bachelor of Horticulture (3 years)
c. Degree, Bachelor of Horticultural Science (4 years)
d. Special post graduate diploma on Horticultural Science offered for specialized study (1 year following B.H.S.)
e. Masters of Horticultural Science (2 years following B.H.S.)
f. The Doctor of Philosophy is offered only in Science (may have horticultural emphasis)

There is a practical work requirement of 48 weeks required for the bachelor degree. This must be done at places of business approved by the college and may be spread out over the four years. A review of the curriculum indicates that the Massey program is excellent. The new greenhouse facilities will further improve the program. Professor Murray Richards is well thought of in the nursery trade. In addition to the educational programs, Massey University also handles short courses, skills programs, and seminars for the nursery industry. No program is offered at present in park administration. Massey University has adequate grounds and facilities for field work. A new climate control laboratory with the finest setup for plant sutdy is located on the same campus. Massey University had by far the best instructional program in ornamental horticulture that I saw "down under."

Lincoln College. Lincoln College (University College of Agriculture) at Canterbury, a suburb of Christchurch, is in south island. The college was established in 1880 and has been in operation since that time. The college is entirely agriculturally oriented, although joint degrees in bioscience are offered in collaboration with the University of Canterbury. Lincoln College offers the following horticultural curricula:

a. Diploma in Horticulture (2 years)
b. Bachelor of Horticulture (3 years)
c. Bachelor of Horticultural Science (4 years)
d. (1) Diploma in Horticultural Science (1 year)
   (2) Diploma in Landscape Design (1 year)
   (3) Diploma in Park Administration (2 years)
   (4) Certificate in Landscape Design (1 year)
e. Masters in Horticultural Science (2 years beyond B.H.S.)
f. Doctor of Philosophy with horticultural emphasis (2-3 years)

Prior practical work in industry is expected of students entering Lincoln College. As at Massey University, 48 weeks of practical work is required for the Bachelor of Horticulture. This work must be spread out over several different areas in the horticultural field. Students must keep diaries of work experience and supervisors are expected to make comments. This is much like the European system. The curriculum is well-balanced and adequate. I was not impressed with the greenhouse facilities. There was no sign of a nursery or ornamental emphasis. It appears that great effort and stress is now being placed on the landscape design field.

Lincoln College has had a good reputation for preparing students for the ornamental horticultural field. I did not see a program there which I felt warranted this endorsement from the nursery industry. The work at Lincoln College on strawberries was excellent and the work on other horticultural crops was good. The program in landscape design was good and developing. The addition of a diploma in Horticulture (1 year) plus 1 year in park administration is a good move. This program is to begin in 1972. It is planned that a student in park administration would first serve 3 years with the park departments or reserves then take the course at Lincoln. It appears that the practical program for which Lincoln College was noted has gone and in its place has come the emphasis on theory and research. Lincoln College is suggesting more practical experience prior to entrance to make up for the reduction of practical work at the college.

Correspondence Courses and Apprentice Programs. The apprentice training program is a well-established and respected program which over a period of time produces well-qualified artisans and technical people. Under the program the apprentice must, along with his practical work, have certain course work. Much of this schooling is done through The New Zealand Technical Correspondence Institute located at Lower Hutt, Wellington. To give an idea of the scope of this educational system, these figures may be of interest. In 1967, 17,000 candidates wrote on 261 different subjects covering 45 different trades. Today there are 220 teaching staff for handling papers, 5 specialists who work with industry in preparation of written work, and four illustrators and photographers who assist in the preparation of the assignments. At present there are 300 students in horticultural courses. Six out of the 220 teaching staff are assigned to the agricultural areas. Each student usually takes four subjects a year for 3 to 5 years, depending upon the program he is pursuing.

For those unable to attend either Massey or Lincoln, this correspondence program does provide uniform information. I have read some of the assignments and observed some of the written answers. My feeling is that a student would have to be very highly motivated to carry this program through to completion. One feature of the correspondence courses for those applying in the apprentice program is the "block courses." For three weeks each year the students go to a suitable center where materials impossible to handle by correspondence are presented (field trips, laboratory skills, equipment operation, etc.). It must also be remembered that the apprentice is working in an establishment approved for the program and is able to get practical work and the application of principles. It is my understanding from talking with men in the nursery trade that the percentage of those who complete the correspondence courses is low (10-15% estimated).

In order for an apprentice program to be fully qualified, the trade or industry must be recognized as such by the Ministry of Education. With this official recognition the proper correspondence courses are established. The nursery trade has such recognition. The apprentice program for the nursery industry is usually for 3 years with 8,000 hours of practical work required for a candidate with a secondary school certificate and 9,000 hours in the absence of a certificate. The places of employment are limited to qualified shops where employers provide proper supervision and make regular reports on the student's progress. Technical Correspondence Institute courses and practical work are carried on simultaneously.

Night Schools. Some adult education courses of 12-week periods are held in New Zealand but were not presented as being a way in which men for the nursery trades were prepared.

Arboreta, Botanic Gardens and Parks. The major cities of New Zealand had excellent arboreta and/or botanic gardens. Surprisingly, the resort town of Taupo with a population of about 1,000 had a 5 acre botanic garden well laid out and planted. This is financed from private funds. The park systems, both municipal and federal reserves, are of great magnitude. Each and every village, town or city has its park systems. Except in the downtown areas, the parks are designed for active sports with large playing fields. The parks are heavily utilized by club and organization competition, particularly on weekends when most businesses are closed. Although there is some vandalism in the parks, it is far less than in California. Many parks showed unique and challenging play equipment designed in storybook fashion.

In addition to municipal parks are the "reserves" comprised of land held by the federal government. Some of this is in national parks, some is in forest reserves, and some just government land held in reserve. The total government land so held is 6,000,000 acres which amounts to ⅛ of the total land in New Zealand. Of course, New Zealand with its adequate rainfall appears much as one gigantic green park area. The low density population is another factor which enhances the beauty and naturalness of the country.

FRIDAY AFTERNOON SESSION

October 8, 1971

MODERATOR HOWARD BROWN: As in all well planned programs, we save a couple of good strong speakers for the end of the program to keep people around I can see from the crowd here that we were justified in putting these speakers on now. The first one for this session is Clyde Elmore, Extension Weed Specialist, University of California at Davis; he'll be talking to us on the use of herbicides. Mr. Elmore:

MANAGEMENT OF UNDESIRABLE PLANTS IN ORNAMENTAL CONTAINERS AND GROUND COVERS

CLYDE L. ELMORE

Agricultural Extension Service (Botany)
University of California
Davis, California

Management of most undesirable plants in the nursery or landscape is possible with herbicides available today. New chemicals are on the horizon for use in ornamentals which will make this costly job easier and cheaper in the future. With the move toward "low maintenance" and "greenbelting" there will be a greater dependence upon chemicals to manage the environment. To get the most from these chemicals their effectiveness must be maximized, and they must be used safely. However, it should not be assumed that chemicals can solve all plant maintenance problems nor replace proper management.

The herbicides discussed here may not be currently labeled and recommended by the manufacturer, thus they should not be construed as recommendations by the University of California. Presently, there are few herbicides that are labeled for use in ornamental containers so I can only report research findings. In ground covers and plants in the landscape, several herbicides are available and have commercial labels. More companies are in the process of requesting labels for their herbicides.

The cost of hand weeding ground covers can be exorbitant on previously used land. Costs would normally be less on cut and fill areas such as highway landscaping. In recent comparisons of weeding costs at Davis and Santa Clara ground cover trials, costs were $2,941 per acre for an untreated area. Some of the treated areas were DCPA (Dacthal®), $281; nitralin (Planavin®), $399; and nitralin (Tok®), $377. These were treatments applied to newly planted ground cover plants as preemergence treatments.

Most selective herbicides that are presently in use do not control all annual weed species. In some areas tolerant weed species such as bur clover, sow thistle, bittercress, and marestail are becoming real problems. The weed species in an area to be planted should be known in order to select the herbicide or herbicide combinations that will be most apt to provide an acceptable level of weed control. The herbicides presently being used, and those under study reported here, have been divided into preemergence (before weeds emergence) and postemergence (young or established weeds) chemicals.

Preemergence Herbicides; Diphenamid (Dymid®, Enide®) is now used widely in new and established ice plant *(Carpobrotus edulis)* plantings Diphenamid is very effective on most weed species by itself in the coastal areas of California. In interior valleys of California, a combination of diphenamid and trifluralin (Treflan®) has given longer grass control than with diphenamid alone. Nitralin (Planavin®) has been used in ground cover plantings and is presently labeled for container ornamentals. Nitralin and trifluralin are principally effective on annual grass species and are less effective on mustard, sow thistle, common groundsel and shepherd's purse.

DCPA (Dacthal®) can be used on most ornamental plantings. Although weed control in some of the high organic matter, heavy clay soils, is less than desirable it is very good on lighter soils and is generally safe on ornamentals. DCPA is presently being used in container ornamentals and ground cover plantings.

Norea (Herban®) is being used in coastal areas of California in *Hedera canariensis* (Algerian ivy) principally for bur clover control. Other ground cover species and some conifers are severely injured by norea.

These herbicides are applied to ground covers before weeds germinate or after the weeds have been removed by hoeing or pulling. On newly planted ground cover, the plants are planted as rooted cuttings or in the case of *Carpobrotus edulis*, unrooted cuttings. The area is irrigated before herbicide treatment to settle the soil around the plants, thus reducing the amount of herbicide moved with the water down around the plant roots. Approximately three days after planting, the area is treated with herbicide and followed with another irrigation.

In some established plantings of *Carpobrotus edulis*, low rates of simazine (Princep®) have been used. If simazine is used in *C. edulis*, it must be applied very carefully to maintain a low rate because there is very little margin of tolerance. Excess applications of this herbicide can severely injure desirable plantings and restrict replanting.

Two possible problems with preemergence herbicide treatment to newly planted ground covers are the possibilities of stunting and/or loss of weed control. If the correct rate is used and the soil is firmly settled around rooted cuttings or the unrooted cuttings are planted deeply enough, there is very little chance of stunting. In the second case, there are two possible explanations—the correct herbicide and rate must be used on susceptible weed species. If tolerant species are present, weeds will not be controlled and must be hand pulled or controlled with a postemergence herbicide.

Several preemergence herbicides have been tested on ground cover species. Listed below are species and herbicides tested and their general tolerance to newly planted ground covers. These data are compiled from three locations in California, (1) South Coast Field Station, Tustin; (2) San Jose Field Station, Santa Clara; and (3) University of California, Davis. The data are summarized from testing during the years of 1968 through 1971 in either fall or spring applied trials. Some of the uses that are indicated as safe here would be influenced greatly by such factors as soil type, organic matter and irrigation practices before and after application. (Table 1 and Table 2).

As indicated by the safety of the herbicides trifluralin, nitralin and DCPA in ground covers, many nurseries are presently using these chemicals in containers. This subject was covered thoroughly in a presentation given by Humphrey (1) to this Society in 1968.

Postemergence Herbicides: Presently, there is no postemergence herbicide that can be used safely in containers with marked success. Nitrofen (Tok ®) has been used on very small areas on seedling weeds in the two to three leaf stage. There are many species not yet tested for tolerance.

In ground covers, only a selected few herbicides can be used postemergence to weeds. In *C. edulis,* amino triazole at 1 pound per acre has been used with considerable chlorosis (yellowing) of the plants; they subsequently recover. Ammonium sulfate or magnesium chloride (bittern) has been used extensively at 3 pounds per gallon of water of either chemical. These are applied at 200 gallons of water per acre. A wetting agent or surfactant must be added at one quart per 100 gallons of water. Temperatures must be above 75° F. for satisfactory results.

In *H. canariensis,* dalapon has been used at 4 pounds per acre plus wetting agent for bermudagrass control. Normally several treatments are necessary. Slight injury may result from this treatment.

Vinca minor will tolei ate 2, 4-D amine for broadleaf weed control; has been used at 1 pound per acre with only temporary curling of new growth of the *Vinca minor.*

Nitrofen or diphenamid has also been used on very young weeds as a postemergence. Nitrofen at 4 pounds per acre has controlled most weed seedlings in the two to three leaf stage. Weed species tolerant of this treatment are *Stellaria media* (chickweed) and members of the *Cruciferae* family (mustards). Diphenamid has been most effective when applied to control young grasses and irrigated well after application. Growth suppression will result even though in many instances the weeds will not be killed.

Listed below are some of the postemergence herbicides and tolerances indicated for some common ground cover species. Vigor of the plant, stage of growth and temperature will all influence plant tolerance to postemergence herbicides. The list indicates tolerance or lack thereof for various herbicides and rates used in University of

Table 1. Relative Tolerance of Ornamental Plants Used as Ground Covers to Post-Plant, Preemergence Herbicides*

	Trifluralin (Treflan®) 2lb / A**	Trifluralin 4lb / A	Nitralin (Planavin®) 2lb / A	Nitralin 4lb / A	DCPA (Dacthal®) 8lb / A	DCPA 16lb / A	Diphenamid 10lb / A
Aloysia triphylla	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Ajuga reptans	▲	—	▲	—	▲	●	—
Baccharis pilularis	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Carpobrotus edulis	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Cerastium tomentosum	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Delosperma 'Alba'	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Drosanthemum hispidum	⊕	⊕	⊕	⊕	⊕	⊕	▲
Gazania rigens	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Hedera canariensis	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Hedera helix	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Hypericum calycinum	⊕	—	⊕	—	⊕	⊕	—
Malephora luteola	⊕	⊕	⊕	⊕	⊕	⊕	▲
Osteopermum fruticosum	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Pelargonium peltatum	⊕	⊕	⊕	⊕	⊕	⊕	⊕
Sedum brevifolium	⊕	⊕	⊕	⊕	⊕	⊕	▲
Sedum rubrotinctum	⊕	⊕	⊕	⊕	⊕	⊕	▲
Verbena tenera	⊕	▲	⊕	▲	●	●	▲
Vinca minor	⊕	⊕	⊕	⊕	⊕	⊕	⊕

⊕ — No injury observed
▲ — Injury observed, such as stunting, burning or dieback, normally regrowth occurs
● — Susceptible to injury, to killing of plants
– — Not sufficient data

*lb / A is pounds active ingredient per sprayed acre

Table 2. Relative Tolerance of Ornamental Plants Used as Ground Covers to Post-Plant, Preemergence Herbicides

	Simazine 1 lb / A *	Dichlobenil 4 lb / A	Nitrofen 4lb / A	Diphenamid 10 plus Trifluralin 2	Simazine ½ + plus Trifluralin 2	Norea (Herban®) 4lb / A
Aloysia triphylla	–	–	–	–	–	–
Ajuga reptans	●	–	⊕	–	●	–
Baccharis pilularis	–	▲	–	⊕	–	–
Carpobrotus edulis	▲	▲	⊕	⊕	▲	●
Cerastium tomentosum	–	●	–	▲	–	–
Delosperma alba	●	●	⊕	⊕	●	●
Drosanthemum hispidum	●	●	–	⊕	–	●
Gazania rigens	●	●	⊕	⊕	▲	●
Hedera canariensis	▲	▲	⊕	⊕	⊕	▲
Hedera helix	–	▲	⊕	▲	▲	–
Hypericum calycinum	▲	–	▲	–	▲	–
Malephora luteola	●	●	⊕	⊕	●	●
Osteospermum fruticosum	–	▲	⊕	⊕	▲	●
Pelargonium peltatum	–	⊕	–	⊕	–	–
Sedum brevifolium	⊕	▲	⊕	▲	⊕	●
Sedum rubrotinctum	–	▲	–	▲	⊕	–
Verbena tenera	●	●	–	▲	–	–
Vinca minor	▲	▲	⊕	⊕	⊕	●

⊕ — No injury observed
▲ — Injury observed, such as stunting, burning or dieback, normally regrowth occurs
● — Susceptible to injury; to killing of plants
– — Not sufficient data

* lb / A is pounds active ingredient per sprayed acre

Table 3. Relative Tolerance of Ornamental Plants Used as Ground Covers to Postemergence Herbicides

	Amino Triazole 1 lb / A *	Dalapon 4 lb / A	22,4-D ½lb / A	2,4-D 1 lb / A	Magne- sium Chloride	Ammo- nium Sulfate	Bromoxy- nil 1 lb / A	MCPP 1 lb / A	MCPP 2lb / A	MSMA 4lb / A
Aloysia triphylla	–	⊕	–	●	–	–	–	–	–	⊕
Ajuga reptans	●	–	▲	●	–	–	▲	▲	▲	–
Baccharis pilularis	–	–	–	–	–	–	–	–	–	–
Carpobrotus edulis	▲	▲	▲	●	⊕	⊕	●	▲	●	▲
Cerastium tomentosum	–	–	–	–	–	–	–	–	–	–
Delasperma alba	●	–	●	●	–	–	●	●	●	–
Drosonthermum hispidum	–	–	–	–	–	–	–	–	–	–
Gazania rigens	●	–	▲	–	–	–	⊕	⊕	▲	–
Hedera canariensis	▲	–	▲	–	–	–	▲	⊕	⊕	–
Hedera helix	▲	–	⊕	–	–	–	▲	⊕	⊕	–
Hypericum calycinum	▲	–	▲	▲	–	–	▲	⊕	▲	–
Malephota luteola	–	–	–	–	–	–	–	–	–	–
Osteospermum fruticosum	–	–	–	–	–	–	–	–	–	–
Pelargonium peltatum	–	–	–	–	–	–	–	–	–	–
Sedum brevifolium	▲	–	▲	–	–	–	▲	⊕	▲	–
Sedum rubrotinctum	–	–	–	–	–	–	–	–	–	–
Verbena tenera	–	–	–	–	–	–	–	–	–	–
Vinca minor	▲	–	⊕	–	–	–	▲	⊕	⊕	–

⊕ — No injury observed
▲ — Injury or symptoms observed, severe chlorosis or twisting; normally regrowth occurs
● — susceptible to injury, to killing of plants
– — Not sufficient data

*lb / A is pounds **active ingredient** per sprayed acre

California testing. These may not always represent label rates and in some instances no label is available for the herbicide listed. (Table 3).

Further research is being conducted in ground covers, ornamental plantings in containers and in the field. Recommendations will be slow in coming because of the wide variety of plants involved and various planting and growing conditions. However, it is hoped that the information contained herein will spur individual experimentation to establish guidelines for proper use of herbicides in ground covers and woody ornamentals.

LITERATURE CITED

1. Humphrey, W.A., 1968. What's new in herbicide use in container-grown plants? *Proc. Inter. Plant Prop. Soc.* 18:199-201.

MODERATOR BROWN: Thank you, Clyde. Now are there questions?

GENE BACIU: In your ground cover tests did you plant weed seeds or did they just blow in naturally?

CLYDE ELMORE: We didn't plant weed seeds there; however we did plant a row of blue grass, rye, fesue grass mix as an indicator grass and we planted dichondria, which often is a good seedling weed. But we did have an excellent natural stand of weeds as well.

GENE BACIU: I was thinking, in my yard, weeds like to collect in certain areas for some reason.

CLYDE ELMORE: Yes. Now, normally we do not seed weeds into the herbicide trials, however, we do seed indicator plants—an annual plant—to get some indication on those. But in most areas we've been fortunate, or unfortunate, enough to have natural weed population.

VOICE: How long after Treflan is applied as a herbicide should you irrigate?

CLYDE ELMORE: Treflan should not be applied to wet soil. It should be applied only to dry soil for greatest activity and if you can incorporate, with a mechanical incorporator, to mix it in the soil, you'll get the greatest activity. You can also reduce the rate that you will use from what I've indicated here. In agricultural soils you normally can get by with ¾ to one pound per acre whereas if you sprinkle it in you almost double everything that you incorporate in. As far as time, it should be within 3 to 4 hours if it's on moist soil or humid days. But I would say definitely in most of California, anyway, we would like to see it incorporated within 24 hours. I would not want to see it go longer than that, even on dry soil.

BRUCE USREY: Do you have any recommendations for spotted spurge control in juniper?

CLYDE ELMORE: No, I don't. You can use the preemergence herbicides. Dacthal is much better as a preemergent than any of the other common herbicides for spotted spurge control. There is no easy answer for spurge control in any of our junipers. But preemergence Dacthal has looked better than anything else. If you have heavy soils, you could even use simizine, but you'd have to be extremely careful with it.

BRUCE BRIGGS: At what time of year and at what temperature should TOK be applied—what sort of weather conditions?

CLYDE ELMORE: We've applied TOK mostly under cool conditions—cool weather when the temperature has been below 75° F. There doesn't seem to be as much difference in temperature as there is on how well the weeds are growing and the stage of growth If you get them at the two to three leaf stage, and the weeds are growing rapidly, temperature does not make that much difference. If you use it at higher temperatures, you're going to increase the injury to the ornamental plant.

MODERATOR BROWN: Clyde, we appreciate your taking time to share this up-to-date knowledge with us. We are looking forward to the Proceedings coming out so we can use the information you have presented here today. Thank you.

Our next speaker will be talking on disease-free propagation in relation to standardization of nursery stock. He is a gentleman who has contributed a great deal to the nursery industry and to all plant propagators; he is known to all of you. Dr. Kenneth F. Baker, of the Department of Plant Pathology, University of California, Berkeley.

DISEASE-FREE PROPAGATION IN RELATION TO STANDARDIZATION OF NURSERY STOCK

KENNETH F. BAKER

Department of Plant Pathology
University of California, Berkeley

It is a truism that there are two sources of plant disease organisms — the soil (including organic matter and water) and the host plant. Thus disease control in the nursery comes down to (a) the use of treated or pathogen-free soil, (b) use of pathogen-free to see it incorporated within 24 hours. I would not want to see it go longer than that, even on dry soil.

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DISEASE-FREE PROPAGATION IN RELATION TO STANDARDIZATION OF NURSERY STOCK

KENNETH F. BAKER

Department of Plant Pathology
University of California, Berkeley

It is a truism that there are two sources of plant disease organisms — the soil (including organic matter and water) and the host plant. Thus disease control in the nursery comes down to (a) the use of treated or pathogen-free soil, (b) use of pathogen-free propagules or planting stock, and (c) routine sanitation to keep them both clean.

DISEASE-FREE PROPAGATION

Soil. Although man has been growing plants in containers for at least 4000 years, only in the last 40 has he examined the bases for the practices employed. The development of nursery soil mixes has been discussed in detail elsewhere (1), and need not be repeated here.

Many troublesome pathogens of nursery stock carry over in soil, and means of combating them have passed through several phases. Before the problem was understood growers had necessarily devised, by trial and error, means of living with such pathogens. For example, very careful manipulation of soil moisture provided useful disease control. With knowledge of the existence of soil microorganisms, the use of soil treatments soon began. The philosophy at that time resembled that of many early settlers in the West, "There aren't any good Indians." Soil treatment by fumigants or by steam has been, and still largely is, based on the idea of overkill It is now clear that we have gone too far in this direction, and that our treatments have eliminated friends as well as foes (3). The contamination hazard in the nursery or the the final planting site is the price we are paying for creating a biological vacuum.

It is a fortunate biological fact that pathogens, because of the specialization necessary for successful parasitism, are easier to kill than some soil saprophytes. The means are now available, furthermore, to make a start in selective killing of pathogens in soil. There are two approaches to this problem:

> (a) Drastic soil treatment may be used, followed by inoculation with selected antagonists which will inhibit the pathogens. Here again the philosophy has progressed from the complex and difficult to a simpler and easier program. At one time it was thought best to isolate individual antagonists and reintroduce them, either singly or a few of them, into soil of near sterility. This would almost require a research program for each new situation. It is now realized that this also produces an unstable situation, and that a natural soil flora that includes many kinds of antagonists is to be preferred (6). How might such a program work? First, it is necessary to locate a soil in which the pathogen is unable to establish or to produce the disease in question. This is not as difficult as it sounds, for as any nurseryman knows, disease in plants is the exception rather than the rule. Such a soil can be freed of all plant pathogens by treatment with aerated steam at 140° F. for 30 minutes, leaving a balanced flora of antagonists. This soil may be used for inoculation of the propagation medium or container mix which has been reduced to near-sterility by

treatment with fumigants or by 212° F. steam. There are many points still to be worked out for this general method, but the results so far appear promising.

(b) Minimal soil treatments of the sort mentioned above, to leave as many saprophytic antagonists as possible, have proved useful in nurseries. Treatment of container soil at 140° F. for 30 minutes avoids producing a biological vacuum; any pathogen inadvertently introduced then encounters competition or inhibition. Most surface soil exhibits such an effect. Soils mined from below the surface, or inert materials such as perlite and vermiculite, naturally contain few organisms, and this protection cannot be expected from them. The object is to select antagonists, not to create them. For this reason, the method is of less use in propagative media than it is in container soil mixes.

Propagules. There have been many methods devised for obtaining clean propagating stock. Some of these are:

(a) Propagules are produced in an area free of the pathogen, or in which the climate prevents infection of the seed or stock.

(b) The propagules are grown in such a manner that they remain uninfected. Taking tip cuttings from plants grown on trellises under non-humid conditions thus effectively produces stock free of *Rhizoctonia*, *Pythium*, and many bacterial pathogens.

(c) Cuttings may be cultured to determine those which are free of infection. The method has been a major factor in the phenomenal decrease in mum and carnation diseases.

(d) Heat treatment of propagative material has proved useful on a wide range of plants. A brief high-temperature treatment with aerated steam (4) or hot water (2) has proved useful for seed, bulbs, cormels, etc. Longer treatments at lower temperatures have been used to free many kinds of herbaceous and woody plants from certain viruses (7).

(e) Prolonged roguing of diseased plants from a stock is beneficial if the pathogen does not spread faster than it can be rogued out, and if the symptoms can be relied on to indicate infected plants. The method is best used on some virus diseases, such as rose mosaic, and is best combined with methods (d), (f), and (h).

(f) Virus indexing methods have been devised to increase the probability of detecting virus-infected stock in roguing This technique has been valuable in reducing viruses in mums, carnations, and certain woody plants.

(g) Growing plants from seed. Most viruses are not seed-transmitted (5), but accumulate during vegetative propagation. Thus, raising freesia, anemone, and ranunculus from seed produces much healthier plants than growing them from corms, roots, or claws. This method presupposes that the plant will breed true from seed. Geraniums are now rapidly changing from cutting to seed propagation, as snapdragons did many years ago.

There is a phenomenon in many kinds of seeds in which a number of adventitious embryos are developed from the nucellus or integuments. These have been found to be virus-free and identical in citrus—a sort of virus-eliminating vegetative propagation. Can ways be devised to capitalize on this phenomenon in other crops as well?

(h) Apical meristem culture is the most recent method of obtaining healthy stock, and usually produces essentially pathogen-free stock (7). The very tiny (0.02-0.004 inch or less) apical growing point is removed and grown in culture. After the plantlet has formed roots, it is transferred to thumb pots, and finally to larger pots. The method is based on the fact that the growing point under glasshouse conditions is essentially free of microorganisms, that some viruses under certain environmental conditions do not reach the growing point, and other viruses only attain such low concentrations there that they are unable to establish and are finally eliminated. This is a laboratory method, and should not be undertaken by untrained personnel

Smaller and smaller vegetative propagating units have been used in the nursery business, shifting successively downward from root divisions to cuttings, to stem tips, to growing points, to meristem-tip cultures, perhaps to single cells. One of the principal reasons for this trend is that the smaller the tissue piece used, the more likely it is to be free of pathogens. However, as the propagule size diminishes, the difficulties of propagation and indexing increase, the complexity of techniques and facilities increases, and the chance of success decreases. However, there are ever smaller worlds to conquer. Several laboratories are now studying the possibility of vegetative propagation from a single cell or tiny clumps of cells. It is probable that, for some plants, this method may eventually provide the means of obtaining pathogen-free stock

There is a very real problem of maintenance of the original pathogen-free stock, since there are no designated places to carry them on. This is now more important than developing new techniques for obtaining clean stocks. This function is being carried on by a number of commercial propagators, but there have been failures to maintain the necessary isolation, controlled sanitation, and indexing.

Perhaps a facility financially supported by industry, but under the supervision of competent plant pathologists, will be the answer.

Sanitation. It is a common misconception that in a program such as this a level of cleanliness to be found only in hospitals would be required. While this condition would be fine for maintaining the valuable mother or nucleus blocks, the cleanliness for most of the operation is more nearly that which one expects in his home, a hotel, or a restaurant. Perhaps in this day of Women's Lib we should ask wives to assist in raising nursery standards of cleanliness to those they demand in their kitchens!

THE PROPAGATOR'S OBLIGATIONS

The propagator holds a key position in the production of nursery stock The earlier in the life of the propagule that it becomes infected with a disease organism, in nearly all cases the greater will be the damage to the resulting plant It is, therefore, especially important that the stock be kept free of pathogens while in the hands of the propagator If the plant becomes infected while in the hands of the propagator, there is often nothing that any subsequent grower can do about it. This imposes the responsibility on nurserymen to produce stock that is not only disease-free, but that is pathogen-free. There is, of course, an important difference between these states.

It is quite possible to produce infested or infected propagules that show no disease. Plants can be grown in soil too dry or at temperatures too high for development of disease. China aster seedlings may be grown, for example, at 60° F. in soil infested with the aster wilt *Fusarium* and develop no disease. When later planted in the yard at soil temperatures of 70-80° F., every plant may die. That, furthermore, is not the end of the matter. The soil becomes infested and asters can then no longer be grown there Similarly, root rot of woody plants caused by *Phytophthora cinnamomi* may be minimized by growing plants in well-drained media on the dry side. In the uncontrolled environment of the yard or orchard, the plant dies and the soil becomes permanently infested. The nursery propagator is indeed his brother's, his employer's, and the customer's keeper. The obligation, although great, is too seldom appreciated.

There is no excuse today for nurserymen to produce stock that is carrying pathogens. It is, in cold fact, immoral and unethical to do so, and short-sighted poor business practice as well. The fault is not wholly with the propagator. He is pressured by salesmen and by some research and extension workers as well, to drench the plants with chemicals when they show disease. Some of these are quite effective in suppressing disease—Dexon for *Pythium* and *Phytophthora,* and PCNB for *Rhizoctonia*. The fact is rarely pointed out that these materials do not kill the pathogens; they merely inhibit them for a time To maintain the inhibition by Dexon it must be applied at least every 10 days; PCNB has a longer life. This may be economically feasible during the brief period in the nursery, but can you imagine the owner of an avocado tree planted in his yard drenching it every 10 days for the rest of his life? Not to tell him that his plant, like a diabetic and his needle, needs an expensive elixir of life every few days is ethically even more questionable. The only answer to this is to grow clean propagules in clean soil in the nursery. It is quite as possible to pollute the environment with pathogens as with fungicides!

PATHOGEN-FREE ANTAGONIST-INOCULATED STOCK

It was mentioned earlier that treatment of soil with aerated steam at 140° F. for 30 minutes eliminates pathogens and leaves many antagonistic saprophytes. If a potent suppressive soil for the principal pathogen involved can be found and so treated, it will provide excellent inoculum for propagative beds steamed to near-sterility at 212° F. for 30 minutes Aside from protecting propagules while in the nursery beds, these antagonists would be carried with the propagules to the planting site. There is much work to be done in this area, but it now seems probable that nurseries will sometime in the future produce not only pathogen-free stock, but pathogen-free antagonist-inoculated materials as well. Work in progress indicates that direct inoculation of seed with antagonists, as with nodule bacteria *(Rhizobium)* on legume seed, is also a distinct future possibility (6).

STANDARDIZATION AND CERTIFICATION

The current interest in standardization of nursery stock has been expressed in specific standards in a number of states. These standards have in common the establishment of specifications for certain plants, without considering how the stock was produced. This trend is puzzling because nurserymen generally recognize that two plants of similar size may have vastly different growth potentials when planted out. A well-grown plant produced unchecked under constantly favorable conditions, and free of root pathogens is certainly a far better buy than a larger specimen more slowly grown under intermittently unfavorable conditions, or one infected with root-rot fungi but not yet showing disease symptoms. The first plant will rapidly equal or exceed the second in size because the latter may start growth slowly or not at all.

Two misconceptions seem to lie at the root of this problem. Seedling diseases are thought not to persist and damage mature plants *Phytophthora cinnamomi* may be acquired by seed in fruit picked up off of the ground; when planted, they give rise to diseased rootstock seedlings and, when they are planted in the orchard, to diseased trees The pathogen may not kill the tree until years later, during a particularly wet winter, after the plant value has increased many-fold. The second fallacy is that infested or infected seedlings can be detected by symptoms or plant appearance. By inversion, this is taken to mean that if plants do not look sick or die, they must be free of root pathogens. Neither is true. Several years ago a long-term investigation at an Experiment Station to determine the effect of viruses on tree growth was upset when it was found that many of the plants had unsuspected Phytophthora root rot. Experience clearly indicates that one cannot positively assess root infection without examination and probably culturing of roots.

The basic problem is to devise specifications which can be readily established by examination but which will accurately assess the growth potential of a plant as well as measure its present size It is not enough to specify, as one state did, "Nursery stock when sold shall not be dead or in dying or seriously damaged condition."

Experience clearly shows that you can truly standardize nursery plants only by standardizing the conditions under which they are grown. This does not necessarily mean that every grower must use the same method for growing a certain plant, but that plants grown under the cleanest and best conditions will receive the best rating. *One must grow plants for standardization, not merely standardize and grade plants randomly produced.*

Many characters suggested for nursery standardization do not reflect growth potential of the plant, but merely measure the existing physical status. It is comparable to judging a car by its overall length or quantity of chrome rather than by its actual performance.

It may be possible to make some assessment of growth potential by examination of the roots. A root-bound condition from too long a period in the container can be detected, and an estimate of root condition and the presence of root rot or nematode damage thus reached.

Standards are a sort of descriptive business shorthand which tell what type of plant is involved. This is necessary for the transaction of business, particularly in mass merchandising, and should be strengthened and improved. It should not be confused, however, with measurement of growth potential.

To supplement these standards, a voluntary certification or registration scheme is needed to evaluate growth potential. Official periodic examinations could record, for example, the time the plants in a given block were grown in a certain size container, the uniformity of growth rate, whether the soil was treated or steamed, whether the lining-out stock used was pathogen-free, whether any plants had died and from what, whether specified sanitary precautions were followed, whether suppressant fungicides had been applied, and whether plants had been excessively forced to reach the prescribed size. Several state certification schemes for seed potatoes, seeds, strawberry plants, avocado and citrus trees, and others establish the necessary precedents. Grower participation should be voluntary, permitting him to decide whether he wishes to have the stock certified or merely described as to physical standards.

It would be relatively easy to apply such a certification scheme to lining-out stock and this would be a suitable place to begin. The propagator is again the key factor!

Under such a program nursery stock would always have a descriptive grade and could have an additional certification. A buyer could then decide whether a Certified No. 2 plant was a better investment for orchard planting than a plain No. 1 plant. It is as important today to assess growth potential, health, and vigor of a plant as to standardize its physical characteristics. A dual system of the sort described appears to be the only feasible way to truly standardize nursery stock. Many details remain to be worked out, but some such program is certain to evolve sooner or later.

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MODERATOR BROWN: Thank you, Dr. Baker. Now are there questions?

ANDY LEISER: Where are these repressive soils—in general, are they found in any particular type of agriculture?

KENNETH BAKER: The one that I was speaking of was *Phytophthora cinnamomi:* and, I might add that *Pythiums* and *Phytophthoras* are the hardest of any of this sort to find. We have one soil staked out in Australia, of all places. It's the only one that I know of in the world that really works this way. And it is the one I was speaking of where the organism, *Phytophthora cinnamomi* is present and it is completely suppressed and has been for 30 years at least, because colossally big avocado trees are growing on it with no root rot at all. Now these are the sorts of things that you really look for, but there are many other kinds, and strangely enough they occur in a wide range of plants. For example, one of the men in Washington state is working on cereal diseases; I never thought of this as a thing that would really work there, but he has found soils there that are utterly suppressant to some of the root rots of wheat. He has a very big experiment that has just been set up that I'm waiting with great interest to see how it is going to turn out with next year's crop. What he did, in effect, was to take wheat seed and mix it with gum arabic. He has taken this suppressive soil from the fields where it retards these organisms and simply pelletted wheat seeds with suppressive soil. Now, this may sound like a long shot, and it may be, but I don't think it is for this reason. He also has shown this year in experiments that by adding this suppressive soil to a field where the disease was formerly active that it did, in fact, suppress it. Now we don't know whether this is going to continue to be a permanent thing or will be a "flash in the pan" for a year or two. But the quantity put on is really surprising. It would amount to 10 pounds of this suppressive soil put on—broadcast over the surface—per ton of the soil that you put it on, figured at a 6" depth—and it suppressed the disease. So I think that the trick is to find these different soils—and there are a number of them for different pathogens that we know of. Probably we shouldn't take time to ennumerate them here, but if you are specifically interested, I'll be glad to tell you about some of the others.

VOICE: Have any antagonistic microorganisms been recognized in these soils?

KENNETH BAKER: In these soils—definitely; and this is where the good part of it comes in, because for the most part, they withstand 140° F., if we're talking about treating soil with aerated steam. These are spore-forming bacteria. They come through—you knock out all of the fungi, and a good deal of the Actinomyces—getting rid of all pathogens while the beneficial organisms come through and actually are stimulated just because they break dormancy from heat treatments.

VOICE: Have you recognized or been able to culture them?

KENNETH BAKER: Yes, but we're going away from this idea of culturing them individually and adding them. I like to use the analogy of a pyramid If you stand a pyramid on its peak, on its apex, it's the most unstable thing in the world. It will fall over one way or the other if you do nothing about it. But if you turn it over and place it with the big side down, it becomes very stable and it stays put. I mean this as a direct analogy, because if you put a single organism in the soil, it's the most unstable thing in the world—it can either go rampant—it can stunt your plants—or it will be lost. But if you take the whole flora that is in there—that is balanced already, it has a built in stability that enables it to stick And this is why we're moving off of this deal; the reason for mentioning it here is that it's the sort of thing that you as individuals can actually do something with. There's nothing complex about it at all once you get zeroed in on the idea of what a suppressive soil is like. And I would put it this way—that if you have a soil where diseased seed has been planted—for example, it's carrying a pathogen — and you plant the seed in this soil for a few years and the disease never appears, then you have a suppressive soil, or if it's in an area where the organism is present, as in the avocado soil, out there, and it can be recovered, and still you don't get the disease. That, indeed, is a suppressive soil. There are a lot of them around—we've just got to find them and manipulate them.

FRANCES SPAULDING: Would you suggest screening for insect vectors—this sort of thing?

KENNETH BAKER: Well, certainly in the maintenance of disease-free stock. We talk about virus-free stone fruits, for instance. The ones that they maintain at U.C., Davis are kept in screened lathhouses for this reason. This is what you have to do once you get clean stock. You have to maintain it. This is where, so often, the program falls flat; they will get it clean, but then it becomes a great chore to maintain it and build it up for commercial use. I think there should be some sort of agency set up to do this; there is, in England, in the floriculture industry. They have put up a series of glasshouses at Littlehampton and the material that they get from apical meristem culture, and so on, goes in there. The support of this is from the industry. They get the material back at no cost to themselves, but it is supervised and run by experiment station people there to make sure that the plant material is kept clean.

MODERATOR BROWN: Dr. Baker, we appreciate the fine work you have done for the nursery industry and thank you very much for giving us this most thought-provoking presentation today. Thank you.

RESEARCH INTO SEED DORMANCY AND GERMINATION

P. A THOMPSON

Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey

INTRODUCTION

Stocks of seed of horticultural and agricultural crop plants must possess germination characteristics which result in rapid germination of a high proportion of the seed to produce evenly distributed, evenly developed stands of plants. Amongst crop plants particular restrictions in the range of conditions which result in germination may limit the geographical range of the plant or determine particular procedures for its cultivation; for example, high temperature sensitivity of leek seed prevents germination in low latitudes or during the summer in higher ones, and the requirements of celery seed demand greenhouse conditions for successful germination in the spring.

Since it is possible to find dormancy mechanisms still restricting germination in seeds of a crop plant as ancient as the leek it is not surprising that such mechanisms should be present in the seeds of plants taken more recently into cultivation, such as hardy ornamental nursery stock, both shrubby and herbaceous, which are the day to day concern of the nurseryman Indeed, in these plants, germination may be so restricted or so uncertain from one year to the next that use of seeds as a means of propagation may be reduced to the point where it is abandoned and replaced by some means of vegetative propagation. This is, of course, a necessary procedure for the multiplication of selected forms, but its use in other cases means that the nurseryman may forgo the advantages of raising stock from seed in favor of a form of multiplication which inherently increases the risk of virus dispersal and stereotypes plant variation in a way which may limit the range of interest within the species and increase the chance of epidemic disease.

Reluctance to depend on seed germination may stem, as implied in the previous paragraph, from poor results when this method has been attempted. Modern requirements tending to more and more precision in the growing of plants set a high standard for a satisfactory performance. Thus it may be, if some form of spaced sowing to obviate pricking-out is used, and if heated glasshouse accommodation is to be used fully, that the nurseryman's requirements fall not far short of those of the farmer or grower who, protected by the Seed Acts expects an assured minimum year-to-year germination within a short period of sowing Perhaps one could go so far as to state this aim in terms of a 75% germination within a fortnight of sowing; if one does so the statement serves well to exemplify how far short the performance of most nurserymen's seed samples falls.

This paper does not attempt to provide information for obtaining such a standard for even a small proportion of species, but is concerned first with a discussion of the part that dormancy plays in the natural distribution and survival of plants and, second, with a few of the techniques that may successfully be used to overcome seed dormancy and induce germination.

DORMANCY IN RELATION TO PLANT DISTRIBUTION

Apart from its main function as the means of propagation of a species from one generation to another the seed also serves other important natural functions. It provides a state of refuge by which plants may survive adverse conditions, such as intense drought or cold, and then ensures that a part, often the larger part, of a plant population in a given area exists in a protected condition most likely to survive the ordinary or even the extraordinary seasonal hazards of the locality. It provides a condition in which plants may easily be transported to extend the range of a species, and also one in which plants may remain present in the ground, sometimes over periods of many years being, therefore, the main agent by which plants are dispersed in time and space.

It can easily be understood that not only must the seed be capable of germination, but also that it must possess checks and controls which act to prevent germination at one time but to permit it at another. These controlling mechanisms, contained within the seed, are actuated or triggered by external conditions such as temperature, light, water tension or the gaseous content of the surrounding soil which provide physical or chemical stimuli to which the seed can respond. The seed's response to these external stimuli is very often modified as time passes by internal changes occurring within the seed itself. Thus germination is dependent on a combination of external stimuli and internal conditions and consequently can be precisely controlled to occur only in response to particular conditions occurring only at particular seasons of the year. Successful adaptation of a species to a geographical area depends on the triggers which promote germination being operated in such a way that when germination does occur it does so at a season which promises a high chance of survival and maturation for the resulting plant Therefore germination controls must be clearly correlated with climatic features of the geographical region in which the species occurs, not only reacting to the stimuli of the past, but also reflecting the conditions of the future.

It is reasonable to suppose that a better understanding of the seed germination behavior of a species in relation to the climate of its natural habitat would provide a valuable guide to the controls regulating dormancy and the conditions needed to promote germination. The discussion which follows draws examples from the European flora to illustrate, for a region in which both the flora and the main climatic features are generally well understood, some of the ways in which climate and germination responses may be linked. The main physical parameters limiting plant growth in the area are: the severity of winter cold (Fig. 1); the severity of summer drought (Fig. 2), and the overall length of the growing season (Fig. 3). There are

Fig. 1. Severity of winter cold. Temperature minima and duration of coldest period.

many ways in which Europe may be divided geo-botanically, but a very simple division is to distinguish five main regions, represented by shading in Figures 1, 2 and 3. The intention here is to consider the climate of these regions in relation to the conditions regulating seed germination of some of the plants which are found within them.

a. **The Mediterranean Basin.** The dominant feature of this area is the regular occurrence of drought during the summer broken, especially in the western parts, by occasional thunderstorms which provide short periods when moisture is readily available but separated

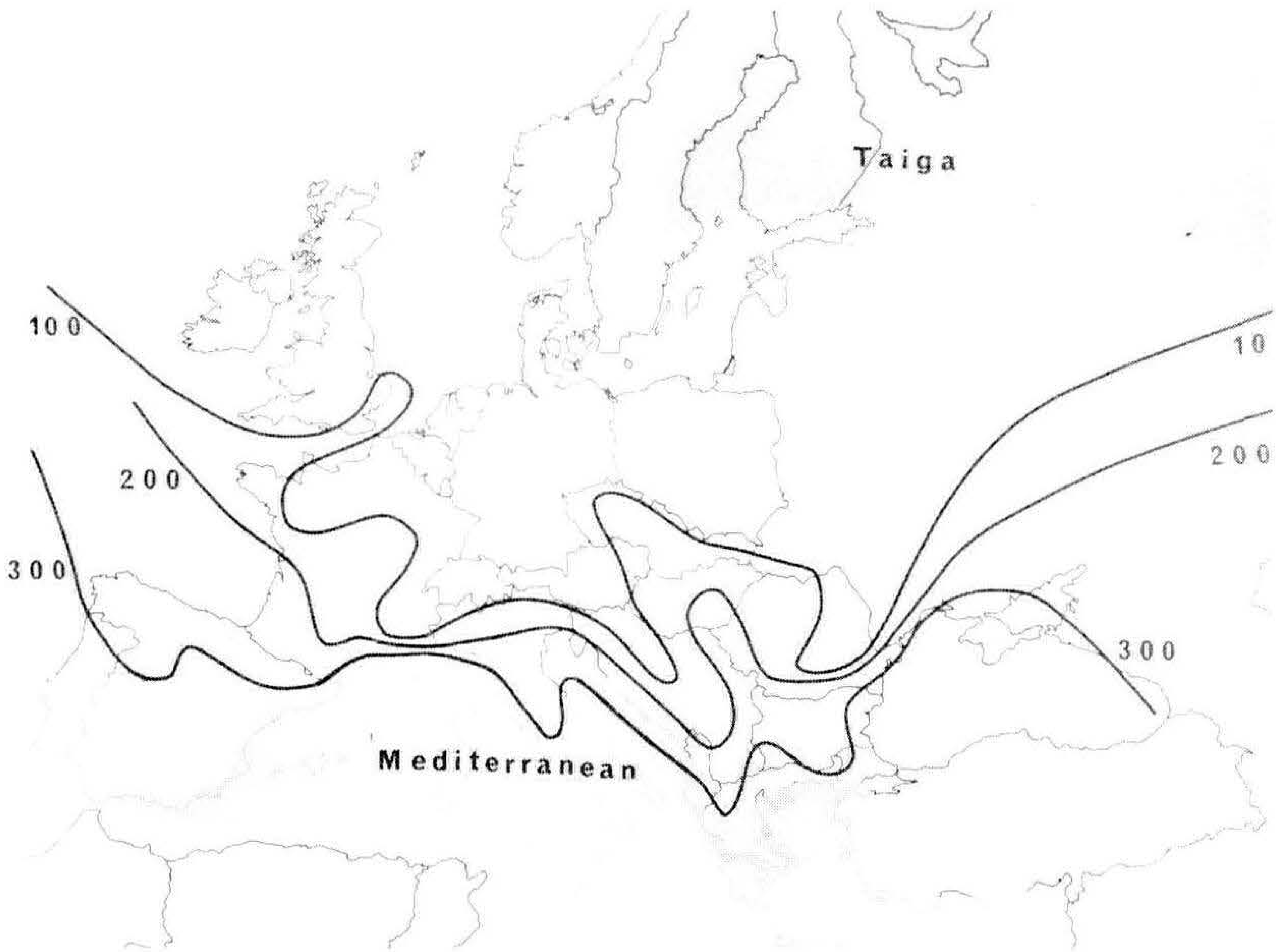

Fig. 2. Severity of summer drought. Average precipitation deficits (mm) — June, July, August.

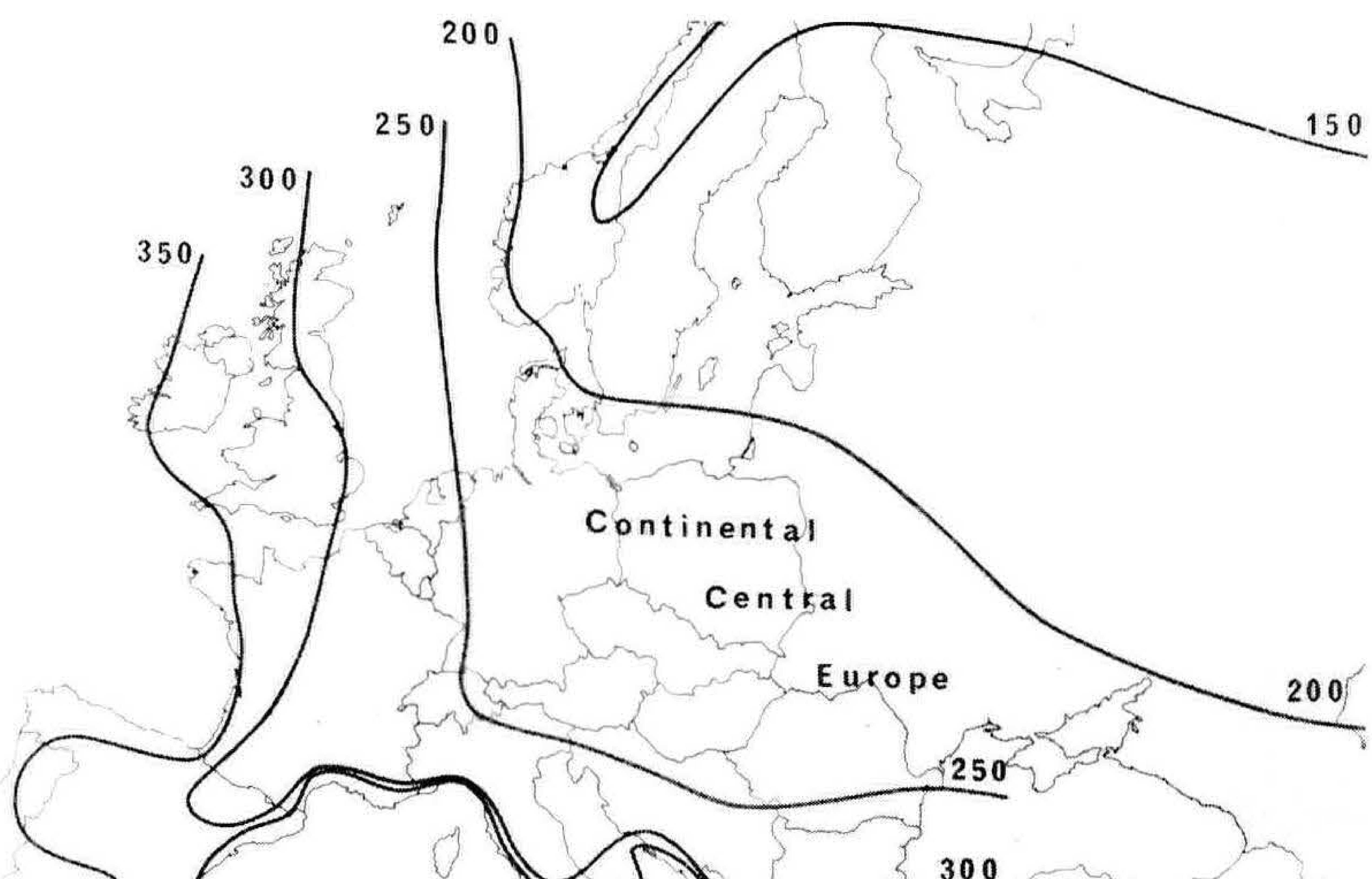

Fig. 3. Length of growing season. Mean days each year with average air temperature above 5° C (41° F) in Europe.

by long periods of intensely arid conditions. In the true mediterranean region winters are mild with a mean minimum for the coldest month around 3-5° C. (37-41° F.). However many areas which are generally mediterranean in character have colder winters than this due either to exposure to cold winds or to altitude Dry summers and mild or cool winters result in a situation where the main season for growth of herbaceous plants lasts from September to April, broken in the colder areas by low temperatures in mid-winter, and where annuals, in particular, survive the summer as seeds. Germination normally occurs as temperatures start to fall in early autumn coincident with the start of the winter rainfall Survival of species within this area depends on their seeds remaining dormant immediately after they are shed in the late spring and during short periods of intermittent moisture in summer, to germinate later under cooler conditions in September or October. The results of germination tests made with seeds of three species from the Mediterranean area are shown in Table 1. An overall view shows that in each case the seeds germinate best at the lower temperatures, though not necessarily at the lowest. They

Table 1.Germination (percentage) of seed of three species of Mediterranean origin comparing responses at a range of temperatures using freshly gathered seed compared to stored dry in the laboratory for six months.

Ranunculus chius. (Southern Greece):

	Day / Night temp. (° C) 15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	77	49	67	0	0	0
Stored seed	87	96	87	85	72	0

Anemone coronaria. (Israel):

	Temperature of test (° C) 6	11	16	21	26	31
Fresh seed	9	68	72	0	0	0
Stored seed	2	91	87	39	0	0

Mandragora officianalis. (Cyprus):

	6	11	Temperature of test (° C) 16	21	26	31
Fresh seed	1	4	12	18	0	0
Stored seed	7	79	100	96	81	0

also show that the germination responses change during storage so that six months after harvest a higher proportion of the seeds germinate over a wider temperature range than was the case when they were freshly shed. Thus at the time the seeds are shed they are in a partially dormant condition so that few or none will germinate at the prevailing soil temperatures During the summer high soil temperatures prevent germination, even if moisture is present, but after-ripening processes occurring within the seed steadily increase the maximum temperature at which germination occurs so that once soil temperatures start to fall in the autumn the first significant rainfall will create conditions in which a very high proportion of the seeds will germinate. Seed dormancy in species occurring in this area is most commonly of this type, induced by exposure to high temperatures and absent at lower ones. In some species high temperatures induce a condition known as secondary dormancy, after which the seed will germinate only if first exposed to temperatures close to freezing point but, in general, chilling treatments of this kind do not appear to be necessary for securing germination of typically mediterranean plants.

b **Continental Central Europe.** This large and complex area contains a variety of distinctively different floristic regions, but is characterized by the occurrence of a continental climate in which winters are cold and summers warm to hot. The length of the growing season decreases and the severity of winter cold increases as one goes east and north from the Atlantic Ocean. Summer drought is a regular feature in the southern parts of the region and particularly in the eastern parts where it is responsible for the development of steppe-like regions in which grassland is the dominant component. Elsewhere the climax vegetation is usually deciduous forest and summer droughts, although sometimes occurring, are neither regular nor severe. Over most of the region the growing season is moderately long. Plant establishment in the area depends, therefore, on adaptations which enable survival through the winter and short periods of drought in the summer The effects of winter cold are tempered by the presence, for long periods, of snow cover which shelter the plants from dessication by wind and protect them from the attacks of mammals, insects, molluscs and fungi by reducing the activity or growth rate of these predators and pathogens. This produces a situation in which many plants survive the winter as seedlings to grow away rapidly as soon as warmer weather comes in the spring to produce flowers and fruits relatively early in the summer. As a result fruit and seed production in annuals and other herbaceous plants, particularly, tends to occur during short periods of summer drought; seeds germinating in late summer and early autumn have time to grow large enough to build up resources of storage reserves to last them through the winter.

The germination behavior of four species that occur in parts of Europe with a continental climate are shown in Tables 2 and 3.

Table 2. **Germination (percentage) of *Delphinium orientale* seed. Fresh seed and seed stored dry in the laboratory for various periods were tested at a range of constant or fluctuating temperatures.**

Temperatures (fluctuating cycles):

	Day / night temperatures (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	36	16	44	39	0	0
Stored seed	68	36	65	53	11	1

Temperatures held constant throughout experiment:

	Temperature of test (° C)					
	6	11	16	21	26	31
One-year-old seed	89	88	12	0	0	0
Three-year-old seed	82	93	30	3	0	0

Delphinium orientale, (Table 2), is found throughout all parts of the Balkan Peninsula extending north into Hungary on arable ground, usually in areas subject to summer drought. Germination tests gave responses rather similar to those already described for mediterranean species, with marked inhibition at high temperatures and some improvement in germination rates after six months of laboratory storage.

Each of the other three species showed high germination rates immediately after harvest, and after a period of storage at most of the temperatures tested, although germination of freshly shed *Lychnis coronaria* seed was restricted or prevented when tested at day temperatures of 25° C. (77° F.). Germination responses of this kind imply that seed shed in mid to late summer would either be capable of immediate germination, given sufficient soil moisture, or would lie in the soil for a short time during the hottest part of the year to germinate in early autumn. In either case it would appear that dormancy plays little part in controlling the season of seed germination and that the species would overwinter as young plants rather than as dormant seed

c. **The North-Western Oceanic Region.** This area extends along the Atlantic coasts of Europe from northern Spain to Norway, and includes the whole of the British Isles. Most of the area is practically free from summer drought except for parts of southwestern France and for occasional isolated short periods in eastern England and western France The growing season is long especially in the extreme west where winter temperatures equivalent to those of the mediterranean result in almost frost-free conditions throughout the year. Winter temperatures in other parts of the area are relatively high with no month where mean monthly temperatures fall below 0° C. (32° F.). Mean values for winter cold, rainfall, or other meteorological parameters are misleading since the area is characteristically highly variable in its weather patterns. Winters vary both in their overall character from relatively severe to mild and in the monthly pattern which is made up of variable periods of cold, or mild or wet weather. Prolonged periods of frost or snow are unusual. It has already been noted that snow cover may not only mitigate the effects of cold, but may also assist plant survival by reducing losses from pathogens and predators. Thus the physically severe climate of continental Europe may be relatively innocuous to plants hardy enough to withstand a period of low temperatures but paradoxically, the milder conditions prevalent in oceanic areas may pose much greater hazards to the winter survival of young plants.

The situation is a complex one in that seed germination in late summer or autumn to produce seedlings that overwinter as young plants provides an inbuilt advantage to the established plants which develop early and are well placed to survive competition from seedlings germinating in the spring. On the other hand, overwintering

Table 3.Germination (percentage) of seeds of three species distributed in parts of Europe having a continental climate.

Salvia sclarea:

	Day / night temperatures (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	83	59	81	80	94	76
Stored seed	89	91	83	87	84	76

Lychnis chalcedonica:

	Day / night temperatures (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	82	93	93	95	96	96
Stored seed	98	87	95	98	91	97

Lychnis coronaria:

	Day / night temperatures (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	85	80	95	72	43	0
Stored seed	77	89	93	90	85	88

as plants rather than seed greatly increases the exposure of the population to unpredictable degrees of varying risk from year to year. There is no single season or period of the year which can be said to be uniquely favorable for seed germination and plant survival, but each poses a balance of advantages and disadvantages.

It is not surprising to find, therefore, a complex of germination responses from the plants growing in the area so that some germinate predominantly in summer and autumn, others predominantly in the spring and, in others, some seed germinates immediately it is shed, while some remains dormant through the winter till the following spring Species from the area frequently display a diversity of germination responses which result in no more than a proportion of the seed population germinating under any given environment, and in this way some of the seeds remain dormant year by year to build up in the soil a reservoir of seed, some of which may not germinate for many years after they are shed.

In Table 4 results are shown of tests done with seed of four species collected in the British Isles, which exemplify some of the problems that may arise, and the variability in response that can be found from one test condition to another. Constant temperatures were unfavorable for germination of *Ballota nigra* and *Stachys silvatica* seed but high temperatures, including fluctuations from night to day, were very favorable (*vide* the comparison between responses at 25 / 25° , 15 / 15° , and 25 / 15°). There were few benefits from storing the seed prior to sowing, or in giving it a chilling treatment. Freshly picked seed of *Meconopsis cambrica* and *Scilla non-scripta (Endymion non-scripta)* failed to germinate, and no improvement was found with the latter when stored or given a chilling treatment. *M. cambrica* seed did germinate a little better after storage, particularly at 15 / 5° , which corresponds to natural cool days and cold nights. The welsh poppy and the bluebell are both species whose seed germinates freely under natural conditions and, in particular, developing bluebell seedlings may be quite conspicuous in early spring in any bluebell woodland. A much more extensive series of laboratory tests than those shown here, however, failed to achieve any better results than the ones shown and it seems likely that seeds of both these species require a succession of alternating leaching and chilling treatments, equivalent to the variable conditions of our winters, before they are able to respond to warmer conditions with the coming of spring. It is often not easy to establish artificial treatments which will produce results equivalent to those found under natural conditions for seed of species from oceanic areas of Europe, but as the first two species in Table 4 show, this is not always so, and frequently quite small variations in ambient conditions may make the difference between success and failure. Similarly preliminary chilling treatments may increase germination, as in *Ballota nigra*, or be disappointingly ineffectual, as in the bluebell.

Table 4. Germination (percentage) of seed of four species collected in the British Isles.

Ballota nigra:

	Day / night temp. (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	2	1	12	47	50	1
Stored seed	4	4	8	56	40	3
Chilled seed[a]	66	40	68	75	47	16

Stachys silvatica:

	Day / night temp. (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	32	0	3	88	78	0
Stored seed	6	5	40	90	70	2

Meconopsis cambrica:

	Day / night temp. (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	0	0	0	0	0	0
Stored seed b	36	0	8	14	5	0

Endymion non-scripta:

	Day / night temp. (° C)					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Fresh seed	0	0	0	0	0	0
Stored seed	0	0	0	0	0	0
Chilled seed c	0	0	0	0	0	0

[a]stored seed chilled at 2° C for 9 weeks after sowing before transfer to test temperatures.

[b]stored for 13 months.

[c]chilled for 6 weeks at 2° C.

d. **The Taiga.** This area, as defined in Fig. 2, is the name given to the coniferous forests of Scandinavia and Russia. In North America the corresponding forest zone is called the boreal forest. Areas of coniferous forest, characteristic of high altitudes, in mountain and alpine areas of Europe have broadly similar characteristics, and since the flora of these regions is of much greater horticultural interest than that of the true Taiga the examples considered here are mainly from such areas. The climate is characterized by a virtual absence of summer drought, even of short duration, and by long and severe winters during which the ground may be continually covered by snow for many months The summers are short and though day temperatures may be quite high the nights are normally cool, or even cold, which emphasizes the natural shortness of the growing season. In some seasons prolonged periods of rain and low temperatures in summer, or the early onset of winter may greatly curtail fruit set and seed production, resulting effectively in intermittent crop failures.

Under these conditions there is usually insufficient time both for seed to ripen and be shed and for seedlings to germinate and build up sufficient resources to survive the winter. Seedlings starting growth in late summer or early autumn are still very small when the growing season ends and are very vulnerable to inclement conditions. There is little of the weather variability found from year to year and from week to week as in the oceanic regions and, in many ways, climatic features of the Taiga region are comparable in their regularity to those of the Mediterranean area—though directly opposite in their nature. The situation is one in which the seed of most species requires protection from germination before the winter starts, but requires the ability to germinate and grow rapidly as soon as the spring thaw is under way. The most characteristic dormancy pattern is one which responds easily and satisfactorily to chilling treatments as shown for three species in Table 5 Usually few changes in germination behavior occur in response to storage, nor are temperature combinations involving fluctuating day/night cycles effective ways of promoting germination

e. **The Tundra.** Tundra, or areas with similar conditions in Europe, occur along the northern fringe of the continent from Northern Norway eastwards, and at high altitudes on most of the main mountain chains. These areas are characterized by extremely short, cool or cold, growing seasons and very long periods of snow cover and winter cold. Usually only the surface layer of the soil thaws each spring, and the sub-soil remains frozen to create a condition known as perma-frost Such areas, especially on mountain tops are frequently

Table 5.Germination (percentage) of seed of species occurring at the altitudes of the coniferous forest in mountainous areas of Europe.

Gentiana verna

	Temperature (° C)					
	6	11	16	21	26	31
Fresh seed	0	0	0	0	0	0
Stored seed	0	0	0	0	0	0
Chilled seed[a]	0	43	68	82	80	24

continued

Primula auricula

	Temperature (° C)					
	6	11	16	21	26	31
Fresh seed	0	0	0	0	0	0
Stored seed	0	0	0	0	0	0
Chilled seed[b]	0	73	62	30	0	0

Trollius europaeus

	Temperature (° C)					
	6	11	16	21	26	31
Fresh seed	0	0	0	0	0	0
Stored seed	0	0	0	0	0	0
Chilled seed[c]	6	43	56	72	14	0

[a]Chilled at 2° C for 8 weeks.

[b]Chilled at 2° C for 8 weeks

[c]Chilled at 2° C for 8 weeks

very exposed, and snow cover in the winter may be almost entirely removed by high winds, consequently plant exposure to winter cold and dessication may be very severe. Seed of plants from these regions probably normally germinates in early spring and the annuals found here are remarkable for the short time they require to complete their life-cycle. Perennial species may take several seasons to attain sufficient maturity to produce flowers. Many of the species found in such areas respond to chilling treatments in the same way as the mountain flora just described, but seeds of others, for example *Silene acaulis* and *Lychnis sibirica,* shown in Table 6, may require no special treatment, but germinate rapidly at a range of temperatures. Low temperatures are often unfavorable for germination, as exemplified here by *S. acaulis* and this would appear to be sufficient protection to prevent seed shed late in the autumn from germinating before the onset of winter. In a sense, therefore, it could be argued that in these circumstances the climate itself is so stringent that it practically predetermines the possible season for germination and only minimal adaptation is required by the plant to ensure correct timing of the process.

Table 6. Germination (percentage) of seeds of two species from Tundra regions of Northern Europe.

Silene acaulis

	Temperature (° C)									
	4	8	12	16	20	24	28	32	36	40
Stored seed	0	0	0	3	37	73	76	52	28	0

Lychnis sibirica

	Temperature (° C)									
	4	8	12	16	20	24	28	32	36	40
Stored seed	6	18	80	96	85	100	80	58	4	0

TECHNIQUES FOR OVERCOMING DORMANCY MECHANISMS

Seed germination occurs in response to the interaction of processes occurring within the seed and the environment in which it is placed. The preceding section, limited in scope though it may be, has outlined some of the significant factors determining whether a seed germinates or remains dormant and has described ways in which these factors can be related to the natural adaptations required by different species for survival in particular parts of Europe. In this section those factors which control germination are considered in relation to ways in which their identification may be used as an aid to increased efficiency when seeds are employed as propagating material for horticultural purposes. For this purpose the factors are most conveniently categorized, and the categories examined in turn to establish the significance of each in terms of its horticultural interest and applicability.

After-ripening responses. Tables 1 to 6 repeatedly present data for freshly harvested and stored seed. In many cases they also show that the stored seed germinated better than the freshly shed, sometimes over a wide temperature range, but sometimes at only one or two particular temperatures. This reflects a condition frequently found in seeds in which germination immediately after harvest is restricted and remains so for a period during which physiological or morphological changes, known collectively as "after-ripening", occur and result eventually in the reduction of the dormant condition. The time taken for the completion of such "after-ripening" changes varies from a few days to several years and the effect may be to remove almost entirely barriers to germination, or to produce no more than a very slight effect over a restricted temperature range. The majority of seeds after-ripen satisfactorily in dry storage at room temperature and the process may be retarded or prevented by storage at low temperatures, particularly below 0° C. (32° F.). After-ripening requirements of this sort mean that, in general, it is preferable to store seed for a short period rather than to sow it immediately after gathering, but care must be taken to provide good storage conditions. Not surprisingly, dead seed germinates less well than living, and there can be little doubt that many reports purporting to compare the performance of freshly sown seed with old seed simply establish the advantage of the quick over the dead. Seeds of most species having small dry seeds are best stored in paper bags preferably over anhydrous calcium chloride; above all, seed storage in damp places with continuously changing temperatures should be avoided.

A minority of seeds complete their after-ripening processes only when they are fully imbibed with water; most of these are species in which the embryo is morphologically immature when the seed is shed. These species mainly require warm conditions for the completion of embryo development before treatments leading to germination are started.

Chilling treatments. This includes techniques often referred to by the gardener as "freezing" or "stratification". However, the three terms are not, in fact, synonymous and the actions covered by them should be distinguished from each other. Examples of seeds responding to chilling treatment have already been presented and it is very common indeed to find that the seeds of species distributed in the temperate regions of the world respond by enhanced germination to a preliminary cold treatment. In practice it is important to separate the two processes of chilling and germination, if both are to be understood and used most effectively. Chilling treatments must be applied to moist seed; low temperature storage of dry seed is ineffective. One of the best methods is to mix the seed with a quantity of moist sand, seal the mixture in a polythene bag, and to put the bag in an ordinary domestic refrigerator. These operate over the range 2-4° C. (36-39° F.) which is suitable for most species; temperatures below 0° C. are not only unnecessary but very often ineffective. This low temperature treatment should be maintained for some weeks, but the minimum effective period varies from species to species. Between one and three months is usually adequate but, generally speaking, the response increases as the chilling period is prolonged so that it is safer to increase rather than to decrease the period.

At the end of the chilling treatment the mixture of seed and sand should be spread out in a thin layer over compost and placed in a suitable temperature for germination. It is not usually necessary to use low temperatures for this phase; about 20° C. (68° F.) provides satisfactory conditions for seeds of many species. In principle, once the chilling treatment is complete the seed should be germinated and the young plants grown on as quickly as possible.

Temperature Treatments. The expression of dormancy frequently varies widely from one temperature to another and several examples of this are recorded in the data presented in Tables 1 to 6. When this occurs seeds that appear to be completely dormant when tested at one temperature germinate well at another higher or lower temperature without the need for any special treatment involving chilling or storage treatments. Some generalizations on the nature of these temperature responses are possible in relation to the natural origin of the seed and these have already been made. In practice the simplest way to guard against restricted germination resulting from particular temperature requirements is to ensure that seed is exposed to a range of temperatures after sowing. Constant temperature sowing boxes or accurately maintained glasshouse temperatures are undesirable and should be replaced deliberately by diurnal fluctuations between day and night temperatures. The difference between maxima and minima should be at least 10° C. (18° F.) and temperatures approximating 20/10° C. to 25/15° C. (day/night) have usually given good results Apart from its value with species whose seeds possess particular specific temperature responses, a fluctuating temperature regime is an essential requirement for seeds of a fairly small group of species which respond only to fluctuating temperatures and fail to germinate at all under constant conditions.

Light. Many seeds require light for germination; many more germinate equally well in light or dark, and a small minority germinate only in the dark. Light requirements seem to follow taxonomic relationships but there is no evidence that they are associated with particular geographical patterns of distribution. Consequently, no mention has been made of them up till now, but Table 7 illustrates results obtained with seeds of six species chosen to exemplify ways in which the presence or absence of light may modify the germination response to temperature. *Gentiana asclepiadea* seed, which was highly dependent on particular temperatures for germination in the presence of light, failed entirely to germinate in the dark, and rates for dark-grown seed of *G. cruciata* and *Meconopsis regia* were extremely low. *Meconopsis napaulensis* seed germinated moderately at all temperatures in the light, but in the dark certain temperatures were much more favorable than others, and this same pattern shows up much more clearly in *Salvia sclarea*. On the other hand, *Gypsophila elegans* seed germinated equally well in light or dark at all the temperatures tested. The results demonstrate ways in which dark-grown seed frequently is more restricted in germination and less predictable in its responses to temperature than seed exposed each day to light. In practice it is not usually necessary to have detailed knowledge of the light requirements of a seed, except in the rare examples of seeds which germinate only in darkness. For all others it is sufficient simply to ensure that they are exposed to light each day by not covering them with light-proof material nor putting them in any kind of lightproof box. The light intensity required to promote germination is very low and may be supplied at any time, even in mid-winter by natural light, or alternatively, by low intensity fluorescent or incandescent lamps.

Table 7. Comparative effects of light and darkness on the percentage germination of seed of six species at different temperatures.

Meconopsis regia

	Temperature (° C) Day / Night					
	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	43	55	39	18	27	15
Dark	11	0	2	0	6	0

M. napaulensis

	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	44	41	39	29	44	28
Dark	6	5	13	11	31	0

Gentiana cruciata

	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	68	59	71	72	75	75
Dark	0	2	0	1	0	6

G. asclepiadea

	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	5	0	9	60	24	5
Dark	0	0	0	0	0	0

Gypsophila elegans

	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	99	100	98	89	98	99
Dark	97	94	98	98	97	98

Salvia sclarea

	15 / 5	15 / 15	20 / 10	25 / 5	25 / 15	25 / 25
Light	89	91	83	87	84	76
Dark	6	9	39	63	81	18

There is some danger of abnormal effects due to the spectral composition of artificial light sources but for most species this is very slight indeed. A further source of failure with seeds which require light for germination may be caused by unnecessarily deep sowing; light exclusion from this cause is particularly likely to result from the use of opaque, light-absorbing, soilless composts based predominantly on peat moss.

Chemicals. A large number of chemicals, including mineral salts and organic compounds, affect germination and may promote the growth of dormant seeds. The most widely used and effective compounds are found amongst the gibberellins including, particularly, gibberellin A4 and A7, and A3 (gibberellic acid). Although the latter is usually much less effective than A4 it is the only gibberellin readily available commercially and, therefore, Hobson's choice dictates that normally it is the one that is used.

The best results from gibberellin treatments occur when seeds are sown on pads of tissue, filter paper, or agar containing a gibberellin solution and left in contact with the chemical throughout the germination period. This technique is not well adapted to the potting shed and depends on some concessions to laboratory practice. Gibberellic acid must be formulated in a water soluble form and made up in a concentration appropriate to the seed being germinated. Table 8 illustrates the effect of gibberellic acid, formulated as the ammonium salt, on germination responses of a number of species, and, as may be seen, effective concentrations vary over a wide range. In general, it

Table 8. The effect of gibberellic acid (GA) treatments at various concentrations on seed germination responses of different species.

Species	Germination without GA	Germination with GA at — (mg / l) 1	10	100	1000
Primula auricula	0	0	32	75	82
Primula reidii	33	48	63	75	74
Lycopus europaeus	0	0	0	10	89
Meconopsis cambrica	0	0	0	38	
Gentiana cruciata	26	23	22	74	68
Trollius europaeus	0	0	17	22	44

seems likely that this compound is most useful in specific situations for seeds of species known to be difficult to germinate by other methods, and for which techniques employing gibberellic acid have been specially developed.

SUMMARY

One conclusion that may be drawn from the experimental results and descriptions presented above is that the mechanisms controlling the germination and dormancy of seeds cannot be summarized in a series of simplified generalizations However, there also seems to be some reason to believe that attention to the natural conditions of the areas in which species grow may indicate conditions most likely to give successful seed germination. Sometimes this approach will lead to the paradox that seed of species from the areas noted for high temperatures, like the Mediterranean region, germinate best when sown at low temperatures, whereas seed of species from areas noted for their freezing winters—like Poland—germinate best when sown at high temperatures. This paradox can be logically resolved, and it is hoped that the results presented in this paper will act in some way as a guide to interpretations of climatic factors in relation to seed dormancy and germination.

SEED COLLECTION AND EXTRACTION

P. DUMMER

Hilliers Nurseries, Winchester

There has over the last few years been a great demand for trees and shrubs in large quantities, and as a result a much larger and improved seed sowing programme has been built up.

HARVESTING

Determining the correct time for harvesting seeds is of vital importance if good germination is to follow. The collector must know the criteria which indicate the optimum conditions for the particular kind of seed he is collecting. These will include size, color and moisture content of the seed.

Before harvesting large quantities of seeds it is advisable to make a cutting test to determine quality and ripeness of the seed sample. It is well known that many seeds will germinate the first year quite freely if the seeds are harvested before completely ripe. With seeds of some species, once the seed coat has hardened germination will not take place until the *second* spring after collection unless special treatments are given.

We have found that seeds which benefit from early harvesting include the following:

Acer campestre, Acer miyabei, Acer tegmentosum, some species of *Viburnum, Cotoneaster* and *Carpinus.*

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We have found that seeds which benefit from early harvesting include the following:

Acer campestre, Acer miyabei, Acer tegmentosum, some species of *Viburnum, Cotoneaster* and *Carpinus.*

Ravaging by birds is sometimes encountered with seeds of such species as *Berberis* and some species of *Sorbus* well before they are actually ripe. In such cases the seeds are harvested and placed in shallow trays in a light airy shed; here they remain for approximately two weeks before they are cleaned The majority of our seeds are collected from our own nurseries and arboretum. The task is sometimes undertaken by the foreman of the nursery or by one of the leading hands. The quantity of fruits to be harvested rests with the management, who must take into account the viability of the seeds in question in order that the correct amount is harvested for any given species For seeds which are difficult to pick, a specially designed platform is brought into use; it resembles a platform as used by the electricity company and is mounted on a fore-loader of a tractor.

SEED EXTRACTION

Dry Fruits. Pods and capsules of such plants as *Laburnum, Genista, Indigofera, Carpinus* and *Phlomis,* etc. are spread in shallow trays and allowed to dry for a period of one to two weeks before the seeds are extracted and cleaned. Hand cleaning using various sizes of sieves is practiced, for in many cases the seeds are rare and hard to obtain.

Fleshy Fruits. Fleshy fruits, including berries such as *Cotoneaster, Sorbus, Crataegus,* Plum, Rose, *Berberis, Vaccinium* and *Aralia,* etc.—and, for convenience, *Rubus* species can be included in this group.

Macerating (Pulping prior to cleaning). A considerable advancement was made last year when we obtained a machine from Germany. The machine is, in fact, used on farms for pulverizing fodder such as swedes, mangles, etc. It can best be described as a cylinder with a waterproof motor underneath. A high-speed rotating plate with low flanges is fitted inside, there is also an adjustable plate on the side which can be moved up or down depending on the type and size of seeds to be macerated; the pulp is released at the base of the machine by means of a large shute. The whole thing is rather like a giant food mixer. This machine works at its best when water is added in equal proportions to the fruits. In most cases it has been found necessary to put the pulp back through the machine a second time in order to separate the seeds completely from the flesh.

Flotation. The seeds are separated from the pulp by flotation, the principle being that all empty seeds, together with the pulp and other waste matter, will float off the top while the heavier, sound, seeds sink to the bottom of the receptacle.

Two or three rinses with water from a high pressure hose is generally required before the seeds are placed in a sieve to remove any excess water; they are then placed in paper-lined seed trays and dried on a greenhouse bench.

The same machine has been used successfully for threshing out seeds of *Laburnum* and *Carpinus;* it was also used with success for de-winging the fruits of *Acer campestre.* In all three cases the chaff was blown away by using a small electric fan; no doubt the chaff could be removed by flotation if one so desired.

PROPAGATION OF LILIES

A. TURNER

The Royal Horticultural Society's Garden
Wisley, Surrey

PROPAGATION METHODS

Nature has provided many ways by which we can increase stocks of lily bulbs but the rate of increase by bulb division, as in *Lilium hansonii,* by bulblets below ground, as produced by *L. speciosum,* by the rhizomatous bulbs of *L. pardalinum,* or the stoloniferous bulbs of *L. superbum,* is far too slow for most of us. A few species and hybrids form bulbils in the leaf-axils at flowering time and, while these can be collected in quantity and grown on, the two main methods adopted for the propagation of lilies involve the use of bulb scales or of seed

Scales. That universally useful item—the polythene bag—has made propagation by scales so simple an operation that I need spend very little time in describing our method. We take our scales in late summer or autumn when the lifting and transplanting of lilies is normally taking place. We drop the scales into a polythene bag, shake them up with enough PCNB dust (Quintozene) to give them all a protective coating then add a mixture of equal parts of peat and sand, shake until the scales are thoroughly mixed with the compost, then seal the bag. It is essential that the peat / sand mixture is moist but not wet and that the bag is well sealed.

We store our filled bags under the staging in a glasshouse with a minimum night temperature of 50° F. and, in late winter and early spring, the scales having formed young bulbs are ready for spacing out in boxes to grow on.

Seed. The germination of lily seed has never presented many problems although for some species—and hybrids from them—a period of exposure to low temperatures is essential before germination will take place.

Some, and among these are *L. martagon, L. szovitsianum, L. canadense, L. superbum* and *L. japonicum,* exhibit hypogeal germination and have the annoying habit of showing no signs of growth any excess water; they are then placed in paper-lined seed trays and dried on a greenhouse bench.

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Some, and among these are *L. martagon, L. szovitsianum, L. canadense, L. superbum* and *L. japonicum,* exhibit hypogeal germination and have the annoying habit of showing no signs of growth above ground in the first year although forming minute bulbs below ground

Our method of sowing seed of hardy lilies enables us to deal adequately with both of these types. We prepare seed beds in containers in the normal manner but after sowing do not top-off with compost. We use instead a thin covering of gravel chippings of ¼ inch grade The containers are then stood, or if small, plunged in a shaded position under the north side of a wall in the open air.

We like to sow our seed in autumn or early winter although this is not always possible as small packets of seed arrive from various parts of the world at various times throughout the year and these we try to sow as soon as received.

A regular check should be made lest germination takes place earlier than anticipated. Seed of *L. auratum* and *L. speciosum,* if harvested under our usual damp and cool conditions and sown immediately, can germinate very rapidly.

It is our practice to bring the earlier sowings into a warm glasshouse (minimum night temperature 50° F.) in late January or early February and then growth is soon visible on those not having hypogeal germination Species known to have this trait are given about four weeks in warm temperatures then placed outside while the night temperatures can still fall fairly low; we find this treatment causes the timing mechanism of the young bulb to register the passing of a second winter and normal top growth appears in May or June, thus gaining one years growth.

The use of chippings for topping-off has a number of advantages over other methods of sowing. The heaviest of rains cannot dislodge either seed or compost; moss, algae, and liverwort does not grow easily on the surface and, something of supreme importance, the seed cannot become waterlogged as air will always follow water down through the chippings to the seed which is kept in contact with but is not buried by the compost.

GROWING.

Composts. It is not easy to specify a compost which is suitable for all lilies. We have in this genus a few which do very well in limy soils and, of these, *L. candidum* and *L. chalcedonicum* come immediately to mind; some thrive in peat (*L. japonicum* and *L. neilgherrense*) and many will do best under conditions between these two extremes. Lilies have, however, some requirements which they all share; they need sufficient humus in the soil to hold a reserve of moisture for them and they must have sharp drainage so that all surplus water rapidly drains away. The vast majority of them will do well in a compost that provides these conditions and is acid in reaction. Most of our loam has a pH of 5.5 and so we can provide suitable growing media by modifying our John Innes composts, stepping up the peat and sand content slightly and omitting the calcium carbonate.

Pricking-off and Potting-on. Almost any reference book on lilies will state that the pricking-off of seedlings should be done with the utmost care as any damage to the root system may result in the death of the seedling It is my experience that however carefully the work is done, the young bulb usually receives a check which causes yellowing of the foliage and the cessation of growth for that year We, therefore, endeavor to avoid pricking off seedlings. The quantities of seed we handle are usually small; we sow thinly 6 or 8 seeds in a 3 or 3½ inch pot and as soon as the root system is strong enough, move the pot-ball complete into a 6 inch pot. This is usually in the first year of growth and by the end of the second year the bulbs can be shaken out and planted in the open ground Some of the quicker growing species can be flowered in 18 months from sowing.

Feeding. We give an occasional watering with liquid fertilizer when the root system is strong enough to warrant this, using a feed with a 6N-6P-8K ratio, plus trace elements; we find this most beneficial, especially with slow growing types like *L. szovitsianum* which otherwise would remain for a long time in seed compost with very little nutrient available.

Disease Control. The foliage of young lilies should be protected throughout the growing season from attacks of *Botrytis; B. elliptica* and *B. cinerea* can cause complete collapse of the foliage and end growth for that season. The old established method of control—Bordeaux mixture—is still much used. More recently Benlate has been used experimentally with good results.

Basal rot, from *Fusarium oxysporum,* is a major risk with many lilies young or old; only *L. henryi* and its hybrids appear to have any real resistance. Sterilized soil, a clean water supply, the prompt removal of any diseased material, and dusting the bulbs with PCNB whenever they are handled are, at present, the best means of control. Benlate is proving useful in the control of basal rot of narcissus and of bulbous iris; it may also be found to be helpful with lilies.

Virus diseases should not be present in seedling lilies and strict control of aphids should keep them free from virus infection. Pirimor is proving useful in this respect.

Finally, may I say, that I fully realize that the methods we use at Wisley for our small quantities of seed may well be impracticable for larger quantities but my experience convinces me that root disturbance in the first year must at all costs be avoided and even if seed is sown in boxes or beds, a liquid fertilizer with high potash will give better results than pricking-off

PROPAGATION OF ACERS FROM SEED

PETER A HUTCHINSON

Brooksby Agricultural College, Brooksby, Melton Mowbray, Leicestershire

The following notes have been made with reference to the species listed below:

> *Acer campestre, A. cappadocicum, A. circinatum, A. crataegifolium, A. davidii, A. forrestii, A. ginnala, A. griseum, A. grosseri, A. grosseri* var *hersii, A. palmatum, A. palmatum* 'Atropurpureum' *A. pennsylvanicum, A. platanoides, A. pseudoplatanus, A. rufinerve* and *A. trautvetterii.*

Source of seed. Collection of seed from local sources is desirable generally; not only is it possible to collect at the optimum time but the seed can be selected from trees with desirable characteristics.

Seed of a limited range of *Acer* species can be purchased, usually from foreign sources, but results from these are often variable. This variability can be attributed to the drying out of the seed coat which, in turn, leads to the embryo becoming completely dormant. The drying of the seed does not necessarily mean it will not germinate, but germination tends to be erratic.

Seed collection. Due to variability in the time of flowering of the various *Acer* species, seeds are ready for collection over a long period, usually during September and early October. It is important not to follow the calendar too closely, but be guided by the appearance of the "keys" on the trees. The seed should be collected before the seed coat hardens. The colour of the "keys" is the best guide, and for the majority of the green-foliaged species it should be when the wings of the "keys" are yellow brown in colour. For *A. palmatum* 'Atropurpureum', the wings of the "keys" should be pink in colour.

After collecting the seed, it should be kept cool and prevented from drying out. This is easily achieved by placing the seed in polythene bags and storing in a cool shed. In order to facilitate sowing, the seed should be cleaned, removing all seed stalks and separating the "keys" singly

Siting of the seedbed. Frost and exposure to drying winds in the spring are damaging to germinating *Acer* seedlings; this should be borne in mind when selecting the site. Generally an open aspect is desirable and, for satisfactory development of the seedlings, the seedbed should be sited on soil which is easily worked and free draining. It is an advantage if the seedbed is raised above the surrounding area giving a greater depth of cultivated soil.

Preparation of seedbed. This operation should be carried out well in advance of sowing, allowing sufficient time for the natural settling of the seedbed. When preparing the seedbed the aim should be to encourage a well-branched and fibrous root system, ideal for transplanting. The seedbed should be prepared by incorporating liberal amounts of well-decomposed leaf mould or peat. If the soil is heavy, sharp grit should be added to aid drainage further.

During the preparation ensure that the soil in the rooting zone is not allowed to remain in large clods as this will not only inhibit root development but lead to the damaging of the root system at lifting time. Final preparation of the seedbed prior to sowing would be firming and raking level.

Sowing rate. Before sowing it is useful to assess the potential of each batch of seed by knowing the proportion of viable seeds in each sample This can be estimated by taking a random sample of 50 or 100 seeds (more if seed is plentiful) and cut through the seed, observing whether or not the embryo has developed.

Having carried out this simple practical test, the aim should be to sow the seed to produce seedlings as large as is economically possible. The viability figure must also be modified by the field factor (the estimated losses after sowing until establishment due to soil and climatic conditions) to give the final sowing rate.

Example—*A. platanoides*

Viable seed per batch 80%

Field Factor 60%

Number of plants required per sq yard: 300

Number of seeds per sq. yard $\frac{100}{80} \times \frac{100}{60} \times \frac{300}{1} = 625$

Seed sowing. It is important that the seed be sown as soon as possible after harvesting. The usual method is to broadcast seed evenly over the seedbed. The seed should then be pressed into the soil surface and covered with ½ in. to 1 in. of sharp grit (¼ in. to ⅜ in. grade). The depth of covering depends on the size of seed. This generous dressing of grit is necessary in order to anchor the seed in the seedbed and prevent erosion by winter weather Covering with grit has several advantages. It prevents surface capping allowing easy penetration of water, conserves moisture, gives good surface aeration and enables weeds to be removed easily. Under most circumstances it will be necessary to protect against birds, mice, etc.

Frost protection. Depending on species and the weather conditions in late winter, germination can be expected from mid-March onwards. The seedlings are easily damaged at this stage and some method of frost protection would have to be employed.

Shading. From germination and throughout the first season it is necessary to shade all species mentioned except *A. campestre, A. platanoides, A. pseudoplatanus* and *A. trautvetteri.* Materials giving 50% shade are ideal.

Irrigation. Apart from the initial watering in, no artificial application of water is usually required until the following spring. However, after germination regular watering will be necessary to keep the seedlings growing in order to promote a vigorous shoot and root system

Weed control. Removal of weed competition at an early stage is vital. Due to the rather loose nature of the surface of the seedbed, weed seedlings are easily and quickly removed by hand. If a weed population builds up before germination commences a contact herbicide, such as Paraquat, could be used to burn off surface foliage.

In conclusion, the importance of early collection and sowing cannot be over emphasized. It is this attention to detail, not allowing the seed to dry out, that ensures an even germination the following spring. If seeds of such plants as *A. campestre, A. circinatum* and *A. palmatum* are allowed to dry out germination will not take place until the second season.

PROPAGATION OF EXBURY AND KNAPHILL AZALEAS

CHRISTOPHER C. FAIRWEATHER

Exbury Gardens Limited, Exbury, Nr. Southampton

Cuttings of Exbury and Knaphill azaleas are taken during late May and early June. The first cuttings are from container plants grown under glass, followed by soft cuttings from outside plants Cuttings generally are about 3 inches long and, from a long shoot, two cuttings can be made. The apex bud is removed from all cuttings and the leaves reduced to about five.

The cuttings are rooted in old span-frames running north to south. The frames have heating cables with individual thermostats for temperature control. Prior to putting in the cuttings, these frames have a layer of sand over the cable, followed by one foot of leaves for drainage and for preventing the mixture from becoming too compacted and, finally, 6 inches of rooting medium, consisting of 75% sharp sand and grit and 25% medium Irish moss peat. The rooting medium is allowed to settle, given a drench of 1% IBA, diluted to 25 c c per pint of water. One gallon of this mix is watered over about three square yards.

The cuttings are then inserted at about 2 inch spacings; bottom heat is set to a minimum of 70° F and the cuttings are given a supplementary cover of polythene. Approximately 15 hours after the

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When the cuttings start to callus (around six weeks) the second covering of polythene is removed and the bottom heat reduced to around 60° F., also some air is given during the early morning and evening. Supplementary light is given from mid-July to early October for three hours per day. The bottom heat is further reduced and completely turned off during the winter. Hand watering is carried out twice daily as required. Any aphid problems are solved with Metasystox.

During the spring the plants begin to grow and will give a batch of early cuttings in late May. If the bottom heat is turned on these cuttings can be rooted very early. After these first cuttings are removed we allow the plants to grow again prior to planting them into well-prepared frames during July, at about 9" spacing. Second year plants can be sold or containered and usually make 18 inch selected plants in the third year

THE DISTRIBUTION OF VIRUSES IN ORNAMENTAL MALUS AND THEIR EFFECT ON GROWTH

A. I. CAMPBELL

Long Ashton Research Station,
Long Ashton, Bristol

Many nursery catalogues list between 10 and 20 ornamental *Malus* species, and with the introduction of new cultivars, usually from America or Holland, the popularity of this group of trees seems to be increasing

Few other ornamental shrubs or trees have such valuable attributes and, although ornamental *Malus* are primarily grown for their spring flowers, many are attractive at other times of the year. Some, for example *Malus x. purpurea* 'Lemoinei' and *M. tschonoskii,* have interesting coloured foliage throughout the summer, while others have highly coloured fruit and foliage in the autumn.

The trees are usually sold after 3 or 4 years in the nursery as standards or half-standards. Seedling crab rootstocks are commonly used because propagation difficulties have increased when clonal rootstocks are used. The problems have taken the form of bud failures with some cultivars, while in others the growth rate has been unsatisfactory and dieback has been common.

One of the main factors causing these difficulties has been shown to be viruses in the propagating material. The same viruses are cuttings are inserted, they are given a good watering—almost to flooding the plants—with a hosepipe and fine rose nozzle. The frames are covered with shading material and, during the initial stages, light is given only during the early morning and late evening.

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One of the main factors causing these difficulties has been shown to be viruses in the propagating material. The same viruses are common in most dessert and culinary apples and in many of the older series of clonal rootstocks where they usually show no disease symptoms.

Experiments have been in progress at Long Ashton since 1967 to examine the propagating material being used in the nurseries and to improve it where necessary.

VIRUS DISTRIBUTION IN NURSERIES

Budwood of 21 *Malus* cultivars was obtained from six of the leading nurseries in the summer of 1968. The material was virus tested on seedling apple rootstocks using the double budding technique commonly used for fruit trees. The virus indicators used and the viruses they show are as follows:

Sensitive indicators	Virus disease
Lord Lambourne	Mosaic, rubbery wood and chat fruit
Russian R12740-7A	Chlorotic leaf spot
Spy 227	Epinasty and decline
Virginia Crab	Stem pitting and stem grooving
Malus platycarpa	Chlorotic leaf spot and scaly bark

It can be seen (Table 1) that virus infections were common and that trees from many sources were infected with more than one virus (Bottom figure shows number of sources tested, top figure number infected). In general, the green-leaved cultivars were more virus tolerant but, although they looked more healthy, they were often carrying several viruses The red-leaved cultivars, by contrast, were often virus sensitive and, since infected trees often died, budwood was only available from healthy sources.

The budwood obtained from some nurseries was considerably better than that from others and, in several instances, virus-free selections were found. The virus incidence in 65 sources of 21 cultivars was as follows:

Virus	No. of Infected Sources
Mosaic	0
Rubbery wood	1
Chat fruit	0
Chlorotic leaf spot	18
Epinasty and decline	24
Stem pitting	17
Stem grooving	3
Scaly bark	5

No evidence was seen that apple mosaic or chat fruit viruses were present in any of the material tested and subsequent experiments have shown that none of the sources were likely to have been infected with star crack virus.

Table 1.Virus infections found in various ornamental *Malus* plants obtained from different sources.

Ornamental Malus	Virus Indicators: Lord Lambourne	Russian R12740-7A	Spy 227	Virginia Crab	Malus platycarpa
'Aldenhamensis'	0/6 *	1/6	1/6	1/6	1/6
'Dartmouth Crab'	1/1	1/1	1/1	1/1	0/1
'Eleyi'	0/1	0/3	0/3	0/3	0/3
'Exzellenz Thiel'	0/1	1/1	1/1	1/1	0/1
floribunda	0/5	2/5	5/5	1/5	0/5
'Golden Hornet'	0/5	0/5	0/5	0/5	0/5
'Hillier'	0/3	3/3	3/3	3/3	3/3
'John Downie	0/5	1/5	3/5	2/5	0/5
'Lemoinei'	0/4	0/4	0/4	0/4	0/4
magdeburgensis	1/6	3/6	4/6	4/6	2/6
prunifolia	0/2	2/2	2/2	2/2	0/2
'Profusion'	0/5	1/5	1/5	1/5	0/5
purpurea	0/5	1/5	1/5	1/5	0/5
sargentii	0/4	0/4	0/4	0/4	0/4
tschonoskii	0/6	2/6	2/6	0/6	0/6

Others tested: —

arnoldiana, hupehensis 'Rosea', 'Gibbs' Golden Gage', 'Wisley Crab', 'Simcoe' and robusta.
(One source of each tested and found to be free from infection)

* First figure —no. of sources infected
Second figure—no. of sources tested

VIRUS DISTRIBUTION IN OLDER TREES

In order to test the virus infection level in twenty-year-old trees of ornamental *Malus*, two museum collections were examined in the same way as the nursery sources. The results indicated that more than half of the trees were infected, usually with chlorotic leaf spot and stem pitting viruses, either in combination or singly. No evidence was found that any of the other viruses were present. The results also suggest that little spread of these diseases occurs after planting and that nearly all the distribution is through the use of infected scions or rootstocks. Similar results have been obtained with this group of viruses in dessert apples and the vectors, if they occur, are either very uncommon or inefficient.

Experiments have shown that these viruses are not transmitted through the seed, therefore the use of seedling rootstocks for ornamental *Malus* has helped to prevent a wider distribution of the diseases. If infected clonal rootstocks had been widely used the virus distribution would have been at a higher level.

VIRUS SENSITIVITY

The sensitivity of 12 *Malus* species and cultivars to 9 different known virus infections was examined by inserting an inoculation bud into 4 trees of each *Malus* species. The effect of the inoculation, as

Table 2. The sensitivity of twelve *Malus* species and cultivars to nine pome fruit viruses.

Ornamental Malus	† *Virus Sensitivity*								
	AM	RW	EDV	CLSV	SPV	VY	QSV	QSRV	RPM
'Cowichan'	VS	VS	S	VS	VS	T	S	T	T
floribunda	S	S	VS	T	S	S	T	T	T
glaucescens	S	VS	VS	S	S	S	S	S	S
'Hopa'	S	S	T	S	S	T	T	T	S
hupehensis	S	T	T	S	S	T	T	T	T
'Lemoine'	VS	VS	S	S	VS	T	T	T	S
prunifolia 'Rinki'	T	T	VS	S	T	T	T	T	T
'Purple Wave'	VS	VS	VS	VS	VS	T	T	T	S
'Robert's Crab'	VS	VS	S	S	VS	S	T	T	S
sargentii	VS	S	VS	S	S	T	T	T	S
sikkimensis	VS	T	T	T	T	T	T	T	T
toringoides	T	T	T	S	T	T	T	T	S

† Key to viruses —

AM = Mosiac
RW = Rubbery wood
EDV = Epinasty and decline
CLSV = Chlorotic leaf spot
SPV = Stem pitting
VY = Vein yellows
QSV = Quince stunt
QSRS = Quince sooty ring spot
RPM = Ring pattern mosaic

* VS = Very sensitive
S = Sensitive
T = Tolerant

measured by the height and weight of the trees produced in two years, is given in Table 2.

It can be seen that the *Malus* cultivars differed greatly in their sensitivity to apple and pear viruses. Since these diseases often occur in groups and different strains are recognized, it is not surprising that the results from each nursery were different.

The virus symptoms begin to appear in the spring soon after infection. Some stock / scion combinations fail completely and the bud dies away slowly. (Fig. 1). Others produce a small rosette of leaves which remain alive for a few weeks, often in a distorted condition, then gradually die back (Fig. 2). Sometimes cultivars produce a weak primary shoot and the virus symptoms can be seen as a ring or line pattern, usually chlorotic, on the leaves which are often malformed and distorted (Fig. 3). The tips of shoots may also die back and become stunted so that a weak worthless tree is produced, often with bark

Fig. 1. Virus symptoms: Failure of stock-scion combination and bud death. *Left. Malus* **'Purple Wave' — healthy.** *Right. Malus* **'Purple Wave' — infected with apple mosaic virus.**

Fig. 2. **Virus symptoms: Leaf distortions.** *Top left. Malus* **'Hopa'—healthy.** *Top right. Malus* **'Hopa'—infected with stem pitting virus.** *Lower left. Malus prunifolia*—**healthy.** *Lower right. Malus prunifolia*—**infected with epinasty and decline virus.**

Fig. 3. Virus symptoms: Leaf patterns. *Left. Malus glaucescens. Center. Malus* 'Cowichan'. *Right. Malus floribunda.* All the above show chlorotic leaf spot virus symptoms.

Fig. 4. Virus symptoms: Shoot dieback. *Left. Malus floribunda* — healthy. *Right. Malus floribunda* — infected with epinasty and decline virus.

breakdown and a poor union with the rootstock (Figs. 4 and 5). Infected trees allowed to continue growing will later produce undersized flowers and fruits which often show considerable distortion and russetting.

THE PRODUCTION OF HEALTHY PROPAGATING MATERIAL

Clones of a number of cultivars have been shown to be free from all virus infections after tests on five indicators and these have been multiplied for distribution. Where no virus-free sources could be found heat treatment has been carried out to inactivate the viruses.

Fig. 5. **Virus symptoms: Shoot dieback.** *Left.* **— healthy.** *Right* **— infected with three viruses: chlorotic leaf spot, stem pitting, and epinasty and decline.** *Malus* x *micromalus.*

The methods used are similar to those employed with fruit trees, and consist of growing young plants in pots in a hot air chamber at 37° C. (98° F.) for 4 weeks. This is followed by wedge grafting the tip

(½ inch) of the young shoot on to an apple seedling. The new plant is later virus-tested thoroughly before final multiplication for distribution. The stages of this process as they apply to fruit trees and ornamental *Malus* are shown in Fig. 6.

Small quantities of budwood of a number of virus-tested clones of ornamental *Malus* cultivars have been available to nurserymen from Long Ashton Research Station since 1970. The number of cultivars has continued to increase as heat treatment and tests at both East Malling and Long Ashton are completed and in the summer of 1972 the cultivars in Table 3 will be available as budwood from Long Ashton. In addition, mother trees of some of these have been raised and will be released through the Nuclear Stocks Association (Tree Fruits) as soon as virus tests have been completed.

Although the use of virus-tested clones will improve the standard of growth of ornamental *Malus* in many nurseries, other cultural factors are also important. Many cultivars, for example, are

Table 3. Virus Tested Ornamental *Malus* species available as budwood from Long Ashton Research Station in mid-1972.

M. x *purpurea* 'Aldenhamensis'	*M.* 'John Downie'
M. x *arnoldiana*	*M.* x 'Lemoinei'
M. 'Almey'	*M.* x *magdeburgensis*
M. x *atrosanguinea*	*M.* 'Makamik
M. coronaria 'Charlottae'	*M.* 'Oaks'
M. coronaria 'Nieuwlandiana'	*M.* x *purpurea*
M. 'Cowichan'	*M.* 'Purple Wave'
M. 'Dorothea'	*M.* 'Red Glow'
M. x *purpurea* 'Eleyi'	*M.* 'Red Jade' (weeping)
M. 'Elk River'	*M.* x *robusta* 'Erecta'
M.'Gibbs' Golden Gage'	*M. sargentii*
M. 'Golden Hornet'	*M.* 'Simcoe'
M. 'Golden Gem'	*M. toringoides*
M. 'Henry F. DuPont'	*M. tschonoskii*
M. 'Hopa'	*M.* 'Veitch's Scarlet'
M. hupehensis	*M.* 'Wisley Crab'
M. hupehensis 'Rosea'	

susceptible to apple mildew and scab and a more efficient spraying programme will often ensure a considerable increase in tree growth. Difficulties have also been experienced by some nurserymen in budding some of the red-leaved cultivars such as *M.* x *purpurea* 'Lemoinei' and *M.* x *purpurea* 'Eleyi'. This is not likely to be a virus problem if strong budwood is available, and the "inverted T" method of budding has given good results with these cultivars at Long Ashton.

More uniform trees of many of the ornamental *Malus* have been raised on a number of the semi-dwarfing EMLA clonal rootstocks such as M.26, MM.106 and MM.111 and these might be of value where smaller trees more suitable for the garden are required.

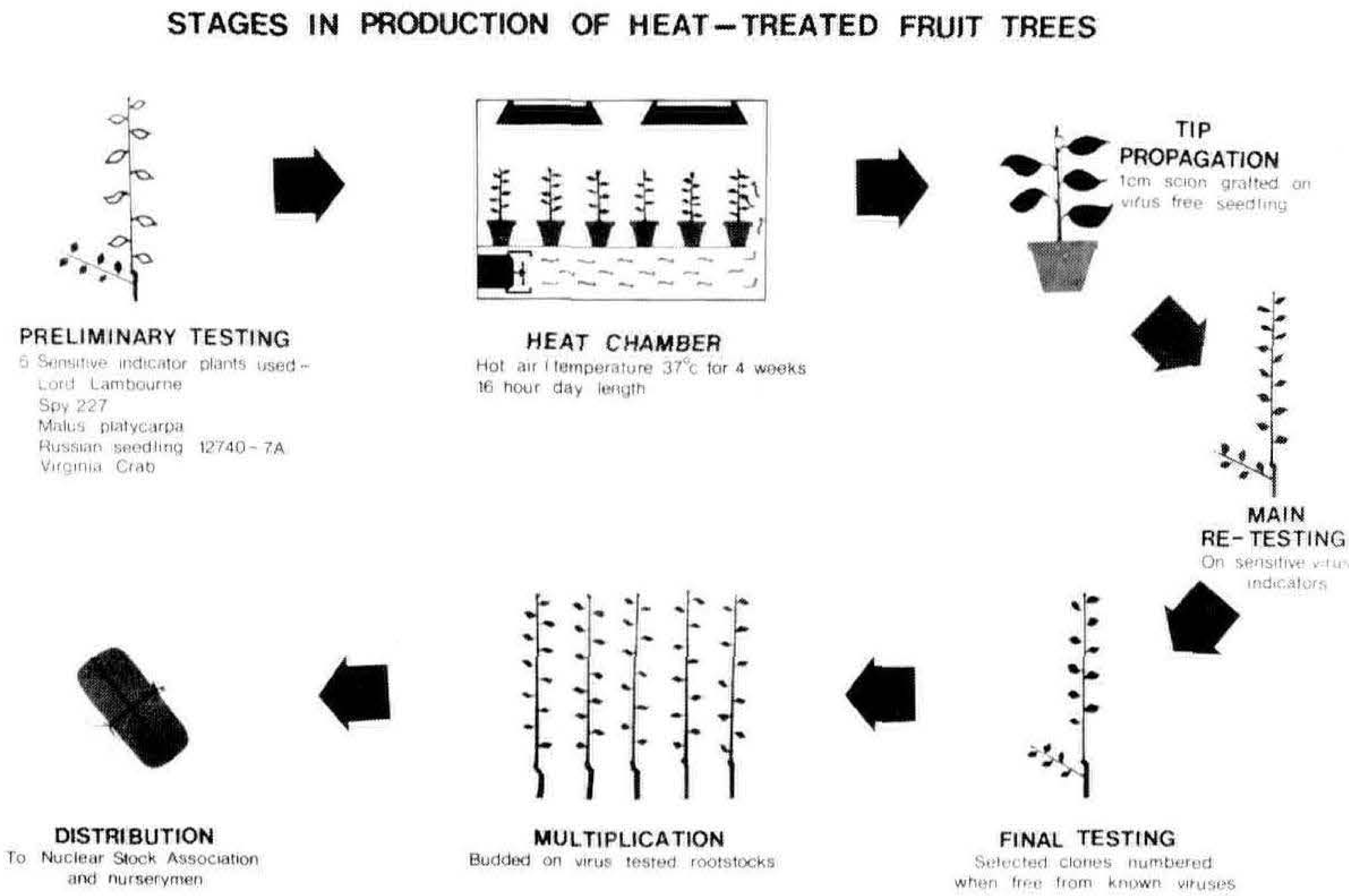

Fig. 6. Stages in the production of virus-tested fruit trees and ornamental *Malus* trees.

PROPAGATION OF CLEMATIS

TOM ALLEN

James Coles and Sons
Thurnby, Leicestershire

Grafting. The *Clematis vitalba* rootstocks are lifted and laid in thinly in the autumn. Stock plants of the scion varieties should be chosen carefully because only strong healthy plants are suitable. These are potted into 5 in. pots using John Innes 3 compost and set up in a house with temperature of 55° F. at the end of December. By the end of January they will have made about four feet of growth and grafting may commence. Rootstocks should be washed as clean as possible. A single side-graft is used; the length of the scion cut exceeds slightly that of the cut on the rootstocks, as the tongue of scion wood protruding below the tie of fine raffia assists scion rooting.

After grafting, the plants are potted as deeply as possible into 2½ in. pots in John Innes seed compost, so that only the leaf and bud is left above the soil. The plants are set into a closed case with a bottom heat of 70-80° F. and watered well. After 2 or 3 weeks callus will form on the top of the stock and the bud will start to grow; the grafts can then be placed on an open bench with house temperature of 60° F. When 6 in.

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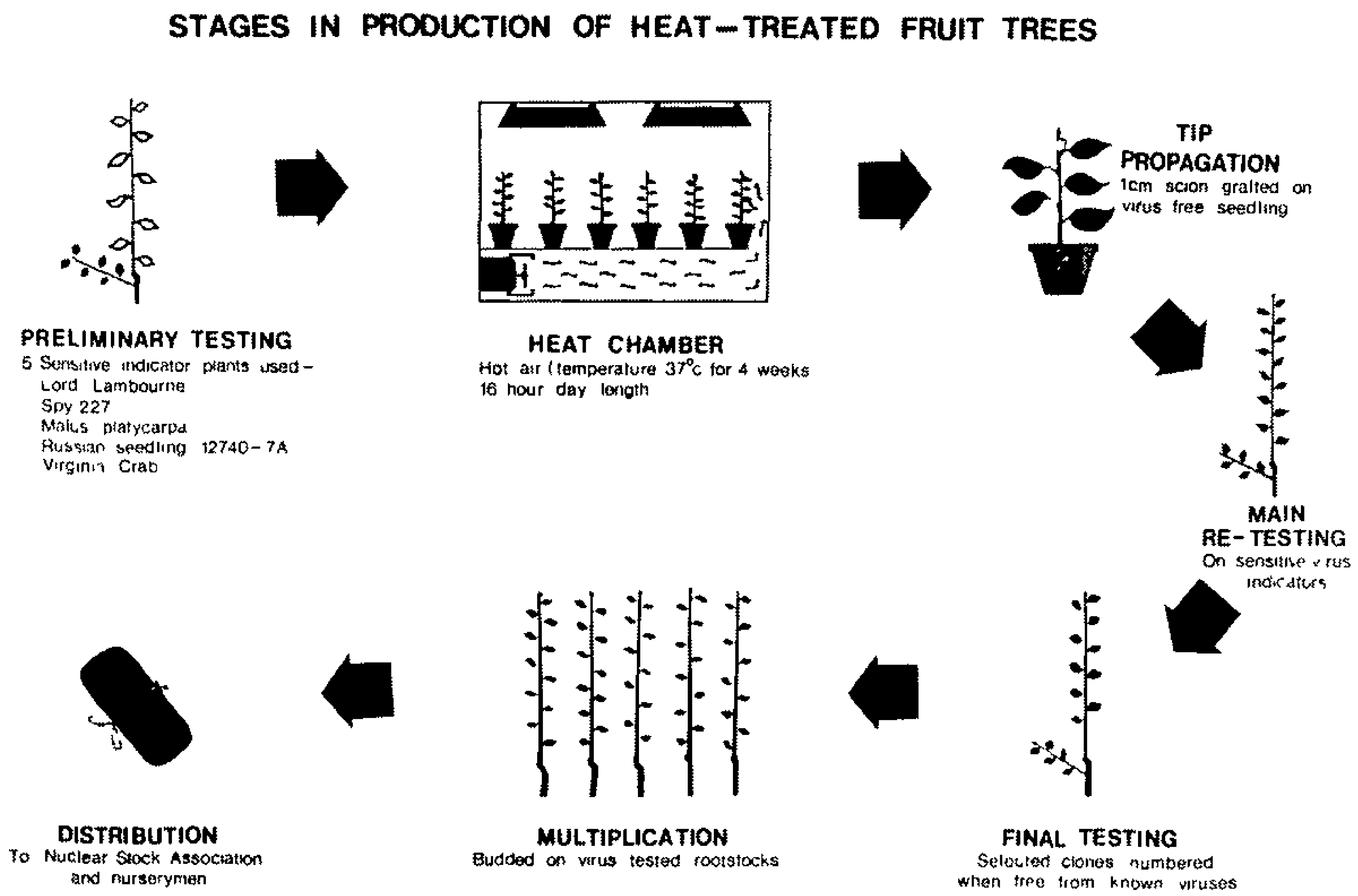

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high they should be staked with 18 in. splits. Six weeks later they will be ready for potting on into larger pots and growing on for sale the same year.

Cuttings. Stock plants should be prepared as for grafting, but they should be kept frost free during the winter. In the spring they will grow away very strongly and by late April or early May the wood should be ready for making the internodal cuttings. Cuttings 2 inches in length are ideal Most of the wood can be used, discarding only the soft tips.

Cuttings are then dipped in Seradix No. 1 powder and inserted eight into a 3 in pot, in a compost of two parts sand, one part peat. The cuttings are arranged around the edge of the pot and dibbed as deeply as possible; by this method the buds are kept soft and moist.

The pots of cuttings are then placed into a closed case with a bottom heat of 70-80° F Great care has to be taken at this stage because the spring sun can be very strong and shading will have to be used. The cuttings will be rooted in three or four weeks and ventilation can then gradually be given When fully aired the cuttings should be potted on. We use John Innes seed compost and 2½ in. pots; the plants can be summered in a cold house or cold frame.

The buds having been kept soft and moist will now break and grow away quickly. The plants must be kept frost free in the early part of the winter and then potted before Christmas into 4½ in. 'Long Toms' using John Innes 3 mixture, and then kept frost free for the rest of the winter. The plants will then grow on early in the spring. By letting them grow this way one can do away with stock plants and use the young plants for propagation. They will still make strong plants for sale by late summer.

BERRIED FRUIT PROPAGATION

A. R FLINT

Woodshoot Nurseries, Kings Bromley,
Burton-on-Trent, Staffordshire

The main reason for choosing our particular site in the Midlands for growing soft and berried fruits was the soil. It is ideal, in our opinion, for producing a strong fibrous root system which, though important to all plants, is especially so with berried fruits. In texture it is a sandy loam overlying water-bearing gravel and is, therefore, well drained and low in mineral nutrients Regular fertilizer applications and FYM, when available, ensure that the plants remain healthy; a heavy rainstorm can wash a fertilizer application straight through but, on the other hand, during a dry period we find our irrigation system invaluable. The spring of each year seems to bring a regular high they should be staked with 18 in. splits. Six weeks later they will be ready for potting on into larger pots and growing on for sale the same year.

Cuttings. Stock plants should be prepared as for grafting, but they should be kept frost free during the winter. In the spring they will grow away very strongly and by late April or early May the wood should be ready for making the internodal cuttings. Cuttings 2 inches in length are ideal Most of the wood can be used, discarding only the soft tips.

Cuttings are then dipped in Seradix No. 1 powder and inserted eight into a 3 in pot, in a compost of two parts sand, one part peat. The cuttings are arranged around the edge of the pot and dibbed as deeply as possible; by this method the buds are kept soft and moist.

The pots of cuttings are then placed into a closed case with a bottom heat of 70-80° F Great care has to be taken at this stage because the spring sun can be very strong and shading will have to be used. The cuttings will be rooted in three or four weeks and ventilation can then gradually be given When fully aired the cuttings should be potted on. We use John Innes seed compost and 2½ in. pots; the plants can be summered in a cold house or cold frame.

The buds having been kept soft and moist will now break and grow away quickly. The plants must be kept frost free in the early part of the winter and then potted before Christmas into 4½ in. 'Long Toms' using John Innes 3 mixture, and then kept frost free for the rest of the winter. The plants will then grow on early in the spring. By letting them grow this way one can do away with stock plants and use the young plants for propagation. They will still make strong plants for sale by late summer.

BERRIED FRUIT PROPAGATION

A. R FLINT

Woodshoot Nurseries, Kings Bromley,
Burton-on-Trent, Staffordshire

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Stock Plants. Stock plants from which to propagate the various fruit bushes are maintained on the nursery. There is no need to go into the do's and don'ts of stock plant maintenance at this time to members of this Society. Suffice to say that they are kept weed free by using Simazine at 1 lb. (a.i.) / acre. Blackcurrants are sprayed with Metasystox from mid-May for the control of aphis, capsid and blackcurrant leaf midge. This is applied at 12 fl. oz per acre in 60 gallons of water, which gives a good control Mildew is controlled with benomyl at 1 lb. per acre in 100 gallons water. Several applications are given from mid-May. Gooseberries and redcurrants also receive benomyl sprays against mildew, and the gooseberry sawfly is sprayed with Gusathion.

Hardwood Cuttings. Having established a healthy source of plant material, *Ribes nigrum* (blackcurrants), *R. rubrum* (redcurrant), *R. rubrum* 'Album' (whitecurrant) and *R. grossularia* gooseberry) are all propagated from hardwood winter cuttings. This is usually kept as a bad-weather job which can be done when there is little else to do. Blackcurrant cuttings are made in bunches with little ceremony. The cuttings are made approximately 8 in. long and, if the weather is unsuitable for inserting, the cuttings are heeled-in to await more favourable conditions.

Redcurrant and gooseberry cuttings are made about 12 in. long and are prepared with more care. The buds of both of these, and the thorns of the gooseberry, are removed on the lower 8 in. of the cutting to make a "leg" for the plant. Care must be taken not to select the soft, unripened, wood of the gooseberry tips as this will rot. Although any time during the dormant period will do, we have found October to be the best month for making gooseberry cuttings. They are then healed in until February, when they are lined out in the field. If the cuttings are inserted before February there is a danger that the cuttings will be lifted by the frost, and then later left with the base of the cutting in an air pocket ¼ in. or so above its original position. There is then very little chance of this cutting growing due to its having dried out. Before inserting the cuttings the ground is prepared with an application of fertilizer. The cuttings are inserted in rows 3 feet apart. These rows are made by single cultivator tines drawn through the ground at a depth of 5 to 6 inches; the cuttings are then pushed into the very soft ground to this depth and firmed thoroughly After a light cultivation between the rows the ground is sprayed with Simazine, which keeps it clean throughout the summer. The plants are irrigated as required, particularly in any dry period in the spring and, in the autumn, the rooted cuttings are lifted, cut back and planted onto nursery rows.

Tip Layering. *Rubus* x *loganobaccus* (loganberry), *R. fruticosus* (blackberry), *R. phoenicolasius* (Japanese wineberry), and other hybrid berries, are propagated by tip layering of the shoots. They can be propagated successfully from summer "hammer cuttings" but, at present, we find that we get a stronger plant for lining out the following year by using the tipping method. This is done using established stool plants from which the shoots have been stopped twice to provide as much tipping material as possible. Tipping is usually done in August by making a sharp angled hole about 4 to 6 inches deep into which the tip of the shoot is placed. The soil is replaced and firmed. The tip roots in about three weeks and the shoot turns back up towards the surface. The following spring the old shoot is removed completely from the stool plant and cut off a few inches above soil level at the tip. The tips are lifted and lined out in the nursery 1 ft. apart in 3 ft. rows. There is a tendency for these plants to produce only one shoot, which is not sufficient, therefore they are usually cut back to encourage branching. The ground is sprayed with Simazine after planting.

Spawn Beds. *Rubus idaeus* (raspberries) are the only plants that we produce on spawn beds. The beds are planted up with small canes, which have been cut down to 4 in. above the root, at 4 in. by 3 ft. This is done in the spring. By November of the same year the saleable canes can be dug up. Any small canes remaining are cut down and, in January, the bed is sprayed with Paraquat. The second year's canes produce a solid bed and no rows can be seen. At the end of the second year's growth the whole bed is dug up, the large canes sold and the remainder planted once more. We find that we cannot leave the canes to spawn more often than this due to weed problems. In our sandy soil couch grass grows luxuriently, appearing from nowhere, and covering a tremendous area in a season. Cultivations are not possible as there are no rows and, so far, we have not found chemical controls good or cheap enough.

ROOTING CUTTINGS UNDER POLYTHENE TUNNELS

J. L. W. DEEN

Glasshouse Crops Research Institute,
Littlehampton, Sussex

In this short review of the use of low polythene tunnels for rooting cuttings it will not be possible to consider all aspects of the technique. The system used at G.C.R.I. will be described and some observations will be made on its use.

The important advantages of low capital cost and labour saving come from the simplicity of the technique and I have tried, therefore, to maintain this simplicity wherever possible.

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Tunnel construction. The tunnel design is basically that widely used in Great Britain for protected strawberry cropping. The wire hoops which support the polythene are bent into the required shape (Fig. 1) on a former from lengths of galvanized wire (8 swg with a tensile strength of 50 ton / in). The hoops are spaced 30 in. apart along the tunnel (Fig. 1). Polythene sheet 6 feet wide is tied to a stake at the end of the tunnel and stretched over the hoops. It is secured by lacing two lengths of polypropylene bailer twine under alternate loops on either side of the tunnel (Fig. 1). This type of construction allows the inspection of cuttings at any time by lifting the polythene at the sides of the tunnel (Fig. 2). The construction can also be mechanized to a large

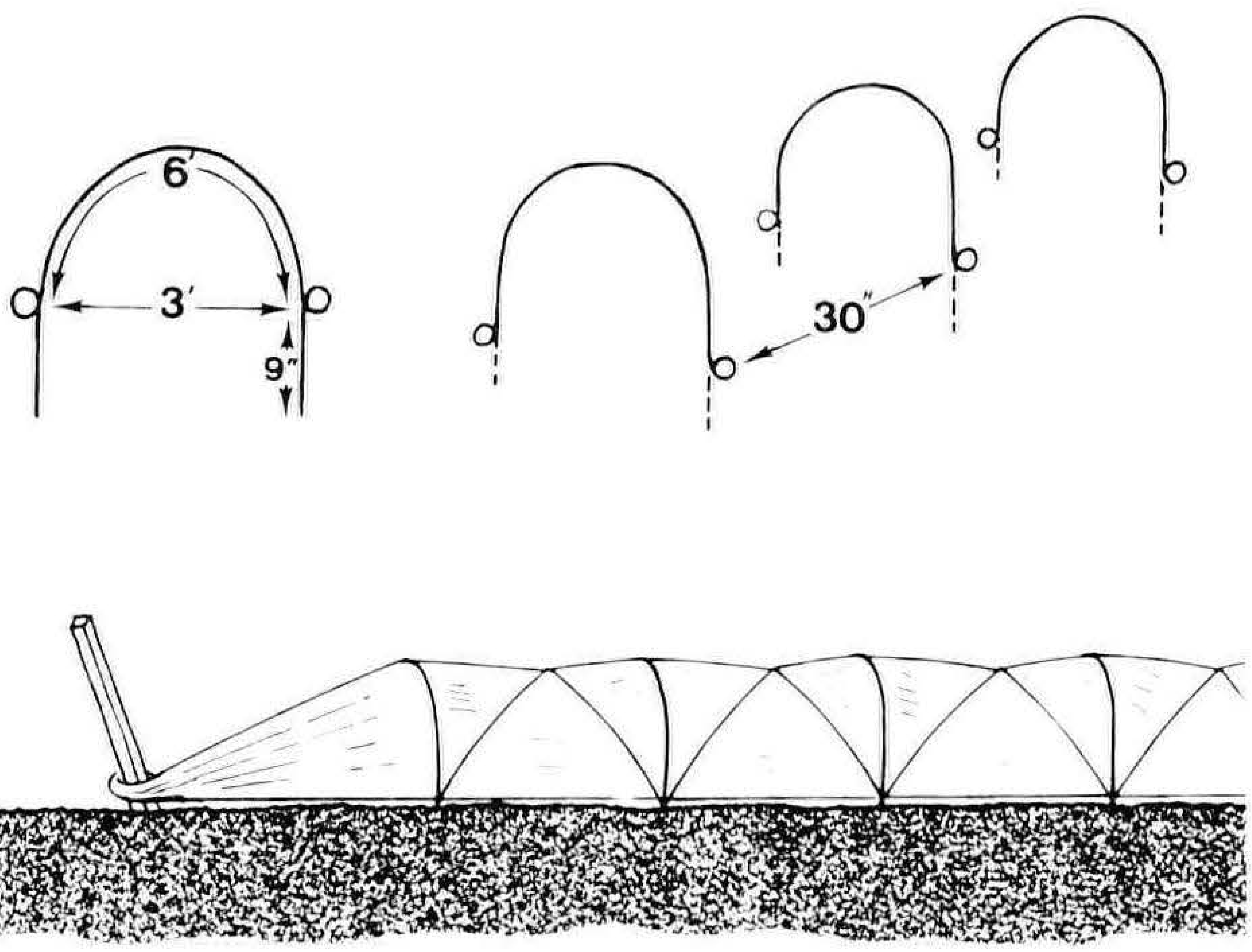


Fig. 1. *Top.* **Hoop construction.**
Left. **Dimensions.** *Right.* **Spacing.**
Bottom. **Polythene tunnel construction.**

extent with simple machinery to construct the hoops, space them out in the field and to lay out the polythene.

Weed control. Control of weeds prior to inserting the cuttings must be good because conditions are ideal for weed growth. Soil fumigants offer a safe and effective method. In trials in 1971 I compared the use of methyl bromide and Dazomet. Methyl bromide has to be applied in Great Britain by contractors and is more costly than Dazomet but it has certain advantages which are worthy of comment.

Methyl bromide is easily applied by injecting the vapour from 1 lb. canisters under polythene sheeting at the rate of 1 lb. / 100 ft. Fumigation is completed in three days and the sheet can be removed to allow aeration for a further two days.

Fig. 2. Completed tunnel with one side raised.

Application of Dazomet is a much lengthier process. The chemical is rotovated into the soil and the surface sealed by rolling and flooding or by covering with polythene sheeting. The seal can be broken after two weeks and a further two weeks are required for aeration of the soil.

Weed control with methyl bromide was excellent. Control was satisfactory with Dazomet applied in the prilled form at 300 lb. commercial product / acre but at half this rate control was very poor.

Soil preparation. After soil fumigation is completed a very simple rooting medium is prepared by turning peat into the top few inches of soil. On less well drained soil a rooting medium of peat / sand, or sand alone, on a raised bed may be required.

Irrigation. Water loss from the soil under white translucent polythene is very low and very little irrigation may be required. A simple trickle irrigation system has been used as an insurance against a prolonged hot dry spell during the propagation period. For relatively easy-to-root subjects overhead misting is not considered necessary.

Cuttings—timing, type and spacing. The simple system described is only suitable for semi-mature cuttings of relatively easy-to-root subjects. Little useful purpose would be served by listing those plants which have been successfully rooted under polythene tunnels. The propagator should use his experience with rooting of a particular plant by traditional methods to assess its potential under polythene tunnels.

Cuttings of the correct maturity are available from late June onwards. Cuttings of certain deciduous subjects must be taken early or poor overwintering will result.

Cuttings are spaced according to the vigour of the plant, 3 in. x 3 in. being the average. After rooting has taken place (a period of about four weeks with most cuttings) weaning is achieved by progressively raising the sides of the tunnel. The raised polythene can be left in position to provide shading and protection or it can be removed when weaning is completed. The cuttings are left *in situ* through the first winter and the following growing season. They are lifted the following winter as well-established field grown plants that have not suffered any of the checks to growth of lifting, potting and planting out.

Soil and air temperatures. Although a white translucent polythene film imported from Denmark has been used very successfully as a covering material for polythene tunnels, it seemed worthwhile to look at the temperature conditions obtained under this film compared with clear polythene, and to see how closely the conditions obtained fitted the known requirements for rooting cuttings. Temperature recordings were made at hourly intervals over a period of several days in the air and at various depths in the soil. The temperatures recorded on two consecutive but contrasting days are presented here (Figs. 3, 4). The first day was generally warm with long sunny periods; the second was dull, overcast and entirely sunless. During the first day the air temperature under both clear and white polythene rose above ambient, but during sunny periods undesirably high temperatures were reached under the clear polythene. Temperatures under both polythene covers and outside fell to within a few degrees during the night and the excessively high temperatures of the first day were not recorded in the second day although the same pattern was followed.

The soil temperature recorded at 1 inch depth, about the level of the base of cuttings, showed a rather different pattern. There was very

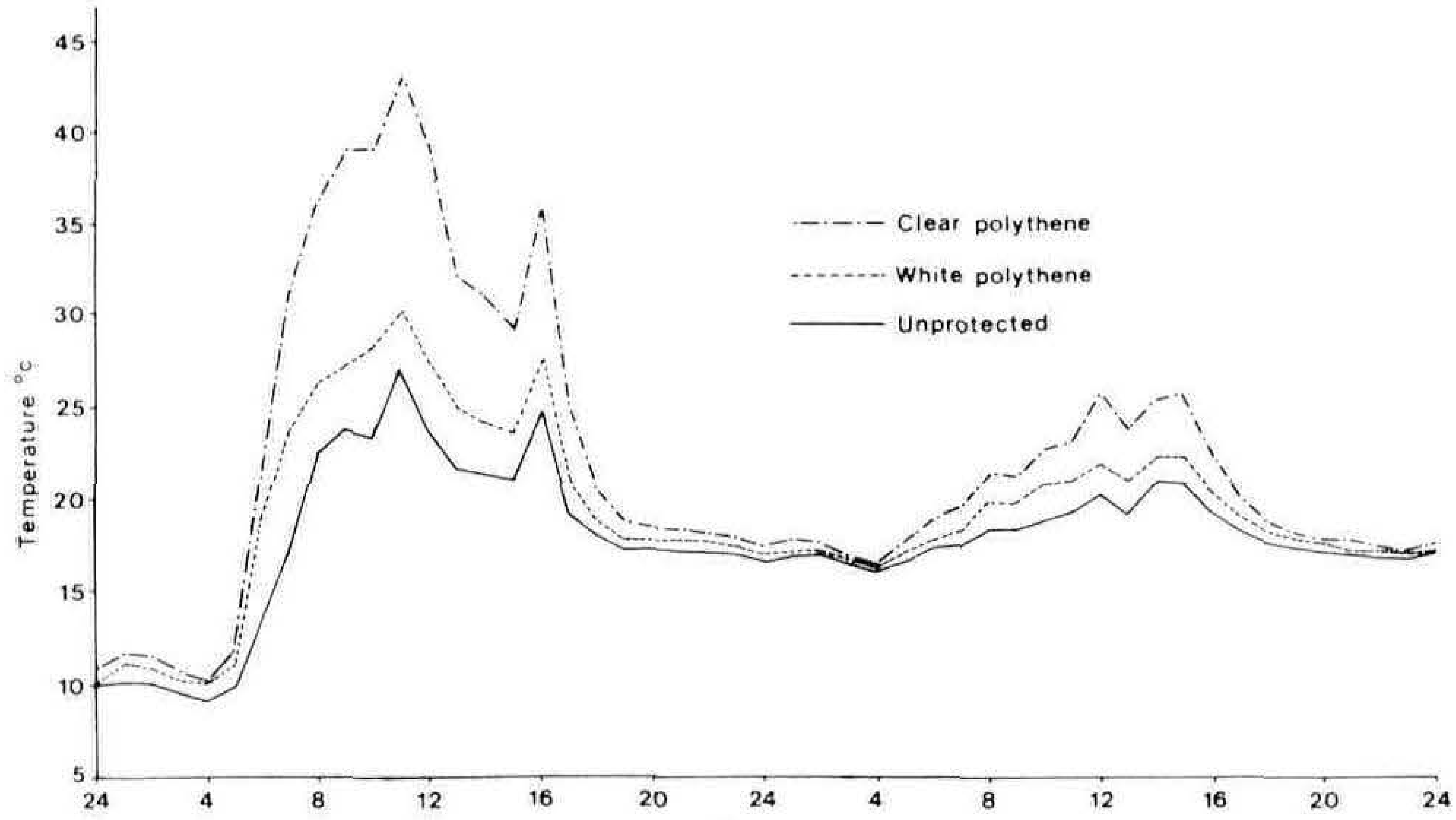


Fig. 3. Air temperature three inches above the soil surface recorded on 8, 9 August, 1971.

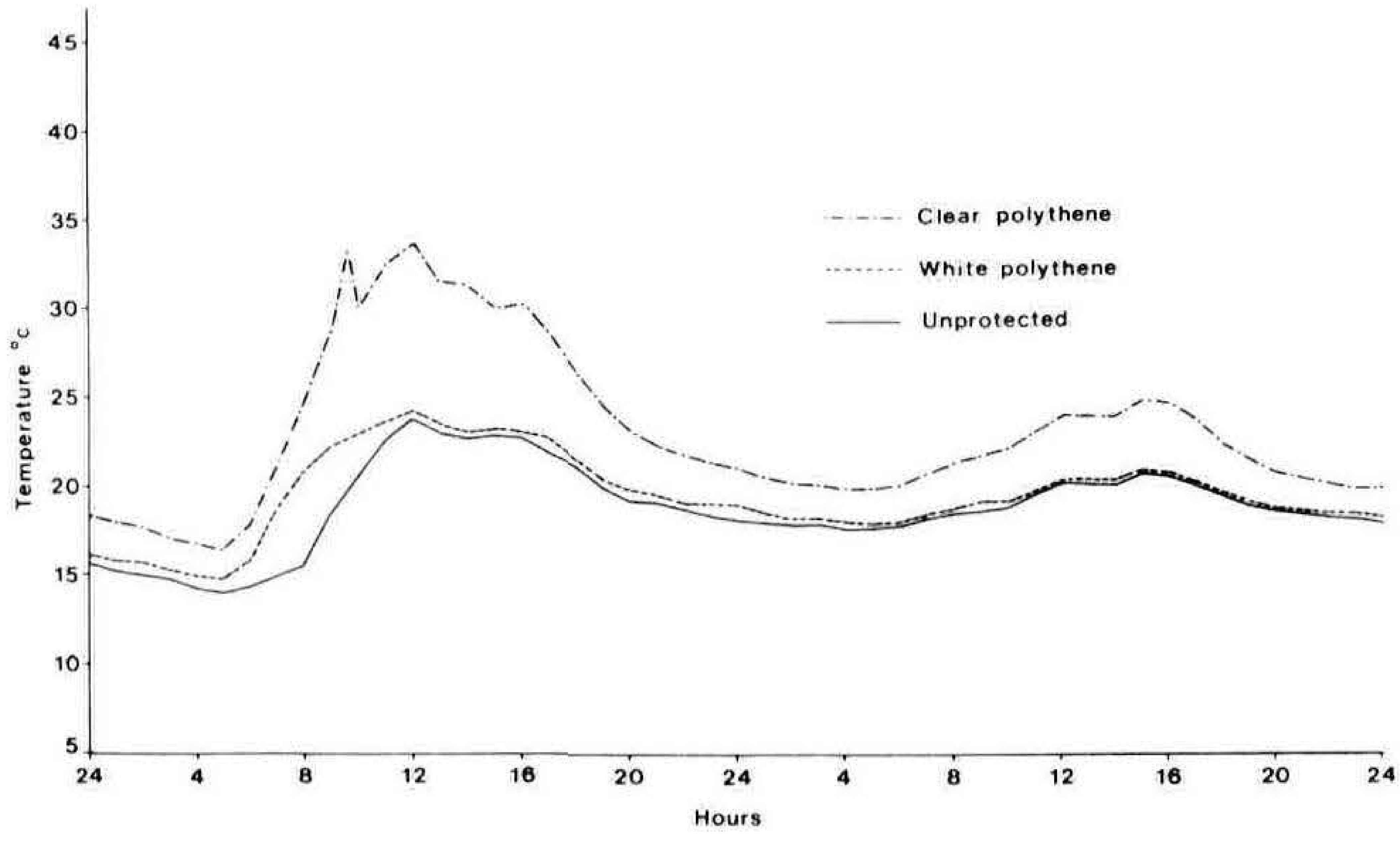


Fig. 4. **Soil temperature at one inch depth recorded on 8, 9 August, 1971.**

little soil warming under white polythene and temperatures at rooting level were generally sub-optimal for rooting even on the first (warm) day. Soil temperatures under clear polythene were considerably higher and there was a reservoir of soil warmth which maintained a temperature of more than 20° C. (68° F.) throughout the night. It is likely that the soil temperatures of more than 30° C. (86° F.) recorded on the first day, would be too high for satisfactory rooting of most cuttings.

The figures presented indicate that the types of polythene film available at the moment and used in these trials are not ideal as a covering for propagating tunnels. A less opaque white polythene which allows a greater degree of soil warming while still not allowing excessively high air temperatures, may be more desirable.

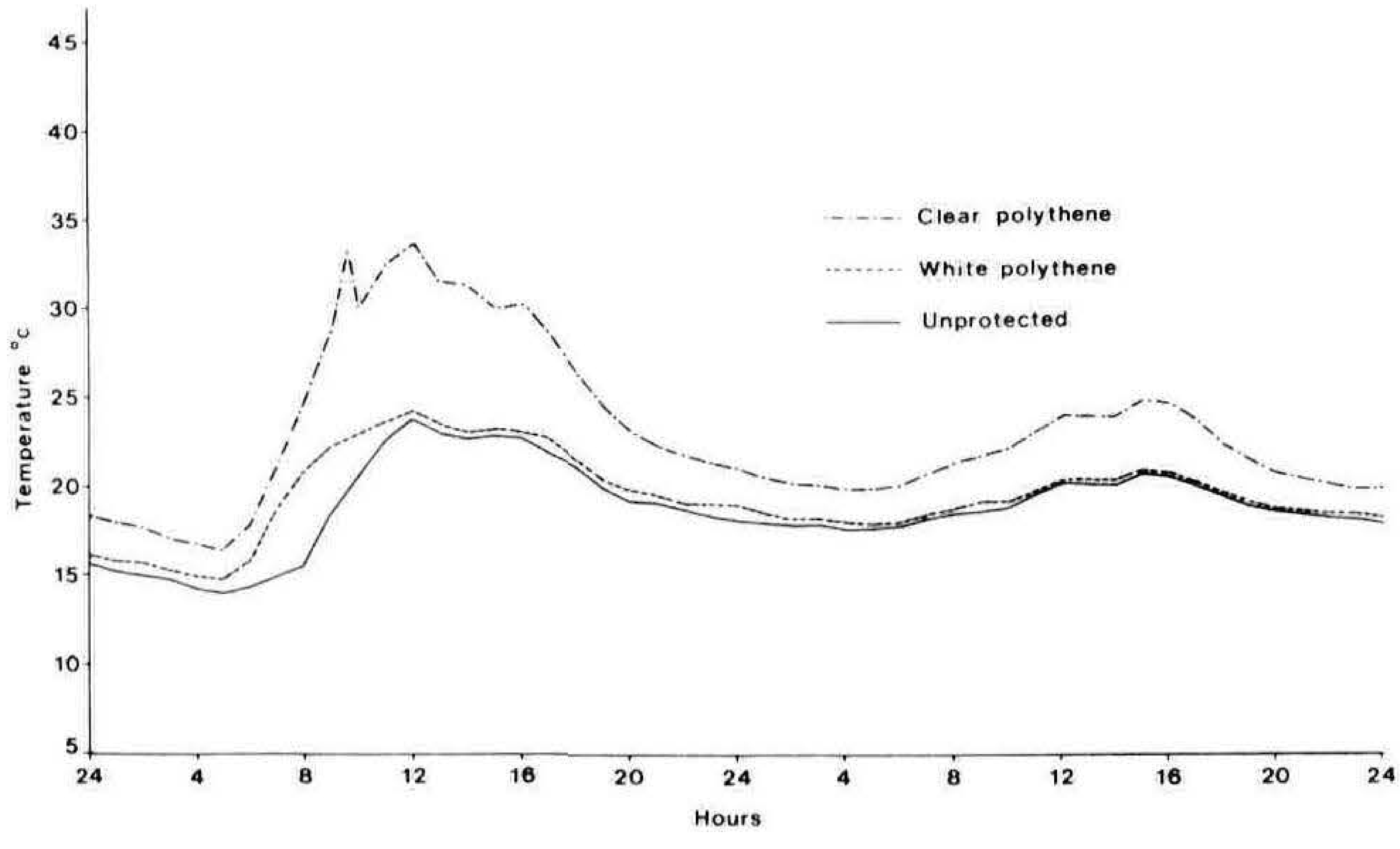
PROPAGATION OF MINIATURE ROSES BY CUTTINGS

D. M. DONOVAN

F. Toynbee Limited, Croftway Nurseries, Barnham
Bognor Regis, Sussex

The method about to be described was developed where a few hundred plants could be produced from a few stock plants, and where facilities are limited to cold frame protection, with a slightly heated house to grow on the rooted cuttings. It was inspired by a few unsold and unpruned plants left to overwinter in a cold house. These developed dwarf shoots in March and April, which were removed, rooted and produced excellent plants by autumn.

Propagation and Production. Well grown stock plants are covered by a frame light in March to protect the breaking buds on last



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Propagation and Production. Well grown stock plants are covered by a frame light in March to protect the breaking buds on last year's growth. When several little shoots have two fully expanded leaves, the upper portion of the stem carrying them is removed to force the lower buds to break and be given similar treatment subsequently.

The shoots are pulled off and the remnant of last year's wood trimmed away; then, having dipped them in rooting powder and boxed up for the mist unit, rooting occurs quickly and potting-on may begin in 17 days. Rooting medium may be peat and grit, sand and grit or just washed sand, but not coarse vermiculite on its own. The harder the growth the easier the operation becomes; our success rate in rooting is 95%.

After potting into containers, the rooted cuttings are grown under glass with slight heat, and given a weekly liquid feed. Six to ten weeks after propagation (in late May and June) they can be sold as small plants in flower. Stopping growth helps to develop branched plants. Disease control is only occasionally necessary.

For quality plants potting-on is essential at this stage and, from a June potting, they grow rapidly outside and are saleable by late July. Disease control now becomes essential and Black Spot is countered by a weekly spray of Captan.

Conventional cuttings can usually be taken twice by mid-summer from the stock plants, after which subsequent growth is left to provide the dwarf shoots the following spring. Summer propagation can be intensified by reducing the shoots to leaf-buds, which grow rapidly after rooting, and produce plants ready to sell in spring. Not unnaturally, to meet the heavy demands for propagation material, the stock plants require heavy feeding and these have to be replaced every two or three years.

Cultivars. No varietal differences are apparent in their ability to root, or in the time taken, but the following comments can be made about the plants so far tried.

'Little Buckaroo', 'Yellow Bantam' and 'Cinderella' may all be grown into bushy plants without stopping.

'Fresh Pink' is vigorous but, even with stopping, produces a one-sided plant of few shoots. It is more disease resistant than any other.

'Tinkerbell', 'Oakington Ruby', 'Baby Masquerade' and 'Easter Morning' require stopping, but form good plants.

'Baby Ophelia', 'Little Flirt', 'New Penny' and 'Perle d'Or', though rooting readily, have not the vigour of the other cultivars, and need to be grown on for a further year.

THE LONG ASHTON GRAFTING MACHINE

J. S. COLES

Long Ashton Research Station
Long Ashton, Bristol

For many years grape growers have bench grafted their cultivars on American rootstocks resistant to root aphis (*Phylloxera*). Since this technique is usually carried out indoors during early spring it has been relatively easy to construct machines which facilitate the operation. Simple matching "joints" are made in both rootstock and scion, and grape vines would seem to be easily propagated by using this technique.

Bench grafting of fruit trees has been practiced in this country only to a very limited extent but at Long Ashton interest in mechanizing this technique was aroused when considerable quantities were required for an experimental purpose.

Whilst grafting machines are available in Europe a certain amount of difficulty was encountered in the purchase of a suitable machine, therefore a purpose designed tool was constructed. Various types of "joint" could have been used but from carpentry experience a mortice and tenon is the easiest to manufacture yet probably the most efficient in operation.

The machine described here is powered by a heavy duty electric motor and all the working parts are well guarded. An important feature is that the guards cannot be removed unless the electric supply

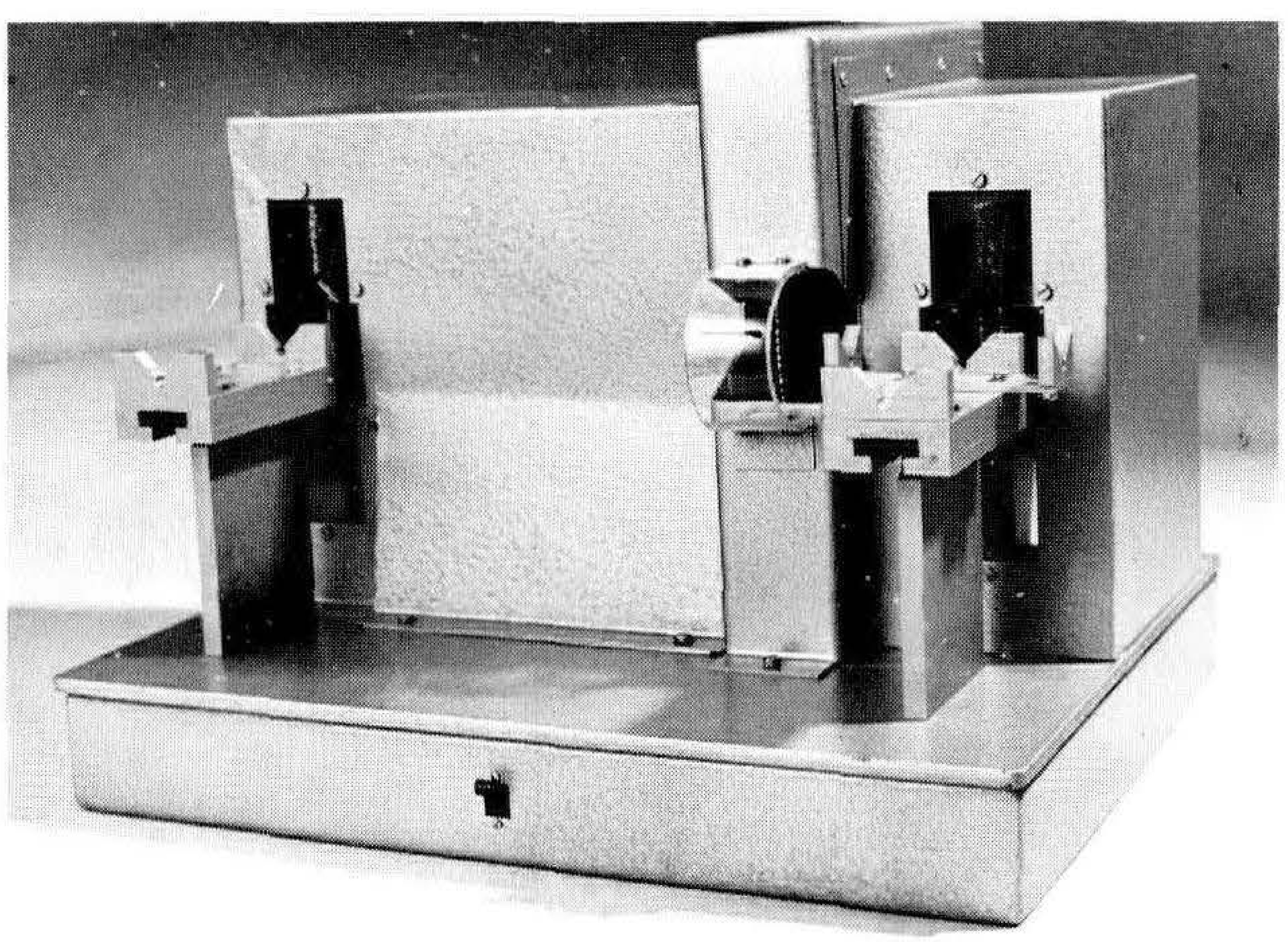

Fig. 1. Long Ashton Grafting Machine.
Note. (1) Well guarded saw blades
(2) Movable platforms for sliding material into blades.

is disconnected. The initial transverse cuts on both scion and rootstock are made with a normal circular saw blade (Figs. 1 and 2). If a simpler type of machine is desired these cuts can be made with secateurs.

The mortice joint in the rootstock is produced by pushing the sliding jig and the cut-off rootstock towards the rotating saw blade (Fig. 3). The resulting cut is thicker than the blade as wobble washers

Fig. 2. Normal saw for making transverse cut on scion or rootstock.

Fig. 3. Mortice cut in rootstock — Single wobble blade.

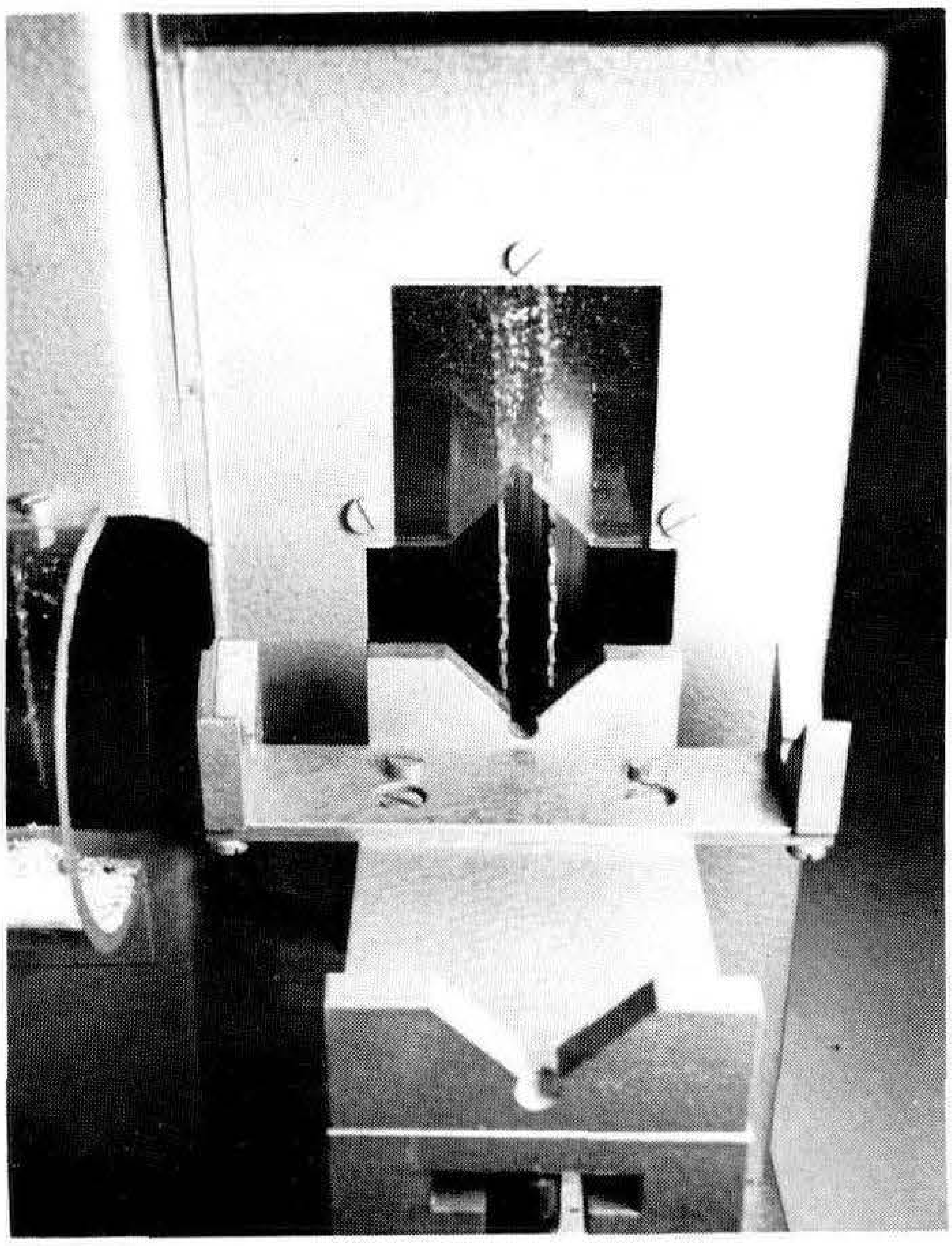

Fig. 4. Parallel wobble blades — Produce tenon joint on scion.

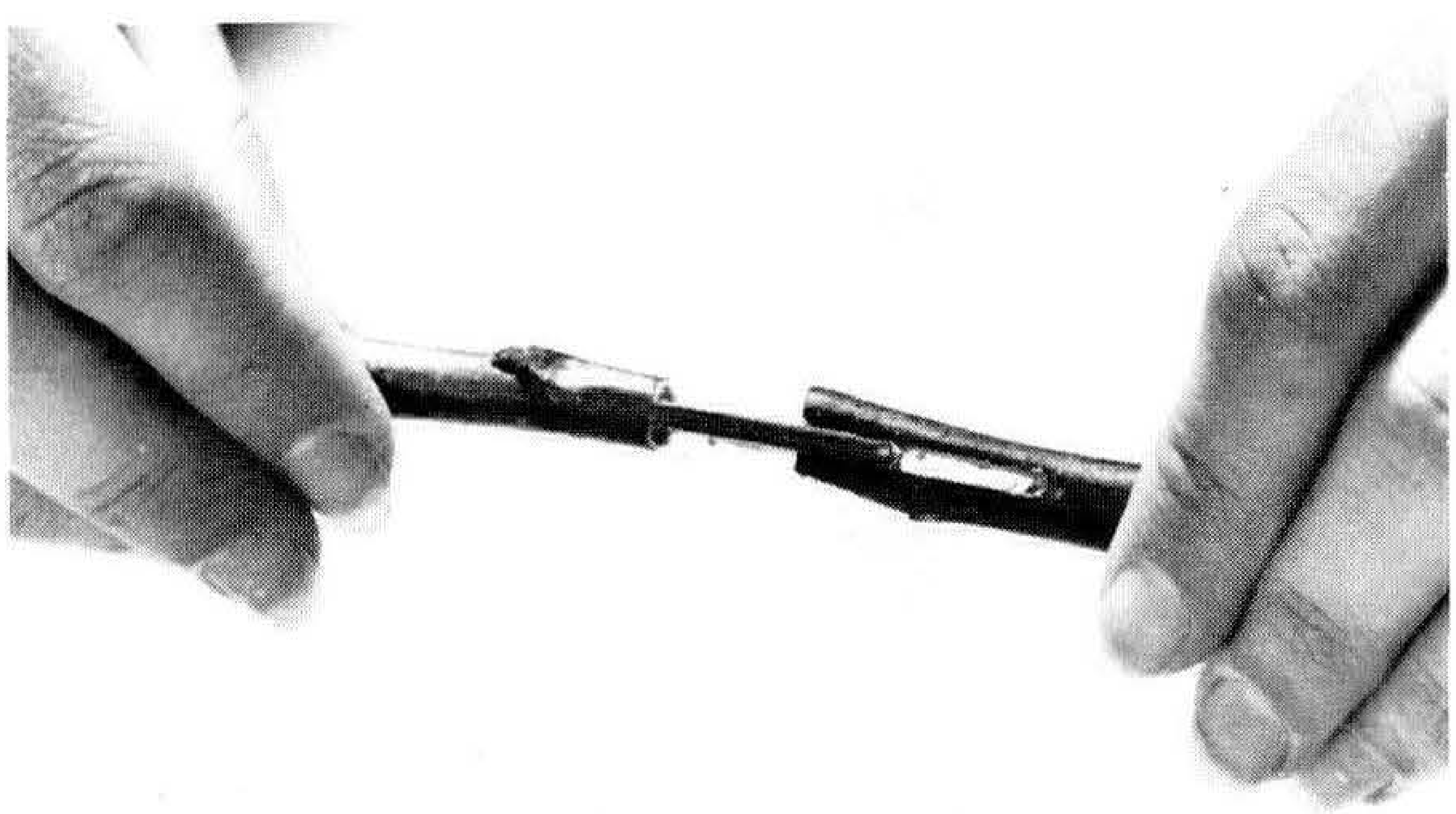

Fig. 5. Prepared graft being assembled.

cause the blade to follow an uneven plane. The scion cut is similarly produced, except that since a tenon joint is required, two wobble blades are used (Fig. 4). The completed mortice and tenon are now assembled (Fig. 5) and secured with 200 gauge, one-inch wide, polythene. It is preferable if the scion and rootstock are the same diameter, but if this is not possible the cambium of each must be matched.

After planting, bench grafts require a very favourable environment. Irrigation, mulching and shelter with windbreaks should all be provided, otherwise failure rate will be very high. It is unlikely that fruit tree raisers will wish to use bench grafting techniques, since other methods are more suitable. However, the general plant raiser already practices hand bench grafting and suitable machines may be very desirable. Machine grafting is not claimed to be faster than conventional methods but unskilled workers can soon be trained to master the technique, thus enabling better use to be made of staff during wet winter conditions. It would seem likely that with the continually increasing demand for trees and shrubs in containers a machine of this type could be invaluable to many nurserymen. Some slight modifications would probably be necessary, but a wide range of species could be tried using these techniques.

GROUND-COVER PRODUCTION FOR MAXIMUM NUMBERS

GEOFF J. E. YATES

Merrist Wood Agricultural College,
Worplesdon, Surrey

While some nurserymen are practicing ways of rooting larger and still larger cuttings to shorten the time between rooting and sale, I have begun to look for ways of propagating ground-cover plants commercially using the least possible plant and container material and, in some cases, to remove the need to stick individual cuttings or to pot or lift from the field. These alternatives are not new, but their use to mass-propagate plant material economically can be pursued with advantage.

Why should it be necessary to consider any new techniques when the majority of ground-cover plants are very easy to propagate and usually make a profit, and when the small numbers now produced are sold at prices as high as those asked for the normal run of flowering shrubs or perennials? In answer, if ground-cover is to be mass-planted as it must be to be successful, the plants offered in Great Britain will have to come down in price to an equivalent level to that of bedding plants and they need to be constantly available in large numbers, which few nurseries could now supply.

Among the present limitations to economic production are:

(a) Running out of stock material for normal division and cutting making.

(b) Slowness of production of some natives from seed or difficulty in rooting cuttings.

(c) Too many handling moves after rooting, e.g. potting, lining out, lifting, bundling and boxing.

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(d) Higher costs of all kinds of individual containers, pots or boxes.

I want to start by looking at the use of parts of the plant other than the leafy green stems or the seeds, for many ground cover species have vigorous colonising roots and, more importantly, rhizomes which enable the plant to renew itself continually.

STICKING, SOWING AND DICING—RHIZOMES AND STOLONS

Sticking and Sowing. Of plants with rhizomes a number can be cut up and propagated from *leafless* stems (1). Although this method of propagation obviates leaf trimming and stripping, the result may only give a saleable plant after a longer period of time than from a cutting taken with leaves. *Pachysandra terminalis* (Fig. 1) has very vigorous underground stolons which can be cut up (30 mm long), stuck and rooted, but as the normal leafy shoots have stiff stems they are easily prepared and more quickly stuck by simply pushing into a cutting compost or into proprietary foam propagation blocks.

Fig. 1. Leafless stolons of *Pachysandra terminalis* cut to 30 mm lengths for sticking and rooted stolons three months later.

However, other plant species have soft aerial stems which are less convenient to stick rapidly or, as with *Ceratostigma plumbaginoides*, these soft stems soon become hardened, making later batches of cuttings for continuous production more difficult to root. This blue flowered perennial has an extensive running rhizome system, which can be lifted at most times of the year and cut into 10 to 20 mm lengths. These pieces are quite leafless, but have leaf scales, and the task of sticking and ensuring polarity can be reduced by *sowing* the pieces horizontally over the surface of a compost. They may be covered slightly to keep moist and dark, and put in a glasshouse. After four weeks in a propagation house a mass of leafy shoots will appear, similar to those produced from root cuttings, and these can be potted in tufts. One step further is to sow the pieces of rhizome in the containers in which the *Ceratostigma* is to be sold The mutilated stock plants need not be wasted but boxed in peat to provide another batch of rhizomes.

When experience is needed to determine the ability of plants to regenerate by this method, the best time to start on the stock is April or early May when maximum rhizome or stolon activity occurs. Maximum activity will follow flowering and will consequently be much later for *Geranium macrorrhizum*. This species will normally divide giving 6 to 8 divisions from one clump in the winter or spring, but if these are lifted again in July each new clump will provide 12 or more new white rhizomes, which can be cut off with secateurs in 20 to 30 mm lengths and sown in boxes or in a prepared cold frame. Not all of the herbaceous geraniums follow this growth pattern, but none are so tolerant of drought and shade as this scented-leaved plant.

With the old favourite lily-of-the-valley, *Convallaria majalis*, an excellent ground cover under cedar trees, small pieces of active rhizome will outgrow older dry material or one and two year old rhizomes. The following plants will respond to adaptations of this method:

Rhizome cut to:

20 - 30 mm	*Campanula poscharskyana* cvs.
40 mm	*Clematis heracleifolia* 'Wyevale'
30 - 40 mm	*Convallaria majalis*
25 mm	*Euphorbia robbiae*
100 mm	*Gaultheria shallon*
20 - 30 mm	*Houttuynia cordata* 'Flora Plena'
15 - 20 mm	*Maianthemum bifolium*, May Lily
40 mm	*Phalaris arundinacea* 'Variegata'
20 - 30 mm	*Saponaria officinalis*, Soapwort
100 mm	*Vaccinium myrtillus* and *V. angustifolium*

Bamboos have long been propagated from rhizomes cut into short lengths in April or May and stimulated to produce new shoots and roots. Whilst there is no shortage of stock to divide—they can be an incredible nuisance on sandy soil—the following are useful for ground cover and the sudden need for maximum increase may require the propagator to use these techniques:

Arundinaria vagans (syn. *Pleioblastus viridistratus vagans*)
A. fortunei (syn. P. *variegatus*)
A. humilis syn. P. *humilis*)
A. pumila (syn. P. *pumilus*)
Sasa veitchii (syn. *Arundinaria veitchii*)

Dicing rhizomes. (a) Leaves removed. The familiar rhizomatous plants *Bergenia, Polygonatum* and *Rodgersia* do not make abundant growth but slowly add to the length and diameter of the old existing rhizome in relation to the numbers of healthy leaves or leaf stems produced. *Bergenia* can be raised from seed to produce mixed races and will divide, but division is severely limited by the amount of available rhizome material. As shown in Table 1, work at Merrist Wood Agricultural College carried out by Diploma students has demonstrated, using all parts of the *Bergenia* rhizomes, old and new, defoliated and cleared of old scales and cut into sections, reproduced best at a length of 30 mm.

Table 1. Effect of rhizome length on root and shoot production. *Bergenia cordifolia.*

Rhizome cut transversly length in mm	Root growth	Shoots growth
2	— — — — — —	— — — — — —
5	— — — —	— — — —
10	— — — +	— — — +
15	— — — —	— — — —
20	— — + +	— + + +
25	+ +	+ +
30	+ + + +	+ + + +

More than one sample taken for each size, age mixed at random

+ ındicates growth from each piece
— indicates no growth from each piece

These apparently lifeless stems (up to 6 years old in these observations(have dormant leaf buds enfolded in them and when inserted in perlite at 20° C. (68° F.) basal heat and kept moist, will break dormancy, by sending up a vigorous leaf to start renewed rhizome activity from an axillary bud. Heavy rooting occurs some weeks later. For our first winter trials (1970/ 71) the diced sections were pushed into perlite, but subsequent commercial procedures of cutting and dusting with captan gave as good results even when using old dessicated rhizome down to 15 to 20 mm length sections and inserted into equal parts of peat and sand compost. Experiments carried out by Jefferies and Thoday (2) at Bath University during the winter of 1969-70 established that *Bergenia* could be readily propagated from single buds excised from dormant rhizomes. It was further shown that the cutting of 70 mm intact lengths of rhizome resulted in a greatly improved yield of young shoots compared with the same total length cut into smaller pieces.

The age of the buds used as starting material, the depth of planting, the ambient temperature, and the length of rhizome pieces were examined for their effects on bud activity. The size of the shoots, the application of indolebutyric acid to the bases of the shoots, and the presence or absence of heels of parent rhizome material at the bases of the shoots were examined for their effects on root production by shoots. The state of root development, and the use of supplementary illumination, were examined for their effects on growing on of rooted shoots.

Other species with which I am working include the ginger roots, *Asarum europaeum* and *A. caudatum, Polygonatum multiflorum, Smilacina racemosa* and *Rodgersia.*

Dicing rhizomes. (b) Types with leaves. The technique without leaves was used with dormant stock or with species that would tolerate removal of all foliage. The need to increase Butchers Broom, *Ruscus aculeatus,* more economically than by ordinary division, led me to see how small one could reduce the hard woody rhizomes. The large dormant buds are not present in large numbers so these are noted and the rhizomes were cut with sharp secateurs to 20 to 30 mm, ensuring that each piece had an active green leaf stalk and a prominant dormant bud. The cut surfaces were dusted with Captan and all were boxed up in peat and placed in a cold frame during February. This has provided a fair and reliable increase for a very slow growing native.

Epimedium spp. divide well in May when there is maximum activity, and with suitable aseptic propagation conditions, moisture, and some heat there is no reason why live rhizomes should not be cut down to 20 mm in length provided a complete leaf is left with each piece. The North American, *Comptonia peregrina,* or Sweet Fern, which is not a fern, has long been subjected to similar methods by American nurserymen, but sufficient stocks are unlikely ever to be available in Great Britain.

ROOT CUTTINGS

Some of the best ground cover species belong to the *Boraginaceae* with rough leaves like comfrey. These are not exploited enough using the simple method of root cuttings; indeed they produce adventitious shoots so rapidly that they may as well be quickly "sown" horizontally in a frame using 30 to 40 mm pieces of thick young root. If you wish for finesse stick them vertically in boxes full of compost-filled peat pots or similar containers.

The following may be propagated from root cuttings: *Symphytum caucasicum, S. grandiflorum,* 'Hidcote Pink' and 'Hidcote Blue' and 'Rubrum'; *Brunnera macrophylla, Trachystemon orientalis, Cynoglossum spp, Anemone vitifolia, A. hupehensis* cvs. and *Myrica cerifera.*

LEAF, STEM AND BUD CUTTINGS.

Although I am more used to preparing cuttings with a knife, readily available stem cutting material that roots internodally can be made ready for sticking more quickly with secateurs or scissors. The ivies and *Rubus* provide two examples of plants used for ground cover effect that can be mass-produced without wasting a scrap of material. Three points should be considered—each cutting must have (a) a sound, well developed leaf, (b) a dormant axillary bud, and (c) sufficient length of stem to permit sticking quickly into a cutting compost, either in boxes or beds, or several cuttings to a small container. This type of cutting, compared to a terminal shoot or a length of shoot with several nodes, will provide a more even batch of plants since the shoots all break from one level. Where space for the stock plants is at a premium, or it is necessary to keep the cutting material clear of soil in case of soil borne infection, the stock plants should be grown up reinforced concrete mesh or pig netting; walls tend to encourage *Bryobia* mite in large numbers.

We sometimes take further rounds of cuttings off the cuttings, but the first batch must be fed, if not moved on, as the rate of growth will diminish if we take cuttings from stock which lacks nitrogen.

Vinca spp. can be placed in this category of cutting. They have opposite leaves so that each cutting can be made with a pair of leaves and has the chance of two axillary buds breaking into growth. In our experience, long cuttings will root as quickly as shorter ones but are not convenient to handle, and may take longer to form useful basal growth.

SHRUBS AND OTHER WOODY GROUND COVERS

Shrubs and other woody plants will necessarily be propagated by all the familiar methods including the rooting of half-ripe cuttings (*Cotoneaster, Euonymus*) and, in a few cases, from seed (*Mahonia*).

Increasing the availability of cutting material can be pursued in two directions: (1) Softwood cutting material forced under glass and (2) Deciduous and evergreen hardwood cuttings.

Softwood cuttings provide a fast means of producing large numbers, e.g. 80 to 90 *Lonicera pileata* cuttings per standard box; a useful increase in the first season's growth of the rooted cuttings can be obtained by starting the stock plants into growth under glass. We use this method where outside growth may give only one round of soft cuttings of the following—*Lonicera pileata, Hypericum x moseranum, Stephanandra incisa* 'Crispa' and some of the thin twigged spiraeas—*S. x arguta* 'Compacta', *S. x Bumalda* 'Anthony Waterer', *S. chamaedryfolia* 'Ulmifolia'.

Hardwood cuttings need little explanation. One deciduous shrub that is in steady demand for ground covering larger sites is the common spreading type of *Rosa rugosa*. It is easy from seed, but this involves more stages in production. Hardwood stems about 125 mm long, prepared in the winter, bundled and lined out in clean nursery land in spring, provide a swift uncomplicated operation. Some cultivars, such as 'Frau Dagmar Hastrup', are more effectively budded on stocks, but its hesitancy to root well can in some ways be overcome by taking hardwood cuttings from well-pruned stock hedges.

The rose 'Max Graf', which is a true hybrid with *Rosa wichuraiana* as one parent is normally budded, but this causes great problems when stock suckers appear at a later date on infrequently maintained landscape sites. Plants on their own roots, which can be made from the abundant annual growth, bundled and lined outside in the spring, are better.

Evergreen hardwood cuttings allow maximum increase, aided by the photosynthesising leaves. Into this group fall the *Berberis* and the more amenable *Mahonia aquifolium* cultivars. Seed of the latter is easily germinated in large quantities in spring if it is stratified for 3 months in sand in a warm glasshouse then sown outside on beds in February. They do, however, take time to make saleable plants, involving two transplanting moves. I find I can root up to three or four hundred cuttings from any old neglected bush. The branches are cut and brought inside during November or December and *all the wood*—some is probably 5 years old—is cut up with secateurs into variable stem lengths, but each with a complete compound leaf attached (Fig 2). The more vigorous top leaves may be shortened by cutting off the terminal leaflet. To encourage heavy rooting the stem bases are dipped into 0.8% IBA dust and stuck in a double-glazed frame outside with soil warming cables holding the media at about 20° C. (68° F.). By early summer the cuttings are well rooted and can be bedded, potted or left for lining out in the early autumn.

Winter propagation of *Hypericum calycinum* is probably as cheap as production from softwood cuttings during the growing season. We make hard stemmed cuttings with two pairs of leaves and with the softer terminal portion removed, dipping the base in 0.8% IBA. As this is mature stem growth not all the leaves are present but the vital axillary buds are. These cuttings are usually boxed and put in a glasshouse or double-glazed frame without heat. The latter facility is slow but eases the pressure on mist benches occupied with conifers.

Fig. 2. Hardwood evergreen leaf stem cuttings and leaf-bud cuttings of *Mahonia aquifolium* made from stems up to five years old (left). Rooted cuttings after four months (right).

CONTAINERISING GROUND COVER PLANTS BY THE USE OF POLYTHENE ROLLS

Ground cover production can be divided broadly into those plants sold from open ground and those produced in containers. Excepting for the woody shrubs and heavy foliaged perennials, smaller leaved ground covers are in the nursery ground for too short a period to pay for planting out, herbicide treatment and lifting. The heavy losses encountered using this open ground material of the common *Hypericum calycinum* on a rigorous landscape site are not really appreciated. Ideally plants, or several rooted cuttings, in a 75 mm (3 in.) or 90 mm (3½ in.) plastic pot, though more expensive to produce and handle, ensure fewer planting losses.

Rooted cuttings in boxes, which have to be separated by being torn apart at planting time like bedding plants, produce the greatest root damage; greatest because ground cover plants may be lying around in boxes longer than petunias or such plants with their more limited shelf life.

Containers, such as plastic foam blocks and individually formed bedding packs, require the stability of at least a standard seed box to hold the unit together; this costs 3½p each for the wood, and the rigid plastic material after separation has to be laboriously picked up from the site, if it has not already blown away! Peat pots are excellent for growth, but the pots and boxes necessary to hold them together add on costs to the lower priced ground covers.

In the *Polythene Roll* method (Fig. 3), rooted cuttings are rolled in polythene, using the same compost and exactly the same quantity as required to pot into 75mm (3 in.) rigid plastic pots. The plants are separated laterally by the polythene strip and, because the roots are able to grow downwards for three times the depth of an ordinary seed box, the plants come out when unrolled with a large "plate" of roots, allowing excellent establishment of the individual plant.

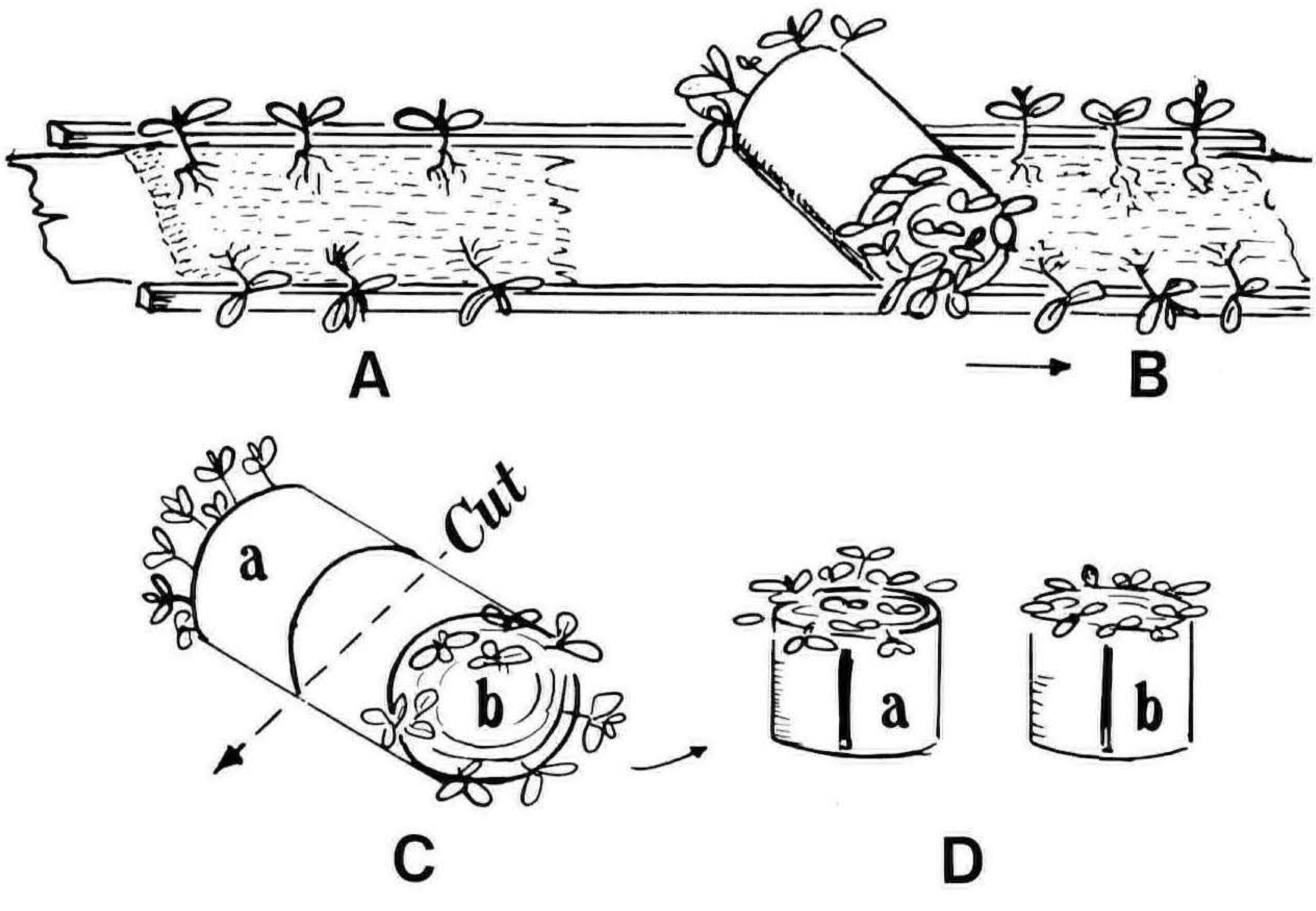

Fig. 3. Consecutive steps shown diagrammatically in making polythene plant rolls.

A roll of black polythene mulch, 150 gauge, is sawn into approx. 300 mm sections. One of these narrow rolls is unwound by laying it on a bench between 12mm (½ in.) battens to contain the compost. About 4 metre of polythene and bench top will be required to make the first stage of the rolls which are in pairs. Compost is laid and flattened out with the hands over the polythene strip to provide an equal quantity required to fill 50 75mm (3 in.) pots. Next 25 to 28 rooted cuttings or divisions are placed along the top edge and the same number along the lower edge of the strip, which is then rolled up tightly by hand and secured after cutting with a narrow strip of PVC tape. The result is a tight "Swiss Roll" with plants sticking out of each end; this is then cut through the middle of the roll with a saw or a long knife and the two units, each with 25 plants are slid onto a flat board or truck for transport to the growing area. The compost does not fall out of the bottomless containers and, after watering and natural settlement, it is easy to move the 25 plants in one quick movement, compared to the laborious picking up and putting down of individual rigid pots. A thousand plants can be rolled as quickly as potting with great saving in time when moving out and setting down.

This method differs from the patented Finnish "Nisula" system developed for forestry seedlings by the following points. The rooted cuttings are not placed on separate pads of compost to separate them longitudinally; a heavier commercial horticultural grade of black polythene is used and normal sand, peat, and soil composts are used rather than one of all peat. Some costs between potting and the use of the polythene roll are compared in Table 2.

Table 2. Current production costs at Merrist Wood Agricultural College for potting and for polythene rolling as determined for *Vinca, Pachysandra, Hypericum, Hedera* and *Ophiopogon*.

Potted	Polythene Rolled
75 mm (3 in) polystyrene pots	25 per roll
£ 13.36 per 1,000	£ 10.00 per 1,000 plus additional saving by reduced handling costs at despatch.

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NURSERY EXPERIMENT REPORT: THE RESPONSE OF CUTTINGS TO BASAL WOUNDING IN RELATION TO TIME OF AUXIN TREATMENT[1]

BRIAN H. HOWARD

East Malling Research Station, Maidstone, Kent

Abstract. Nineteen similar experiments were carried out on 16 nurseries by members of the Society.

Treatments, comparing the effect upon a range of species of making a basal wound, either before or after auxin application, together with non-wounding, gave results of three main types which appeared to be in part related to the kind of auxin preparation used, rather than the species

(1) Wounding before auxin treatment was beneficial, with the suggestion that this was through improved uptake of IBA applied as a powder formulation.

(2) Wounding before auxin treatment was also detrimental, usually when IBA was applied in a readily absorbed alcoholic solution, suggesting supra-optimal uptake through the wound.

(3) With some subjects wounding was beneficial irrespective of the time of auxin application

The value of a better understanding of these processes is discussed relative to the need for achieving optimal conditions for propagation

INTRODUCTION

Wounding the base of cuttings prior to insertion in the propagating medium is a recognised way of aiding root development, and is widely practiced for some plants (4).

Speculation as to the mechanism of the wounding response has been made (3). Enhanced auxin and water uptake through the wound may take place, or endogenous growth factors may be produced or caused to accumulate. It is also possible that the wound disrupts schlerenchymatus tissue which may be depressing root emergence (1).

Wounding necessitates an extra stage in cutting preparation which may be essential, or avoidable, depending upon the reason behind improved rooting following the wounding treatment. A better understanding of the mechanism may well enable more efficient use to be made of this method.

As one of three experiments proposed at the Second Annual meeting of the Great Britain and Ireland Region, an investigation has

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[1]Ed. Note — This report is Dr. Howard's final assessment of this particular set of experiments and includes more information than was given in the Progress Report at the Conference.

been made into the value of wounding under nursery conditions, and of possible relationships between improved rooting following wounding and the more effective entry of auxin into the stem tissue.

MATERIALS AND METHODS

Of the 41 members who asked to take part in this experiment and who were supplied with detailed instructions of procedure, bench layout and recording, 16 members returned 19 completed trials. These were carried out on commercial nurseries or in the propagation departments of Institutes, Universities and Botanic Gardens.

Most of the subjects used were evergreen and the greatest proportion of these were conifers. Propagation was under mist with bottom heat in most cases.

Wounding was almost invariably by means of a slice of tissue removed from the proximal portion of stem, and 4 (indolyl-3) butyric acid (IBA) was used in all but two cases, as either a proprietary powder formulation (Seradix) or as an alcoholic solution applied as a "quick dip". Details of individual experimental conditions are given in the appendix.

The following treatments were applied:

A. Normal cuttings with usual auxin treatment—no wounding.

B. Cuttings wounded and then given auxin treatment.

C. Normal auxin treatment, followed by wounding.

Auxin treatment was to a sufficient depth to ensure the wound, when present, was treated.

Individually randomised layouts were used on each nursery, with five replicates of 20 cuttings per plot per treatment.

Recording. When cuttings were assumed ready for potting off, those in each plot were categorised into some or all of the following classes: *Dead, Poor, Satisfactory, Good, Excellent.* After the records were returned to East Malling, and prior to the analysis of variance, a weighting factor was applied which progressively favoured improved rooting. This was on the assumption that those cuttings with the best root systems would produce the best plants, and that nurserymen would not wish to handle dead or poorly rooted cuttings.

RESULTS

Wounding before treatment with auxin (B) was significantly better than wounding after treatment, or not wounding, in two cases (Table 1, Part 1). The results of seven other experiments showed a similar but non-significant trend (Table 1, Part 2).

All the subjects in Table 1 were treated with auxin in powder for-

Table 1. Mean rooting scores per cutting.

Part 1	Potential	A	B	C	SE±	P<
1) *Prunus lauro-cerasus* 'Otto Luyken'	3.00	1.13	1.99	1.20	0.083	0.001
2) *Juniperus squa-mata* 'Meyeri'	4.00	1.98	2.45	1.41	0.195	0 05
Part 2						
3) x *Cupressocyparis leylandii*	2.00	1.55	1.62	1.54	0.082	
4) x *Cupressocyparis leylandii* 'Stapehill'	4.00	2.04	2.42	2.11	0.176	
5) x *Cupressocyparis leylandii*	4.00	1.62	1.85	1.41	0.151	
6) *Rhododendron ponticum*	4.00	2.70	2.73	2.41	0.152	
7) Floribunda rose 'Ohlala'	4.00	2.38	2 49	2 31	0.162	
8) *Euonymus fortunei* 'Silver Queen'	3.00	2.85	2.90	2.82	0.072	
9) *Juniperus virgin-iana* 'Grey Owl'	2.00	1.60	1.64	1.54	0.082	

mulation with the exception of X *Cupressocyparis leylandii* (item 3). Full details are given in the appendix.

A preliminary sample of the juniper cuttings (item 2) after three weeks showed that all cuttings in treatment C, but only about half those in treatments A and B, were callused. Rooting had commenced in two out of 25 cuttings in A and B but none in C. After a further two weeks, treatment B showed superior root development as in the final assessment.

For three subjects, wounding before auxin treatment (B) was detrimental (Table 2, Part 1) and two others showed a similar but non-significant trend (Table 2, Part 2).

Table 2...Mean rooting scores per cutting

Part 1	Potential	A	B	C	SE ±	P<
10) *Chamaecyparis lawsoniana* 'Allumii aurea'	3.00	2.62	2.40	2.64	0.057	0.05
11) x *Cupressocyparis leylandii*	4 00	2.73	1.66	3.96	0.146	0.001
12) *Rhododendron* 'Lady Clementine Mitford'	2.00	1 75	1.15	1.80	0.070	0.001
Part 2						
13) *Juniperus sabina* 'Tamariscifolia'	4.00	2.48	2.03	2.49	0.139	
14) *Thuja plicata* (Lobbii)	2.00	1.67	1.60	1.68	0.063	

All the subjects in Table 2 were treated with alcoholic preparations of auxin with the exception of X *Cupressocyparis leylandii*. Full details are given in the appendix.

For X *Cupressocyparis leylandii,* wounding after auxin treatment (C) was markedly beneficial. It is therefore possible that wounding was of general value in this case, as for subjects shown in Table 3, but that this was masked by a superimposed detrimental effect of previous auxin application.

Wounding, irrespective of when the auxin was applied, was significantly better than not wounding in two cases, (Table 3, Part 1). Two other subjects gave a similar but non-significant trend (Table 3, Part 2).

Table 3. Mean rooting scores per cuttings

Part 1	Potential	A	B	C	SE ±	P<
15) x *Cupressocyparis leylandii*	4.00	2.08	2.94	2.98	0.185	0.05
16) Apple rootstock M.26	4.00	1.38	2.07	2.14	0.108	0.01

continued

continued

Part 2					
17) *Ilex* x *altaclarensis* 'Purple Shaft'	3.00	2.25	2.80	2.76	0.161
18) *Polygonum baldschuanicum*	4.00	1.00	1.49	1.61	0.333

For one subject wounding after auxin treatment (C) was inferior to other treatments, (Table 4).

Table 4. Mean rooting scores per cuttings

	Potential	A	B	C	SE±	P<
19) *Daphne* x *burkwoodii*	3.00	2.23	2.31	1.72	0.117	0.05

DISCUSSION

The results obtained fell into three main categories:

(1) Improved rooting was obtained by wounding cuttings before auxin treatment and is probably explained by the more efficient uptake of the auxin through the wound than through the cut end of the shoot. A powder formulation of auxin was used for both subjects which gave a significant response to wounding before treatment (Table 1, Part 1), and also for six of the seven subjects showing a similar but non-significant trend (Table 1, Part 2). It is reasonable to suppose that IBA applied as a powder is less efficiently absorbed than when applied as an alcoholic dip, and consequently it would be expected to improve most in effectiveness when applied to a wounded stem.

(2) Wounding prior to auxin treatment was detrimental (Table 2) and is most likely explained by supraoptimal absorption of IBA through the wound It is significant that four of the five subjects giving this response were treated with alcoholic preparations of IBA which would be expected to be absorbed more efficiently than powder formulations. This argument is supported by the fact that in practice much higher concentrations of auxin in talc are found necessary to obtain similar results to those from using alcoholic solutions.

(3) Wounding both before and after IBA treatment was beneficial and this may be connected with various of the suggestions made for the success of wounding treatments mentioned earlier. The most likely would seem to be enhanced water absorption in the early stages of propagation. The possibility of this has already been considered (2), and wounding hardwood cuttings of fruit rootstocks has been found to differentially affect the response of cuttings to propagation in dry and moist environments (Howard, unpublished data). The absence of a specific wound mechanism in these experiments is supported by the observations that in the case of apple rootstock 'M.26', floribunda rose 'Ohlala', and *Rhododendron ponticum* the position of roots was definitely not associated with the wound in the first two cases and only partly so (lower portion and cutting base) for the last subject.

Some other observations are worth noting. The results from the preliminary sample of *Juniperus squamata* 'Meyeri' cuttings gave support to the view that rapid callusing does not necessarily predispose or indicate subsequent optimal rooting.

The replicated layout used in these experiments also enabled a substandard section of bench to be pinpointed in the case of X *Cupressocyparis leylandii* shown as item 3 in Table 1, Part 2. Total dead cuttings from the three treatment plots arranged across the bench were, in order along the bench, 7, 3, 5, 2 and 32.

The main conclusion from these results is that the benefit, or otherwise, of wounding cuttings appears to be related to the conditions of propagation, such as the method of auxin application and possibly moisture regime, than to the species involved; x *Cupressocyparis leylandii* featured in each type of main response.

A better understanding of the role of basal wounding in both the response to auxin and to moisture conditions of the rooting environment is clearly necessary to achieve optimal propagation conditions. With this understanding these conditions might be achieved in some cases by modifying the auxin treatment or the rooting environment, rather than resorting to wounding, which is an extra stage in the preparation of cuttings.

Accordingly, provision was made at the 1971 Annual Conference at Merrist Wood Agricultural College to investigate in a new nurserymen's experiment, the interplay of wounding with the method of IBA application and the moisture regime of the propagating environment using x *Cupressocyparis leylandii.*

ACKNOWLEDGEMENTS

Thanks are due to Miss C. Jackson of East Malling Research Station for handling the statistical aspects of these trials. Participating nurserymen are to be congratulated on the standard of records taken.

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APPENDIX

Conditions

1. J. G D. Lamb and J. C. Kelly, The Agricultural Institute, Kinsealy, Dublin. 16.1.70 to 10.2.70. 2.0 to 2.8 in nodal cuttings with 0.8 in wounds treated with Seradix No. 2 powder where appropriate.
2. J. P. Sutherland, North of Scotland Agricultural College, Inverness. 3.2.70 to 23.3.70. 4.0 to 4.7 in lateral cuttings with 1.0 in wounds treated with Seradix No. 3 where appropriate.
3. J. Watts, Darby Nursery Stock Limited, Thetford. 20.2.70 to 24.6.70. Nodal cuttings with brown wood at base. 5.0 in nodal cutting. 0.4 in wound treated with 1250 ppm IBA in alcoholic solution where appropriate.
4. A. Turner, Royal Horticultural Society's Gardens, Wisley. 11.11.70 to 8.3.71. 5.0 to 6.0 in heel cuttings with 0.5 in wound treated with Seradix No. 3 where appropriate.
5. Member not identified. 13.4.70 to 13.10.70. 2.5 to 3.0 in soft tip cuttings with 0.5 in wound treated with Seradix No. 2 where appropriate.
6. D. Mansell, Meadow Cottage Nursery, Chelwood Gate. 20.10.70 to 20.5.71. 3 0 in internodal cuttings with 1.5 in wound treated with Seradix No. 3 where appropriate.
7. M. E. Marston, School of Agriculture, Nottingham University, Sutton Bonington. 3.8.70 to 11.9.70 1.5 in leaf-bud cuttings. 0.75 in wound treated with Murphy Hormone Rooting powder where appropriate. (NAA and Captan).
8. J. G. D. Lamb and J. C. Kelly, The Agricultural Institute, Kinsealy, Dublin. 2.12.70 to 7.1.71. 2.0 to 3.0 in nodal cuttings. 0.8 in wound treated with Seradix No. 3 where appropriate.
9. P. D. A. McMillan-Browse, Hadlow College, Kent. 10.1.70 to 5.4.70.

4.0 to 5 0 in lateral cuttings, mature at base. 1.0 in wound treated with Seradix No. 3 where appropriate.

10 J. Watts, Darby Nursery Stock Limited, Thetford. 3.2.71 to 7.6.71. 4.0 in nodal cuttings. 0 4 in wound treated with 1250 ppm IBA in alcoholic solution where appropriate.

11. G. P. Chandler, Stewarts (Ferndown) Nurseries Limited, Wimborne. 21.1.70 to 7.4.70. 4.0 in cuttings of previous season. 1.0 in wound treated with Seradix No. 3 where appropriate.

12. B. Humphrey, Hillier and Sons, Winchester. 21.9.70 to 10.6.71. 3.0 in cuttings 1.0 in wound treated with 5000 ppm IBA in alcoholic solution where appropriate.

13. J. Hulme, University of Liverpool Botanic Gardens, Wirral. 12.2.70 to 7.7.70. 3.0 in lateral cuttings with trimmed heel. 0.5 in wound treated with 1000 ppm IBA in alcoholic solution where appropriate.

14. T. Allen, J. Coles and Sons, Leicester. 25.7.70 to 12.10.70. 3.0 in heel cuttings. 0.5 in wound treated with 500 ppm IBA in alcoholic solution where appropriate.

15. F. Willard, Messrs. A. Goatcher and Son, The Nurseries, Pulborough. 21.1.70 to 14.9.70. 4.0 to 6.0 in nodal tip cuttings. 0.6 in wound treated with Seradix No. 3 where appropriate.

16. B. H. Howard, East Malling Research Station. 19.3.70 to 16.4.70. 24 0 in basal hardwood cuttings propagated without mist. 0.7 in wound treated with 2500 ppm IBA in alcoholic solution where appropriate.

17. B. Humphrey, Hillier and Sons, Winchester. 5.10.70 to 10.6.71. 4.5 in cutting. 1.0 in wound treated with 10,000 ppm IBA in powder formulation where appropriate.

18. D. M. Donovan, F. Toynbee Limited, Croftway Nurseries, Bognor Regis. 11.1.70 to 5.4.70. 3.0 to 4.7 in nodal hardwood cutting, 0.6 in wound treated with Boots Hormone Rooting powder (NAA, IBA and Thiram).

19. R. J. Hares, Pershore College of Horticulture, Worcs. 17.6.70 to 4.7.70. 3.0 in soft tip cuttings. 1.0 in wound (incision) treated with 1000 ppm IBA in alcoholic solution where appropriate.

A TIME MEASUREMENT STUDY: BENCH GRAFTING OF WOODY PLANTS UNDER GLASS

JOHN B. GAGGINI

Northampton Development Corporation

Northampton

INTRODUCTION

This study was made during my employment in the Ministry of Agriculture, Fisheries and Food when I was employed as a Horticultural Advisor. All the time studies referred to here were made on the nursery of Messrs. John Waterer Sons and Crisp and I would like to thank the management and staff for allowing me to undertake this work and to submit this paper to the I.P.P.S.

The reasons I chose to study bench grafting were that, as an area of work, it seemed to be unduly complex and time consuming in terms of output.

My objectives were to: (1) Eliminate unnecessary work; (2) To simplify the process; (3) To make it a more pleasant job; (4) To speed up work throughout.

The first question to be asked is—what is the end product? In this case, a grafted plant in a closed frame is required and all work must therefore be directed towards reducing the time taken to achieve this end; in so doing, one must eliminate or simplify the job elements. Any alternatives should be judged on efficiency and convenience and on improved technique. Eight plants were studied in detail: *Hamamelis, Fagus, Prunus* (2 species), *Clematis, Picea, Hibiscus,* and *Cupressus;* three others—*Cedrus, Wistaria, Betula*—were studied briefly.

Time study observations were made with a "split-action stop watch" (Heuer Taylor—costing £25). The watch has 2 hands of distinguishing colours; the small left-hand push-button stops one hand whilst the other hand continues. When the push-button is pressed again the stopped hand catches up with the one still recording. To stop or start both hands simultaneously the winding button is pressed consecutively It is easy, therefore, to take cumulative times without the need for subtractions at the end of the study. This is known as "fly back timing".

Times shown here can only be taken as a guide and should not be taken as a true indication of time taken to graft any particular subject or of the time difference between one species and another. Every worker will vary in his dexterity according to the ergonomic circumstances in which he operates and the materials with which he has to work. Basic times for each operation can be obtained if the rate of each person's working performance is taken into consideration before meaningful times are given.

Obviously an initial study such as this taken on only one nursery *with observations made on just 4 workers cannot make this a complete* time study of bench grafting under glass. In view of the many details recorded for each study I will confine my main remarks to *Hamamelis mollis* grafting and then finalise with specific tables and general comments covering all species studied.

Grafting Hamamelis. *Hamamelis virginiana* stocks are purchased from U.S.A. one year prior to grafting and potted up into 3½ inch clay pots. During the first week in January these are brought into a glasshouse at a temperature between 50° F. and 70° F. and stood on solid benches 39 inches high. The bench surface is covered with 2½ in. of sphagnum peat. Stocks are grafted two weeks after bringing into the glasshouse. Scions are collected by the foreman and cut into common lengths of 4 to 6 inches, having 2 buds on each scion. The stock is cut 1½ inches from the base to which a scion with a ½ inch long sloping cut is joined to form a side graft and then tied with raffia.

If one examines the job elements, from picking up the potted rootstock to putting down the English light on the frame, there are 10 operations, 2 inspections, 6 transports, 3 storages and 8 delays (see Appendix No. 1). Quite a formidable list, but from such an observation, key operations can be picked out and a calculation made of the number of observations needed on each of these to obtain a true picture (see Appendix No. 2.). An example of a time study recording sheet can be seen in Appendix No. 3.

When the recordings necessary for a reliable time study have been taken and when the man being studied has been rated, a calculation for basic time can be made To obtain basic time, multiply observed time by the rating factor and divide by 100; e.g. observed time = 0.50 mins., rating factor = 70: $\frac{0.50 \times 70}{100} = 0.35$ Basic Time = 0.35 mins.

Basic time is the time necessary for carrying out an element of work at standard rating.

To find what the standard time should be for a given job one adds contingency allowance for delay, unoccupied time, and interference allowance, where applicable. A relaxation allowance must also be made before calculating standard performance. Relaxation allowance is an addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological efforts of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on the nature of the job. Taking bench grafting as an example the following relaxation allowances could be added to the basic time:

A.	Energy Output — very light Light bench work — standing Equivalent to handling 0-5 lbs.	6 to 7½ %
B.	Posture — standing (both feet)	1 to 2½ %
C.	Motions — normal	0
D.	Visual Fatigue — nearly continuous eye attention Lighting, poor variable	2%
E.	Personal Needs — Women 4% Men	2½ %
F.	Thermal Conditions — normal 55° to 70° F normal humidity	0
G.	Atmospheric Conditions — good	0
H.	Other Environmental Influences Absence of company	1
	RELAXATION ALLOWANCE	12½ to 15½ %

The minimum overall allowance for women is 12% and for men 10%. An improvement of 2½ to 5½ % could be made if the operator is seated comfortably in a well lighted room with one or two people working nearby.

Job Breakdown. In timing *Hamamelis* grafting I found it necessary to break the job down into 14 divisions (see Appendix No. 4.). Looking more closely at these divisions there were 5 key operations which were essential to the completion of the job. Such key operations are best called "job elements" since there is a clear distinction between one element and another. These elements are:

1. Weed pot and behead stock.
2. Make sloping cut on stock.
3. Select and cut scion.
4. Join and bind stock and scion with raffia.
5. Inspect and trim completed graft.

Obviously there is a limit to the breakdown of jobs into elements and this is usually determined by the time needed to record each stage. For instance, *Element 1.* "Weed pot and behead stock" was made up of 4 parts, *a.* pick up stock; *b.* weed pot; *c.* behead stock, *d.* put down stock; but because of the time factor these had to be made into a combined element.

Furthermore, some elements are not repeated so regularly as others; e.g. 5. "Inspect and trim completed graft", only occurred in 14 out of 21 observations so the times have to be aggregated and divided by 21 to obtain the average time per plant for that element.

If one wishes to interpret these figures into meaningful cost studies, then one should remember that they only constitute one job connected with the whole grafting process. They do not take account of cutting scions, proximity to glasshouse and subsequent operations such as pot movement, ventilation, graft failures and reties, etc. However, by studying the grafting operation in depth it is easier to pinpoint limitations in the method and unnecessary labour usage. This is where "method study" comes into its own and "critical examination" begins. By minor improvements such as graded stocks and scions, clean compost to the top of the pot, the use of rubber ties, use of a swivel seat on large caster wheels, and a hosepipe gun, the whole job could be completed in 5 operations compared with 10 operations in the original method (see Appendix 5). Appendices 6 and 7 illustrate present and possible new method man type process charts.

Grafting Other Subjects:

1 *Prunus x hillieri* 'Spire'
Rootstock—roots of *Prunus avium*
Method: whip tongue graft, root wiped with rag, raffia-tied graft painted with cold wax (Creotex).
Average time for grafting, including rootstock preparation, 2.12 mins.
Rating, 55.
Basic time, 1.16 mins.
Relaxation allowance, 14%=0.15 mins.
Standard time=1.31 mins.

2 *Prunus mume* 'Beni-shi-don'
Rootstock—'St Julien' roots.
Method—whip and tongue graft, on washed roots, tied with nutscene twine.
Average time for grafting, 1.10 mins.
Rating, 100.
Basic time, 1.10 mins.
Relaxation allowance, 14%=0.15 mins.
Standard time=1.25 mins.

3. *Fagus sylvatica* 'Riversii' ('Rivers Purple')
Rootstock —*Fagus sylvatica* in pots.
Method: side tongue graft, tied with raffia.
Average time for grafting, 1.92 mins.
Rating, 70.
Basic time, 1.34 mins.
Relaxation allowance, 14%=0.20 mins.
Standard time=1.54 mins.

4. *Picea pungens* 'Glauca Pendula' ('Kosteriana')
Rootstock—*Picea abies* in pots.
Method: side veneer graft, tied with raffia, removal of needles from base of scion.

Average time for grafting, 1.41 mins.
Rating, 100.
Basic time, 1.41 mins.
Relaxation allowance, 14%=0.20 mins.
Standard time=1.61 mins.

5. *Cupressus macrocarpa* 'Donards Gold'
Rootstock—*Cupressus macrocarpa* in pots.
Method: side veneer graft, tied with raffia, stocks cut back to 1 foot high.
Average time for grafting, 0.95 mins.
Rating, 105.
Basic time, 1.00 mins.
Relaxation allowance, 14% = 0.14 mins.
Standard time=1.14 mins.

6. *Hibiscus syriacus* cultivars
Rootstock—*Hibiscus syriacus*, sections of washed roots.
Method: veneer graft, tied with 2-ply fillis.
Average time for grafting, 0.67 mins.
Rating, 110.
Basic time, 0.74 mins.
Relaxation allowance, 12%=0.09 mins.
Standard time=0.83 mins.

7. *Clematis* cultivars
Rootstock—*Clematis vitalba* 3-in pieces of root.
Method: split leaf-bud root graft, tied with very thin raffia.
Average time for grafting, 0.69 mins.
Rating, 105.
Basic time, 0.72 mins.
Relaxation allowance, 12%=0.9 mins.
Standard time, 0.81 mins.

Discussion of Methods and Equipment Used. Observing and timing people in the working environment is fraught with hazards and this particular study was no exception. Apart from the actual job being examined it is important also to take account of other aspects, indirectly or directly affecting the welfare of the worker and his work output. The working situation here was generally poor—workers standing next to a high bench in a dripping, low-roofed glasshouse or, alternatively, sitting on uncomfortable, unadjustable seats with insufficient room for maneuverability and with a naked light bulb hanging a foot or so from their faces.

Glasshouse benches were generally too high and too wide making examination of grafts difficult. Putting down and picking up grafts was awkward and speed of throughput was limited. Bottlenecks were mainly the result of scion collection as the material always had to be obtained some distance from the propagation unit and it was very often necessary to travel long distances by vehicle.

Poor results and inconsistent quality were often due to the following:

1. Poor tying materials.
2. Bad knives.
3. Indifferent stock plants—ungraded, differing in thickness and depth in pot.
4. Scion wood not grown on plants for specific scion wood production and consequently ungraded.
5. Not enough trained staff (especially younger members).

Suggested Improvements. 1. Grow stock hedges of each cultivar for scion production and situate these close to the propagation unit 2. Grow stock plants in pots, filled to brim, making grafting easier. 3. Grade stock plants when potting off and when bringing into glasshouse. 4. Grade scions according to diameter of stock plant stems. 5. Prepare plants, materials and equipment well beforehand. 6. Teamwork is essential and the people studied could improve their performance on certain species if they worked in co-ordinated groups; e g one person preparing stock plant, one preparing scion, and another joining them together. 7 The working environment could be vastly improved if the job took place in a strip-lighted and heated room, with reasonable comfort on swivel chairs which should be adjacent to a bench of the correct height. 8. For most woody plants the knife should be sharpened on one side of the blade only. Why not use a scalpel, particularly for more delicate subjects? 9. Tying materials should be pre-cut into lengths. Materials which can be easily made into a slip knot are desirable. Rapidex rubber ties seem to have many advantages. Tying appears to take up the largest percentage of time of all the grafting operations and a close investigation of materials used, methods of tying and, indeed, the necessity for tying could prove very rewarding. A few comments have been made in Appendix 8. 10. Use secateurs whenever possible; e.g. beheading rootstock.

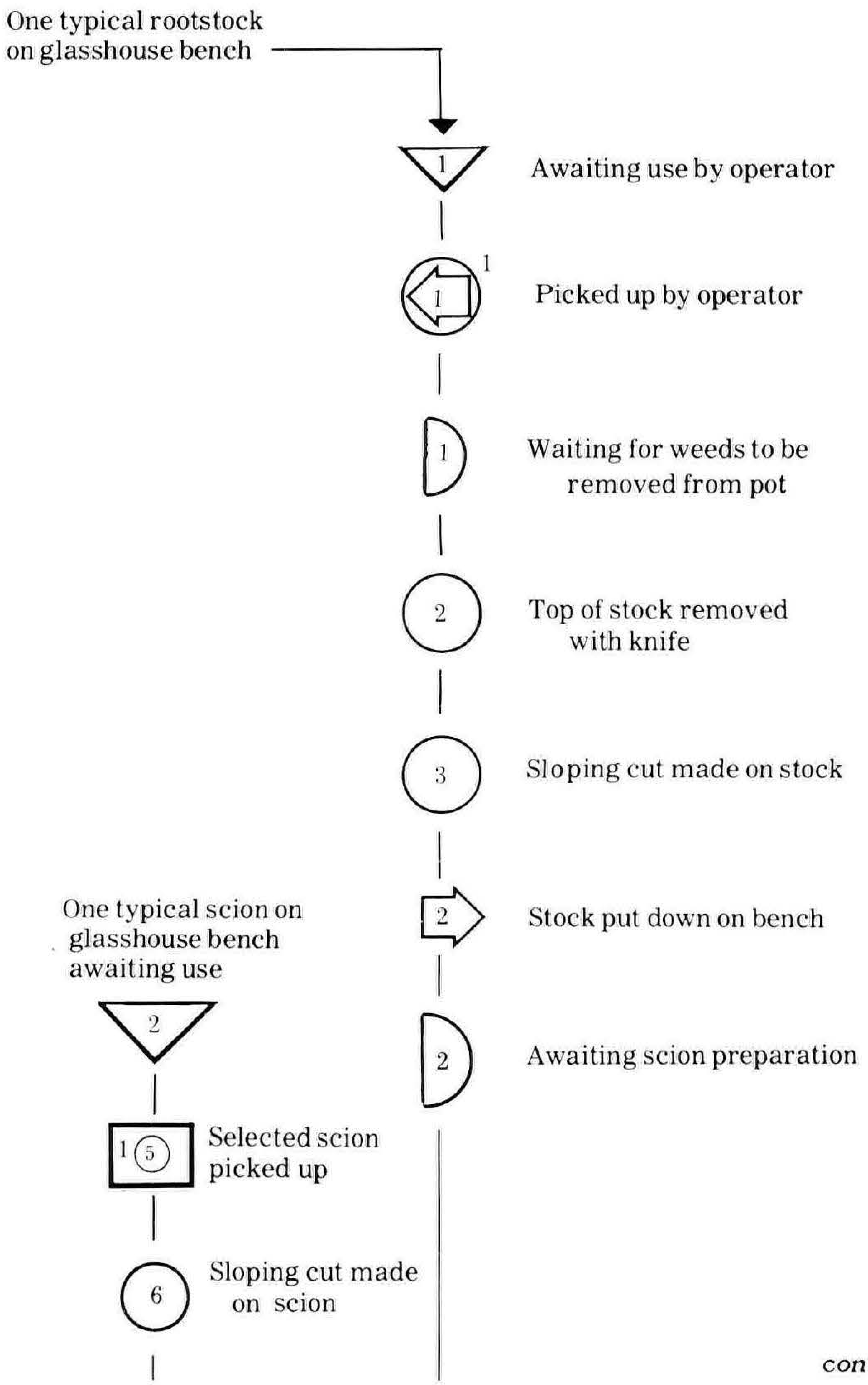
Glasshouse bench grafting is a costly technique in terms of heated glasshouse, glasshouse space and the skilled labour essential to do a worthwhile job, therefore it is important to achieve the maximum throughput with the minimum of effort and the highest percentage take. One can only achieve such high ideals by paying attention to detail, providing a reasonable working environment with the right equipment and having a nucleus of skilled, motivated workers.

APPENDIX NO. 1

PROPAGATION STUDY: *HAMAMELIS* GRAFTING, SURREY, JANUARY 1971. ORIGINAL METHOD.

FLOW PROCESS CHART (MATERIAL TYPE).

JOB: Grafting *Hamamelis mollis* scions onto *Hamamelis virginiana* rootstock.
CHART BEGINS: Potted rootstocks on bench in glasshouse.
CHART ENDS: Grafted rootstock in closed frame (case) in glasshouse.



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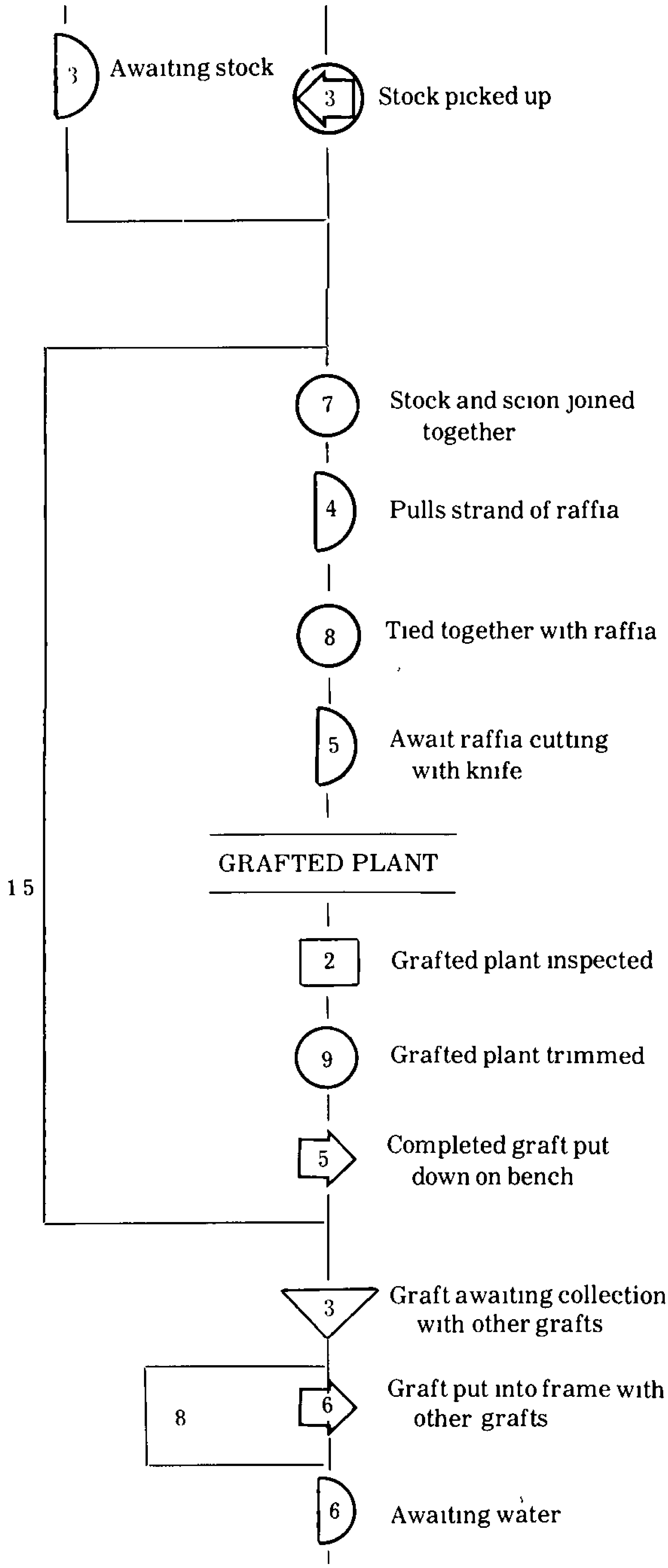

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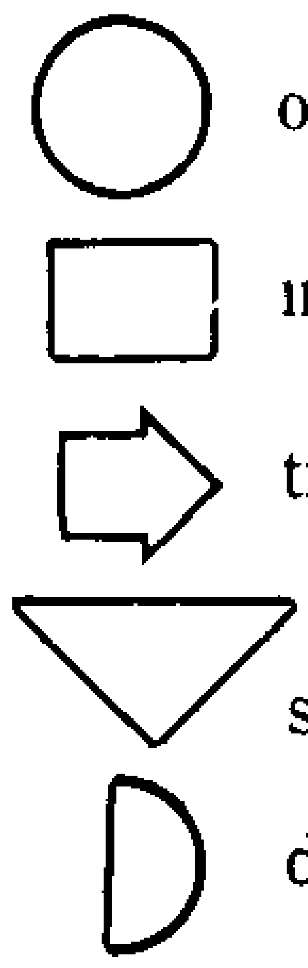
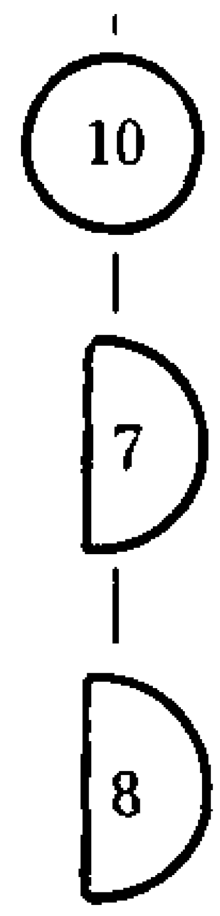
SUMMARY



	operations	10
	inspections	2
	transports	6
	storages	3
	delays	8



Watered

Peat wetted in frame

Light put down on frame

APPENDIX NO. 2

CALCULATION OF NUMBER OF OBSERVATIONS NEEDED

SELECT STOCK

12 observations = total time of 1 93 mins = average time of 0 16 mins

Difference between highest and lowest observations = 0 14 mins (9 = lowest, 23 = highest)

Using $N = \dfrac{(r)^2}{(0\ 077)\,\bar{x}}$ N = number, r = 14, $\bar{x}$ = mean

$$\therefore N = \frac{(14)^2}{0\ 077) \times 16}$$

$$\therefore N = \frac{(14)^2}{(1\ 232)} = 128$$

Number of observations needed for $\pm$ 5% at the 95% confidence limits is 128

At $\pm$ 10% confidence limits is 32 observations

SLOPING CUT ON STOCK

12 observations = total time of 4 76 mins = average time of 0 40 mins

Difference between highest and lowest observations = 0 21 mins (29 = lowest, 50 = highest)

Using $N = \dfrac{(r)^2}{(0\ 077)\,\bar{x}}$

$$\therefore N = \frac{(21)^2}{(0\ 077)\ 40}$$

continued

continued

$$\therefore N = \frac{(21)^2}{(3\ 08)} = 44\ 89$$

Number of observations needed for ± 5% at the 95% confidence limits is 45

At ± 10% at the 95% confidence limits is 11 observations

APPENDIX NO. 3

TIME STUDY — RECORDING SHEET:

JOB: *Grafting Hamamelis. Semi skilled male standing, operating at mobile bench in glasshouse.*

STUDY NO 1
SHEET NO 1
DATE 19 1 71
TIME OFF
TIME ON
ELAPSED TIME
RECORDER J B Gaggini

EQUIPMENT USED

Budding knife, raffia

SUBJECT *Hamamelis*

LOCATION *In glasshouse in top prop*

Element Description	R	OT	BT	Element Description	R	OT	BT
Move bench ready for grafting	70	54					
Sharpen knife		28					
Take 8 stocks out of frame		57					
Weed rootstock pot		21					
Cut stock		21					
Select and cut scion		34					
Tie raffia		53					
Pick up rootstock and cut		28					
Sloping cut on stock		25					
Cut scion		16					
Tie raffia		56					
Inspect graft and put down		20					

R = rating OT = Observed Time BT = Basic Time

APPENDIX NO. 4

JOB BREAKDOWN — *Hamamelis* GRAFTING TIME STUDY:

	Operation	No of Stocks or Observations	Average Time Per Plant / Observation
1	Cleaning weeds from pot / cutting off top of stock	3 85 mins	0 18 mins
2	Sloping cut on stock	3 30 mins	0 16 mins
3	Select and cut scion	4 79 mins	0 22 mins
4	Bind stock and scion	13 65 mins	0 65 mins
5	Inspect and trim graft	1 65 mins	0 08 mins
6	Taking stocks from frame	1 46 mins	0 05 mins
7	Putting grafts in frame	2 33 mins	0 12 mins
8	Filling jug with water	0 40 mins	0 02 mins
9	Watering peat in frame	0 66 mins	0 02 mins
10	Watering pots with jug	0 45 mins	0 01 mins
11	Putting down and covering frame	0 49 mins	0 02 mins
12	Moving grafting bench	0 54 mins	0 02 mins
13	Sharpening knife	0 28 mins	0 01 mins
14	Miscellaneous time	1 50 mins	0 05 mins
	TOTAL TIME PER GRAFT		1 61 mins

Rating = 70 $\therefore \frac{1\ 61 \times 70}{100}$ = 1 03 mins Basic Time

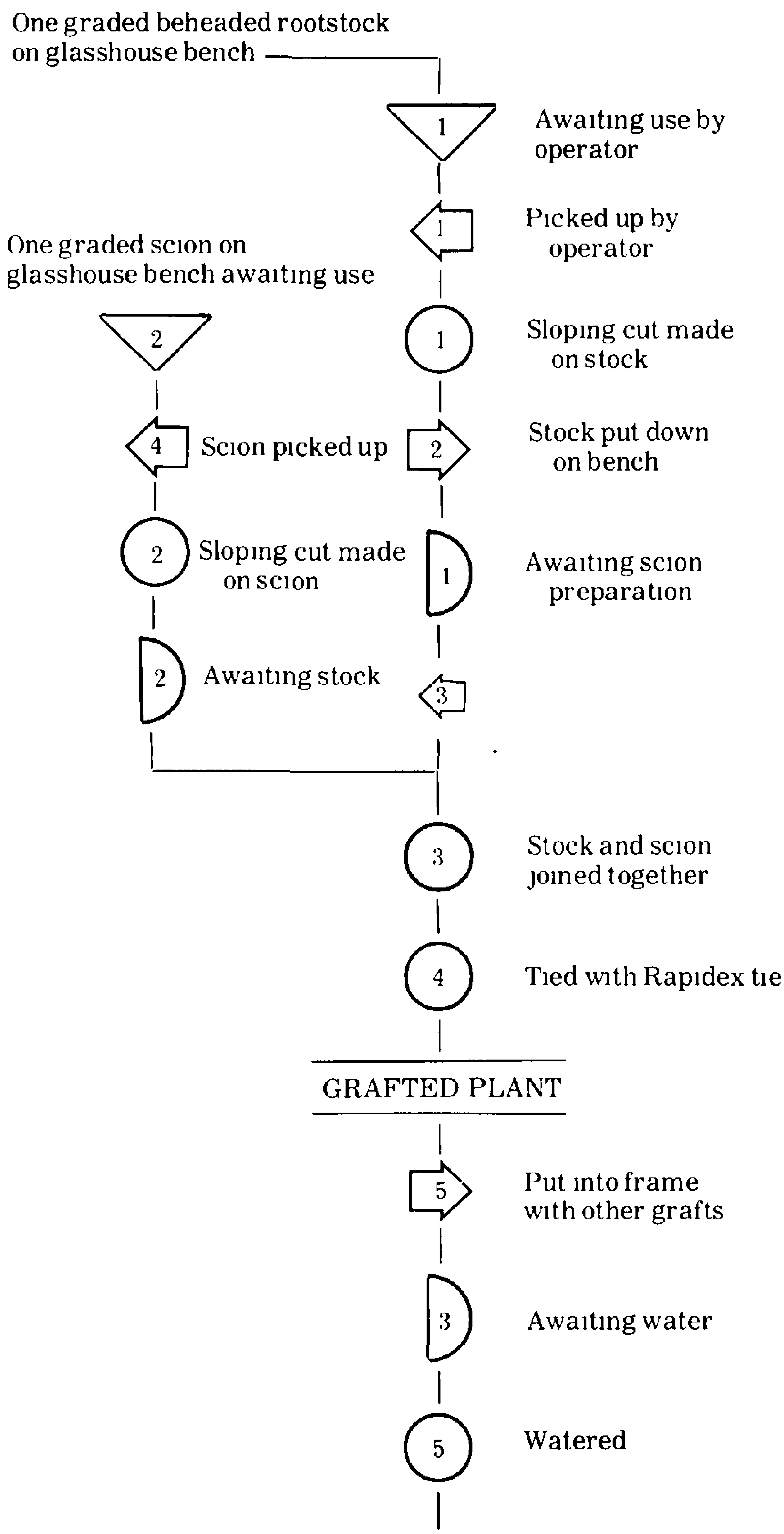
Add 14 % for relaxation allowances = 0 14 mins

$\therefore$ 1 03
0 14+

STANDARD TIME = 1 17 mins

APPENDIX NO. 5

FLOW GRAFT CHART — *Hamamelis* GRAFTING. Possible new method·



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4 Peat wetted in frame

5 Light put down on frame

SUMMARY

○	operations	5
⇨	transports	5
▽	storages	2
D	delays	5

APPENDIX NO. 6

FLOW PROCESS CHART (Man Type):

JOB: *Hamamelis* grafting PRESENT METHOD

CHART BEGINS Picking up rootstock

CHART ENDS Closing frame

1 Picking up rootstock

2 Removing weeds from pot

3 Cutting off top of stock with knife

4 Make sloping cut on stock

5 Put stock down on bench

1 Select scion

6 Pick up scion

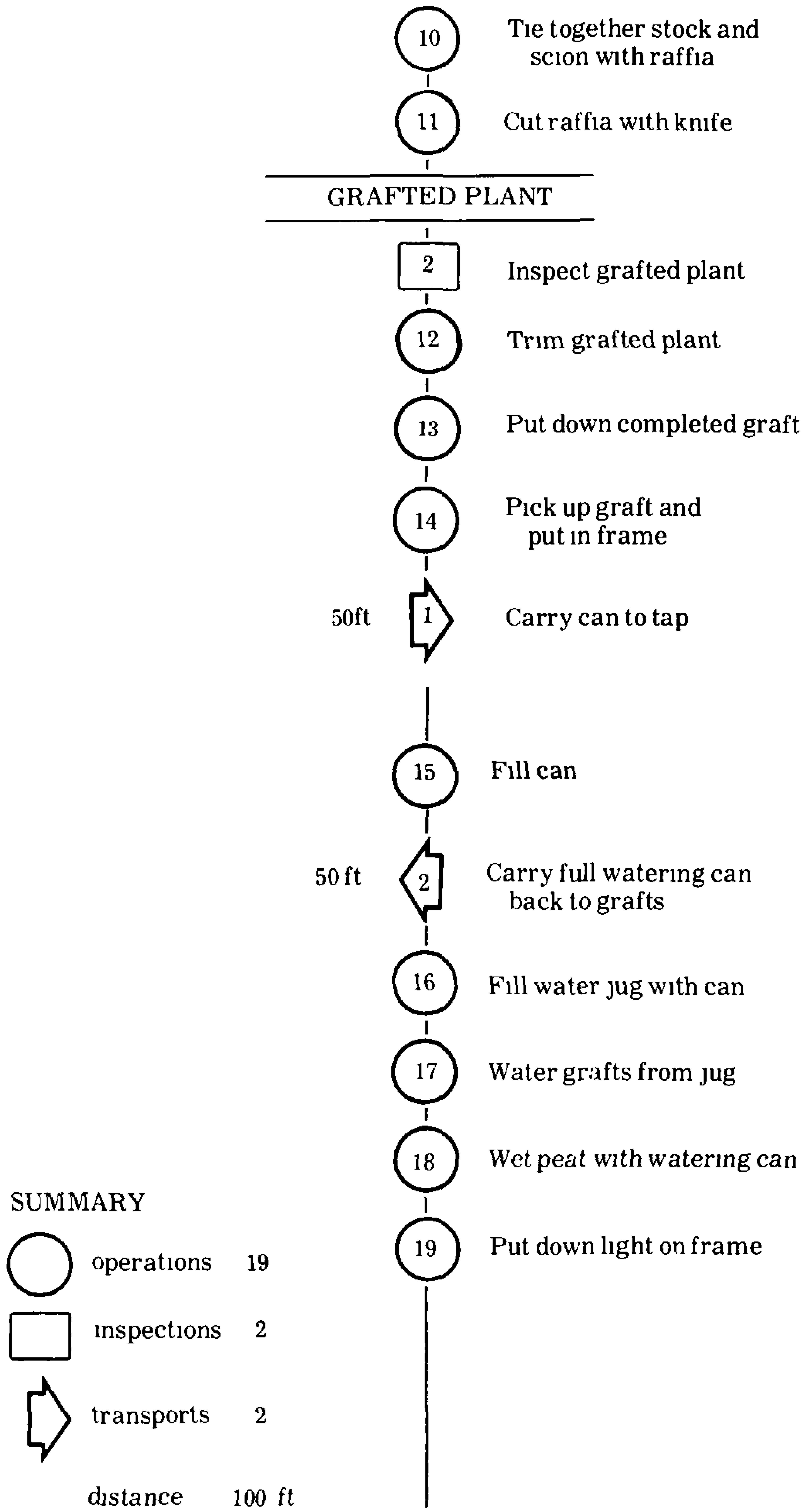
7 Make sloping cut on scion

8 Join stock and scion together

9 Pull strand of raffia

continued

continued


10 Tie together stock and scion with raffia
11 Cut raffia with knife
GRAFTED PLANT
2 Inspect grafted plant
12 Trim grafted plant
13 Put down completed graft
14 Pick up graft and put in frame
50ft 1 Carry can to tap
15 Fill can
50 ft 2 Carry full watering can back to grafts
16 Fill water jug with can
17 Water grafts from jug
18 Wet peat with watering can
19 Put down light on frame
SUMMARY
operations 19
inspections 2
transports 2
distance 100 ft

APPENDIX NO. 7

FLOW PROCESS CHART (Man Type):

JOB: *Hamamelis* grafting

CHART BEGINS: Picking up rootstock

CHART ENDS: Closing frame

POSSIBLE NEW METHOD

(1) Pick up rootstock

(2) Make sloping cut on stock

(3) Put down stock on bench

(4) Pick up scion

(5) Make sloping cut on scion

(6) Join stock and scion together

(7) Tie with Rapidex tie

GRAFTED PLANT

(8) Put down graft in frame

(9) Water grafts and peat in frame using trigger operated hose

(10) Put light down on frame

SUMMARY

○ operations 10

APPENDIX NO. 8

TYING SCION AND STOCK TOGETHER:

Subject (stock)	Tying Material	Time Taken	Percent of Grafting Time
Fagus sylvatica	Raffia	0 83 mins	43
Hamamelis mollis	Raffia	0 65 mins	41
Picea abies	Raffia	0 53 mins	38
Prunus avium	Raffia	0 52 mins	25
Cupressus macrocarpa	Raffia	0 40 mins	42
Prunus 'St Julien'	Green twine	0 41 mins	37
Clematis vitalba	Raffia	0 28 mins	41
Hibiscus syriacus	Fillis	0 27 mins	33

COMMENTS

Slow speeds of working are due to the use of raffia which is of poor quality, breaks easily, has to be split further by the knifesman, is not cut to pre-determined lengths and is of variable thickness Good raffia at a reasonable price is a scarce commodity

Green twine and fillis is easy to use if cut to pre-determined lengths and one needs to bind it in position to obtain a similar finish to raffia tying Therefore, ease of grasp and uniform thickness of twine brings the final time taken into line with raffia

I have not considered polythene or rubber strips which seem to have certain advantages over other materials studied and have given every indication of higher percentage takes

The advantages of cutting raffia or twine to length, or having other materials of pre-determined lengths, is cancelled out if there is a wide variation in size grade of stock or size grade of scion

G. YATES: You started your study with work measurement of the existing situation. Why wasn't *method study* rather than the *time measurement* carried out first in order to cut out some of the unnecessary movement of stocks, scions and materials which you highlighted in your case study?

J. GAGGINI: You have hit the nail on the head; it could certainly be argued that this is a method study job and this should have been looked at first. My reasons for proceeding as I did were purely personal, as I wished to find the basic times for some of these traditional operations. In the Advisory Service we were being asked how many grafts should one do in a day, and we have no information from which to answer such questions. I take the point, however, that there is scope for method study here.

B. HALLIWELL: Surely it must be important to take into account the percentage of successful takes?

J. GAGGINI: Not for the actual grafting operation. You take this factor into account in the subsequent business study of the whole nursery.

J. WELLS: I spent two years at D. Hill Nursery, Dundee, Illinois, and they had a very well planned production line for grafting junipers. The jobs were divided up, with everybody sitting down in a warm place; it was a well organised unit producing a quarter of a million junipers each year. When I was there they wanted to apply the same techniques to Koster spruce and I argued against it. Tony Thomson (a member of this Region, now in Denmark) and I, grafting in the orthodox manner, averaged 700 a day between us with 86% success. The production line did about 5,000 grafts and got 14% take.

J. GAGGINI: I am not advocating speed rather than skill. All that I am doing is to try to compare the time it takes, for example, to graft 100 *Fagus sylvatica* with that to graft 100 *Picea pungens* 'Glauca'. I want some figures on which to base our future programmes; if I want to expand a certain line I want to know how much labour is required for that particular purpose.

F. WILLARD: But if this labour is not the right kind you will get back to the low percentage take again.

J. GAGGINI: Yes, but of course the manager should realise this before he starts on this kind of investigation. He has to examine his workers critically. He must know what he has got and, if suitable workers are not available, he clearly cannot proceed with that type of programme.

F. WILLARD: A man can be motivated to do a job without necessarily having the skill to be able to perform it successfully.

J. GAGGINI: I would not start any measurements on anyone who did not have the basic skills. He would either be trained until he was proficient or he would be discarded.

DR. B. HOWARD: Were any of the persons on whom the measurements were taken producing bad results?

J. GAGGINI: They were all producing average takes, and there was quite a variation of performance as you can see from the rating of 55 to 110. So some people were producing twice as many grafts as others yet the percentage take was about the same.

F. WILLARD: This emphasises the point I am trying to make—with such variation can you really define what is an average time for a good job? One man might do a thoroughly good job at a much faster rate than another.

J. GAGGINI: I am sure you have got to do so. This is a business and we have got to look at it that way.

B. HALLIWELL: You do not speed up a job to do it inefficiently. You aim to use the skills as effectively as possible in relation to time. One of the important things which comes out of such a study is the knowledge of how much should be done in a certain time and it is not good management expecting double this to be achieved. Management must see that quality control is effectively applied and, if rates go up beyond a certain level, it may well be seen that quality is suffering.

J. WELLS: I am sure that this methodical approach to our problems is extremely important, and John's talk today is one of the most important things you are likely to hear at this Conference. This is fundamental, and if you put your mind against it you are making a great mistake.

P. THODAY: Would Jim Wells tell us whether, if he and his colleague had placed themselves in key positions in the grafting team which he described recently, they could have raised the abysmally low percentage of take and maintain their own individual performances?

J. WELLS: Yes. I think that if we had placed ourselves in the production line putting stock and scion together and binding them we could have greatly improved the overall take.

DR. CAMPBELL: The fact that tying took 40% of the time suggests that this is the part of the operation you want to attack. Why were you using so many tying materials?

J. GAGGINI: In this case there were three materials used, fillis, Nutscene and raffia, and I think the reason was just tradition.

C. A. WILLIAMS: May I add that with a lot of grafting the union is buried in soil or peat; you must, therefore, have the type of material which will not come undone under these conditions. For example, using Nutscene, I can do *Hibiscus* and know that the string will last the whole of its time, and when it starts swelling it will burst; this cannot be done with raffia or rubber ties.

PLANT PROPAGATORS' QUESTION BOX

DAVID CLARK, *Moderator*

DR. B. HOWARD: Has anyone any information—with references if possible—on whether the form the resultant plant is influenced by the position on the stock plant from which the cutting is taken?

J. WELLS: There are a number of simple illustrations of the effect of taking cuttings from different places on the parent plant. *Taxus cuspidata* comes to mind; if you take a cutting from the side of the plant you get a spreading type plant. If you want an upright form (i.e. to continue the natural habit which is produced from seed) then you must take a terminal cutting. The same thing is true of a number of *Piceas,* and *Picea abies* 'Nidiformis' is, I believe, produced in that way. This is true of *Sequoias* also.

D. HARRIS: What has been said of the Japanese yew *(Taxus cuspidata)* is equally true of the Irish yew *(Taxus baccata* 'Fastigiata').

P. THODAY: It is interesting that all these examples belong to the Coniferae. I think that the effects are rather more subtle in the Angiosperms compared with the Gymnosperms. I cannot quote examples without notice but I think it can be said that the effects in these broad-leaved subjects are generally less noticeable but still present.

THE CHAIRMAN: It has been suggested that, with the increased use of soft terminal cuttings rather than heeled material which, by its very nature, was usually taken further down the plant, such subjects as *Chamaecyparis lawsoniana* 'Elwoodii' are tending to become more vigorous and upright in form.

D. WEGUELIN: We have this problem with *C.l.* 'Elwoodii'. Cuttings taken from different parts produce entirely different plant habits. Never go above 2 ft. height for 'Elwoodii' if you want to keep its typical form. Cuttings from the tops of larger trees develop into something more like *C.l.* 'Allumii'; always propagate from juvenile growth.

C. A. SIMPSON: Can we have full details of the method of placing seeds in moist sand in polythene bags to chill them? What temperature is required and how long should it be maintained?

P. McMILLAN BROWSE: It should be emphasised of course that the seed must be moist when it is cooled if dormancy is to be broken. The critical temperature at which most refrigerated cabinets operate is 38° F. and anything below that will be satisfactory. Dr. Thompson recommends 8 weeks treatment.

DR. B. HOWARD: With apple seed we sow directly onto compost in seed boxes and stack these in cold stores which we have available at the time. We either leave them until they slowly start to germinate, perhaps after 15-16 weeks, or bring them out after 8-9 weeks.

J. WELLS: There is an invaluable book published by the U.S. Department of Agriculture, "The Woody Plant Seed Manual", which will provide this kind of information.

R. F. MARTYR: Has any grower had experience in growing the cloudberry *(Rubus chamaemorus)*, the fruit of which is held in very high esteem in Scandinavia where it grows profusely on upland acid peat? How is the plant propagated?

B. HALLIWELL: It is rhizomatous; if the long straggly growths are chopped and placed on a peat compost they will root fairly readily.

R. F. MARTYR: It is a fruit of quite distinctive flavour and considerable potential. People go a long way for it and, I assume, would pay a high price for it but, as far as I know, it is not cultivated.

J. P. SUTHERLAND: In nature this plant doesn't grow below 1,000 ft; above that level it fruits very prolifically and is eaten voraciously by grouse and ptarmigan. I don't know anyone who has cultivated it.

B. HALLIWELL: It is in cultivation on the rock garden of Edinburgh Botanics, but it exists rather than grows.

P. HUTCHINSON: When and how can you propagate *Prunus tenella* 'Fire Hill' by stem cuttings?

THE CHAIRMAN: I have also had disastrous results with this plant. What method have you attempted?

P. HUTCHINSON: My percentage success has been about 10%. Cuttings are usually taken about May; after flowering growth is rapid and I have taken 3 to 4 in. cuttings, firming a little bit at the base. The growth tip is still active and I am wondering whether this is a case when the tip should not be too active when we take the cuttings. They have had the usual sort of treatment under mist using Seradix 1.

THE CHAIRMAN: I wonder whether the use of B-9 might help here In the absence of any experiences or suggestions from members here, I will make a note of this question for next year's Conference.

DR. B HOWARD: One year we had a student who sprayed the vigorous Myrobolan B with B-9 and the cuttings—which were reduced to about half their normal length—rooted better than the controls. I certainly would not recommend this treatment on one year's results and, in any case, you are dealing with a dwarf growing plant so you might end up with no growth at all.

THE CHAIRMAN: We have had excellent results from the use of the fungicide Benlate in controlling *Botrytis*, and in generally improving propagation results. (**Ed. note**: The Chairman showed the effectiveness of this material with *Garrya elliptica* by producing boxes of cuttings). Can we ask Doug Harris to fill us in with further information about Benlate?

D. HARRIS: Very briefly it is a broad spectrum fungicide, has systemic action, some eradicant action as well as being a protectant. Work has been done on showing the effect of this use by watering this on to the soil to be absorbed by roots. It has been used to control mildew, blackspot, and a whole range of diseases. I can send on to anyone interested a list of references if they will let me know.

J. DEEN: On the systemic properties, I understand that Benlate is only really systemic when applied as a soil drench. Otherwise its movement is very limited. Secondly, its action on certain fungi is fungiestic, i.e. it tends to hold them in a state of limbo rather than killing them out.

THE CHAIRMAN: Has anyone experience in using Benlate as a dip in the same way as we use Captan?

D. WHALLEY: It does appear to promote the formation of callus over a wide range of species. Its movement appears to be limited to the basal few millimeters of the cutting.

M. D. FARMER: Has anyone had experience in rooting cuttings of *Cupressus macrocarpa* 'Lutea'? We are interested in this plant as a windbreak at Rosewarne We carried out experiments in 1968 and 1969. We were then using *C.m.* 'Lutea', 'Goldcrest', 'Erecta Aurea' and *C. sempervirens* var. *horizontalis* 'Aurea' We applied Seradix 3, Rhizopon AA 2% dust, and Rhizopon liquid, as recommended for conifers. I have some notes of the results, the records of rooting being taken 3 months after insertion.

The best and most consistent results this year came from July and August rooted cuttings with Seradix 3. *C. macrocarpa* 'Lutea' and 'Goldcrest' cuttings rooted best with Rhizopon AA 2%, but the former rooted better in July and the latter in August. *C.m.* 'Erecta aurea' cuttings were very difficult to root, the only success being 10% in July using Seradix 3. *C. sempervirens* var. *horizontalis* 'Aurea' was easier to root than *C. macrocarpa* 'Lutea', the best month being August using Rhizopon AA 2%. This year we have done an experiment again with 'Lutea' and 'Goldcrest' using B-9 as a quick dip, as well as Seradix 3 and Rhizopon AA.

D. WHALLEY: Using B-9 on *C.m.* 'Lutea' cuttings and contrasting that with IBA, B-9 treated and control cuttings rooted better than when IBA was used in solution dips. IBA appeared to depress the rooting.

B. HALLIWELL: I have a comment which might be of interest. In New Zealand we used to root *C.m.* 'Lutea' cuttings and other yellow forms with 100% success using Seradix 3 and Captan. I have done exactly the same in this country but with no success at all. Is this because in New Zealand there is higher sunlight intensity and over here the plants have a carbohydrate-nitrogen ratio problem?

THE CHAIRMAN: It could, of course, also be a clonal problem.

J. WELLS: I am sure the comment about the light problem is valid. In America we grow the Oriental Biota (*Thuja orientalis* 'Aurea Nana') and growers in the South from Tennessee and Kentucky can grow this in great numbers from cuttings. In New Jersey, when I tried to grow these plants from cuttings under glass, I took cuttings every week of the year and rooted none. Directly I put the cuttings outside, without cover, under constant mist, I rooted them 100% and I am sure this was due to the greater light intensity.

G. J. E. YATES: At Merrist Wood last year there seemed to be an indication that, with 'Firecrest' and *C. sempervirens* var. *horizontalis* 'Aurea', the much younger softer tips were rooting better than the conventional cuttings where the base has hardened. The material does not root well if it is too mature.

C. A. WILLIAMS: There are several clones of *Cupressus macrocarpa*, 'Lutea', and I have found that the one which roots the best—and it can be done in late autumn or under mist in the summertime—is *Cupressus macrocarpa* 'Donard Gold'.

M. D. FARMER: We have that one but our experience has been the reverse.

C. SALTER: Care must be taken to use the right formulation of Metasystox for ornamental plants; you must use Metasystox R—if you don't know what you are buying you can run into trouble. Can anyone explain further?

D. HARRIS: In the Agricultural Chemicals Approval Scheme two formulations are mentioned.

Metzsystox 55 is Demeton-D-methyl and a warning is given that this material may damage certain ornamentals.

Metasystox R is Oxydemeton-methyl, which does not have this warning, and is therefore the one the nurserymen should use.

JIM WELLS: Before the end of the Conference I would like to say what a tremendous pleasure it has been for me to be here; I am going back to the Eastern Region meeting with a full report and, if all our plans go forward as we hope, you can look forward to a substantial American contingent in 1973. At least I am going to work towards this and I only hope that many people come over because your meetings are in the best traditions of the Society, and I thank you all once again for having me.

CHAIRMAN: Jim, we are looking forward to seeing you next year as well as in 1973.

A. B. MACDONALD: I have been asked to express, on behalf of all members, our vote of thanks, firstly to Mr. Harris, Principal of this College, for allowing us to use his marvellous facilities here for our Conference, and also for the personal interest he has taken in the Proceedings during the last two days. We must thank Geoffrey Yates for his administrative help in running the Conference and his Nursery

Staff who gave us such a good look round their department this afternoon. Our thanks also to the domestic staff here for the excellent way in which they have looked after us. Finally, our thanks to Arthur Carter, now our President but who, as Vice-President, had the responsibility for arranging such an excellent programme.

NOTES ON THE PROPAGATION OF SOME ORNAMENTALS AT THE NURSERIES OF THE CAPITAL CITY DEVELOPMENT CORPORATION, LILONGWE, MALAWI

D. A. J. LITTLE

Lilongwe, Malawi

Stocking of the nurseries commenced in January, 1970, and it is hoped that the following notes on our experience to date may be of interest to others starting from scratch under tropical or sub-tropical conditions.

Climate. Lilongwe is situated 14° south of the equator, at an altitude of 3,500 ft. Annual rainfall is about 33 in., almost all of which falls between late November and early April. Mean relative humidity during January-February is approximately 85%, falling steadily during the dry season to 52% in October.

Mean temperature throughout the day rises to 74° F. in November and falls to 59° F. in July. Occasional frosts are experienced during June-August. Mean surface wind speed is approximately 4 mph in January and February, increasing steadily during the dry season to reach over 7 mph in October. Climatic data is shown in Table 1.

Leaf fall of most trees begins in June and much vegetation is defoliated by August. Many shade trees and shelter belts are, therefore, ineffective from June to November, although some recommence growth in September—long before the rains arrive.

All of the above factors influence the nursery propagation routine.

Experience to date has shown that the most productive methods of propagation under these conditions are by hardwood cuttings and by seed.

Hardwood Cuttings. Suitable material becomes available after leaf fall but hardwood cutting propagation can also be carried out at other times, in which case material should be defoliated. Material inserted in August when temperatures begin to rise will make adequate growth by the November-February planting season. Hardwood material is convenient to use during the August-November period of low humidity, minimum cloud amount and rising temperatures and air movement.

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Table 1. Temperature, humidity, wind levels, and cloud cover at Lilongwe, Malawi.

Monthly Means	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Mean daily temp., ° F	70	69	69	68	64	60	59	62	68	73	74	72
Mean daily humidity, %	84	85	80	76	71	68	61	58	54	52	60	76
Daily humidity at 1400 hrs, %	67	68	61	54	46	43	37	36	35	33	42	60
Mean surface wind, mph	4.2	3.8	4.2	4.6	5.0	5.4	5.6	5.9	6.5	7.1	7.2	6 4
Cloud amounts, octas	6.4	6.5	5.9	4.0	3.3	3.1	2.8	2.0	1.5	2.1	4 3	5.8
Mean maximum ° F	80	80	80	80	78	75	75	78	82	86	86	82
Mean minimum ° F	63	63	62	57	50	45	43	46	52	58	62	64

Selection and preparation of material. Most subjects are made into cuttings 8-12 in. in length. In some cases age or thickness of material is not critical, and cuttings up to 3 in diameter of *Bougainvillea, Datura, Buddleia, Hibiscus, Nerium, Poinsettia* and *Lagerstroemia* root readily. Material over ¾ in diameter is sawn to length by hand. Smaller material is cut with secateurs. No rooting compounds are used but a stone dust dip containing 10% Captan has been used with advantage.

Facilities. Propagation frames are constructed of brick covered with 500-gauge opaque polythene sheeting on 4 ft. x 3 ft. timber lights. Drainage is provided by a layer of broken bricks topped by ½ in granite chippings. The rooting medium is 1/4—1/16 in crushed granite from the local quarry. Pots (black polythene containers) are manufactured locally to specification.

Insertion and management. Although, at first, care was taken to insert material directly into the propagating medium in spaced rows, experience and necessity have led to close packing, rather as in a rooting bin. Most material produces roots freely in these conditions, but breakage of roots and other losses due to handling in dry conditions have led to the practice of direct insertion into polythene pots for some subjects, e.g. *Bougainvillea* and *Lagerstroemia*.

Some of the hardier species—*Datura, Nerium* and *Poinsettia*—are potted directly into 3 in black polythene containers and placed in a shade house (50%) until established.

Experience has shown that hardwood material in the propagation frames has not required shading and new growth produced within the frames is not damaged by the high temperatures achieved during the middle of the day.

Material propagated as above includes the following species:

Acalypha hamiltoniana
A. wilkesiana cvs.
Allamanda cathartica
Alstonia scholaris
Bougainvillea cvs.
Buddleia asiatica
B. madagascariensis
Cestrum nocturnum
C. purpureum
Clytostoma binatum
Codiaeum variegatum 'Pictum'
Cuphea micropetala
Datura arborea
D. chlorantha
D. suaveolens
Euphorbia fulgens
E. leucacephala
E. pulcherrima
Ficus spp.
Heterocentron roseum
Hibiscus x *archeri*
H. mutabilis
H. rosa-sinensis
H. schizopetalus
H. syriacus
Holmskioldia sanguinea
Hypoestes aristata
Iochroma tubulosa
Jacobinia spp.
Lagerstroemia indica
Malvaviscus arboreus

Continued

Continued

Megaskepasma erythrochlamys	*Russelia juncea*
Morus nigra	*Sanchezia nobilis*
Moschosma riparium	*Solandra grandiflora*
Nerium oleander	*Solanum rantonnettii*
Odontonema nitidum	*S. wendlandii*
Punica granatum	*Strobilanthus isophyllus*
Pyrostegia venusta	*Vitex agnus-castus*

Seed. A number of subjects are raised by the Government Forestry Department by direct sowing into 2 in black polythene tubes filled with forest soil and placed in blocks 3 ft. to 4 ft. wide under shade. This method has been adopted for the production of ornamentals with the following modifications: perforated bags, instead of tubes, were found to be more satisfactory, necessitating less frequent moving to break any roots developing in the standing ground.

Some species with hard seed coats are germinated in polythene bags after initial chipping or hot water treatment. In this way a periodic selection of seeds which actually "popped" are sown directly into the pots giving uniform batches of plants for handling, e.g. *Delonix regia* (*Poinciana regia*), *Schizolobium excelsum* and *Cassia* spp.

Capping of soil is a problem and this has been resolved by topping the direct sown seed with granite chippings (1 / 4 in-1 / 16 in). This also serves to indicate where sowing stopped on the previous day.

In order to avoid drying out and to reduce soil compaction in the containers the blocks of containers are covered after sowing with coarse hessian which is left in place until germination is well advanced. The hessian protects the soil structure, holds the seed down during initial germination, raises the temperature of the compost when the sun shines, ensures a more even distribution of water from the overhead hand-irrigation and reduces the amount and frequency of irrigation required.

On germination, the hessian is raised on a bamboo framework about 18 ins. above the containers to protect the seedlings from desiccation and from occasional frost at night.

Certain species which germinated with the seed leaves still enclosed in the testa after emergence suffered from drying out and hardening of the testa on exposure to the air and had to be helped out by hand—a laborious, delicate and often fatal operation. These included *Schizolobium excelsum* and *Bixa orellana*. In future these will be germinated in cold frames where the atmospheric humidity is more easily controlled.

Species sown directly into pots as above include the following:

Acacia spp.	*Ipomea arborescens*
Afzelia quanzensis	*Jacaranda acutifolia (J. ovalifolia)*
Albizia spp.	*Jatropha multifida*
Aleurites moluccana	*Khaya nyassica*
Allamanda neriifolia	*Melia azedarach*
Bauhinia purpurea	*Moringa oleifera*
B. monandra	*Deloniz regia* (syn *Ponciana regia)*
Bixa orellana	*Rauwoflia caffra*
Caesalpinia pulcherrima	*Ricinus communis*
Cassia spp.	*Schizolobium excelsum*
Eriobotrya japonica	*Solanum seaforthianum*
Erythrina spp.	*Theveha peruviana* (syn. *T. nereifolia*)
Gmelina arborea	

Numerous other species with seeds too small to be handled individually are sown in boxes of forest soil—surprisingly free from weed seeds—and covered with an appropriate depth of granite chippings (3 / 4 in-1 / 16 in) to facilitate watering and prevent capping. Seed sowing commences in August to provide material of planting size by December.

TECHNICAL SESSIONS

Thursday Morning, December 2, 1971

The twenty-first annual meeting of the Eastern Region of the International Plant Propagators' Society convened at 9:00 a.m. in the Azalea Room of The Golden Triangle Motor Hotel, Norfolk, Virginia. Mr. William Flemer III served as moderator.

MODERATOR FLEMER: On behalf of President Tom Pinney, Jr., I want to welcome you all to the 21st annual meeting of our Society. We are going to start right in on this morning's program and the first paper is by Joseph Dallon, Jr. and is entitled, "Culturing Geraniums from Seed". The paper will be presented by Dr. Hess.

CULTURING GERANIUMS FROM SEED

JOSEPH DALLON, JR. AND DOMINIC DURKIN

Rutgers University
New Brunswick, New Jersey

Abstract. Geraniums (*Pelargonium hortorum* Bailey cv Carefree Deep Salmon) were cultured from seed to maturity using growth retardants, and environmental conditions known to affect flowering in a number of plant species High intensity lights and growth retardant treatments were effective in reducing the time required to flower. Geraniums normally require an average of 100 - 115 days to flower, depending on the variety. A study of shoot tip morphogenesis revealed that flowers are initiated at the seventh week, indicating that the process of flower differentiation and development in geraniums is a relatively slow one.

INTRODUCTION

The production of geraniums from seed is a relatively new practice, which was initiated by a group of plant breeders in Holland. Subsequently, researchers in the United States became interested in the subject and were first to develop a true breeding geranium from seed (7). However, in spite of the successes in producing newer geranium varieties from seed, there were a number of problems associated with these plants, among which were: (1) low germination percentage, (2) excessive height and spread, (3) lack of uniformity in flowering, and most significant of all (4) excessively long growing period required before the production of flowers. This remains a problem.

Inasmuch as the geranium ranks high in its commercial value as a bedding plant and has good potential as a pot plant, it would be desirable to gain more information on the control of flowering, thus permitting quicker flowering.

Germination. The major seed producers have indicated that seed germination percentage is generally high (above 80%). However, it has been our experience that under normal greenhouse conditions the germination percentage varies among seed lots and sources, ranging from a low of 16% to a high of 84%. Germination of 100% can be obtained when the tip of the cotyledonary end of the seed is removed, a clear indication of seed coat dormancy. Since this process is obviously too time-consuming for the commercial operation, seeds are scarified. Comparative results of germination in clipped versus unclipped seeds are shown in Figure 1.

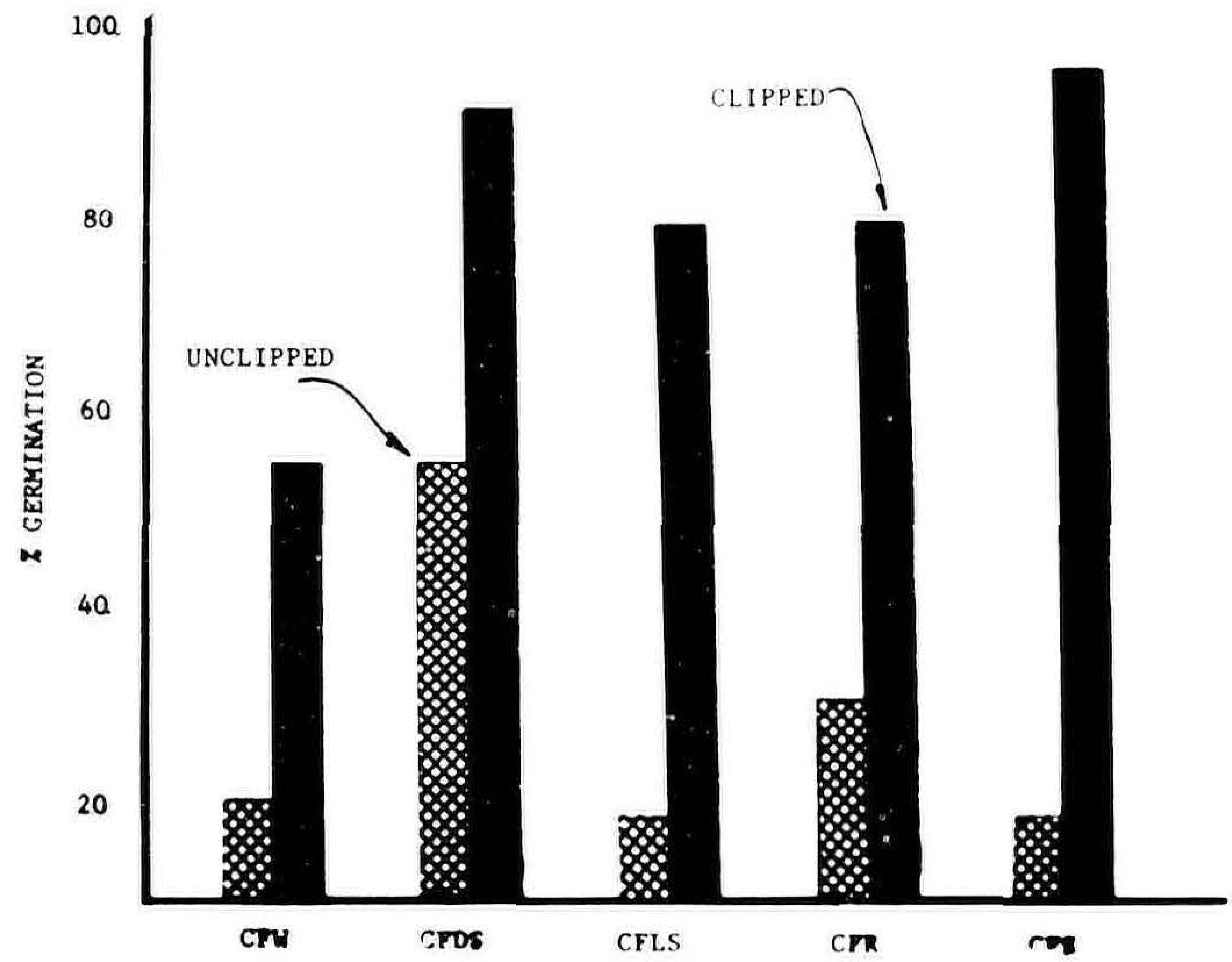

Fig. 1. Comparative germination results in five Carefree varieties in clipped versus unclipped seeds. (CF=Carefree,=DS Deep Salmon, LS=Light Salmon, R=Red, S=Scarlet, W=White).

In germination tests of seed lots obtained in September, 1970, unclipped seeds were germinated in petri dishes and in several mixes (Table 1). The germination percentage of seeds sown in Redi-Earth (a commercial mix) was significantly higher than that obtained in all the other mixes and of that obtained in petri dishes. The same type of response was obtained in subsequent tests, an indication that germination in geranium may be affected by conditions in addition to seed coat dormancy. Nevertheless, the survival rate of seedlings was always above 95% (6, 8) when grown in a mixture containing equal parts (by volume) of top soil, peat, and perlite.

Table 1. Germination percentages obtained with geranium seeds sown in various mixes in controlled environment.

Germination Medium	Number Sown	Percent Germination
Redi-Earth	100	92
Terralite	100	67
Sand + peat	100	69
Peat	100	73
Soil + peat	100	68
Petri dishes	100	73

Flowering Response. With the use of Cycocel as a drench it has been possible to reduce the time required for flowering (1, 3, 10) in addition to reducing the height and spread of geraniums at maturity (7, 10). However, the time reduction is slight and it is not known whether Cycocel has its effect on hastening the induction, initiation, or developmental process. The time of floral differentiation was determined using seeds that were sown in May, 1971. The vegetative process persisted for 5 weeks after sowing; the early floral differentiation stage could be recognized at 6 weeks, and flower primordia could be seen at the 7th week, (Figures 2-5). These results may not be typical for the normal propagation period of seed geraniums, which is mid-February.

The most significant aspect of flowering in geraniums lies in the fact that it does not matter whether flowering occurs in 90 days or in 120 days, the initial flower is almost always produced at the 18th node[1], regardless of temperature, fertilizer level, growth regulator, or photoperiod treatment, suggesting the presence of a very rigid flowering mechanism.

When geranium seedlings started in January, 1971, were grown under high intensity lights (General Electric cool white, plus 60 watt incandescent lamps to give 2000 footcandles), flowers were produced earlier in an 8 hour photoperiod than in seedlings that were grown with natural light alone under the same photoperiod, (Table 2). This difference in flowering response might be due to increased photosyn-

[1]Unpublished data. Carlson *et. al* (1) observed that flowers were initiated in 'Nittany Lion Red' in 13 weeks when the seeds were sown on May 12 and the plants were grown under natural photoperiod. Carefree cultivars sown at this time would produce approximately 24 nodes in 13 weeks This might be taken as an indication that 'Nittany Lion Red' flowered at the 24th node

thates resulting from the higher light intensity and the increased temperature resulting therefrom.

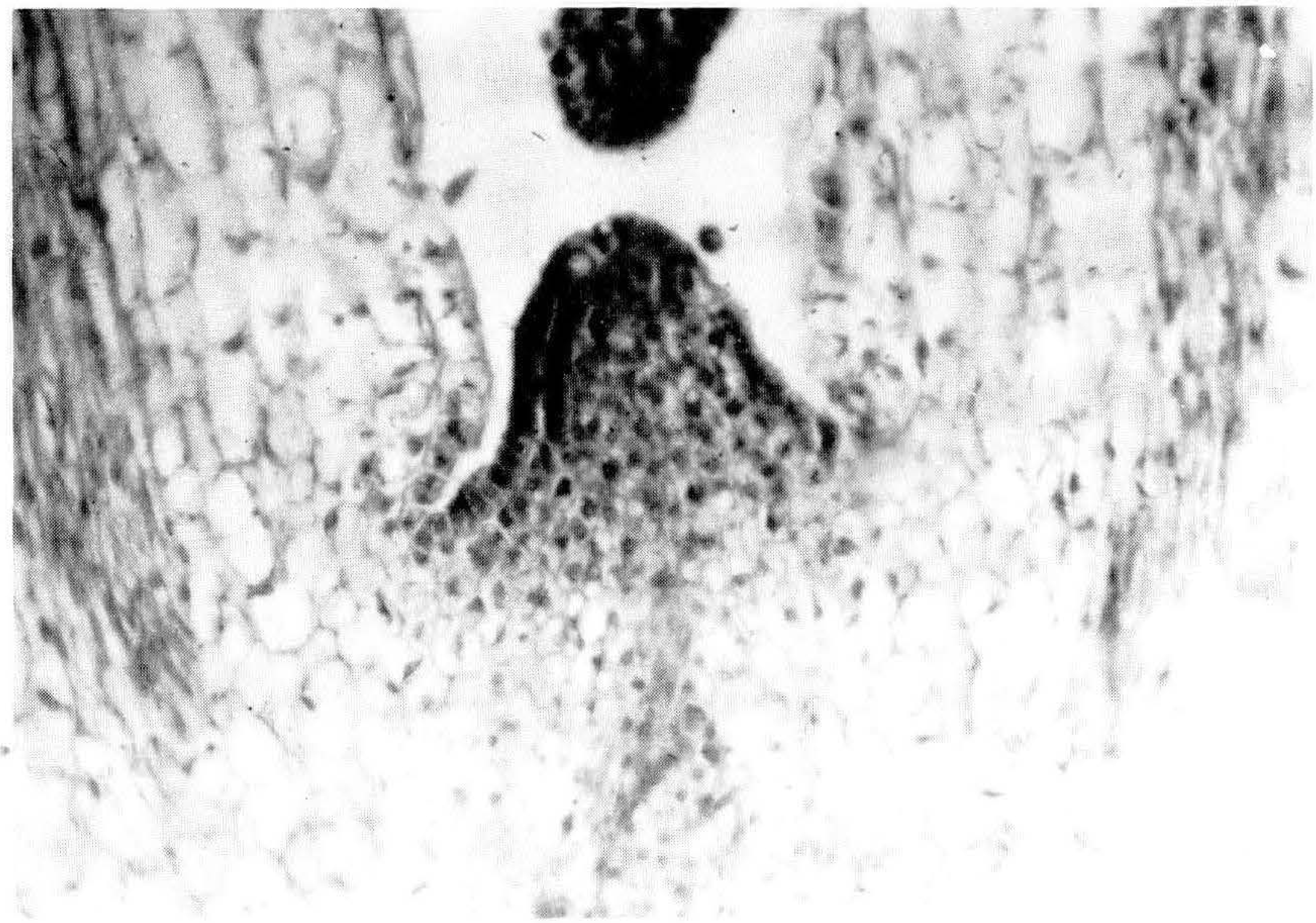

Fig. 2. Completely vegetative condition of shoot tip after 2 weeks of growth.

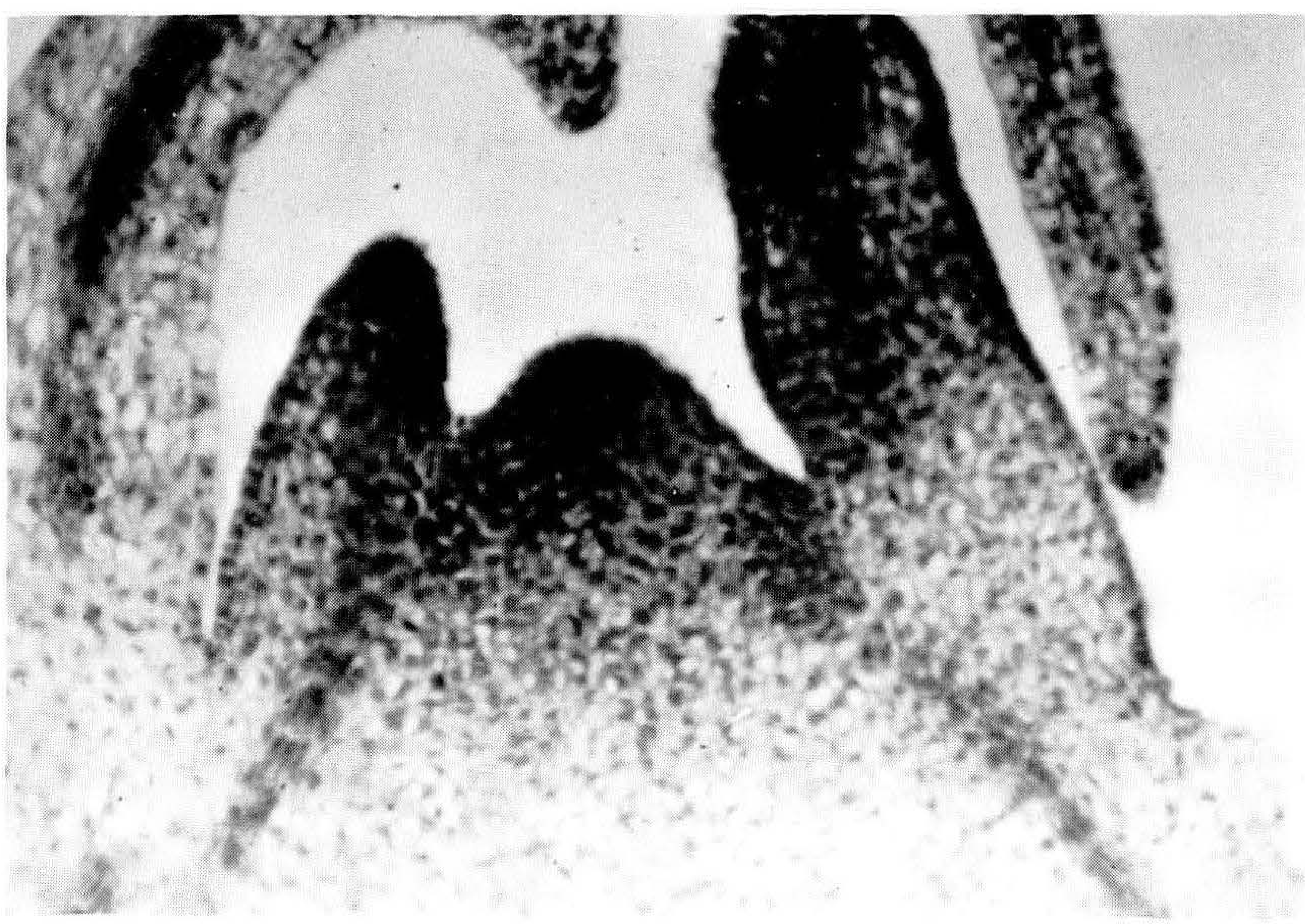

Fig. 3. Late vegetative stage in the shoot tip. This stage marks the transition period at the end of 5 weeks of growth.

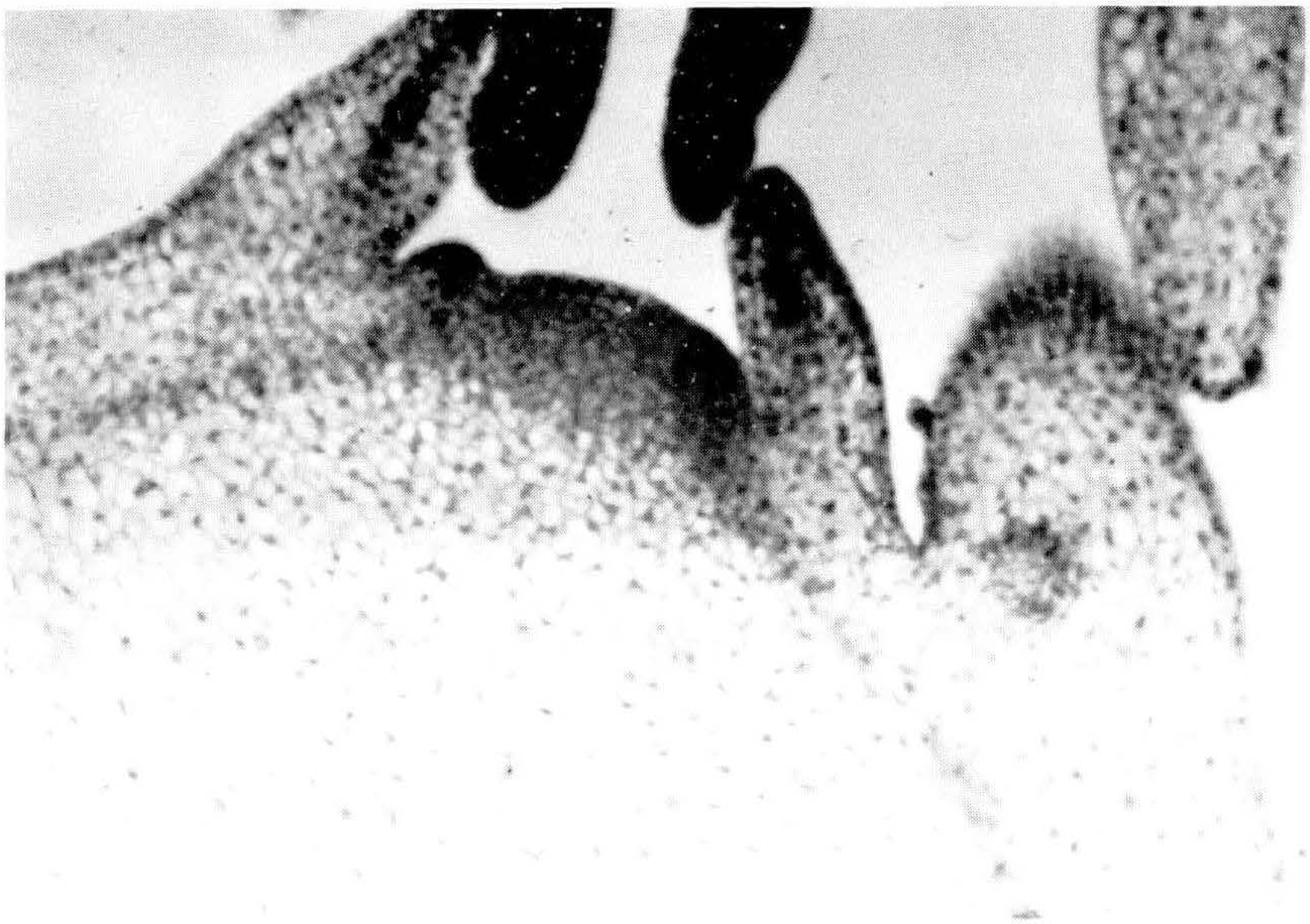

Fig. 4. Early stage of floral differentiation after 6 weeks of growth.

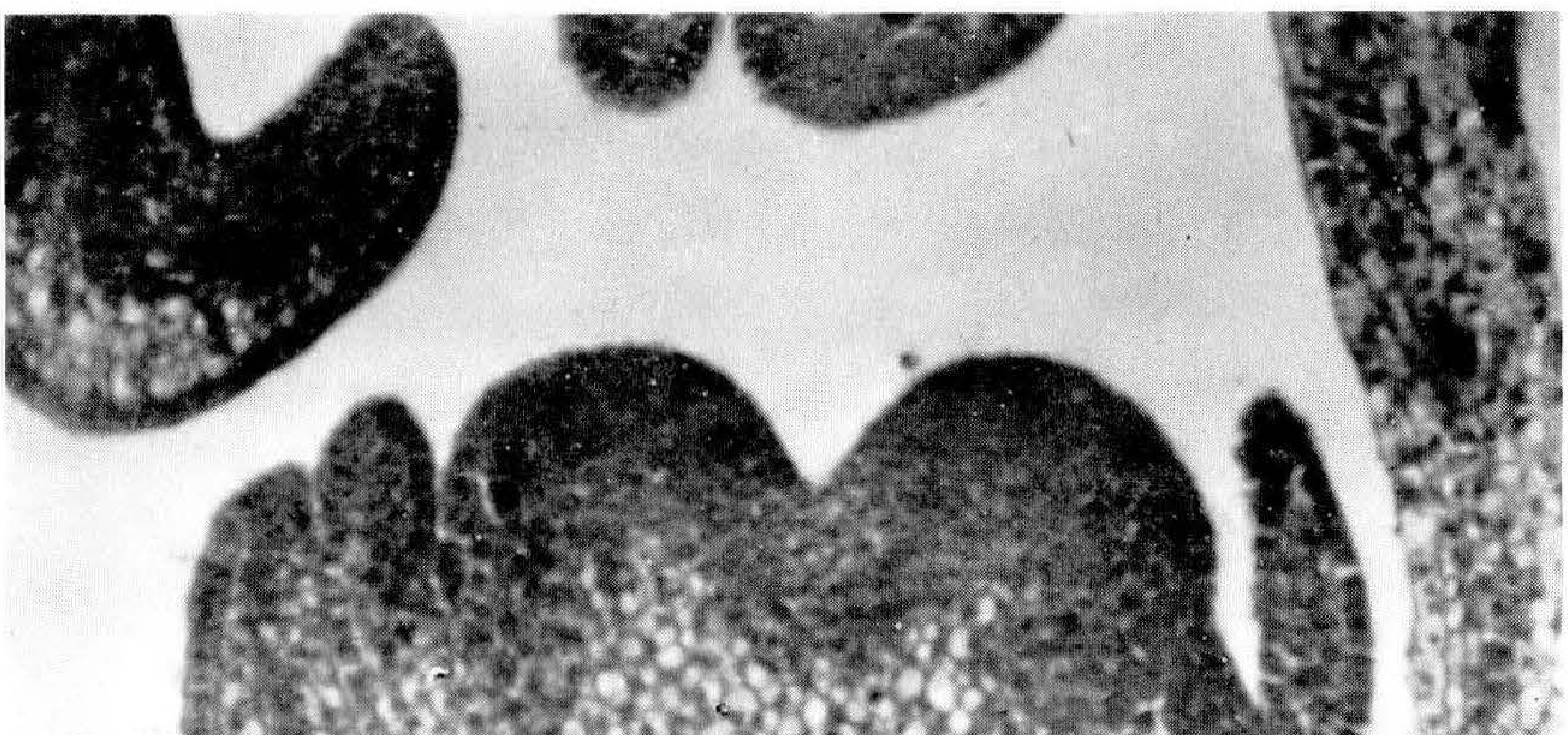

Fig. 5. Early stage in the formation of the flower part.

Table 2. The influence of high intensity light on the promotion of earlier flowering in seed geraniums, cv. Carefree Deep Salmon.

Treatment	Photoperiod (Hrs.)	Number of days to flower	Node no.
Natural daylight	8	115	18.3
Natural daylight + high intensity light	8	97	18.8

Height and spread of geraniums at maturity varies with the rate of growth over the entire growing period, particularly during the early stages, and this seems to be proportional to the light intensity and the temperature. During the high light intensity periods the plants are taller and broader and flower earlier, while during low light intensity periods they are shorter and more compact and flower later (8, 12). The earliness of flowering in geraniums relative to light intensity and temperature has previously been reported (9, 11). However, it has not been reported elsewhere that flowering occurs at the same node under both conditions (high and low light intensity).

SUMMARY

Based on our results from studies on shoot tip morphogenesis, it appears that floral initiation in geraniums begins early enough to allow for earlier flowering. The slowness in the final response appears to be due (at least in part) to a slow process of differentiation and development. The results of previous work with geraniums in response to photoperiod, cold treatment, nutrition, and temperature (2, 6, 12) indicate that environmental manipulations have been substantially ineffective in hastening flowering. The solution to producing earlier flowering in geraniums grown from seed may be found through physiological or biochemical manipulations, but the long term solution may be through efforts in breeding. Until such time, the best known response can be obtained in an average of 100 to 115 days using commercial preparations for germinating the seeds and growing the plants in a medium consisting of equal parts of top soil, peat, and perlite containing 15 pounds of superphosphate per cubic yard at a pH of 6.5—6.8. The fertilization program should consist of the following: (a) **Transplant Stage:** 6 ounces each, KNO_3 + NH_4NO_3 per 100 gallons of

water; and (b) **Established Plants:** 15-15-15 or 20-20-20 at 200 ppm nitrogen once per week during low light intensity periods and 2 to 3 times per week during high light intensity periods. As a preventive measure against root rot, Dexon (35%) may be applied at bi-monthly intervals at ¼ pound per 100 gallons of water.

ACKNOWLEDGEMENT: Seeds for this work were provided by the Pan American Seed Company.

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PROPAGATING THE NEW UNIVERSITY OF MINNESOTA HARDY DECIDUOUS AZALEAS[1]

RICK HENNY AND PAUL E. READ

Department of Horticultural Science
University of Minnesota
St. Paul, Minnesota

Abstract. Cuttings from selected clones of deciduous azaleas, specifically hybrids resulting from reciprocal crosses of *Rhododendron* x *kosterianum*[2] x *R. roseum*, which are winter hardy in Minnesota, were successfully rooted with plastic-tent propagation. Rooting under mist was unsuccessful because of hard water and subsequent salt buildup on cuttings Best rooting occurred in a 1:1 peat-vermiculite or a 1:1 peat-perlite medium, but no single rooting compound gave consistently superior results Succulent cuttings in the elongation stage of growth, having expanding leaves, and cuttings with fully expanded leaves but no terminal bud formation rooted well

INTRODUCTION

Many desirable ornamental plants cannot be widely used in the Midwest due to a lack of sufficient winter hardiness. Such was the case of many deciduous azaleas until the University of Minnesota developed hardy plants from reciprocal crosses of *R.* x *kosterianum* x *R. roseum*. These plants have withstood mid-winter temperatures to — 35° F. in open field conditions and bloomed profusely the following spring in various shades of pink. However, until recently, difficulty in asexual propagation has prevented multiplication of desired plants.

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[1]Miscellaneous Journal Series Article No 1430 of the University of Minnesota Agricultural Experimental Station

[2]*R. kosterianum* is the specific name referring to the cross, *R. japonicum* x *R. molle*, (mollis hybrids) as a collective group.

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LITERATURE REVIEW

In previous work, with various kinds of deciduous azaleas, most propagators (1, 2, 4, 5, 6, 7, 8) preferred using softwood cuttings taken in the spring before the apical bud was formed. However, in one rooting trial (3) hard cuttings with an obvious terminal bud rooted better than very soft cuttings without a terminal bud evident. Cuttings were successfully rooted in plastic-tents (1, 2, 6, 7) and under mist (3, 4, 5, 8). Hormodin#3 was the rooting compound used in most cases (2, 4, 6, 8) whereas Jiffy Grow#2 (20:1) also gave satisfactory results (5). Some people recommended removal of terminal buds (1, 4) and others did not (7), while wounding cuttings was done fewer times (2, 4) than not (1, 5, 7, 8). The propagation medium for deciduous azaleas almost always contained peat moss (1, 2, 3, 4, 6, 7, 8) with sand (1, 2, 6, 7, 8) or perlite (1, 2, 3) added to improve drainage and aeration.

MATERIALS, METHODS AND RESULTS

Preliminary tests proved that mist was unsuccessful, so cuttings were rooted in a plastic-tent in a heavily shaded greenhouse cooled with a fan and pad system. The plastic-tent consisted of 4-mil polyethylene fitted over 12" high sideboards and sealed with lath tacked over its edges. In addition, black polyethylene was suspended over the bench at a 45° angle to keep out afternoon sunlight (Figure 1). Cuttings were hand syringed 2-3 times a day to prevent wilting. Three different rooting media were used: 1:1 peat-perlite, 1:1 peat-vermiculite and 1:1:1 peat-perlite-vermiculite. All media were steam sterilized, treated with Terraclor (1 Tbsp./gal.), and soaked with Peters Acid Grow Fertilizer (21-7-7) at 1 Tbsp./gal. To help prevent disease, cuttings were drenched in a solution of Captan 50% WP (2 Tbsp./gal.), Wiltpruf (0.5% by vol.) and Tween 20 (0.5% vol.) and stored in a cooler until placed in the rooting medium. Light intensity varied within the bench from 200 to 500 ft-c. Temperatures of the media were measured by a Barber-Coleman temperature recorder and ranged from 64° to 80° F, but usually were around 70° F. Medium pH (Table 6) was measured at 10 day intervals using Lamotte indicator solutions and standards. Cuttings were rated on a scale of 1 to 7 (Figure 2) when dug. The total rating for an entire treatment was used when any statistical comparisons were made.

Experiment 1. An experiment was conducted to determine effect of the fungicide drench, five different rooting compounds, and plastic-tent versus mist as a means of propagation. On June 13, 216 cuttings 3-4" long were taken from an F_1 population, designated U. of M.#66190, during the later stage of a growth flush when most of the lower leaves were fully expanded but the terminal buds were not yet formed. After 54 days in a 1:1:1 peat-perlite-vermiculite medium, cuttings from the plastic-tent had rooted significantly better than those under mist

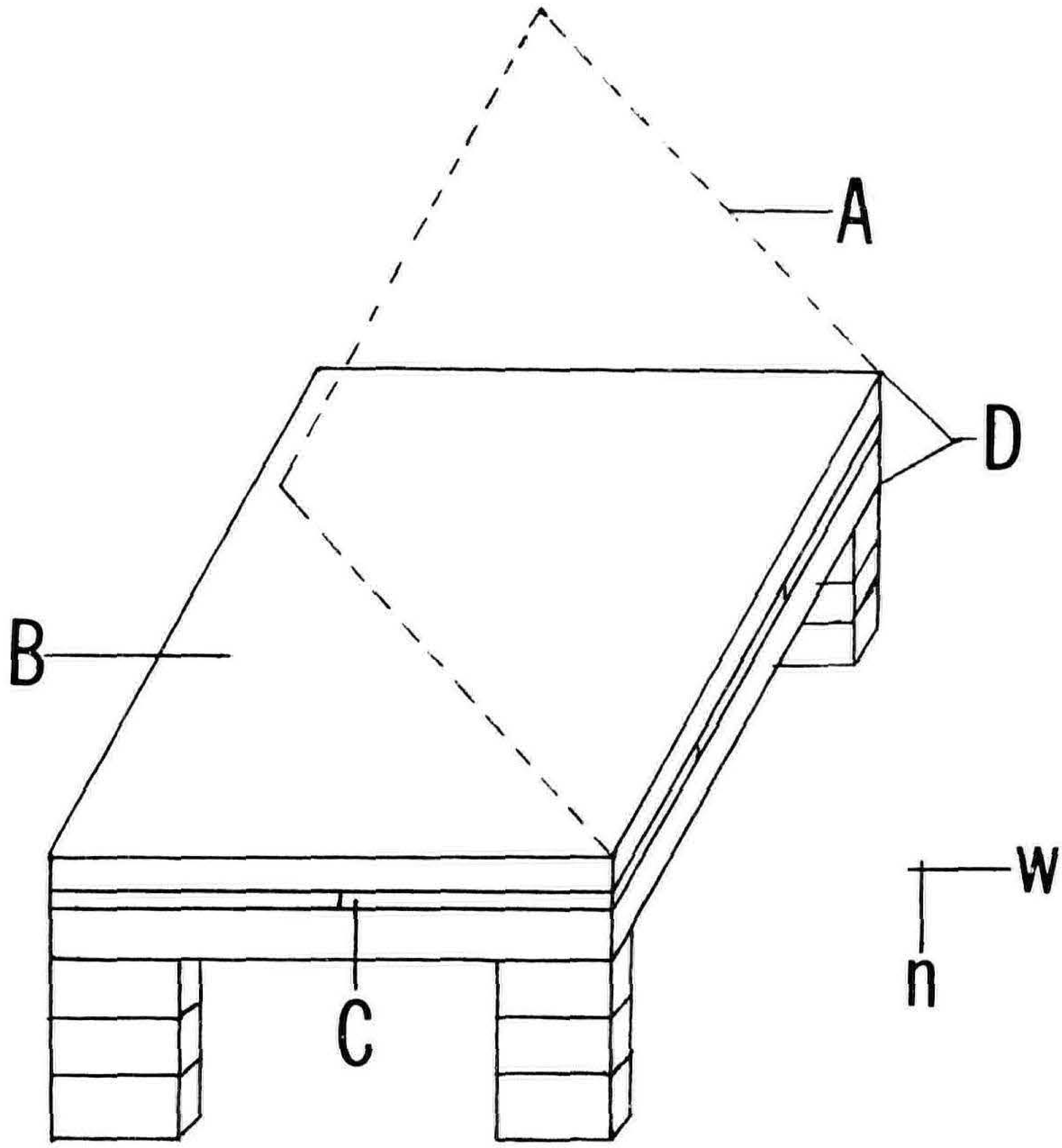

Fig. 1. Diagram of plastic-tent used for rooting U. of M. deciduous azaleas. Components are: A, black polyethylene; B, 4-mil clear polyethylene; C, lath tacked on to hold plastic seal; D, 12" high sideboards.

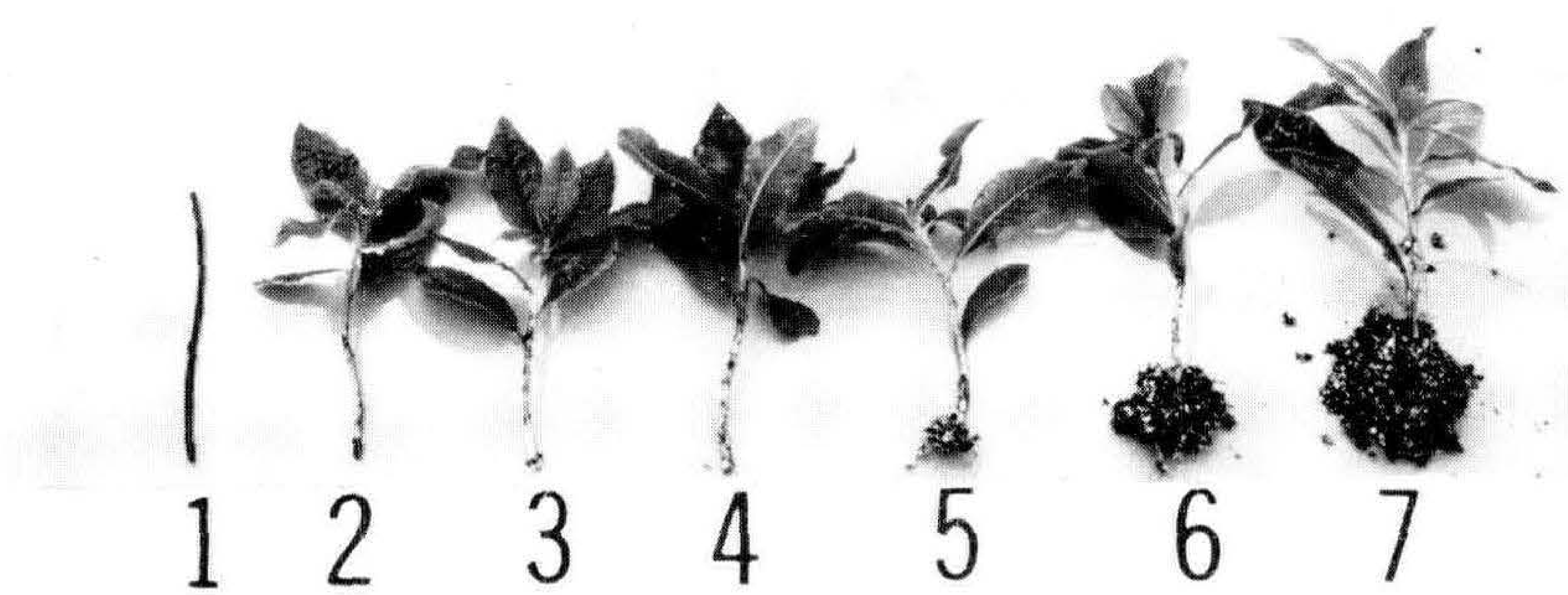

Fig. 2. Method of rating deciduous azalea cuttings. Ratings correspond to: (1), dead; (2), alive but no callus; (3), callus; (4), 1-5 small roots; (5), several roots but no root ball; (6), root ball less than 1½" in diameter; (7), root ball larger than 1½".

(Table 1). Salt buildup under mist during rooting was enough to cause an overall browning and brittleness of the leaves which then abscised. The plants died even if rooted. Drenching the cuttings with the fungicide solution had no apparent effect on cutting performance. All five rooting compounds produced better results than the non-treated checks (Table 2), with Germain[3] and Hormodin#3 the most consistent promoters under all three conditions.

Table 1. The effect of mist, plastic-tent and a Captan drench on the mean rooting response of U. of M. #66190 deciduous azaleas.

Treatment	Ave. Rating per Cutting	Mean of Total Ratings of 6 Treatments[1]	Mean Total % Rooted
Plastic-tent (Drench)	5.8	69.5 a[2]	94.4
Plastic-tent (Drench)	5.6	66.8 a	93
Mist (Drench)	4.3	51.7 b	82

[1]12 cuttings per treatment

[2]Means followed by the same letter do not differ significantly at the 5 percent level (Duncan's New Multiple Range Test)

Table 2. The effect of 5 rooting compounds on drenched and undrenched U. of M. #66190 deciduous azaleas in a plastic-tent and on drenched azaleas under mist.

Treatment	Ave. Rating per Cutting	Mean of Total Ratings[1]	Mean Total % Rooted
Germain	6.2	74.0 a[2]	97.3
Hormodin 3	6.0	71.7 ab	100
Hormodin 2	5.2	63.0 abc	97.3
Jiffy Grow No. 1 (Quick dip)	5.2	62.3 abc	89
Rootone	4.6	54.7 cd	78
Check	4.2	50.3 d	72

[1]12 cuttings per treatment

[2]Means followed by the same letter do not differ significantly at the 5 percent level (Duncan's New Multiple Range Test).

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[3]Talc preparation of equal parts 4.0% indolebutyric acid (IBA) and 4X Cutstart with 1/16 by volume Phygon.

[4]All IBA solutions contained 5% ethanol

Experiment 2. To determine the effect of cutting maturity on rooting, 40 cuttings were taken at 8-day intervals six different times, beginning May 22 and continuing to July 1, from the same plants of the F_1 population U. of M. #66190. Cuttings taken May 22 were succulent and in the elongation stage of a growth flush with small expanding leaves. Those taken July 1 were semi-hard, green to the base and had terminal buds clearly evident. The cuttings were treated with a 1-minute dip in 100 ppm IBA and one-half placed in a medium of 1:1 peat-perlite and one-half in 1:1 peat-vermiculite. After 75 days, best rooting occurred with the younger cuttings (Table 3) although the results were not consistent in both media. In most instances cuttings rooted better in a medium of 1:1 peat-vermiculite than in 1:1 peat-perlite.

Table 3. Effect of cutting maturity on rooting response of U. of M. # 66190 deciduous azaleas in 1:1 peat-perlite and 1:1 peat-vermiculite media after 75 days.

Date Cuttings were taken	Ave. Rating per Cutting	[1]Total Rating	Total % Rooted
1:1 peat-vermiculite:			
5-22	7.0	140	100
5-30	6.8	135	100
6-7	6.3	126	90
6-15	5.7	113	90
6-23	5.6	112	80
7-1	4.8	95	80
1:1 peat-perlite:			
5-22	5.9	118	85
5-30	4.3	86	60
6-7	3.6	72	40
6-15	4.8	95	75
6-23	5.6	122	95
7-1	4.9	99	70

[1]20 cuttings per treatment

Experiment 3. The effects on rooting of a terminal bud pinch, three hormones, Captan, and two different media were tested using 180 soft cuttings with fully expanded leaves taken June 5 from the F_1 population U. of M. #66192. The four treatments plus an untreated check were duplicated with pinched and unpinched cuttings in a medium of 1:1 peat-perlite and 1:1:1 peat-perlite-vermiculite. A 1 minute dip in 100 ppm IBA, containing 5% dimethyl sulfoxide (DMSO), gave significantly better results than the non-treated cuttings (Table 4). Captan significantly inhibited rooting compared to controls. A 1:1:1 peat-perlite-vermiculite medium caused some inhibition of rooting compared to 1:1 peat-perlite (Table 5) while unpinched cuttings rooted better than pinched cuttings in the same medium.

Table 4. Effect of 3 hormones and Captan on mean total rating of pinched and unpinched cuttings of U. of M. # 66192 deciduous azaleas in two different media for 75 days.

Treatment	Ave. Rating per Cutting	Mean Total Rating[1]	Mean Total % Rooted
IBA 100ppm, 5% DMSO, (1 min)	5.6	50.5 a[2]	83.1
5% DMSO, (1 min)	5.0	45.0 ab	75
Hormodin #3	4.9	44.2 abc	69.4
Check	4.5	40.5 bc	66.7
Captan	3.5	31.8 d	50.0

[1]Ave. of 4 treatments with 9 cuttings in each.

[2]Means followed by the same letter do not differ significantly at the 5 percent level (Duncan's New Multiple Range Test)

Table 5. Mean total effect of pinching terminal bud vs. not pinching on U. of M. #66192 deciduous azalea cuttings in two different media for 75 days.

Treatment	Ave. Rating per Cutting	Total Rating[1]	Total % Rooted
1:1 peat-perlite, No Pinch	5.2	46.4 a[2]	71
1:1 peat-perlite, Pinch	5.2	46.2 ab	84.4
1:1:1 peat-perlite-vermiculite, No Pinch	4.5	40.4 abc	62.2
1:1:1 peat-perlite-vermiculite, Pinch	4.0	36.4 c	53.3

[1]Nine cuttings per treatment.

[2]Means followed by the same letter do not differ significantly at the 5 percent level (Duncan's New Multiple Range Test).

Smaller individual experiments involving a total of more than 1000 cuttings from different stock plants were also conducted. Rooting percentages ranged from 70 to 100 with an average success of 87%. Effects of rooting compounds varied indicating interactions with plants of different parentage.

Table 6. Effect of environment and media composition of pH as measured with Lamotte Indicator Solutions and Standards.

Medium	Initial pH	pH after 60 days
1:1 peat-vermiculite in plastic-tent	4.2	4.5
1:1 peat-perlite in plastic-tent[1]	4.3	4.7
1:1:1 peat-perlite-vermiculite in plastic-tent	4.5	5.8
1:1:1 peat-perlite-vermiculite under mist	4.5	8.4

[1]Ave of 3 separate media.

DISCUSSION

In areas where hard water prevents successful mist propagation of deciduous azaleas, a plastic-tent gives excellent results. A cool area is essential and no direct sunlight can be allowed to strike the plastic enclosure at any time or excessive heat buildup under the plastic can damage cuttings.

Rooting compounds gave inconsistent results in our work. Timing did not seem to be critical, but best results can be expected from younger cuttings taken after the first 2-3 weeks of growth when shoots are 3-4" long with expanding or nearly expanded leaves. In addition, taking cuttings earlier in the spring or summer allows more time for newly rooted plants to produce new shoots before going dormant in the fall, which greatly increases chances of buds breaking dormancy the following spring.

In the interest of producing better branched plants, we do not recommend terminal bud removal. Typically there are several vegetative buds developed at the apex by the time a cutting is rooted. Most of these buds can be induced to develop shoots if the first ones to break are pruned after 3-4 new leaves are produced. Pinching a cutting tends to limit the new shoots to the 1 or 2 lateral buds which develop first.

Cuttings taken in mid-May were potted by mid-July and had 6-8" of new growth by the end of August. Beginning at the end of July the photoperiod was extended from 6 p.m. to 6 a.m. using incandescent lights 3 ft. apart, suspended 2½ ft. above the plants. Plants were then hardened off in cold frames in September or kept under lights to serve as a source of fall cuttings. Initial results indicate it is possible to take 1 or 2 successive crops of cuttings from the young plants rooted during the summer with no ill effects to them. A rather large population of plants can be built up rapidly in this manner.

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MODERATOR FLEMER: We have time for a few questions.

JOE McDANIEL: Do these hybrids have good fragrance?

PAUL READ: Yes, they do; they are quite desirable plants in most of the commonly desired characteristics, however, they are not evergreen.

JIM WELLS: What is the rate of rooting?

PAUL READ: Good, well-rooted cuttings are obtained in less than 2 months, but there is variability among the clones—the easiest rooting one, roots 95-100% all the time and the more difficult ones, 60-80%.

KNOX HENRY: Did you say that the results with Hormodin No. 3 seemed to be better than with the other commercial compounds?

PAUL READ: There was not that much difference and we were quite satisfied with all of the materials used as well as those we formulated ourselves.

JOERG LIESS: Did you use bottom heat?

PAUL READ: We did the first year, but not in later tests. I don't think we need it in the system we are using but I do think it is essential for a mist system.

PETE VERMEULEN: What time of the day were the cuttings taken, what was the environmental conditions of the stock plants, and what was their condition?

PAUL READ: The cuttings were taken in late morning. In some cases, they were placed in a cooler for a day or two before being stuck so I don't think this is a factor to consider. The stock plants were grown in the field and are 10-12 feet tall.

SID WAXMAN: What were the light intensities under the plastic?

PAUL READ: It varied between 200 and 500 ft-c, depending upon the time of the year that the reading was taken.

VOICE: How often did you apply water in the tent?

PAUL READ: This was applied twice a day by hand, but commercially this would be done automatically.

SID WAXMAN: Did you feel you had to water twice a day?

PAUL READ: I don't believe we did, but the student doing this work was from Oregon and he used techniques which were familiar to him and this is one he continued. The cuttings will wilt on the first few hot days after sticking and misting would be beneficial, but beyond this I don't think it is needed with the tent system if you keep the light intensity and the heat down.

JIM WELLS: Are you shading as heavily now as you did in June?

PAUL READ: No, the shade is off the greenhouse now and tents are under a suspended shade cloth because we don't get much light at this time of year.

MODERATOR FLEMER: We thank you for a very fascinating paper, Paul. Our next paper is by an old professional, John Roller. John is going to tell us how to go about rooting juniper softwood cuttings under mist.

ROOTING JUNIPER SOFTWOOD CUTTINGS UNDER MIST

JOHN B. ROLLER

Cartwright Nurseries
Collierville, Tennessee

We became interested in rooting softwood juniper cuttings under mist about two years ago. Our interest was brought about by a new customer wanting a very large quantity of rooted juniper cuttings to be delivered in November and December. We received the order about the middle of June. This presented quite a challenge to produce this large number of plants on such relatively short notice, out of our normal season and not on our production schedule.

We began taking the cuttings the first week in July and finished about the middle of August. We started taking the varieties that, in our experience, rooted more slowly first, and finished with the more easily rooted varieties.

The cuttings were in soft growth, but we cut them back far enough to get into the bark area that had begun to mature enough to change to their naturally brown color of firm wood. Then we made the basal cut and trimmed off the very tender tips, leaving about a 5 or 6 inch cutting. All cuttings were treated with Hormex #16. This is a 1.6% indolebutyric acid concentration in talc.

I know that it is generally thought that the more tender the cutting the weaker the hormone should be but, in my experience, the opposite is true; a soft tender cutting can take a hormone strength without burning and root that would be fatal to a hardwood cutting. There are exceptions, I am sure, but I have found this to be generally true. The strength of hormone we used was considerably stronger than that we use on greenhouse cuttings in winter.

Our mist beds are ground beds filled with sharp sand. They are in full sun with only a wall about 3 feet high around them. Since the beds were rather dry at the beginning they were heavily misted until they were properly moistened. Some of them were hose watered, as they were extremely dry. After sticking the cuttings, the mist was reduced to the point that they received just enough to keep them from drying out. This is the most critical part of the operation and they were carefully watched because if they get too much water they rot, if not enough, they dry out and fail. I hesitate to give any settings because of the differences in temperature, wind, and humidity in the different parts of the country but I am sure you are experienced enough to regulate the misting time to suit your particular locality.

The following cultivars of junipers were rooted in this manner:

J. chinensis	'Blue Vase'
J. c.	'Burkii'
J. c.	'Hetzii Glauca'
J. c.	'Maneyi'
J. c.	'Mint Julep'
J. c.	'Pfitzeriana'
J. c.	'P. Compacta'
J. c.	'P. Glauca'
J. c.	'P. Nana'
J. c.	'Pyramidalis' (*J. excelsa* 'Stricta')
J. c.	'Sargentii Glauca'
J. c.	'San Jose'
J. communis	'Stricta' ('Fastigiata')
J.	*davurica* 'Expansa'
J. horizontalis	'Plumosa'
J. h.	'Plumosa Compacta'
J. procumbens	
J. virginiana	'Densa Glauca'

The total number of cuttings stuck in the mist beds amounted to about 225,000. All cultivars rooted as well as, or better than, our greenhouse percentages with a few exceptions. 'Burkii' failed almost completely with only 5 or 10% rooting. 'Maneyi' did not do quite as well, only about 50% rooted. *J. virginiana* 'Densa Glauca' rooted about 10 to 15%. *J. c.* 'Pfitzeriana Nana' would not tolerate quite as much water as it received and only about 50% rooted. We thought this could have been caused by getting too dry from a clogged nozzle and then receiving normal mist. *J. c.* 'Pfitzeriana Nana' appears not to tolerate as much water as other varieties. Our experience this season bears this out also.

In the future more and more of our juniper production will be done by this method. It has certain advantages and some drawbacks. If you are in a climate that is not too cold the plants can be left in the beds until spring and field planted, or they can be potted off in the fall. In our case the surplus plants that were not delivered to our customer were simply left in the beds undisturbed and covered with plastic until spring.

Leaving them in the beds would certainly pose a problem in the North where winter protection would be a necessity, however, plastic covering might be sufficient. Mist propagation is certainly more economical than greenhouse propagation so this method is definitely going to be a permanent part of our operation from now on.

JOE McDANIEL: Did you start taking cuttings earlier this year?

JOHN ROLLER: No, this year I started later because of weather conditions. I would recommend starting earlier, however.

JIM WELLS: Do you wound the cuttings in any way?

JOHN ROLLER: Only by stripping them.

JIM WELLS: Did you notice roots coming from the wound areas?

JOHN ROLLER: Not particularly, mostly the rooting is basal.

PETE VERMEULEN: Would you tell us a little more about the construction of these beds?

JOHN ROLLER: They are made by placing a very coarse, sharp sand on top of the ground with drainage provided beneath and a 3 ft. side wall around them with no cover.

ED DAVIS: Was the base of the cutting stuck down to the soil or was it in the sand?

JOHN ROLLER: It was in the sand.

CHARLIE HESS: What was the depth of the sand?

JOHN ROLLER: It would vary from 8-10'' deep.

HANS HESS: Do you find that the upright types do as well on their own roots as they do when grafted?

JOHN ROLLER: Yes, we see no difference; however, ours are field-rooted except for varieties normally grafted.

JOERG LEISS: Do your cuttings dry out any? It seems to me that you are misting quite a bit and junipers do hold water quite well.

JOHN ROLLER: The cuttings do not dry up and, as I mentioned, the misting will be different in each situation. We mist about 10 seconds every 1½ minutes.

RALPH SHUGERT: Is it your intention to tie this July sticking into a fall planting program or will they be potted and spring planted?

JOHN ROLLER: No, we don't intend to use these for fall planting; we will pot as many as we may want in the fall, but the rest will stay in the beds and be planted out in the spring.

HARRY BAKKER: With a 3 foot side wall how high above the bed do you set your nozzles?

JOHN ROLLER: About 2 feet.

PETE VERMEULEN: What nozzle do you use?

JOHN ROLLER: Monarch.

MODERATOR FLEMER: Thank you for a very interesting and informative talk. The next paper is by Dr. Harold Tukey and concerns the induction of root-promoting substances under mist. Harold.

DEVELOPMENT OF ROOT-PROMOTING SUBSTANCES IN EUONYMUS ALATUS 'COMPACTUS' UNDER INTERMITTENT MIST[1]

CHOONG IL LEE AND H. B. TUKEY, JR.

Department of Floriculture and Ornamental Horticulture
Cornell University, Ithaca, New York

Abstract. In *Euonymus alatus* 'Compactus' plants grown under intermittent water mist during September, leaf senescence and onset of dormancy were delayed and natural root-inducing substances accumulated in the leaves Consequently, stem cuttings from plants grown under intermittent water mist rooted easily, whereas cuttings from non-misted plants rooted with greater difficulty When rutin, a substance similar to those which accumulated in misted leaves, was applied with IBA to stem cuttings from non-misted Euonymus, the cuttings rooted as well as cuttings from misted plants. These results provide an additional explanation for the great success of mist propagation techniques, emphasizing that many substances in addition to auxins and rooting cofactors may play a significant role in rooting

INTRODUCTION

The success of modern mist propagation techniques has been attributed to the cooling effect of the mist on air and leaf temperatures, thus reducing transpiration and respiration rates in cuttings (5, 8). In addition, if nutrients are added to the mist, both water and nutrients can be absorbed by the cuttings with beneficial effects upon rooting (15). However, these effects have not always explained satisfactorily the universal success of intermittent mist propagation.

Stem cuttings of *Euonymus alatus* 'Compactus' are easily rooted, especially in the spring and summer under intermittent mist propagation. However, as plants approach dormancy in the fall, cuttings are more difficult to root, but the difficulty can be partially overcome by use of intermittent mist. The purpose of this study was to investigate the seasonal variation in rooting of cuttings taken from euonymus plants grown under intermittent mist as compared with cuttings from non-misted plants, and to determine what substances were responsible for the effect.

EXPERIMENTAL

In September, two-year-old uniform plants of *Euonymus alatus* 'Compactus' from rooted cuttings were separated into 3 groups of 25

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[1]Contributions CHO-3154-2, U S. Atomic Energy Commission Contract AT (11-1)-3154 Adapted from Lee and Tukey (10).

plants each. From the first group, a sample of leaf tissues was collected for chemical analysis. Simultaneously, 45 stem cuttings from these same plants were wounded slightly, treated with Hormodin (0.8% IBA), and placed in a propagation bench in the greenhouse in a rooting medium of sphagnum peat moss and perlite (1:1 v/ v) under intermittent mist with a cycle of 20 sec of mist every 30 min during the day. After 1 month, the cuttings were harvested and the rooting percentage and the diameter of the root ball determined.

The second group of 25 plants was placed in 5-inch plastic pots in the greenhouse under intermittent water mist with the roots and root medium protected from the mist by aluminum foil. For comparison, the third group of 25 plants was grown in the same greenhouse adjacent to the propagation bench with the same environmental conditions, but without mist. One month later in October, 45 stem cuttings were taken from both the misted and non-misted stock plants and were rooted under intermittent mist as described previously. Simultaneously, leaf samples together with the samples collected before propagation were analyzed for a number of plant constituents implicated in root initiation and development (10).

The results of the rooting study showed that cuttings from stock plants misted for 1 month rooted better under intermittent mist (93.3%) than did cuttings from either non-misted stock plants (73.3%), or stock plants before any treatment (70.2%). In addition, root-ball diameters were greater in the cuttings from misted stock plants, indicating not only a greater rooting percentage, but also development of a heavier root system during propagation. These results show an effect of mist on the rate of rooting, for all the treatments would eventually root at or above 95% if left in the bench.

Chemical analyses were made of several constituents in leaf tissues from stock plants before propagation to see if they could be related to the observed differences in rooting. For example, carbohydrates were analyzed as they provide a source of energy and are used in syntheses of other substances important in root initiation. The dry weight of leaves from misted plants was greater (8.4 mg per cm^2) than from non-misted plants (7.5 mg per cm^2) indicating a higher net photosynthetic activity in misted leaf tissues. As a result, leaf tissues of misted euonymus contained more total sugar and starch (Table 1) than did either the non-misted stock plants or the plants prior to treatment.

The concentration of total N in the leaf tissues of non-misted plants was decreased by dilution due to vegetative growth of the plants during the treatment period. The concentration in the misted plants was reduced even more due to leaching by the mist (14).

The carbohydrate-nitrogen relationship (C / N ratio) is used as an indicator of potential rooting. In the experiment, the greater carbohydrate accumulation and decrease of N resulted in a higher C / N

Table 1. Chemical substances in the leaves of *Euonymus alatus* 'Compactus' plants as influenced by 1 month of intermittent water mist.

Substances	Before treatment	After treatment: No mist	After treatment: Mist
	(mg / g dry wt)[d]		
Total sugar	40.0	52.6	57.9
Starch	52.3	48.2	59.5
Total N	31.4	25.6	22.1
C / N ratio[a]	3.0	3.9	5.0
PAL[b]	0.5	0.5	1.4
Chlorogenic acid	0.4	0.9	1.3
Flavonol	2.6	3.9	4.4
Total flavan	4.6	6.7	10.2
Leucoanthocyanin[c]	1.3	2.4	3.6

[a]Carbohydrate-N ratio was calculated by dividing total carbohydrate by total N

[b]Phenylalanine ammonia lyase expressed as μM cinnamic acid / hr / g fresh wt.

[c]Expressed as mg cyanin produced / g dry wt.

[d]Mean amounts of all constituents differ statistically between treatments at the 5% level.

ratio (5.0) in the misted leaf tissues than in non-misted (3.9) , indicating a greater rooting potential in misted stock plants. Whether the C / N ratio had a direct effect in these experiments was not clear, for in spite of a greater C / N ratio in non-misted plants (3.9) than in the plants before treatment (3.0), little difference in rooting was noted.

Phenolic compounds, in addition to auxin, are strong stimulators of adventitious root initiation (2, 3, 6). The biosynthesis of these compounds in plants involves the shikimic acid pathway in which the enzyme phenylalanine ammonia lyase (PAL) is prominent (10). The PAL activity before treatment was 0.5μM cinnamic acid / hr / g fresh wt. There was no apparent increase in the PAL activity in the leaves of non-misted stock plants after 1 month, whereas the leaf tissues of misted stock plants showed a 3-fold increase in PAL activity. Apparently, because of the higher PAL activity, total phenolic content was somewhat higher in the misted leaf tissues than in non-misted tissues. This suggests that the misted plants were still metabolically active (were not dormant) and had an increased potential for production of phenolic substances to promote directly or synergistically root initiation of the cuttings.

Of greater significance than total phenolic content was the qualitative distribution of phenolic compounds in the misted plants (Table 1). Concentrations of chlorogenic acid, flavonols, flavans, and leucoanthocyanins were much greater in the leaves of misted plants than of non-misted plants. All of these substances have been implicated in root initiation (1, 4, 12) and their accumulation may explain in part the propensity for better rooting in the misted plants.

Auxin-like activity in the leaf tissues was determined using the oat coleoptile bioassay (11) in which elongation of the coleoptiles is related to auxin activity. The activity of auxin-like substances in the plants before treatment was considerable (11.6% elongation). However, after one month with no mist, the activity was reduced to a low level (2.6% elongation) suggesting the state of dormancy in these plants in October. In contrast, activity in the misted plants was greatly increased (20% elongation) indicating increased levels of auxin-like substances.

The levels of rooting cofactors, also implicated in root initiation (4, 6, 9), were somewhat greater in misted leaves than in non-misted leaves, and were much greater than the initial levels.

In the previous experiment, one of the dominant effects of the intermittent mist was the apparent enhancement of endogenous root-inducing substances, such as phenolic compounds, rooting cofactors, auxins, and flavonoids. Thus, it was of interest to see if these substances could be added exogenously to non-misted plants to improve rooting. This was tried first with Mung beans, commonly used in the Mung bean bioassay for rooting. Since the effect of auxins has long been known and used in the propagation industry, and since the identity of 2 and perhaps 3 of the rooting cofactors is not firmly established, a flavonoid compound, rutin (quercetin 3-rutinoside), was chosen for this study. Two ml of rutin solutions at concentrations varying between 5×10^{-4} and 10^{-6}M and 2 ml of indoleacetic acid (IAA, 10^{-6}M) were applied to Mung bean cuttings. For comparison, Mung bean cuttings were also rooted with IAA (10^{-6}M) alone, rutin (10^{-6}M) alone, and water alone. Rutin alone and IAA alone did not produce a significant increase in root initiation as compared with the water controls. However, when rutin was added, together with IAA, root initiation in Mung beans was promoted at all concentrations tested, especially at rutin concentrations of 5×10^{-5} and 10^{-5}M. This indicates that rutin, like some other flavonoids, may act synergistically with IAA to produce adventitious roots (13).

A similar experiment was conducted with cuttings of non-misted euonymus, using rutin as an example of a typical flavonoid, and indolebutyric acid (IBA) instead of IAA as the auxin. In August, 450 five-inch stem cuttings (mature) were collected from clonal stock of euonymus growing on the Cornell campus, and were separated into 3 groups of 150 cuttings each. The stem bases of the first group were dipped in a solution containing 2000 ppm IBA and 1500 ppm of rutin.

The second group was treated with 2000 ppm IBA alone, and the third group was treated with water, as the control. All cuttings were then placed in the propagation bench under intermittent mist. Each week 30 cuttings were harvested and rooting percentage and root ball diameters were recorded.

Control cuttings (Fig. 1) treated with water showed no root initiation until the 4th week after start of propagation and, after 5 weeks, only 40% of the cuttings were rooted. Cuttings treated with IBA alone commenced rooting after 3 weeks, but only 65% of the cuttings had rooted at the end of the experiment. In contrast, root initiation was improved in cuttings treated with both IBA and rutin. For example, after 2 weeks, 50% of the cuttings had rooted, and after 5 weeks all were well rooted. In root quality, cuttings treated with both IBA and rutin produced a more compact root system with a root ball diameter more than twice as large as cuttings treated with IBA alone.

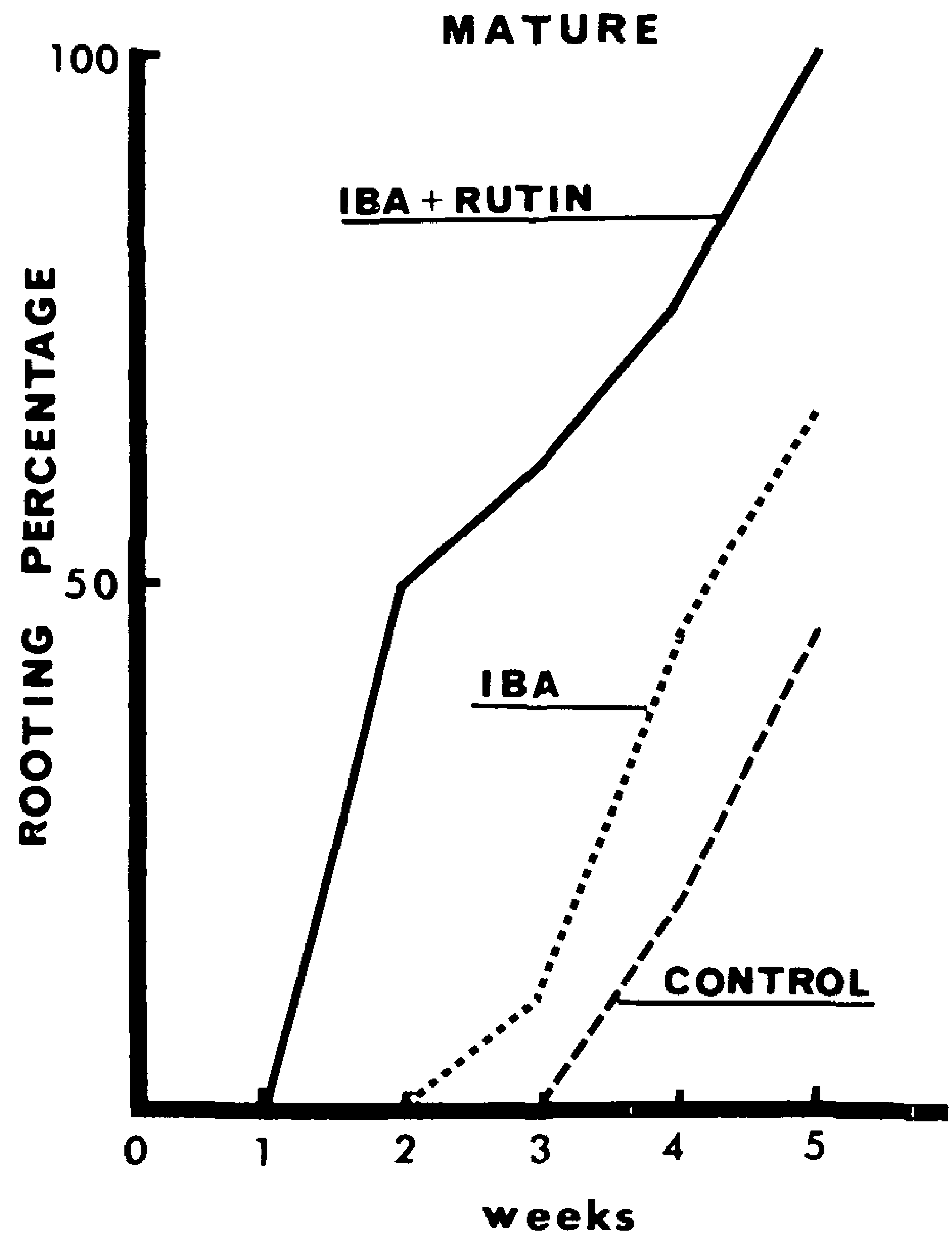

Fig. 1. Rooting of *Euonymus alatus* 'Compactus' cuttings as influenced by applications of IBA (2000 ppm) and rutin (1500 ppm).

In similar experiments conducted with immature cuttings taken in June, there were no significant differences in the rooting percentage and root quality among the 3 treatments. All cuttings were well rooted after 5 weeks, and all had approximately the same root quality rating.

DISCUSSION

When *Euonymus alatus* 'Compactus' plants were grown under intermittent water mist during September, the onset of dormancy was delayed, leaf abscission was delayed, anthocyanin production was inhibited, and there was an increase in the production of natural flavanoid compounds, auxin-like substances, and rooting cofactors. As a result, mature stem cuttings taken from the misted stock plants rooted much earlier and produced a higher quality root system than did cuttings from non-misted plants.

Evidence in the literature supports the suggestion that the accumulation of auxin-like substances, rooting cofactors and flavonoids, may be responsible for improved rootability, including substances such as catechol, pyrogallol, rooting cofactors, chlorogenic acid, quercetin, kaempferol, anthocyanins, leucoanthocyanins, and even "rhizocaline" (1, 2, 3, 4, 6, 9, 10).

When rutin, a flavanol, was applied to mature cuttings from non-misted euonymus, rooting was greatly increased over control plants and similar to rooting of untreated mature cuttings from misted stock plants. However, when immature cuttings were treated with rutin plus an auxin, no significant increase in rootability was noted. This suggests that immature cuttings may have sufficient amounts of natural flavanols or other natural root-inducing substances for good root initiation.

It is not clear how intermittent mist alters the metabolism of the plants. One possible explanation is leaching by the mist of metabolites, including inhibitors, involved in senescence and dormancy (14), allowing synthesis of compounds normally found in vigorously growing tissues. Growth inhibitors have been detected in the leachates of many plants (14). In fact, this was put to practical use in ancient times by plantsmen who placed cuttings in a stream of running water overnight before planting in order to promote root initiation. More recently, immersion of sugar cane cuttings in water prior to planting caused a definite increase in root initiation, due to leaching of inhibitors (7).

The cooling effect of the intermittent mist (5, 8) did not seem to be the primary cause of the observed changes in metabolism, for the temperature changes induced by the mist were a maximum of 3° C, and then only when the mist was on. In addition, accumulation of root-inducing substances noted in these experiments is not usually associated with reduced leaf and air temperatures.

Similarly, the moisture status of the plants did not seem to account for the results, as both the misted and non-misted plants were grown similarly, except for the mist. However, a possible effect cannot be eliminated.

These results offer an additional explanation for the success of modern mist propagation techniques. It has long been known that intermittent mist lowers air and leaf temperatures, thus reducing the rates of transpiration and respiration in cuttings (5, 8). However, the benefits of mist could not always be explained satisfactorily by these effects alone. As these experiments demonstrate, intermittent water mist delays senescence of plant tissues and stimulates an accumulation of natural root-inducing substances in the tissues, thus, in effect, conditioning a plant to better rooting. These results pertain specifically to *Euonymus alatus* 'Compactus' and, although there is evidence that the results are applicable to other species, they have not been tested as yet.

The results reemphasize that there are many endogenous substances in plants which may have a role in root initiation and development, including not only auxins and rooting cofactors, but other phenolic substances such as flavans, flavonols, and anthocyanins. This may be one of the reasons why the results of many rooting studies are difficult to interpret if only one group of root-inducing substances is considered. For the nurseryman, identification and application of these substances to cuttings offers great potential for improved rooting.

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MODERATOR FLEMER: Thank you very much for an interesting and provocative paper; it certainly indicates that mist does something besides just keeping the cuttings turgid.

KEN REISCH: You said that when misting the stock plants they continued to grow, do you mean linear growth regardless of photoperiod in the fall?

HAROLD TUKEY: That is right. There was a period in the fall. when the linear growth slowed down starting at about July when the terminal bud was set. There was a reduction in growth after that but then they began to grow again in October or November and about the end of November the new terminal bud began to grow.

DICK BOSLEY: You mentioned that you had less disease under the mist; would you speculate on this please?

HAROLD TUKEY: The pathologists are quite intrigued as to how this works. It has been suggested that the spores can be washed off by the mist and thus prevent germination. Some pathologists do not believe this but it is true that disease control is better with the mist than without the mist. Whether it is as simple as washing the spores off I do not know.

BRUCE BRIGGS: Can you feed fertilizer through the mist lines to the unrooted cuttings and help rooting?

HAROLD TUKEY: We did not use nutrient mist in these studies but Dr. John Wott, now the Secretary of this Society, did a considerable amount of this work when he was a graduate student at Cornell. The results of his work have been published in previous Proceedings. Specifically, yes you can increase the rootability of cuttings by correct additions of nutrients during the rooting period. Those cuttings which are growing the most, particularly softwood cuttings, respond best whereas the more mature cuttings which are not making a great deal of growth during the rooting period, do not respond particularly well.

MODERATOR FLEMER: Several years ago our Society became interested in the finding and introduction of new plants on a commercial scale A committee under the able chairmanship of Jim Wells was appointed to look into this question and report back to the Society. This report will now be presented to you by Jim Wells.

REPORT OF THE PLANT EVALUATION COMMITTEE

Composed of:

WILLIAM FLEMER III — PETER VERMUELEN
WILLIAM SNYDER — JAMES S. WELLS—CHAIRMAN

Presented by

JAMES S. WELLS

Your Plant Evaluation Committee met four times and I am glad to say that substantial progress was achieved. At our first meeting held November 29, 1970 we first considered whether we needed a scheme for plant evaluation and introduction. It was unanimously agreed that we did. Next followed the consideration of what form it ought to take. Possibilities considered were as follows:

1. A strictly commercial plan for testing, selecting and ultimately introducing first class plants.
2. A non-commercial evaluation system similar to the Royal Horticultural Society in England, the introducing then to be left to the originator.
3. A combination of 1 and 2.
4. A survey type such as the evaluation of hybrid French lilacs carried out by John Wister and published by the Arthur Hoyt Scott Horticultural Foundation.

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Careful consideration of these possibilities led us to the conclusion that in these times and in this country the only acceptable organization should be commercial, discriminating and profit-oriented.

Having come to this decision it was clear that the sponsoring body should not be the International Plant Propagators' Society and that a separate organization would have to be established. We then went onto consider ways and means for establishing such a group and an outline of a proposed scheme was developed.

A second meeting was held on December 29, 1970 in which all these suggestions were considered in more detail. Proposals were then drawn up in the form of a simple document which members of this committee used to discuss the idea with other interested people at various winter meetings. There was mixed reception. Some felt that the idea was excellent, others felt that they would like to wait and see; a few felt that, "there hasn't been a plant worth introducing in the last 20 years". In other words, the response was entirely typical of any broad group of people.

We consulted a law firm in Washington, D.C. in regard to possible implication of anti-trust laws and obtained suggestions as to proper forms of organization. The committee was particularly interested in the development and operation of the Canadian Ornamental Plant Foundation. William Flemer attended their 1971 annual meeting and learned that their operation is proceeding well, that it is achieving the purposes outlined for the Foundation, and they would welcome an opportunity to cooperate with a similar organization in this country. We also investigated the operation of the All-American Rose Selections and the All-American Seed Selections and, with this information before us at our third meeting, we were able to come to the following conclusions:

1. There is a real need for such an organization.
2. Similar organizations are operating successfully and there is an immediate willingness to cooperate.
3. The operation should be simple and entirely commercial.
4. Your committee should now present this report which presumably would complete its work under the aegis of the I.P.P.S.
5. A steering committee outside I.P.P.S. should be formed and widened to include interested people with the intent of setting up a foundation in this country to accomplish the objectives proposed in the attached outline.

REASONS FOR A PROMOTIONAL ORGANIZATION

The American nursery industry has not evolved a successful formula for the selection, introduction, and promotion of superior new woody plants, except for isolated and specialized groups like roses. The present method is piecemeal and haphazard. Individual firms with new varieties of merit describe them in their catalogues or a few advertisements are put in trade journals and they gradually seep into the trade and thence to the public. If a new plant proves to be commercially important, by the time large sales develop it is widely disseminated and the introducer does not benefit much from his innovation.

Even if the new plant is protected by a patent, it is very difficult for an individual firm (especially a small one) to promote it effectively. The merit of a novelty is accredited only by the unsupported opinion of the innovator, who has a special interest in it. Thus it is difficult for him or his firm to secure enough licensees to achieve the royalty income and production adequate to support effective promotion to the consuming public. On the contrary, if a number of firms have a vested interest in a new variety, their combined individual promotions and their joint participation in retail advertising can insure success.

National programs for the promotion of new woody ornamentals have been proposed and considered on several occasions. In a country as large as the U.S.A. with subtropical, temperate, and very cold areas, no woody garden plants exist which are of universal use. Therefore, the only practical solution would appear to be a trial program confined to the temperate zones (USDA Hardiness Zones 5, 6, and 7) in which a majority of the gardening public live. A major portion of the American nurseries producing ornamental plants who could support such a program are also located in these zones. A logical starting place is in the northeast because reasonably close proximity would make communication and coordination less difficult. However, membership should be open to any reputable firm growing plants or selling in these zones.

The International Plant Propagators' Society at its last annual meeting appointed a small committee to prepare and submit a recommended plan for the introduction and promotion of new plants. After careful consideration the committee proposes the formation of a corporation tentatively to be called the "American Ornamental Plant Foundation, Inc.". Its stated purposes would be;

1. To encourage the breeding, finding, evaluation, selection and introduction of new ornamental plants for the benefit of the gardening public.

2. To provide the originator or finder with a suitable monetary return through an efficient and businesslike method of propagation, growing and distribution of the selected plants.
3. To provide a means of cooperation with similar foundations, both domestic and foreign.

It would perform five services for its member firms, serving as;

1. An agency to gather for commercial consideration as many as possible of the new plants appearing each year.
2. A disinterested and respected tribunal to judge their horticultural and commercial value, whose endorsement would carry weight with the consuming public.
3. A means of assembling funds sufficient for effective promotion at all levels.
4. An experienced agency to arrange production licenses and collect royalties for originators.
5. A knowledgeable agency to locate and develop sales outlets for new plants and enlarge their market.

Thus originators could find a market for their innovations, growers who are not originators could find commercially profitable new products to grow, and retail merchandizers could find profitable new plants to increase their sales.

HOW THE FOUNDATION WOULD OPERATE

Step No.

1. Solicitation to all breeders, commercial and amateur for new plants to be screened. Originator must submit 10 specimens for examination, or color pictures where more practical.
2. Screening Committee meets and indicates preliminary interest or disinterest in a plant.
3. If a plant is accepted for preliminary trial, propagating wood or young plants are sent to official testing stations. Scions or cuttings would go to a nurseryman for propagating and later distribution to the testing stations. Statement of intent binding originator and organization is signed. The naming of a plant would be done by consultation with the originator, but at the final say of the organization.
4. Screening Committee meets and evaluates material, choosing acceptable material and rejecting unuseable clones. If accepted, originator applies for a patent and assigns it to the organization. If not accepted, trial plants are returned to the originator at his expense or, at his option, he receives a cer-

tificate of destruction issued by the Screening Committee through the President. Directors negotiate with the originator and determine what the royalty will be and when it will be due.

5. Directors plan entire introduction program considering;
   a. Potential sale quantities likely.
   b. Potential outlets—mail order, etc.
   c. Speed of acceptance—how much per year.
   d. Promotional efforts—direct ads, articles, slides for talks, flower shows.
   e. Name and form of special identification.
6. Directors draw up propagation schedule. How many will be grown and the minimum size which will be sold at retail.
7. Directors send out invitations to produce the introduction.
   a. First, to the membership.
   b. Second, if undersubscribed, to a selected list of potential members.
8. Letting of propagation contracts, with notification of the royalty rate and when it is due.
9. Activate promotional plans, keyed in with Step 8.
10. Collect royalties, and distribute to the originator his own share (possibly 60 to 80 percent).

This is a summation of the committee's work and is presented as a report only.

MODERATOR FLEMER: Thank you very much, Jim. This report was purposely presented as the last item on this morning's program so as to allow sufficient time for discussion, any comments you may have as to its feasibility, or if you would like, more clarification as to how it would work. Because of the mixed membership of our Society we recognize that this is something that it would not do but, rather, that it would be an independent organization with the profit motive clearly in mind. We think that universities and other public institutions which are doing plant breeding would be interested in introducing their new plants through this new proposed foundation. We think that this could be a source of revenue to support research at such institutions. At this time I'll turn the microphone back to Jim Wells and we can begin a discussion of the report.

PRESIDENT PINNEY: On behalf of the Society members I heartily thank Jim and his committee for their work. It is an excellent example of a small group in one grographical location accomplishing a tremendous task. We asked them to do this and they have fulfilled the requirements exceptionally well. I might make one further comment;

this will be brought up at the business meeting simply to ask your blessing and the Society will no longer be involved and, at that time, we will discharge the committee. From that point they may pursue it, but outside the Society's framework.

L. C. CHADWICK: At the present time what is the thinking as to the range of plant materials which would be handled?

JIM WELLS: I don't believe the committee has set any limitations at the moment.

L. C. CHADWICK: Would this then also include sports or only plants resulting from cross breeding?

JIM WELLS: I would say it would include any plant which is clearly distinctive and has merit.

MODERATOR FLEMER: And is stable.

JIM WELLS: Yes, it must be a stable plant.

LARRY CARVILLE: Was it envisioned that in the formative stages I.P.P.S. might subsidize your organization to get the ground work laid for it?

JIM WELLS: No, it did not; we had in mind soliciting, or we might in turn be solicited by people of sufficient interest and financial weight who would be prepared to support the concept by making an initial contribution or fee of, perhaps, $500 per person, which would not be returnable. This is how we had hoped to obtain money in the beginning and the Foundation should be self-supporting relatively soon.

JOE CESARINI: Are you going to limit this to plant patents or are you going to extend it to the area of trademarks?

JIM WELLS: We did not consider trademarks; however, I see no reason why an originator should not trademark it, subject of course, to the rules of the Foundation.

PETE VERMEULEN: I would like to elaborate on the funding and trademark points. In our discussions we did consider income sources other than an initial contribution; we considered an annual dues of perhaps $50 per year per individual. There would also be income from the plant introducer for registration and other required procedures. I also recall our discussing the areas of plant patent or trademarks which would be a cooperative agreement between the Foundation and the producer at such time as the plant is evaluated and considered worthy of introduction.

KEN REISCH: Do you envision that this would be an aid to the smaller introducer rather than the large firm that is currently investing many dollars into promotion and introduction of new plants?

JIM WELLS: We would hope that the Foundation would be worthwhile to both the small and the large producer.

KNOX HENRY: Would it be necessary for foreign companies to be members of this organization or would you arrange distribution through, for instance, our Canadian organization?

MODERATOR FLEMER: I think the distribution would be arranged through C.O.P.F. in order to get maximum distribution in Canada.

KNOX HENRY: Will it be necessary for originators to be members of the Foundation in order to utilize its services?

PETE VERMEULEN: I believe our thinking on this was that the originator would not have to become a member if he did not see fit. He would certainly be welcome to join and would be encouraged to do so, but by the payment of a registration fee for his plant he could submit it and have it evaluated by the committee. If the plant is subsequently selected it would once again be his option to join but he would not need to do so. The details do have to be refined, but to limit plant submission to members would thereby limit the number of plants submitted and it is the intention of the Foundation to test as many plants as is feasible. One further comment with respect to finances; in our committee meeting it was mentioned that it takes between $25,000 and $30,000 just to promote a new plant, so it is important that the Foundation have immediate funding.

JOE CESARINI: Will this be individual membership or firm membership?

JIM WELLS: It doesn't matter since we are interested in plants, not people. Whether they are submitted by an individual or a firm is inconsequential.

DAVE DUGAN: How long a testing period do you have in mind?

JIM WELLS: This will probably vary from plant to plant. Hopefully, we will have used our expertise in selecting the plant initially; the length of time that it may need to be tested would depend upon the kind of plant that it is. A tree might take as long as 10 to 12 years while an herbaceous plant might require only 1 or 2 years. Nothing would be done, however, until the plant was thoroughly tested and showed indications of being worthy of introduction.

LEN SAVELLA: How will you determine how much will be spent to promote a plant?

JIM WELLS: Once again I believe it will vary with the plant and it will vary with the media in which it is advertised.

OTTO TIMM: What is the difference between the Foundation and plant patenting?

JIM WELLS: They are complementary. Patenting is a part of the process we are proposing. We are primarily concerned with the production and promotion of the plant. Patenting the plant does not make a good plant nor does it put it on the market. We propose, first of all, to find out if it is a good plant, then patent it, then finally promote it.

PAUL BOSLEY, SR.: I've had a great deal of parallel experience with American Rose Selections, plant patenting, etc. There are many problems which can arise in a program as extensive as the one you are envisioning. You mentioned the possibility of institutional materials which might be introduced; I think this might cause you some trouble because those institutional developments were paid for with tax dollars and, probably, can not be handled through a Foundation.

The All-American Rose Selections were well managed by good businessmen but recently they have been in near financial problems with the set-up they are using, which I feel would be hard to improve upon. Even though it is a well managed organization, there were many legal problems which arose as a result of plant patents. I would suggest that you start off on a less extensive scale; I think a good deal more study and thinking needs to be done.

KNOX HENRY: I am quite extensively involved in the Canadian Ornamental Plant Foundation and it appears that you are attempting to emulate some of our better ideas. During the past 5 or 6 years that the foundation has been operating in Canada we have not been without problems. Getting the organization off of the ground involved a lot of headaches, with conflicting interests and other problems involved. I think such an organization would work down here as well as it does in Canada. We do not have a plant patent act in Canada and are not obliged to pay royalty to anyone on plant material. Thus material in Canada is not protected but, as Canadian nurserymen, it is our intention to respect royalties or premiums that are due on plant material that has been originated by persons or companies. We are now introducing patented material into Canada through the offices of C.O.P.F. and royalties on this material will be paid to the originators in the United States or other countries. In Canada, universities and government research stations which introduce material, do so through C.O.P.F. and the royalties for these introductions are being turned back for research in Canada. I think such an organization can work and will work very well for you, and I wish you good luck.

JOHN ROLLER: How do you intend to go about policing your plant patents and trademarks?

JIM WELLS: We recognize that there will be problems and, if this organization operates as we intend it to, we will spend days in court. It would seem to me that one of the best protections we could have would be a name, trademark or some clearly defined identity which will sell the plant and which belongs to the Foundation. If someone suddenly appears with an identical plant you can take them to court but, even then, it isn't of so much value if they have to call it by, perhaps, 'Pink Cascade' while we sell ours under the name of 'Fire Glow'.

LEN SAVELLA: If an introducer feels the Foundation is not doing a satisfactory job of promoting his material could be cancel or retract his patent?

JIM WELLS: No, I wouldn't think so. A plant originator would present the plant to the Foundation, the Foundation would then critically evaluate it through the screening committee and, if they decide that the plant is worthy of introduction, then a contract would be drawn up which would bind both parties, and contracts are not readily broken.

Our time is just about up but before we leave I would like to ask that we have a show of hands, first by those of you who believe that the Foundation is a good idea, and then by those who are opposed to it. (Editor's note: The show of hands was overwhelmingly in favor of the Foundation. Only five hands indicating opposition to the Foundation). We are out of time but I would like to ask that those of you who are opposed to the Foundation make your feelings known either to the committee or, preferably, at the Business Meeting on Friday evening. I wish once again to thank the committee for their cooperation and you for listening.

MODERATOR FLEMER: We stand adjourned until 1:30 this afternoon.

THURSDAY AFTERNOON SESSION

December 2, 1971

The afternoon session convened at 1:30 p.m. in the West Ballroom. Mr. William Flemer III served as moderator.

MODERATOR FLEMER: We will begin this afternoon's session with a talk on new techniques for budding difficult plants, particularly with regard to shade and flowering trees. Many of our members are Hollanders; grafting is the main vegetative method used in Holland, while budding is a particularly American method of reproducing shade and flowering trees. Budding has reached its perfection both in speed and accuracy here in American and Harry Hopperton, who is an expert in budding, is going to tell us about some of the new techniques he is using. Harry.

NEW TECHNIQUES IN BUDDING DIFFICULT TREES

HARRY W. HOPPERTON

Hopperton Nursery, Inc.
Naperville, Illinois, and Warsaw, Kentucky

Our first step in budding *Quercus* varieties is to line out our 2 year *Quercus palustris* seedlings in the early spring. This seedling is grown for one year.

Early in the spring of the following year, we go in and cut the seedlings back to ground level. After secondary shoots start to appear and have made a growth of 5 or 6 inches, we take off all shoots except one. In early July or August depending on growing conditions, while the shoots are vigorously growing, we start to bud. The following year when new growth appears, we cut back to the eye and the budded tree takes over. It is extremely important to have good budwood with big eyes. In the spring we severely trim our stock trees from which we cut our buds so that they produce lush, plump buds. I cannot overemphasize the importance of good plump budwood.

Another successful method we use for budding *Quercus* is to go into a block of young *Quercus palustris* with a caliper of from 1 to 1½ inches and insert a top bud about 5 to 6 feet above the ground. Always insert the eye on the back side of a crook; it is amazing how straight the tree will become. However, this procedure must be done very early. We do this in early June in the Cincinnati area. After approximately 3 weeks, we cut back the entire top of the tree. The new bud will make 12 to 18 inches of growth during the year. This method will make a larger caliper, salable tree much sooner. This procedure of top budding is also used for *Ginkgo, Aesculus brioti* and *Aesculus parviflora* that is budded onto *Aesculus glabra.*

The only really successful method that we have found to bud *Cercis canadensis* varieties is to line out our 18 to 24 inch seedling stock in very early spring. We side dress with nitrogen as soon as the seedlings start to grow. We then cut them back to ground level. After new shoots appear and start to grow, all but one shoot is removed and we bud onto this remaining shoot as soon as our budwood is ready. Approximately 3 weeks after budding, we cut back to the eye and get anywhere from 12 to 15 inches of new growth that same year. If we do not cut back the same year, the eyes are all dead the following spring. But once again I wish to emphasize that the budwood should be full and plump to get the best results. This is the only sure way that we have been able to bud *Cercis.* We achieve a 90% stand with this procedure.

In summary, I believe the key to successful budding lies in a vigorous growing understock, good, plump budwood, and a tight patch budband to cover the eyes. With a little bit of moisture and a lot of luck, you should have excellent results.

ED DAVIS: You said you bud these oaks as soon as the buds will slip in the spring, so I assume you are using past season's growth. Is this correct?

HARRY HOPPERTON: No, I use current season's growth. If you have a stock tree of say a 2" caliper, cut it way back and you will soon get 2-foot branches which are nice and lush; use that wood as soon as it will slip.

VOICE: How is the fall maturity of those spring-budded trees?

HARRY HOPPERTON: Fine, they'll go to maturity just like the other seedlings

VOICE: Have you noticed any incompatibility with the oaks thus far?

HARRY HOPPERTON: None whatsoever.

VOICE: How long have you had them grafted?

HARRY HOPPERTON: I have trees with 2½" caliper.

HANS BERGER: Do you take the wood out of these buds?

HARRY HOPPERTON: There is no wood attached. The timing is wrong if wood comes with the bud. They must slip freely.

CASE HOOGENDOORN: I budded some 'Kwanzan' cherries in August and about a week later all of the buds were being pushed out. How do you account for that?

HARRY HOPPERTON: In many instances I have observed that the wrapping band does not hold the eye sufficiently tight; when this happens things such as you describe will occur. The wrapper is just as important as the budder. He must get that tie tight.

ED DAVIS: Since the band you use covers the bud up entirely, do you watch this and take it down later to prevent heating?

HARRY HOPPERTON: Yes, I do when I use this patch band.

ED DAVIS: When patch budding pecans we are now usimg polyvinyl tape about ½" wide and we cover everything but the eye.

MODERATOR FLEMER: When do you bud *Cercis*?

HARRY HOPPERTON: That will, of course, vary with the season and the area, but mainly as soon as you can get the budwood; cut the stock plants back and when the budwood is ready start budding.

MODERATOR FLEMER: Thank you very much, Harry. For those of you who have other questions you can drop them into the Question Box. Our next speaker is the President of the American Horticultural Society and is also a long time member of the International Plant Propagators' Society, Mr. David Leach. He is going to talk to us this afternoon about objectives and parent plant selection in azalea and rhododendron breeding.

OBJECTIVES AND PARENT STOCK SELECTION IN RHODODENDRON BREEDING

DAVID G. LEACH
1674 Trinity Road
North Madison, Ohio

The breeding of rhododendrons is in many ways akin to H. L. Mencken's description of marriage; "it is", he said, "like reaching into a bag of snakes and hoping to come up with an eel". The breeding of rhododendrons for garden decoration began just 150 years ago when Michael Waterer at the famous Knap Hill Nursery in England crossed the N.C.Catawba Rhododendron with the Rosebay Rhododendron. Some years later there was introduced the scarlet flowered tree, *R. arboreum* which came from India. It created a sensation when it flowered in England for the first time and a hybridizing explosion began which has never ceased. Before long, the opulent *R. griffithianum,* another Asian species with 6 inch white flowers arrived on the scene; this too is a tree-like species and is very tender. To produce hybrids which were hardy enough for general cultivation in England the English breeders crossed the tender exotic rhododendrons with the American natives, with *R. ponticum,* a species from Asia Minor which grows about 15 ft tall and with *R. caucasicum,* a 3 ft shrub which grows at higher altitudes in the Caucasus Mountains. With this latter exception all of these species which figured in the rhododendrons of commerce were of large stature. The result of using these tall rhododendrons as parents was inevitable and if you go down to your local nursery and buy rhododendrons and set them out beside your house, before long the rhododendrons will strangle the building. What we need are semidwarf hybrids which will stay in scale with the modern house. What then can be done about this problem?

George Forrest began his plant exploration in Southeast Asia in 1904. When he died 30 years later in the course of his seventh expedition to China, he had found the incredible number of 260 species of *Rhododendron.* Among them was one from Tibet found at 13,000 ft, the scarlet-flowered, *R. forrestii,* which matures at about 8 inches. It is not hardy in the Northeast nor are its direct descendants able to endure our climate. However, Dietrich Hobbie in Germany crossed it with an old semihardy red hybrid called 'Prometheus' and obtained an intermediate which he called 'Gertrud Schale' but which was still far from hardy in our climate. In 1956 he kindly sent me pollen of this plant; I used it on one of my early red hybrids called 'Fanfare' which has an open, ungainly habit of growth. The result of this mating produced the clear scarlet 'Small Wonder', an intermediate hybrid which matures at about 4 ft and is hardy to about 20° F below zero. In addition to being semi-dwarf it is compact and densely foliaged. It is now being propagated for release in 1974.

Another species which contributes dwarfness is *R. williamsianum* discovered by Ernest Wilson in China in 1908. I made many crosses with this species and all were failures; the seedlings languished in the heat and aridity of our eastern summers and those that survived often took 10 or 12 years to bloom. Finally a European breeder crossed the Williams Rhododendron with an old Dutch hybrid called 'Adriaan Koster'. I crossed one of this progeny with the white form of our North Carolina Catawba Rhododendron and from this combination obtained 'Robin Leach' a semidwarf white which matures at about 4 ft and inherits its dwarf stature and dense foliage from its grandparent *R. williamsianum*. This hybrid is tolerant of summer heat, a characteristic frequently obtained from *R. catawbiense*.

R. yakusimanum has been known by rhododendron breeders only since 1947 when it was first shown at the great Chelsea flower show in London It was found on an island south of Japan some years earlier but its ornamental value was not appreciated. Upon exhibition at the Chelsea Show this species became the sensation of the English horticultural world and a big demand arose for it both here and in Europe. The flowers are very beautiful pink and white and the species has almost a perfect habit of growth. My largest specimens are 2½ ft high by 5 ft wide, thick in foliage density because the leaves persist for 4 years. This is close to being the ideal garden rhododendron, hardy enough for most of the Northeast, but it has one fatal fault. It grows so slowly it is not a practical commercial rhododendron. I crossed a selection, which I call 'Pink Parasol', with the white form of the Catawba Rhododendron and obtained a hybrid which I named 'Spring Frolic'. It has a satisfactory rate of growth, and at the same time retains the compactness of its pollen parent, *R. yakusimanum*. This plant will be introduced in 1973. It matures at about 5 ft and has extraordinary foliage, with deep pink buds opening to pink flowers which age white.

Rhododendron chrysanthum has been known by botanists since 1776, but not by horticulturists because it is so hard to grow, coming from Siberia and Hokkaido. A 30 year old plant may only be 6 or 8 inches tall and it seemed a natural to impart dwarfness. I tried for years to obtain a form which could be cultivated in this country. After many importations of both seeds and plants a variant was finally found in the southern limit of its distribution which could be grown to flowering maturity I crossed this variant with one of Tony Shamarello's hybrids called 'Belle Heller', which is a very vigorous grower, and obtained a large flowered dwarf white with very dense foliage which matures at a height of about 30 inches. The problem here was different. In rhododendron breeding it's usually a problem of capturing the desirable qualities of the tender Asian species by crossing them with the hardy American natives; in this case *R. chrysanthum* was hardy enough but it lacked adaptability. By crossing it with a very complex hybrid of exceptional vigor, a hybrid was obtained which combined dwarfness, foliage density, large flowers and the ability to thrive in our hot, dry summers.

Another goal of the rhododendron breeder is the production of hardy hybrids with the exotic flower colors which have been obtained by hybridizers in the mild climates of southern England and the West coast. 'Crest' is one of the more famous of the tender yellow rhododendrons but combining yellow flower color with hardiness proved to be a very difficult goal. Lionel de Rothschild who produced 'Crest' at his famous Exbury estate in Southhampton also crossed *R. wardii* from Yunnan province in China with the semihardy *R. fortunei* from the lower elevations of eastern China. This mating produced a pale yellow which he called 'Prelude' and it is not at all satisfactory for the eastern United States but inasmuch as it had the semihardy *R. fortunei* in its parentage, it was crossed with *R. catawbiense* var. *album* which produced a pale yellow with a full, firm truss and exceptionally large flowers which was called 'Limelight'. It's completely hardy anywhere, is unlike any hybrid now in commerce but was not as yellow as I hoped nor quite as vigorous as I would have liked.

There were indications at this time that red rhododendrons carry a recessive gene for yellow. So the red form of the Catawba Rhododendron was crossed with the *R. wardii* which was used to produce 'Prelude'. This crossing yielded the yellowest, fully hardy hybrid that I have yet seen. I think the result of this cross is important for anyone who wants to breed yellow rhododendrons that can survive in the Northeast. If you are technically minded, the hypothesis is that rhododendron flower color is controlled by five genes plus a diluting gene, with two genes epistatic.

It probably would have been impossible to produce hardy rhododendrons with pastel flower colors of any degree of purity or clear scarlets had not a white form of the native *R. catawbiense* been found in Virginia a few years ago. Until 1937 the only successful parent to impart hardiness was the typical *R. catawbiense* which blankets the elevations of the Blue Ridge Mountains It appears to possess a gene for magenta in the dominant homozygous condition. With this situation, breeders for a hundred years produced pinks and reds which were badly flawed with blue. 'Roseum Elegans', the most widely grown of the hardy hybrids, is an example, as are 'Parsons Grandiflorum', 'Mrs. C. S. Sargent' and 'Henrietta Sargent'.

It might be interesting to trace the parentage of some of the newer hybrids. (**Editor's note:** At this point Mr. Leach showed slides and traced the derivation of several hybrids which he has developed using the white form of *R. catawbiense* var. *album*. Some of these are in the trade and others are slated for release in the future. 'Duet', 'Peach Parfait' and 'Virginia Leach' were among those discussed.)

Breeders should have all sorts of diverse goals to meet the demands of the commercial grower and the gardening public. There is a need for rhododendrons of compact habit which are precocious about blooming and are particularly adapted for growing in containers 'Flamenco' is one which meets these criteria; plants 6 inches tall may have flower buds on every terminal. It can be grown in a small container at minimal cost and after use for indoor decoration can be planted out of doors by the consumer and will make a hardy dooryard plant which will mature at about 3 feet.

Another need is for rhododendrons which will respond to the sophisticated growing techniques which are becoming more popular. With the aid of artificial light, early season heat, and the precise prescription of nutrients, it is now feasible to produce 18 to 24 inch heavily budded rhododendrons by the end of their second growing season. 'Lodestar' and 'Pink Flourish' are two which are responsive to this type of treatment.

Another goal in which I personally believe, but for which I have no support from professional nurserymen, is the extension of the flowering season into late spring and early summer. We Americans have become a nation of suburban patio dwellers and it would seem to me that the public would welcome shrubs which would flower and decorate their garden and terraces when they can enjoy them most. 'Summer Snow' produces flowers 4 inches across about the first of July. It has immense leaves and makes up into a tree of exotic appearance, but it has been greeted by such a display of under-enthusiasm that I no longer expect it to blossom from a wallflower to the belle-of-the-ball.

Most of the crosses which I have been discussing are relatively simple, whereas the best results are always obtained in a second or more advanced generation. Hoping to improve both the plant habit and the color purity of the reds now in commerce, I crossed 'Mars' with the red form of the Catawba Rhododendron and the result was 'Blaze'. I felt that 'Blaze' was not equal to the potential of 'Mars' as a parent and so I backcrossed 'Blaze' onto 'Mars' and obtained a vivid scarlet. To my surprise the inconspicuous blotch in the center of 'Mars' was transformed into a white center which I can only describe as "undeserved". To further illustrate the returns to be found in advanced generations, the tender English hybrid, 'Mrs. Furnival' which is heavily blotched in the flower, was crossed with *R. catawbiense* var. *album* and the result was a delicate pink flowered plant which flowered after withstanding 35° F below zero weather in 1963 and is now being propagated for introduction. Though this plant is very beautiful to me, I had still failed to obtain the striking contrasting blotch which I sought and so I backcrossed this hybrid onto 'Mrs. Furnival' and obtained a boldly blotched hybrid pale pink which blooms heavily at an early age.

In closing, I would like to point out that I have described only my successes. If I were to discuss my failures with you, you would still be sitting here next week sound asleep.

MODERATOR FLEMER: Thank you very much for a very professional and informed talk on a rather complicated subject. We will have time for a couple of questions.

CASE HOOGENDOORN: All of the yellow rhododendrons you showed were rather pale. The best yellow I have seen is 'Goldsworth Yellow'. What do you see wrong with it?

DAVE LEACH: For one thing, it is difficult to root and for another, some people would disagree with you that it is yellow. I agree that the slides I showed of the yellows do appear pale, but mostly the insufficiencies of the color film are responsible for that. Breeding yellow rhododendrons is extremely difficult; in fact, it is far more difficult than any other thing I have tried to do.

CARMINE RAGANESE: Would you say that 'Full Moon' is the most desirable yellow?

DAVE LEACH: No, I would not. Disregarding hardiness there is one on the West Coast called 'Hotei' and I think it is the yellowest rhododendron in the world today. It's a new hybrid and is pollen sterile so I am using it as a seed parent by growing it in a container and protecting it in the winter time. It is a butter yellow and nearly unbelievable; it was a great triumph for the hybridizer to have produced a yellow with that pigment intensity.

MODERATOR FLEMER: Thank you once again, Dave. While we are on the subject of breeding ericaceous plants we are fortunate in having with us a man known as "Mr. Kalmia" in the Eastern United States today and that is Dick Jaynes from the Connecticut Agricultural Experiment Station. He has been doing some wonderful things in breeding mountain laurel to expand its color range, rootability, and other potentials which have never received much scientific attention until Dick Jaynes began doing this work. He is a skilled hybridist and is going to address us this afternoon on "Selection and Propagation of Improved *Kalmia latifolia* Cultivars."

SELECTION AND PROPAGATION OF IMPROVED KALMIA LATIFOLIA CULTIVARS

RICHARD A. JAYNES

The Connecticut Agricultural Experiment Station
New Haven, Connecticut

Abstract Mountain laurel occurs in many forms and superior selections are available for propagation Red-budded and white-flowered laurels come true from seed if both the seed and pollen parents are of similar kind. Seed sown in a greenhouse in November will produce plants of sufficient size by the following June to transplant into outdoor beds. Although of limited commercial value, grafting on forced stock in early spring or on unforced stock in June is suc-

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cessful Clones vary in their ability to root from cuttings and display an increased reluctance to root as the stock becomes older Cuttings from cuttings or young grafts root more readily than cuttings from the original stock plant. The more "juvenile" the tissue, the more readily it roots. White-flowered and red-budded laurels can be propagated from cuttings by using seedlings of known pedigree as stock plants

"The mountain laurel of the American states (*Kalmia latifolia*) is one of those plants which, if of recent introduction, would be eagerly sought after; but having been an inhabitant of our gardens for nearly a century and a half, it receives but little attention."—a quote from a British magazine published in 1882 (1). We won't make up for 250 years of "under-attention" in the next 30 minutes but let's see where we are and whether this plant deserves more of our attention in the next 10 years.

Variation within the species is considerable and many selections from the wild and from nurseries have been named over the years. Some of these have cultivar names, others are recognized merely as botanical forms.

White-flowered forms (called 'alba') have been cultivated since 1840 (10). Like many "white" rhododendrons most of these show a hint of color in bud or have faint pigment in the open flower.

Pinks—A wide range of superior pink flowering plants are known but restraint has been shown in naming them because of the propagation problems. 'Clementine Churchill' is a pink-flowered cultivar selected at Sheffield Park, Sussex, England.

Red-buds—These plants are striking in bud and as the flowers open. 'Ostbo Red' (also known as 'Ostbo 5' or 'West Coast 5') is a good red-bud cultivar that has been propagated to some extent from cuttings.

Feather petal—A botanical form (*polypetala*) that has 5 petals. A garden oddity rather than a form prized for its floral beauty.

Banded laurel—A botanical form (fuscata) characterized by a deeply pigmented band on the inside of the corolla. The band may be continuous or interrupted.

Large-flowered types—One called 'Silver Dollar' has flowers which are indeed the size of a silver dollar.

Foliage types—Compact and dwarf kinds are known. One of the most striking is the form called 'Myrtifolia' which is a miniature replica of the normal mountain laurel.

So much for a sampling of the variation and horticultural types available within the species. How can they be propagated?

PROPAGATION BY SEED

Seed propagation of mountain laurel has been used by a few nurserymen for years and a commercially accepted method was described at these meetings by Peter Vermeulen in 1967 (12). Seldom do we find two propagators following exactly the same procedures. Weston Nurseries in Massachusetts grows large numbers of laurel from seed using the same general principles described by Vermeulen but the method varies in several details (personal communication). In general the methods used for *Rhododendrons* will work for *Kalmia*.

The incentive to propagate laurel from seed will increase as we learn how to obtain some of the best forms true from seed. There is now a means to mass produce true-breeding seed on caged plants using bumblebees as pollinators (7, 8). Seed of white-flowering or red-budded plants can be produced by this method.

Fresh *K. latifolia* seed is partially dormant but this fact can be ignored unless the seed is in short supply (9). Fresh seed gives 40-50% germination but seed stratified (moist-cold) for 8 weeks gives 60-75% germination, or 50% greater. The same effect can be obtained by soaking the seed overnight (12-24 hrs) on filter paper saturated with 100 ppm Gibrel (80% gibberellic acid) (Figure 1), a technique we use

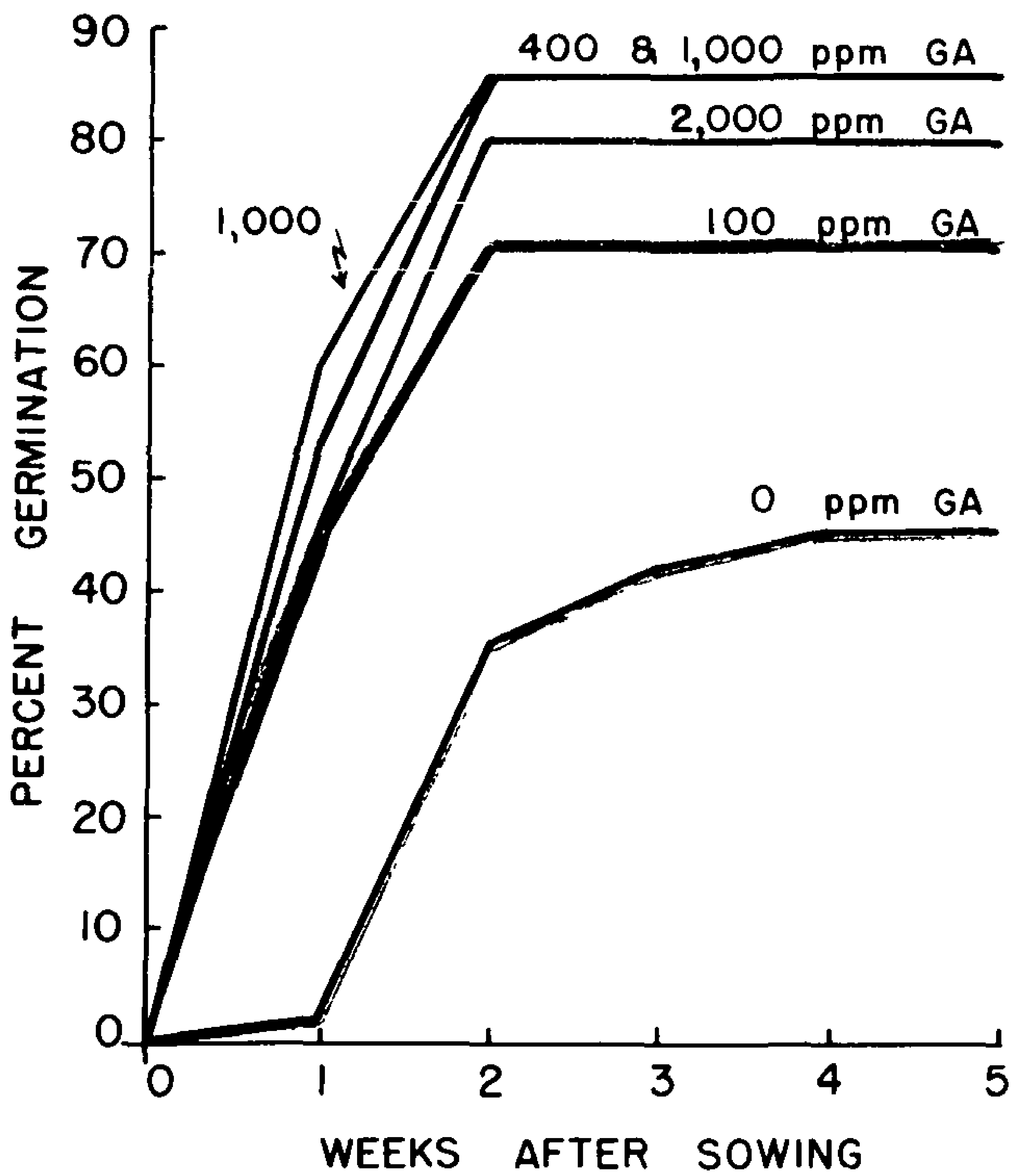

Fig. 1. Effect of gibberellin (GA) on germination of *K. latifolia* seed. Data based on 3 replications of 50 seeds each per treatment. Seed treated with moist-cold conditions for 8 weeks respond as do the gibberellin-treated seeds. After Jaynes (9)

routinely. *Kalmia latifolia* seed that has been stored dry for a year loses its dormancy and requires no treatment.

The beneficial effect of a mycorrhiza (root-associated fungus) on young seedlings was demonstrated by William Flemer in 1949 (4). Whether the fungus is normally present in peat moss or sphagnum moss is not known. Flemer's hope of commercially propagating laurel in sterile culture like orchids has not yet been realized.

Some aspects of our routine for raising laurel from seed in our breeding program may have commercial application. We sow seed in plastic boxes (2" high x 3½ x 7") on top of ⅝" of mix composed of 5 parts sphagnum-peat moss, 4 parts ground sphagnum moss, and 3 parts sand. The boxes are kept under fluorescent lights (about 500 ft-c at the level of the mix, obtained with the boxes 10" below a bank of 4 bulbs) with a daily photoperiod of 16 hrs. Temperature is kept between 70° and 80° F. It is important that temperatures during and immediately after germination not be above 80° nor much below 70° (Figure 2). Above 80° germination is greatly decreased, a

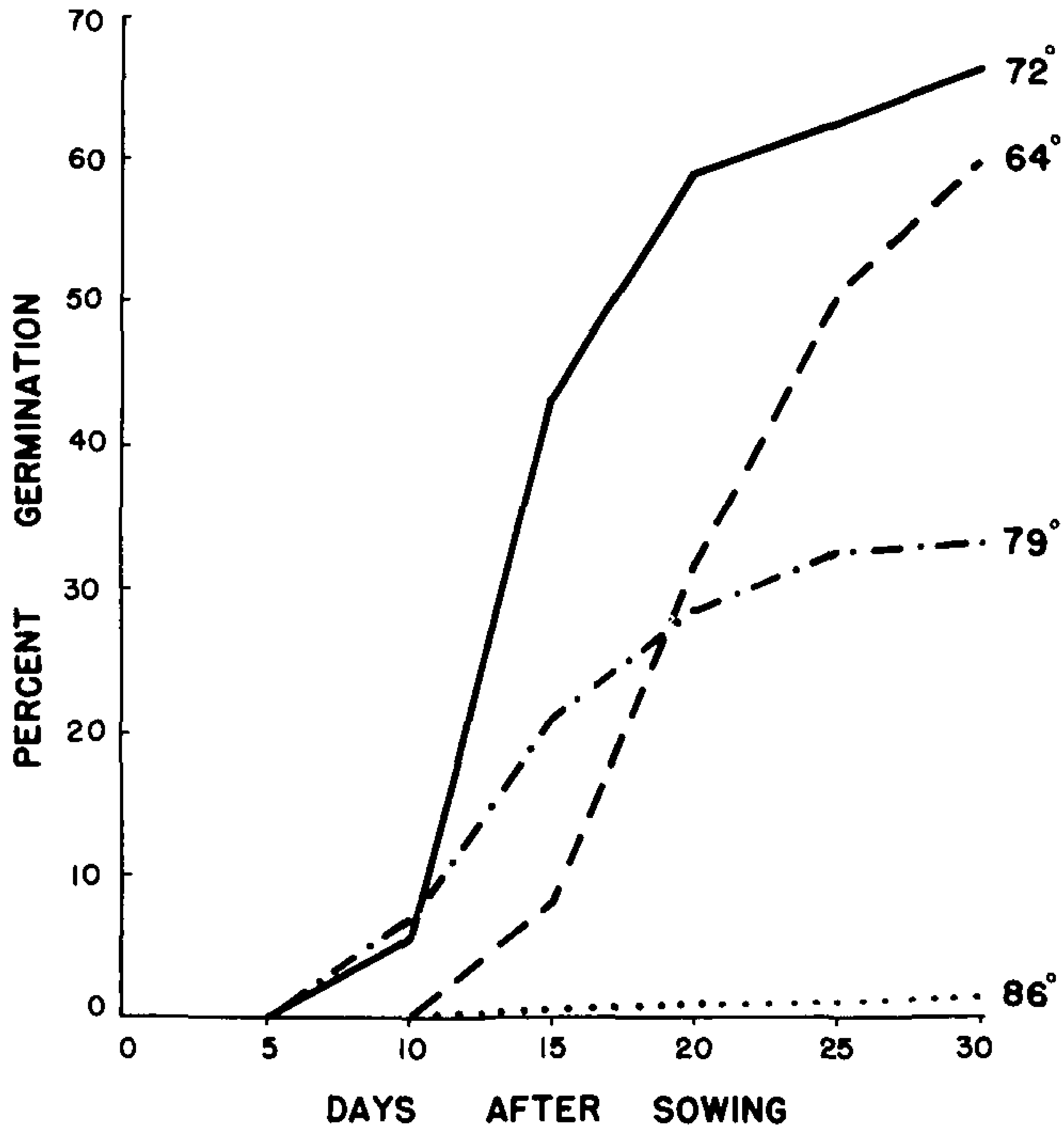

Fig. 2. Seed germination of *K. latifolia* at 64°, 72°, 79°, and 86° F. Note particularly the low germination percentage at the two high temperatures. Data pooled from experiments on 2 northern and 2 southern sources of mountain laurel which showed no correlation between source and germination response at the different temperatures. Each treatment based on 12 replications of 50 seeds each.

phenomenon not observed with other laurel species (9); below 70° growth is retarded.

Seed is best sown in November. The seedlings form 1 to 3 true leaves within 8 weeks at which time (January) they are pricked-off into flats, 60 plants to a 13 x 20 inch flat. Forceps are used for transplanting to holes made by a board with 60 equally spaced nails.

The transplant mix is composed of 4 parts peat moss, 2 parts perlite, 2 parts vermiculite, 1 part ground sphagnum to 1 part composted soil; 1 oz of hydrated lime is added to each bushel of mix. Why use this mix for transplanting and the other for germination? At least a dozen different media were tried for each and these worked best under our conditions. Bands and peat pots were tried but I see no advantage to either for laurel and some disadvantages.

Our plants are grown in a fiberglass house, shaded with 50% saran cloth from April to November. Plants are fertilized with soluble 20-20-20 as indicated by soil testing. No fertilizer is used the first 6 to 8 weeks in the germination boxes. If soil temperatures are 64°, instead of 74°, plant growth is slow and ammonia nitrogen tends to build up. It is best to keep the medium warmer at night than the air temperature by forcing heat up through the flats.

I like to have the plants at least 1 inch high and leaves of adjacent plants touching by June when they are transplanted from the flats to raised beds in a lath house. The plants are spaced 4 inches apart within the row and 7 inches between rows. At the end of the first year plants should be between 2 and 6 inches high. They are ready for the field after the second growing season.

PROPAGATION BY GRAFTING

Mountain laurel can be grafted with little difficulty and suckering is not a serious problem on established grafts. Grafting is generally not commercially economical and is only warranted in special situations Spring grafting in the greenhouse on forced rootstocks is the normal procedure. Dormant scions are side-veneer grafted onto young plants as low as possible. The techniques described for rhododendrons (6) are applicable.

I have found June grafting to be successful and convenient. When I select a flowering plant for use in crosses or additional testing, I like to propagate it immediately. Scions are the current season's growth, firm but not woody. Stocks are small plants which grew vigorously the previous year. Scions are side-veneer or cleft grafted onto last year's growth on that part of the stem which is smooth and has few leaves. Cut rubber bands (# 16) are used to tie the unions. Grafts are placed in a closed plastic tent, shaded from direct sun. After 4 weeks the tent is gradually ventilated over several days, so that after 6-7 weeks the plants can be set out in shaded outdoor beds. Few June-grafted clones put out a flush of growth until the following spring. Thus little is gained over spring grafting other than possible convenience. The survival of our June grafts has consistently been 80-85%.

PROPAGATION BY CUTTINGS

The inability to readily propagate laurel selections from cuttings has certainly been of prime importance in limiting distribution of improved cultivars. I will review some of the information in the literature on rooting cuttings and add to this from my own work.

The time of the year to take cuttings is the first consideration. The literature is confusing. Tincker (11) had success in January, Curtis (3) cites March, Briggs (2) lists June and July, and Fordham (5) recommends hardwood cuttings from August to December. That about covers the year! Various types of wounding, auxins, and media have been used as well as plastic tents or mist. The closest area of agreement is the application of bottom heat of 70 to 80° F. Rooting, if it occurs, is generally in 3-5 months.

At the Arnold Arboretum, Fordham (5) found the two most effective auxin treatments on hardwood cuttings taken in the fall were a 5 sec dip using IBA plus NAA at 5,000 ppm each, or treatment with a powder formulation of 2,4,5-TP (Silvex) at 1,000 ppm. Cuttings in plastic tents rooted better than those in mist. Our experience with plastic tents and mist has been the same as at the Arboretum, and I suspect the real difference is not one of moisture but of temperature. In the same greenhouse the medium under a tent will run at least 5° and often 8-10° warmer than medium in an open bench receiving mist. If the temperature of the medium is below 70°, root formation is notably slowed. Fordham used a mix of equal parts sphagnum-peat moss and horticultural grade perlite. We use a mix of 5 parts peat to 2 parts perlite.

For fall cuttings the extension of the daylight period to 16 hrs, or interruption of the night with artificial lights, is suggested. A controlled experiment needs to be run but long days appear to benefit rooting and subsequent growth.

One important aspect of the rooting of *K. latifolia* that has received little attention in the literature is the age of the stock plants. It has been known for years that cuttings from young plants generally root more readily than those from older plants. The classical example is the difference in rooting ability of "juvenile" and "mature" English ivy (*Hedra helix*).

Tables 1 and 2 summarize the results of experiments in rooting laurel cuttings from different age stock plants. These results from 1970 confirm my observations of previous years. Cuttings from young *K. latifolia* plants root more readily than from older plants. Cuttings taken from rooted cuttings or from young grafts will root more readily than cuttings taken from the original stock plant (Table 2). The data from these experiments also indicated clear differences in rooting ability of cuttings from different plants of the same age and size.

Table 1. Rooting of *K. latifolia* cuttings taken in October and examined in February (1970-1971). No auxin or fungicide treatment. Data from cuttings under mist and in a plastic tent.

Source of cuttings (Stock plants)	No. cuttings	No. rooted	Percent rooted
At least 4 yrs. old	1294	269	21
2 yr. seedlings	45	15	33
1-3 yr. old grafts and rooted cuttings	136	81	60
1 yr. seedlings	123	109	89
TOTALS	1598	474	30

Table 2. Comparative rooting of cuttings of one clone (137) of *K. latifolia* taken from stock plants of different ages. No auxin or fungicide treatment.

Age of stock plant	No. cuttings	No. rooted Oct-Feb	Percent rooted
Orig. plant 15 yrs	10	3	30
8 yr. rooted cutting	16	5	31
1 yr. rooted cutting	34	32	94

Thus, we should select clones that root most readily, and once rooted plants are obtained, cuttings should be taken from these and not the original plant to maintain juvenility. If we have seedlings of known pedigree and flower color, then cuttings can be taken from 1 to 2-year-old seedlings. The more juvenile the cuttings the faster they root and the faster they flush out new growth.

By using mountain laurel stock that has an inherent capacity to root, then meaningful experiments on auxin treatments, fungicides, wounding, etc. will be possible. The proper use of benomyl may give us valuable assistance as discussed by our next speaker.

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MODERATOR FLEMER: That was certainly a masterful and complete paper on the status of *Kalmia latifolia*. I look forward to the day when we will have plants which have flowers just as deep a red inside as were some of those which you showed us. We do not have time for questions now and so we will proceed to the next paper which concerns the use of benlate and indolebutyric acid combinations to promote the rooting of cuttings. This will be presented by Dr. John McGuire of the University of Rhode Island.

INTERACTION OF 3-INDOLEBUTYRIC ACID AND BENOMYL IN PROMOTING ROOT INITIATION IN STEM CUTTINGS OF WOODY ORNAMENTAL PLANTS[1]

JOHN J. McGUIRE and VINCENT H. VALLONE[2]

Department of Plant and Soil Science
College of Resource Development
University of Rhode Island
Kingston, Rhode Island

Abstract. Cuttings from twelve clones of *Ilex, Rhododendron, Sciadopytis, Magnolia* and *Vitis* (woody ornamental plants) were tested for rooting response to combined treatments of benomyl and indolebutyric acid. Response was variable Better rooting was obtained with combined treatments in clones that are normally difficult to root Clones that normally root easily did not show improvement in rooting when benomyl was used with IBA. It is suggested that benomyl may act as a mobilizer in stimulating rooting.

INTRODUCTION

Combinations of auxins and fungicides have been common in plant propagation for many years (4, 9, 10, 12). More recently systemic fungicides have been employed with some success (3, 6). Results have not always been demonstrated to be the results of disease control since in many cases untreated plants showed no evidence of fungal or bacterial invasion. This leads to the conclusion that at least some of the beneficial effect of fungicides in general, and systemic fungicides in particular, may be due to some effect other than fungicidal properties.

The two systemic fungicides most commonly used over the past three years are Benlate (benomyl) and Mertect or TBZ (thiabendazole). The two compounds are very closely related. Benomyl decomposes to benzimidazole carbamic acid methyl ester (BCM). This is thought to be the active ingredient in fungicidal activity. Benomyl breaks down rapidly in water to BCM and in the bean plant it breaks down completely in five days (7). Less is known about TBZ.

A recent study (11) showed that five systemic fungicides commonly used in plant propagation improved rooting of rhododendron cuttings but had no effect on disease control. The response in that study suggested that other genera of plants should be treated with the

[1]Approved for publication by the Director of the Rhode Island Agricultural Experiment Station as Contribution Number 1421.

[2]Assistant Professor and Graduate Research Assistant, Department of Plant and Soil Science.

more promising systemic fungicides to determine if they also exhibited beneficial additive effects on rooting when systemic fungicides were used with auxins.

MATERIALS AND METHODS

Treatments with auxins and fungicides were applied as talc formulations of 3-indolebutyric acid, with or without benomyl, (methyl 1-(butylcarbomoyl) 2-benzimadazolecarbamate). The numbers of cuttings used in the replicates were determined by available supply but were never less than 25 nor more than 75. All tests were replicated four times and only clonal plant materials were used. The experiments were carried out throughout the year 1970-1971, with cuttings taken at the optimum time for rooting each clone.

Plants included were: *Rhododendron* 'English Roseum', 'Catawbiense Grandiflorum', 'Cunningham's White', 'Lees Dark Purple', *Ilex glabra* 'Leucocarpa', *Ilex opaca, Magnolia conspicua, Sciadopytis verticillata, Juniperus chinensis* 'San Jose', *Vitis labrusca* 'Moore's Early'. There were two clones of *Ilex opaca* and Rhododendron 'Lee's Dark Purple' to make a total of twelve clones in the test. All cuttings were propagated in a rooting medium of equal parts by volume of sphagnum peat moss and coarse grade horticultural perlite in flats on raised beds in a greenhouse. No bottom heat was used but minimum air temperature was 65° F. Mist was electrically controlled to provide six seconds of mist every three minutes. Cuttings were all terminal shoots approximately 4-6 inches long, depending on the clone.

Data were recorded on the basis of percentage of cuttings rooted and on rooting quality. Quality was determined either by counting actual number of roots per cutting or by measuring diameter of rootballs of cuttings with fibrous root systems. A third observation was made of root quality based on the number of primary root connections to the base of the cutting but it was not tabulated in this paper.

RESULTS AND DISCUSSION

When rooting responses were tabulated (Table 1 and 2) it was apparent that addition of benomyl significantly improved rooting quality on some cultivars and in some cases percentages of rooting. This was particularly true of *Ilex opaca, Sciadopytis verticillata* and *Juniperus chinensis* 'San Jose' as well as *Rhododendron* 'Lee's Dark Purple'. In the case of *Ilex* and *Rhododendron,* where two clones were tested, most striking results were obtained with the clone that is more difficult to root. This trend has been observed with other clones not reported in this paper. The reverse can be seen in the clones of *Rhododendron* that are easy to root. They did not exhibit any significant improvement in rooting with the addition of benomyl although there was some increase in root quality.

Table 1. Effect of IBA and benomyl on rooting of stem cuttings of woody ornamental plants

	Treatment											
	4.5% IBA		4.5% IBA + 5.0% benomyl		3.0% IBA		3.0% IBA + 5.0% benomyl					
Cultivar + propagation period	No. Roots *	%	No. Roots	%	No. Roots	%	No. Roots	%	No. Roots	%	No. Roots	%
R. 'English Roseum' 10/25—2/2/71	1.4	95	2.2	100	1.1	95	2.3	100.0	0.9	95.0	1.6	95.0
R. 'Cat. Grandiflora' 10/27—2/2/71	2.4	100.0	1.3	100.0	2.0	100.0	1.6	66.7	0.0	50.0	1.2	83.0
R. 'Cunningham's White' 10/27—2/2/71	0.8	75.0	1.6	87.0	1.3	57.0	1.3	71.0	1.1	100.0	1.0	57.0
Ilex glabra 'Leucocarpa' 10/22—12/12/71	1.7	80.0	2.1	83.3	1.5	60.0	2.4	100.0	1.0	63.3	1.5	79.2
Sciadopytis verticillata 11/3—6/28/71	0	0	1.0	25	0	0	40.5	25.9	8.0	7.1	8.0	54.4
Magnolia conspicua 7/5—10/15/70	2.9	60.2	20.9	100.0	3.0	60.2	11.3	92.3	0.0	0.0	0.0	0.0

* Root ball diameter for rhododendron cultivars

Table 2. Rooting response of woody cuttings to treatment with IBA and benomyl

Cultivar + Propagation period	Treatment: 4.5% IBA		4.5% IBA + 5.0% Benomyl		3.0% IBA		3.0% INA + 5 0% Benomyl	
	No. Roots	%	No. Roots	%	No. Roots	%	No. Roots	%
Ilex opaca 12/30—3/18/71								
Female	4.3	45.0	8.4	36.3	6.6	37.5	23.2	81.8
Male	11.3	80.0	30.5	100.0	15.4	100.0	35.8	100.0
Juniperus chinensis 'San Jose' 12/29—3/5/71	13.5	90	14.5	95	14.1	90	16.8	90
Vitis labrusca 'Moores Early' 3/10—4/4/71	6.1	18.7	18.7	56.2	—	—	—	—
Rhodendron 'Lee's Dark Purple' 11/25—2/26/71								
Curly Leaf	0.9 *	70.0	2.5	90.0	—	—	—	—
Smooth Leaf	3.5	90.0	3.8	100.0	—	—	—	—

*Data for rhododendron expressed as rootball diameters.

Hoitink (6) reported a decrease in time required to obtain a good root system when systemic fungicides were used in combination with auxin. This was also observed with some of the clones tested, particularly *Vitis* and *Magnolia*. This would have commercial importance even if no substantial increase in rooting was observed.

One fairly consistent trend observed in this study but not shown in the data was the number of primary root connections on cuttings treated with IBA and benomyl. This has significant commercial importance since a heavily rooted cutting with few primary roots cannot be handled in commercial planters and may be lost even with manual planting. It has been consistently observed at this station that when cuttings with fibrous root systems develop after treatment with systemic fungicide alone, without auxin, few primary roots develop but when the fungicide and auxin are used together the number is increased. This is not necessarily reflected in the data and was not tabulated here because no way has been derived to obtain the data without destroying the cutting.

The question of why fungicide-auxin combinations are effective as root promoters cannot be answered at this time. The first objective of this work was to determine if they were effective and to determine if the differences were significant for a larger number of plant species. This has been determined. Research will now be directed toward answering the more basic questions of how the fungicides act to stimulate root initiation and development when used alone and with auxin.

Structurally BCM resembles many compounds that are known to have biological activity as growth regulators or auxins. BCM may act in woody plants as either a weak auxin or as a mobilizer to cause other endogenous materials to move to the site of root initiation and stimulate more rooting.

Other researchers have found that BCM interferes with DNA synthesis in some but not all fungi (1, 2). Sels (8) reported that it acts as a purine antimetabolite and can replace nicotinamide in NAD. Kapoor (7) stated that it forms a benzimidazole adenine nucleotide in yeast but how this may relate to higher plants is not known at this time. Benomyl has been shown to retard senescence and in this respect it may be thought to resemble kinetin or benzyladenine. If this is the case, BCM could well be a mobilizer as has recently been reported for kinetin (5).

Most researchers agree that since very small quantities of the systemic fungicide are taken up by the plant the site of action must be quite specific. Though the site for improved rooting and that for fungicidal action may not be the same it does appear that small quantities are needed for rooting also. Since growth regulators have been used in excess in most rooting experiments reported here it is believed at this time that the action of the fungicides cannot be that of a weak auxin and is more likely that of a mobilizer. Work will be done over the next two years to accept or reject this hypothesis.

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MODERATOR FLEMER: That was very well presented, John. We do have time for a couple of questions.

JIM WELLS: I would just like to add that we have been using Benlate this year just as we were using Captan in the past and it does have a good effect on many, many varieties. It not only improves the rooting, it improves the quality of the rooting. Captan improves rooting one step, Benlate improves it two steps.

JOHN McGUIRE: I have heard of two cases of injury from the use of Benlate. Dave Leach mentioned one of them. Perhaps he would like to comment here.

DAVE LEACH: What I found was that it inhibited rooting with the system I used. I used Nearing propagating frames which are essentially a cold frame with a visor on the south side and no heat. It would seem to me that when you are using mist propagation there is a good possibility that the Benlate is diffused. Using about 120 clones and a 1000 cuttings, the evidence was rather strong that in using this method of rooting, Benlate inhibited rooting.

MODERATOR FLEMER: Thank you once again, John.

As part of our program this afternoon, we have a panel which is going to brıng us some short reports on "Propagating Experiences, Old and New". Mr. Zoph Warner will act as moderator for this panel.

MODERATOR WARNER: When Bill asked me to organize this panel, I decided to choose some individuals who I thought might have some interesting things to talk about and then give them as much leeway as possible in choosing their subject. So I didn't ask them to stick to the panel title too closely, but I think we are all right because I heard one of the participants say he wasn't even going to talk about propagating. We are a little short of time and so no questions will be taken until each of the participants has presented his paper.

In choosing people for this panel one of the things I thought about was the fact that in the commercial world one is often judged by how much money he makes and so with this in mind, I would like to lead off the panel with Joe Cesarini because before he got into this business he was a bricklayer and everyone knows how much money they make.

PROPAGATION OF CARPINUS BETULUS 'FASTIGIATA'

JOE CESARINI

Johnson Avenue Rare Plants Nursery
Sayville, New York

At Johnson Avenue Rare Plants Nursery, I used to propagate cultivars of *Carpinus betulus* by grafting them, during the winter months, on previous spring-potted understock of *Carpinus betulus* or *Carpinus caroliniana*. The grafting was done in the greenhouse at a temperature of 65° F, using the modified veneer system. I was somewhat annoyed by the unpredictable results so I explored a different way of propagation.

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ROOTING SOFTWOOD CUTTINGS WITH MIST

Although I have been propagating *Carpinus betulus* 'Fastigiata' from cuttings for only 3 years, I thought the little bit of knowledge I have gained may be of interest to you. From my trial and error system and my crude way of observing things it has been noticed that the most important factors can be pinpointed, but I really don't know which ones should be given the priority on the list. However, the combination of all give some pretty good results.

Source and Type of Cuttings. The stock plant should be healthy and vigorous, free from insects and diseases. The cuttings should be the current season growth about 6 to 8 inches in length. A shallow side wound is beneficial.

Time of Taking Cuttings. This varies according to the type of growing season so I don't like to give a set date. However, I take the cuttings just about the time that the last leaf on the cutting reaches the ultimate size and the last bud is not fully developed. At our place of operation, this happens on the average about the middle of July.

Rooting Medium. In our preliminary trial we used different types of media—sand, perlite, peat moss, mixtures of sand and perlite, sand and peat moss and perlite and peat moss. The results ranged from a complete failure to quite rewarding. The best result of all was with a mixture of perlite and peat moss.

Strength of Hormones. Here we tried different types of hormones. Hormodin No. 2, Hormodin No. 3, and our own mixture that we call 2% IBA. Without any doubt in my mind, to root *Carpinus betulus* 'Fastigiata' as of now, 2% IBA is required.

Dormancy Period. I have found that in order for the cutting to grow well the following year, the rooted cuttings of *Carpinus betulus* 'Fastigiata' require a dormancy period. I place them after they are well-rooted in a greenhouse where I try to keep them at a temperature as close to 32° F as possible during the winter months. About late March or April the weather warms up and, as they start to grow when the danger of frost is over, I transplant them in containers for continued growth.

CONCLUSION

By following the combination of these few old but simple rules, some nice plants of *Carpinus betulus* 'Fastigiata' can be grown without going through the costly and laborious task of grafting. This system works so well that I am rooting these cuttings right in pots. I think that I have this type of propagation worked out and now to satisfy my curious mind I am trying to root them from hardwood cuttings during the winter months. This method still is in the infancy stage but is starting to make sense. So I hope some day to have all the problems worked out and come up with the right combination and report to you and share my information. If somebody is also doing such work, I really would like to hear from them.

PROPAGATING EXPERIENCES

E. STROOMBEEK

Roemer Nursery

North Madison, Ohio

This "Propagating Experiences" panel we have embarked on now will likely turn out to be the surprise package of our annual meeting since it is open to so many interpretations.

It took our moderator, Zoph Warner, who was responsible for arranging this discussion, a great deal of persuasion to convince me that I ought to participate on this panel. Not only do I suffer from a liberal amount of stagefright when it comes to giving a talk, but I simply could not get excited about the subject: Propagating Experiences—Old and New.

I could not help but think that here we have a highly successful Plant Propagators' Society, which for the last 20 years has made great strides in promoting and discussing the newest techniques in the field of ornamental horticulture, and here am I trying my darndest just to keep up with them. How in the world can I tell you good people something that's really new in plant propagation?

And as far as old propagating experiences are concerned, here again it is all well and good to sit down and reminisce about the good old days, especially when one is in a slightly sentimental mood while in the company of fellow nurserymen and with the help of a tall glass of beer to refresh the old memories.

But in this Society which is so geared for the exchange of new ideas, dwelling on obsolete practices of years ago is somewhat irrelevant to say the least. However, I then happened to look over the list of names of the participants in this discussion and I changed my mind somewhat. It struck me that all the growers on this panel at one time or another received their training in Europe. One can say that this is a mere coincidence. I prefer to think that there is some significance.

Each one in this group got his horticultural education and training in those so-called old days that we are supposed to touch upon this afternoon. They became thoroughly familiar with the then existing propagating techniques and the hard ways of growing nurserystock with limited mechanical means and without the help of hormone substances, mist systems, polyethylene and peat pots—just to mention a few. They certainly had to have a great deal of motivation and spunk starting to make sense. So I hope some day to have all the problems worked out and come up with the right combination and report to you and share my information. If somebody is also doing such work, I really would like to hear from them.

PROPAGATING EXPERIENCES

E. STROOMBEEK

Roemer Nursery

North Madison, Ohio

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Some of the listeners in this audience might by now wonder why I am deviating somewhat from the actual subject: I feel that there are a few valid reasons for it. Let's take a quick look at our nursery industry. It has been prosperous and steadily expanding since World War II; and especially now, at the beginning of the seventies with the big boost of the ecology wave, it looks like there is no limit to how far we can go in the near future. Yet at the same time, we are facing severe bottlenecks threatening this future growth.

Here I would like to dwell for a moment on the key factors mentioned before: education and training. Our large and medium sized nurseries have relatively few problems filling their management positions. There is a reasonably good supply of horticultural college graduates to fill those spots. The real rub is in the education and training of the middle-management or the supervisory employees. This category, by the way, also includes the people that ought to fill the propagator and assistant propagator slots.

The way the majority of the nurseries are trying to solve this problem at present is by the "hit and miss" method of training on the job. I say "hit and miss", because when we start out with this method we never know what the end result will be and especially whether the employee after the long and involved training will stick it out with us for a reasonable length of time.

In short, it is and has been my strong conviction for quite some time that this inadequate type of training on the below college-level is incompatible with the healthy growth of our industry which we can anticipate through the seventies and beyond. I realize that this Society has been aware of this problem for a long time and actually has discussed it several times in the past. At the same time, it has done a tremendous job of gathering, disseminating and publicizing propagation and growing know-how in a truly impressive way which, in essence, is a vital part of education. It has, in the process, gained a first class reputation and a prestige that few other horticultural organizations can match.

But, in my humble opinion, the time has come for a slight change in emphasis. Our industry is rapidly becoming more specialized, more complicated and more demanding; we will have to come up with a more comprehensive and uniform training-system for our future fulltime employees. I do not profess to have any of the answers to this vexing problem but I do know that, for instance, the federally subsidized vocational horticultural training program within the metropolitan highschool systems, with a number of notable exceptions, has turned out to be less than a successful undertaking.

Whenever in the past our Society decided to support a new important endeavor, it has always succeeded. Within our organization we have an education committee. I feel strongly that if we decided to energetically start promoting the instituting of schools, like the one in Farmingdale, or the one we visited during our Toronto meeting in the Niagara Parks System, in various parts of this country we would be well on our way to overcome the training bottleneck mentioned before.

The panel that is sitting in front of you here this afternoon is living proof that it has been done in the past, that it is getting done at present in Canada and across the Atlantic all the time. A progressive and prosperous nursery industry in our United States can afford no less! I know that I have touched on a sensitive subject, but keeping in touch with the close intermediate training that is taking place in Holland, Denmark and especially West Germany, I feel we cannot afford to fall so far behind.

VIBURNUM DENTATUM AS AN UNDERSTOCK FOR VIBURNUM CARLESII OR V. CARLESII 'COMPACTUM'

CASE HOOGENDOORN

Hoogendoorn Nursery
Newport, Rhode Island

As we all know, everyone all these years has used *Viburnum lantana* as a viburnum understock, either for budding or grafting. However, over 30 years ago we stumbled into using *Viburnum dentatum*. The reason? We did not have any *V. lantana* that year, but did have *V. dentatum*—so we used it hoping for the best. We not only found it satisfactory, but far superior to *V. lantana*. When we used *V. lantana*, we were always bothered with black spot, which develops about mid-August. Naturally, we had heavy leaf drop which weakened the plants. Ever since we have used *V. dentatum* we have not been bothered with black spot, consequently we have stronger plants and better growth.

Now a word about the *V. dentatum* seedlings that we use. We always try to get a strong 1-year seedling, grafting size. The reason is that a 1-year seedling does not have as many sucker buds as a 2-year seedling or transplant. Before we start potting these seedlings we trim them and start to eliminate the danger of suckers by carefully going over the neck of the root and through the root itself and cut out whatever buds we can find. We pot these in the winter and graft them by the end of August, or beginning of September, under double glass. When we graft these we cut the understock off to about 1½ inch above the pot. After about 4 weeks they are ready to be picked up. Now if metropolitan highschool systems, with a number of notable exceptions, has turned out to be less than a successful undertaking.

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While I am on the subject of *Viburnum carlesii*, I would like to mention a hint about *Viburnum carlesii* from softwood cuttings. Every so often people will ask me what is wrong with their *Viburnum carlesii* cuttings. They can root them without any trouble but cannot get them to start growth in the spring. Of course we used to have that trouble too, but through experience we have learned how to overcome this. It seems that *Viburnum* does not like to be disturbed after it is rooted, so we do not stick them in frames or benches from which they will have to be removed. Instead, we stick these cuttings in flats of sand in the summer. In the fall after they are rooted, we move the flats to a frame with a heating pipe and set the thermostat at 35° F to prevent freezing and stem splitting, but still they have a long dormancy period. In the spring they come along with the weather, each plant responds and, by June, we have a strong, healthy flush of growth without any setback, ready to be planted in a frame with shading. We use the same procedure for *Hamamelis* and we are finding the same results with *Acer grisseum* which we are now trying to grow.

I understand that this forum was to tell about old methods and new methods of propagation. I don't know, anymore, what is considered old or new; but here is a real old one. Did you ever hear of grafting *Parthenocissus (Ampelopsis)*? Well, I did it when I was a youngster. Years ago we grew *Parthenocissus tricuspidata* 'Veitchii' either by hardwood cuttings or grafting. You can graft *P. t.* 'Veitchii' on a 1-year rooted cutting of *P. quinquefolium* and in 1 year you have a heavy 3-4 ft plant. This is a quick way of getting heavy saleable stock when they are scarce.

Years ago when we could not root cuttings of *Juniperus sabina* 'Tamariscifolia', we layered them. We also layered *Rhododendron* 'Cunningham's White' and 'Catawbiense Grandiflorum' or dug a deep hole and sunk a 15-18 inch plant in it and filled the soil back in the center and spread the branches all around, but all other hybrid rhododendrons were grafted on *Rhododendron ponticum*.

Another good old-fashioned trick is to graft beeches outside in the field in the spring. Use a well-calipered 5 or 6 year old *Fagus sylvatica*, cut it back to about 12 inches above the ground, graft it, wax it and in a year's time, you have a 3-4 ft 'Rivers' beech.

'Kwanzan' ('Sekiyana') cherries are still being budded but we have rooted them from softwood cuttings for several years now; we find such plants superior to the budded ones. We produce a beautiful straight whip without any knobs by budding or grafting high. We have a perfectly clean stem whether they are 30'' clearing or 6' clearing and also find them to caliper up much better and we have a beautiful root system. We also root *Prunus cerasifera* 'Thundercloud', *Prunus triloba* and beach plum for the very same reason; we can produce plants with a much better root system and most important—without suckers.

THE OLD WAYS

JOHN RAVESTEIN

Painesville, Ohio

I was told not to talk too much about the old plant propagating ways. I don't agree with that view; we are all becoming part of history. So why don't we talk about it. I admire the old plantsmen who took the time to teach us the basics of this trade, and what a wonderful trade this is. If I compare the facilities and conditions they had to work with and under, then a salute is in order for them.

There is a great difference in the way they used to produce and the present methods. They were also more secretive about their work and the only exchange of information took place on Sunday morning either inside or outside the church. Location depended a lot on the type of sermon for that day.

Let's take the item — rhododendrons; making cuttings was unheard of, you had to graft them. That was done in the spring in cold frames under double glass. Sometimes with disastrous results, but there was no research or any other information available, and still they produced good saleable plants. A lot of real hard work went into it.

At the present time, we have every imaginable piece of information at our fingertips; we have come a long way. There are also several ways of producing plants that are completely done away with—layering, for instance, is little used anymore for ornamentals. Still that particular method for that time was a sure thing. It worked better with difficult-to-root items than any other method that I have ever seen. In the early days they did a lot more grafting than we do now. For instance, when the time arrived for the dormant grafting the whole family got into the act. During the day there was absolutely no time to waste on dormant grafting, that was done nights. There was no television to distract you. Everyone worked and practically everything was grafted right there in the home: wisterias, flowering crabs, lilacs, weigelias, golden chain, etc. etc. The next morning some have rooted them from softwood cuttings for several years now; we find such plants superior to the budded ones. We produce a beautiful straight whip without any knobs by budding or grafting high. We have a perfectly clean stem whether they are 30'' clearing or 6' clearing and also find them to caliper up much better and we have a beautiful root system. We also root *Prunus cerasifera* 'Thundercloud', *Prunus triloba* and beach plum for the very same reason; we can produce plants with a much better root system and most important—without suckers.

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In the fall we grafted hollies, roses, and clematis. Holly grafting was done in the later part of October; clematis was done about the same time. Roses were done later, but it was all hard work endlessly caring for these things. Then there was the outside spring job of grafting in the field, mostly on crisp cold days. Looking back on this I think we have come a very long way. All one does now is read the *Proceedings,* or the *American Nurseryman* and one picks up a tremendous wealth of information and advice. At this point, I could go into a discussion pro or con of some of the values written in these things but I am getting too old to argue. Nevertheless it is there for everyone to read and evaluate. My respect and admiration goes out to all the old real plantsmen who, sometimes under the worst conditions imaginable, made a success out of their operations.

Now we have mist systems, beautiful greenhouses, all the help we want from all sources. Computers are also in the act. We probably don't realize how lucky we are, but sometimes I doubt if we are any happier.

GRAFTING TREE PEONIES

JOERG LEISS

Sheridan Nurseries Ltd.
Mississauga, Ontario

We have handled tree peonies for a long time, buying from Europe, then from Japan when our European sources dried up. Japanese suppliers we found to be not too reliable in supply—and naming especially—so we decided to propagate them ourselves.

Surveying the stock available to us, we felt that only the best would do. Up to this time we bought what the supplier offered, often inferior varieties. European varieties, while being developed from the same source, are quite distinct from Asiatic varieties in that they are usually fully-double, large-flowered, often so heavy that the stems cannot carry the bloom which then is hidden by foliage.

Asiatic varieties, in contrast, are of semidouble to double types with stiffer stems which carry the flowers well above the foliage. There are exceptions to both rules of course.

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Tree peonies *(Paeonia suffruticosa)* are usually propagated by grafting on well-branched roots of *P. lactiflora*, the herbaceous peony. Grafting commences toward the end of August. We now dig our roots a few weeks before the actual grafting. When the roots have a rubbery feel they will not split away from the scion. We use triangling as the grafting method. We graft from 1-year wood, only one bud per scion is needed; indeed 2 buds have no advantage as only one bud breaks and grows usually. The stock plants can be cut back quite drastically as long as there are buds left near the ground on each shoot. Only one-year wood has well developed buds. Leaves are reduced but left on the scion—we feel it helps to knit the graft.

The graft is tied with rubber budding strips and all exposed surfaces covered with a wound dressing. The back of the triangle especially should be covered.

The finished grafts are plunged into a coldframe so that only the tip of the bud shows. The frame is kept shaded, watered and checked weekly. A fungicidal spray is helpful to prevent *Botrytis*. Any affected leaves have to be removed immediately. By November the grafts of most plants have knitted and all leaves are removed. The frame is then kept closed and shaded until spring; frost does not seem to hurt the plants.

In early spring two options are open for further handling. One is to remove the rubber and plant them out as deeply as possible (since the bud has only just started this cannot be too deep). The herbaceous root is only to be considered a nurse root; the deeper the tree peony portion is planted the sooner it will develop its own roots. Therefore, the second course of action is to be preferred. That is to leave the plants in the frame until fall (make sure that good spacing has been provided) and then plant very deep. The rubber budding strip has to be cut in spring. Quite often young plants do flower and any bloom developing has to be removed. We cut our plants back at least once to get a bushy plant using the wood for grafting.

There seems to be great confusion in the naming of plants. Japanese exporters often will send any variety you desire from the same cracker barrel. A few which we think outstanding, and have been true-to-name are;

'Godaishu'	white semi-double	both vigorous growers
'Horme'	white semi-double	
'Tamafuyo'	pink semi-double—very good	
'Kamata Fuji'	purplish pink	
'Shogyu-kuden'	semi-double red	
'Kagura-jishi'	semi-double pink large	
'Alice Harding'	yellow, double	
'Yae-sakura'	pink semi-double	

continued

continued

'Hinadi-jor'	pink semi-double
'Ubatama'	maroon, semi-double, large
'Dai-kagura'	semi-double pink, large

PROPAGATION IN THE LATE SEVENTIES

MARTIN VAN HOF

Van Hof Nurseries
Portsmouth, Rhode Island

Some of us can remember back quite a few years—let us say 70-75 years. This, of course, cannot be called ancient but neither is it new, so let us call it old. I want to dwell a couple of minutes on propagation in Boskoop, Holland. I recall propagation by hardwood cuttings where wounding was used with a double long cut which gave a larger surface for callus which meant also a better chance for rooting. Wounding was and still is practiced in propagation by layering. Even evergreens, such as junipers, in a somewhat crude way were propagated by cuttings on the north side of a windbreak. The medium, generally dredged out of a canal, was mud; later it was mixed with peat moss. The cuttings were inserted by pushing them into that mixture with the finger so that below the soil the cutting was "V" shaped with the base of the cutting heading up. Softwoods were grown too but this required either frames with double sash or a greenhouse.

At the age of 24 I came to these United States and worked one season at Hicks Nurseries where I was introduced to propagation in hotbeds and this was novel to me. The method used was a layer of fresh horse manure about 3 ft deep, wetted and packed down and covered with a layer of sharp sand 6 inches deep. The cuttings were covered with sash and shaded with cloth overhead on a wooden frame about 5 ft above the sash The cloth was rolled up on dark days and every evening. The cuttings were kept moist by hand syringing according to the weather.

After spending 3 years in Painesville, Ohio and 3 years in Long Island I had the good fortune of joining the firm of The Rhode Island Nurseries. In 1924 we propagated about 300 sash of softwood cuttings at about 800 cuttings per sash (240,000) and at the peak of production approximately 500 sash (400,000 cuttings). All this was done in cold frames with about 70% shade and were kept moist by hand syringing 2-3 times a day. All those shades were carried on and off every day; it was really a chore.

After Mr. Vanicek, the founder of the business, passed away I was given a free hand in the propagation department and it was soon

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After Mr. Vanicek, the founder of the business, passed away I was given a free hand in the propagation department and it was soon proven that one can sometimes kill cuttings by being too kind and cautious. The first thing that we eliminated was the carrying on and off of the shades. This also meant one less syringing job. From this point we made rapid steps towards easing the constant care of softwoods. Note the word "easing". When we introduced the use of polyethylene—which I call a major breakthrough—to our operation and, close upon that the mist system—also a major breakthrough in the field of propagation—plus the hormone powders, we really had it made and the final results were much better.

This year I started making cuttings on April 15 and continued until August 12. I still enjoy my work, noting of course that I have no labor problems. I cut most of the cuttings myself, or supervise it, and have a man who does all the sticking for me. I started in April with junipers in outside frames with intermittent mist, most of the cuttings being treated with Hormodin No. 3 and, as the season advances, some are treated with Hormodin No. 2. Some of the more difficult ones, such as *Juniperus* 'San Jose', *sargentii* and 'Blaauwi', we treat with a double dip, that is, 5 seconds in straight Chloromone and, after drying them a while, in Hormodin No 2 We make all our rhododendron and azalea cuttings from July 14 through August 10—and all the deciduous material as they become ready The use of benlate mixed with Hormodin (9:1 v/ v) has really some value. We have found that this treatment gives a more solid root system and no trouble with fungus at the basal ends.

Now I come to the title of my talk, "Plant Production in the Late Seventies". This is the title I had chosen but when I received the program I found it had to be "Propagation Old and New". I would like to show that a healthy, active man in his seventies without any hobbies other than the nursery business does not have to be put on the inactive list especially when it comes to the production of plants. When I told Mr. Vanicek in 1965 that I was going to retire the following year he took it with a grain of salt and made the remark, "How could you retire, you are too active". He asked me to stay, on whatever terms I wanted, but I always said if I cannot be a 100% asset to the business then I want to leave it. When I told my sons my intentions they asked me to do some propagating for them in my spare time, using their facilities of course. This spare time job has become almost a full time one. Help is provided whenever I need it as you understand I could not make all the cuttings alone. I also do not overly neglect my wife. After all I *am* retired so once in a while I take her out to lunch or on a short vacation. Nothing is more important than having a pleasant home. By now you might understand the title of my talk because in a little less than 2 months I'll be 80 and if this is not the late seventies, I would like to know what is. If there are some of you oldsters who would like to have less responsibility; look around, you might find it in your own profession.

FRIDAY MORNING SESSION

December 3, 1971

The Friday morning session began at 9:00 a.m. in the West Ballroom of the Golden Triangle Motor Hotel. Mr. William Flemer III served as moderator.

MODERATOR FLEMER: We have a full program this morning and in order to allow as much time for questions after each talk as is possible, we will start right in on this morning's program with Hans Hess who is going to tell us how to succeed with the after-care of grafted plants.

HOW TO SUCCEED WITH THE AFTER-CARE OF GRAFTED PLANTS

HANS HESS

Hess' Nurseries
Cedarville, New Jersey

This is a very long title relating to what do you do with those grafts after you receive them in the hectic spring season. You have already said four or five times that you should never have ordered them after the poor experience of past years. Next year you will not take that extra drink or two and this won't happen, but the fact remains that here are these 500 or 1000 plants just delivered by United Parcel Service or Air Freight, and what are you going to do to improve last year's results.

Well, after a long trip you are usually tired and thirsty, so it is logical to feel that these plants are also tired and thirsty. Let's unpack them and see what they look like, and give them a drink of water; your preference of beverage might not give the results hoped for. Now that their thirst has been met let's put them in a shaded area protected from the wind for a day or two, so that they can become accustomed to normal light after having spent several days in nearly complete darkness. When you feel that the plants have successfully readjusted to normal light you should prepare them for planting, which means removing the rubber bands or string from the union and putting a short strip of half inch masking tape around the union to hold it properly to prevent breakage. If you were going to personally plant each graft this would not be necessary, but, since the planting is to be done by highly trained migrant labor you had better put tape on the union. Oh, I almost forgot to mention why the rubber band or string should be removed. Leave them on a few grafts, and after 2 or 3 years examine the union. The bands in particular, and in most cases the waxed string, will be around the union in the same place as when you received the plants with a layer of callus tissue covering the area. Hold the graft just below the union and push the top; it will usually break at the tie area. One customer of ours who had failed to remove bands from juniper varieties had them break off at the union after they had grown 3-4 feet tall. This is rather expensive. The masking tape on the union deteriorates rapidly when in contact with the soil.

The grafts are now ready for your technicians to plant, but where are you going to plant them? Your past sad experiences tell you that dogwoods, beeches, and Japanese maples burned very badly in the field when the first hot sun warmed them. This was to be expected since they had been in a shaded greenhouse 2½ inches apart until the time you received them If you put on your shorts or bikini and lay on the beach the first good summer weekend, the results are also painful.

The hemlocks, *Chamaecyparis,* and firs also are quite subject to sunburn the first season and should have shade provided. These plants, which are extremely subject to sun injury, should be planted in a bed under 50% shade for the first summer. The beeches and some Japanese maples have additional requirements since they are subject to frost splitting the first year; to grow these successfully they should have the added protection of a plastic cover the first winter. Container growing of these plants for a few years and protecting them in a plastic greenhouse gives excellent results.

The rugged individuals who can stand the abuse of direct field planting are the juniper varieties, the spruces, cryptomerias, *Cedrus,* and most pines. Somehow they can thrive without the added protection required by most deciduous plants.

Now that we have separated the varieties which need protection from those that can be field planted we should decide how to put this youngster in the ground or container medium. For field planting the soil should be prepared as for any other liner as far as fertilizer and organic material is concerned, and it should be loose to a depth of about 6 inches. The graft should be planted with 1 inch of soil above the top of the graft union, in order to protect it from breaking and to cover the scar area. The same applies to stock planted in beds or in containers.

Some growers like to stake new grafts, especially juniper varieties, for the first year or two. When staking is used be sure that your ties do not restrict growth when the plant increases in caliper.

Weed control in field planted grafts does require extra care the first year, so pick out the tractor driver who has graduated from the hot rod stage or you might find your expensive bushes on top of that well-prepared soil. The same pertains to the man with the hoe if you have not graduated to weed killers and "bush killers".

That just about covers my suggestions on how to increase your graft stand from 25 to 50%. After all, if I told you how to increase it any more all of us propagators would have to apply for relief.

MODERATOR FLEMER: Thank you, Hans, for a very clear paper dealing with those extremely costly losses. Too many people accept losses in the field as a matter of course and the care given after grafts are received is one of the major sources of loss in this business of ours. I remember several years ago when Jack Hill said that he doubted if over 10% of the plants which any nursery propagates ever ends up being sold by that nursery. Those numbers were shocking at first, but I thought about it quite a bit since then and I believe that if you look very carefully and honestly at your whole production I believe you will have to agree that there is a tremendous attrition rate and in many cases only about 10% of those that start the race finish it.

JIM WELLS: I was interested in your remarks about weed killers, do you not use them or do you not advocate their use?

HANS HESS: I advocate using anything that will do a good job for you. From my own experience, I don't care to use weed killers in lining out stock. If you are using weed killers, the plant must obtain its water and nutrients from the same soil on which you are trying to control weeds and these materials are a deterrent to the growth of the stock as well as the weeds. We do fumigate our soil for weed control, but my past experiences with weed killers which are applied to the soil has not been too happy.

JIM WELLS: Last year one of the young men working for me who came over from England made a statement which literally made my hair stand on end. He said "no nursery should own a hoe". I disagreed with him, but I must say that it is a rather proud record that I have to report that this year is the first year that we have not touched a hoe.

RALPH SHUGERT: Whether you should maintain weed control on a block of plants with a hoe or with a chemical weed program depends, in my mind, on economics. There is a cost of maintenance on that plant in that block per season. If you have a good crew who can maintain that block with hoes until harvest time at a less cost per unit than can be done by using chemical weed control equipment then that is the way it should be done.

VOICE: Do you have a preference as to the type of container, that is clay pot, plastic or metal container, that the stocks are in for grafting? I have had much better luck in clay pots and was wondering if you know of any reason for this.

HANS HESS: I would certainly agree that clay pots are far superior to either a plastic or metal container. However, the weight and breakage in handling clay pots must be considered. We have put some grafts in plastic pots and carried them for 1 year and they have done very well as far as loss is concerned. I haven't used metal containers so I'm not sure how they would respond, but I do prefer clay pots.

MODERATOR FLEMER: Hans, I want to thank you for a very useful paper and I believe it should save someone a lot of money.

Our next subject concerns, "Top Grafting Japanese Maples and Dogwoods" and will be presented by Leonard Savella.

TOP GRAFTING OF JAPANESE MAPLES AND DOGWOODS

LEONARD SAVELLA

Bald Hill Nurseries, Inc.
Exeter, Rhode Island

My talk today will be on top grafting *Acer palmatum* var. *dissectum* and *Cornus florida 'Welchii'*, although any of the Japanese maples or the tree form dogwoods can be grafted in the same manner if you so desire

Top grafting of *Acer palmatum* var. *dissectum* and *Cornus florida* 'Welchii' to many propagators may not be something new; however, the methods we use to propagate these two particular plants may be an improvement over the old methods.

The preparation of understocks are the same for both maples and dogwoods. We start by selecting our understocks in the spring. This is not always an easy task because the supply of straight, strong stems may be short. The propagator then has to select the best he can from what is available.

For maples the understocks should be tall enough so that when they are decapitated and ready to graft, the stem will be at least 18" tall and have a caliper of 3/16 inches or more. In my experiences stems grafted at 18 inches and up to 3 feet have made the best plants.

Dogwood understocks are easy to obtain and the propagator should have no trouble selecting straight stemmed plants. If you choose to grow your own dogwood understock, a good practice to follow is to seed them in a bed and let them grow undisturbed for 3 or 4 years. The closeness of the seedlings will make them grow tall and straight and will eliminate the lower branches, giving the plant a clean stem. Dogwoods grafted 4 to 5 feet high, in my opinion, make the best plants.

Once we have selected our understocks they are potted in containers and placed outdoors in beds where they are mulched, shaded and watered and grown that year until they are ready to be grafted the done very well as far as loss is concerned. I haven't used metal containers so I'm not sure how they would respond, but I do prefer clay pots.

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Once we have selected our understocks they are potted in containers and placed outdoors in beds where they are mulched, shaded and watered and grown that year until they are ready to be grafted the following winter. The purpose of this is to establish good root systems on the understocks.

Before freezing weather comes, the plants are brought into holding houses where they are cared for until they are ready to graft. During the first two weeks of February we start to do our top grafting. A plastic tent 30 inches high is constructed over the greenhouse bench. The length of the tent is determined by the number of plants to be grafted. The tent is constructed high enough so that the grafted plants placed within do not touch the top of the plastic. The tent must also be constructed in a way that will make it airtight once the grafts are within and it is closed tight.

We start by grafting the maples first. The stems are brought to the workbench where they are cut at 18 inches to 2 feet. The scions are spread on the bench, where the men doing the grafting can select the scion to match the stem. We try to match the stem and scion as close as we can. This will hasten the healing and make a better union. The scion is cut to a sharp wedge about 1½ inches long. Care is taken not to separate the bark from the wood at the base of the scion.

The stem, or understock, is cut the same length; as close to the center of the stem as possible, without splitting the stem, causing jagged edges. The scion is placed into the cut made on the stem and tied with rubber grafting strips. Three or four ties are sufficient to hold them together. Make sure that the rubber band does not cover the base of the scion. If the rubber band covers the base of the scion, every scion will rot. No wax is used on the union.

The grafted plants are brought into the greenhouse and placed upright, side by side, on the bench within the plastic tent. The propagator should try to graft as many plants as he can within 2 or 3 days. If the grafting period takes more than 3 days, a separator should be installed to separate the plants that are yet to be grafted from those already grafted. The reason for this is that the grafted plants, once placed inside the tent, will start to grow leaves in 3 weeks. Once the scions start to grow leaves they must not be allowed to remain in the closed tent; they must be aired or they will "cook'. By placing the separators in the tent, you can air the growing plants and leave the others undisturbed. Once the grafts are out of the tent, they should be syringed daily, as often as necessary.

The procedure for top grafting 'Welchii' dogwood is somewhat different. The understocks are decapitated at 4 to 5 feet. The top of the stem is cut on the side 1½ inches down and made ready to receive the scion. Unlike the maples, the dogwood scion is not cut to a wedge. It is cut 1½ inches long and the angle cut at the base is slightly elongated. Caution should be taken not to separate the bark at the base when making the angle cut. The scion is then placed into the cut of the stem and tied with rubber grafting strips. If the propagator wishes to, he may put two scions, one on each side, of a single stem.

A ball of wet sphagnum moss is tied below the union, and a plastic bag, large enough to cover the scion and union, is inflated and tied just below the moss The ball of wet moss will give enough humidity within the plastic bag to sustain the scion and insure the healing of the union and the growing out of leaves.

The grafted plants can be stored at the ends of the greenhouse walks or stacked anywhere in the greenhouse where there is room. Once the leaves have started to grow, open the bottom of the plastic bag and allow air to enter. The plastic bag is left on the graft with its bottom open for 2 or 3 days, then it is removed permanently.

A step-wise summary is as follows:

1. Select straight strong stems and pot the understocks in the spring.
2. Match scion and stem as closely as possible when you graft; no waxing of the union is necessary.
3. Make sure the poly tent is airtight and the scions are not touching the plastic.
4. Air the tent as soon as the leaves start to grow.
5. Once the plants are out of the poly tent and plastic bags, care for them in the usual manner.

MODERATOR FLEMER: Thank you, Leonard, for that explanation of a successful method of grafting maples and dogwoods and, I must say, it is an unusual one too.

JOHN ROLLER: Have you tried the poly bags outside of the tent or under a lot of shade?

LEN SAVELLA: If I put them in the tent, then I don't use the poly bag. The poly bag is used when we run out of tent space. But the best way is to build a tent big enough to take these plants because it is trouble free. You don't have to syringe them or worry about them drying out.

HARRY HOPPERTON: Why don't you just bud them and save 90% of the cost of all this work?

LEN SAVELLA: We have over 300 acres and are running out of space. We feel that by doing it this way we can do it during the winter and get a lot more done than what we could do in the field.

MODERATOR FLEMER: Our next speaker is Hoy Grigsby from down in Louisiana and he is going to talk to us about the handling of southern pine cuttings prior to sticking them.

HANDLING PRIOR TO STICKING AFFECTS ROOTING OF LOBLOLLY PINE CUTTINGS

HOY C. GRIGSBY

Southern Forest Experiment Station, USDA Forest Service
Crossett, Arkansas

Abstract. Cuttings taken in December from 6-year-old *Pinus taeda* L. trees rooted 110 percent better when they were stored upright for 48 hours at 35° to 38° F, left intact, and treated with indolebutyric acid (IBA) than when they were oriented horizontally, reclipped at their bases, and treated with IBA without storage or chilling Mixed with Captan in talc, a 0.6 percent concentration of IBA produced more rooting than concentrations of 0.8 and 1 0 percent. N-dimethylaminosuccinamic acid (B-Nine) at 1,500 and 3,000 ppm in combination with IBA and Captan was detrimental to rooting.

The need to propagate pines from cuttings has increased rapidly as new forms have been selected for ornamental planting, Christmas trees, and forest tree seed orchards. But progress in rooting pine cuttings has been slow, and when a technique has shown promise in one test, results in subsequent tests have often been disappointing.

Part of this inconsistency in rooting may be due to annual variation in rooting ability and differences among trees from which cuttings are selected, but another major cause may be variation in methods of handling from clipping in the field to sticking in the propagation bench. The principal objective of the study described here was to compare the effects of two methods for handling cuttings prior to sticking.

MATERIALS AND METHODS

Cuttings were taken from throughout the crowns of 6-year-old loblolly pines (*Pinus taeda* L.) in mid-December. Half of the cuttings were 4 inches long. They were removed before 9:30 a.m. and stored at 35° to 38° F for 2 days prior to treatment and sticking. These cuttings were held in a vertical position from the time they were taken, and they were not reclipped prior to treatment. The other half of the cuttings were 6 inches long. They were taken between 9:30 a.m. and noon, reclipped to 4 inches, treated, and stuck in the afternoon of the same day. These cuttings were kept horizontal until placed in the bench. They were not chilled.

The rooting medium was a 1:1 mixture of sand and perlite which was kept at 78° F with bottom heat. Minimum greenhouse temperature was maintained at 75° F. Misting duration varied from 4 to 12 seconds per minute during daylight hours, depending upon weather conditions. Fifty percent continuous shading was provided by slatted awnings.

Just before sticking, nine treatments were applied to the cuttings in a split-plot factorial design. Treatments were: three levels of indolebutyric acid (IBA) in talc—0.6, 0.8, and 1.0 percent—times three levels of N-dimethylaminosuccinamic acid (B-Nine)—0, 1,500, and 3,000 ppm. The two methods of handling cuttings served as the major plots. Each subplot contained 9 cuttings. Each major plot was replicated 10 times in a randomized block design. Thus, there were 90 cuttings in each treatment and 1,620 cuttings in the entire study. Because of my success with Captan in previous rooting studies (1), all powders contained 25 percent Captan. The study was concluded at the end of 26 weeks. Differences due to treatment were tested for statistical significance at the 0.05 level in all cases.

RESULTS

The two methods of handling cuttings produced significant differences in rooting success. Cuttings that were initially clipped to 4 inches, kept vertical until stuck, stored for 2 days in a cold room, and not reclipped (Method I) rooted 110 percent better than cuttings that were kept horizontal, reclipped, and treated without chilling or storage (Method II) (Table 1). In none of the nine treatments was this trend reversed.

The IBA and B-Nine treatments significantly affected rooting (Table 2). The best IBA treatment was the 0.6 percent application, which produced 23.3 percent rooting. B-Nine adversely affected rooting (Table 1). The zero level treatment produced 63 percent more rooted cuttings than the 1,500 ppm treatment and 97 percent more than the 3,000 ppm application.

Differences in survival were significant between the two methods of handling cuttings. Those that were vertically oriented and kept in cold storage (Method I) survived best (Table 2). The 0.6 percent application of IBA resulted in more living cuttings than the two higher concentrations.

Although treatment effects on number of roots per cutting were not analyzed, vertical cold storage appeared to produce a better balanced root system than horizontal orientation without storage. Method I resulted in longer roots than Method II.

There were no significant interactions among the treatments.

DISCUSSION

Within the two methods of handling cuttings there are five differences which this study was not designed to measure individually: (1) hour of collection; (2) orientation; (3) storing; (4) chilling; and (5) clipping. A new study is being installed to determine

Table 1. Rooting success with all cuttings receiving each treatment.

Treatment	Total Cuttings	Number Rooted
Handling method I[1]	810	82
Handling method II[1]	810	39
IBA (percent)		
0.6	540	59
0.8	540	30
1.0	540	32
B-Nine (ppm)		
0	540	57
1500	540	35
3000	540	29

[1]Handling methods defined in text.

Table 2. Percent of cuttings living and percent rooted, by treatment, after 26 weeks.

Powder Contents[1]	Handling Method I[2]		Handling Method II[2]	
	Percent		Percent	
	Living	Rooted	Living	Rooted
0.6% IBA + 0 ppm B-Nine	33.3	23.3	16.7	12.2
0.6% IBA + 1500 ppm B-Nine	27.8	11.1	10.0	8.9
0.6% IBA + 3000 ppm B-Nine	16.7	7.8	6.7	2.2
0.8% IBA + 0 ppm B-Nine	14.4	6.7	5.6	5.6
0.8% IBA + 1500 ppm B-Nine	11.1	5.6	8.9	1.1
0.8% IBA + 3000 ppm B-Nine	14.4	11.1	7.8	3.3
1.0% IBA + 0 ppm B-Nine	27.8	10.0	6.7	5.6
1.0% IBA + 1500 ppm B-Nine	18.9	18.9	3.3	3.3
1.0% IBA + 3000 ppm B-Nine	10.0	10.0	5.6	5.6

[1]All powders contained 25 percent Captan.

[2]Methods defined in text.

the effect of each of these. In the meantime, results of previous studies may explain some of the results.

Horizontal and vertical orientations of stored cuttings have been used in horticulture to demonstrate that the naturally occurring root-inducing substances in some cuttings move downward in response to gravity. If cuttings are placed in positions other than upright, or if they are recut, rooting is delayed and often the percent of rooting is reduced. Ridgway (3) mentioned that Cathey had observed this gravity effect after as little as 2 hours of orientation. Cathey[1] reported that if chrysanthemum cuttings are taken and chilled immediately, the rooting cofactors are apparently slowed in their response to orientation. Cathey further stated that softwood cuttings appear to be most sensitive to orientation and chilling and that species vary in their response to this treatment.

While B-Nine was found to inhibit rooting in the present study where it was used in combination with IBA and Captan on hardwood cuttings, Read (2) found similar concentrations of B-Nine when used by itself more beneficial than IBA, or IBA plus B-Nine, in rooting chrysanthemum, geranium, and dahlia cuttings.

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3. Ridgway, H. W. 1970. Comments on Maryland meetings. *Geiger News* 6(2):1.

[1]Cathey, H M. ARS, USDA, Beltsville, Md., Personal communication, 1971

MODERATOR FLEMER: Thank you very much, Hoy, for an interesting and unusual paper. So often in propagation we deal with easily rooted material and don't give much thought to such refinements, but when we begin to deal with the more difficult-to-use materials, modifications and refinements obtain great importance.

BRUCE BRIGGS: Did you try putting the IBA on, then storing them in the cold and putting the B-Nine on when you brought them back out.

HOY BRIGSBY: No, we did not try that. All treatments were done at one time.

BRUCE BRIGGS: I wanted to clarify that because there have been some tests where it has been found that it is better if the B-Nine is put on afterwards.

JIM WELLS: When you gathered the cuttings, were they maintained in an upright position from the moment they were cut until they were rooted?

HOY GRIGSBY: I would imagine that for a few minutes while they were being treated they were laid down.

CARMINE RAGONESE: Did you injure the base of the cuttings in any way and what was the caliper at the base?

HOY BRIGSBY: We used reasonable care but I did notice that the bark was torn on some of them. The caliper at the base of the cuttings was approximately ¼ inch or a little larger.

CASE HOOGENDOORN: Did you take these cuttings at random or is there a clonal difference among the materials you were propagating?

HOY GRIGSBY: Yes, we did take them at random and we have observed a lot of difference between clones in the rootability.

WAYNE MEZZITT: Did you try any of your cuttings without any IBA treatment?

HOY GRIGSBY: In this instance I did not, but in the past I have attempted to root them without any treatment and occasionally I do get a few of them to root.

MODERATOR FLEMER: We are now going to hear from one of our older members on his refinements with the burlap cloud chamber. He took the Society by storm when he first explained it to us a number of years ago in Cleveland and now Leslie Hancock is going to tell us about soil heating in his chambers.

SOIL HEATING IN CUTTING PROPAGATION UNDER BURLAP CLOUD CHAMBERS

M. LESLIE HANCOCK

Mississauga, Ontario, Canada

My talk today concerns the addition of soil heating to the previously described Burlap Cloud method of summer cutting propagation. This method is not new, and has been presented twice at previous annual meetings of our Society. It has also been described in the book, *Plant Propagation*, by Mahlstede and Haber.

Briefly, it is an economical method of taking advantage of all natural agencies that promote plant growth and rooting, namely high humidity, filtered sunlight and abundant soil moisture. The chamber is a lightly constructed frame of 1-inch cedar boards, 3'9'' x 12', to which is fastened along one side a length of 40 inch width of jute burlap, 10 oz. grade. During the hot part of the day, this burlap cover is stretched over finishing nails along the opposite side of the wooden frame or chamber. When in this position no dry outside air or direct sunlight can enter the chamber except through the moist burlap.

Preparation of soil. Soil for the cutting beds is rubbed through a ¾ or 1 inch sieve; a sticking depth of 3½ inches for the cuttings is provided. Because capillary moisture is so important, the soil floor below this sifted soil should be firmed. The soil within the frame should be about 2½ inches higher than in the paths, so as to ensure that the cuttings, before and after rooting, are on raised beds. The soil surface is spirit levelled before sticking so that it can be uniformly puddled as required. After treating with hormone and fungicide, the cuttings are inserted as quickly as possible into the mud and pushed firmly home.

As each chamber is filled, the burlap cover is put in place, and the burlap covers of all completed chambers are drenched manually with a fairly high-powered hose about four or five times a day on dry days. On wet or very cloudy days the frames are left open to full light and air. Even on sunny days the frames are only covered about 10 hours a day. From about 6:30 p.m. to 8:30 a.m. the following morning the burlap is thrown off and the cuttings left open to receive the benefit of evening and morning sunlight and night dew.

The method has given us such consistent success over the years that it has become standard practice. Only a few items of deciduous shrub material eluded success, namely those items which until very recently were normally propagated by budding or grafting. After a number of failures or partial failures with these items by open air misting as well as burlap chambers, we decided to try adding soil heating to the burlap chambers.

We are using thermostatically controlled lead cables at present, but probably a low voltage chicken wire would be still better. We keep the soil at about 80° F. The most successful items so far are *Prunus cistena*, certain varieties of French hybrid lilacs, *Prunus glandulosa* and *Prunus triloba*. The hardest item, *Viburnum carlesii*, has given results so encouraging in two years trial that commercial success appears possible. In all these operations we find that the best results come from prime cutting material gathered early in June.

The problem in regard to Viburnums, as everyone knows, is overwintering. The rooted *Viburnum carlesii* were lifted last fall and stored in a cold pit. This year my propagator and I disagreed as to whether it might not be better to leave them sit where they are rooted. So we have lifted some, and left some in their rooting site, to see what happens in each case next spring.

MODERATOR FLEMER: Once again you have given us a fascinating account of a very inexpensive and practical method of rooting cuttings with a nimimum of equipment.

KNOX HENRY: What is the soil mix you are using?

LES HANCOCK: We are not using any mix. It's just a regular sandy nursery soil. I believe the closer you keep to nature the better off you are.

JOE CESARINI: Have you tried this method with rhododendrons?

LES HANCOCK: We tried it with the deciduous azaleas but it just wouldn't work.

MODERATOR FLEMER: The next paper concerns a very important subject—namely, weed control in container production and will be presented by Tom Fretz.

WEED CONTROL IN CONTAINER PLANT PRODUCTION

THOMAS A. FRETZ[1]

Department of Horticulture
University of Georgia
Georgia Station
Experiment, Georgia

Abstract. A series of experiments on weed problems associated with container plant production are discussed. In weed competition studies both *Amaranthus retroflexus* L (pigweed) and *Digitaria sanguinalis* (L) Scop. (crabgrass) at densities of 1, 2, 4, 8, 16 and 32 plants per 1 gallon nursery container significantly reduced the size of *Ilex crenata* Thunb 'Convexa' (Japanese holly) over the hand-weeded controls. Japanese holly plants were 30-75% reduced in size from the controls due to weed competition effects.

After 2 years of study the following herbicides, CIPC + PPG-124 at 8 lb ai / A, EPTC at 5 and 20 lb ai / A, CIPC at 8 lb ai / A, dichlobenil at 4 and 12 lb lb ai/A, and diphenamid at 20 lb ai / A when impregnated on milled pine bark mulch calculated to deliver the expressed rate when applied at a depth of ½ inch provided adequate control of both broadleaf and grass weed species for 150 days in container grown *Rhododendron obtusum* Planch var. *amoenum* Rehd 'Hino Crimson' (Hino Crimson azalea) and Japanese holly Severe injury was observed on both container grown species from the use of dichlobenil at the 12 lb ai / A rate. EPTC at the 20 lb ai / A rate caused excessive injury to only the Hino Crimson azalea

Studies conducted for 2 growing seasons showed that preemergent herbicide applications of the following materials, dichlobenil at 12 lb ai / A, trifluralin at 8 lb ai / A, EPTC at 5 and 20 lb ai / A, CIPC + PPG-124 at 8 lb ai / A and diphenamid at 20 lb ai / A provided adequate broadleaf and grass weed control 163 days after application when employed on container-grown *Rhododendron obtusum* Planch var. *amoenum* Rehd. 'Coral Bells' (Coral Bells azalea) and Japanese holly EPTC at 20 lb ai / A caused excessive injury to the Coral Bells azalea, while dichlobenil at 12 lb ai / A severely injured both species

The growth of the containerized nursery industry over the past few years has led to increased interest in controlling weeds that invade containers. Unfortunately, herbicide practices employed under field production schemes cannot be directly related to container plant production due to the limited soil volume and more frequent water and fertilization practices. Ideally, nurserymen start with a weed-free medium, but seeds are introduced into the medium via wind and water. Estimates of $500 per year per acre for manual removal of weeds from container-grown stock appears to be a realistic value. Accordingly, if weeds are not removed plant growth is seriously retarded.

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[1]Technical assistance of Mr L. Freeman is gratefully acknowledged

During the past 2 years, several studies have been initiated at the Georgia Station to investigate the problem of weed control in container grown nursery stock. A synopsis of these studies will be presented in this paper.

WEED COMPETITION STUDIES

Review of Literature. It is axiomatic to say that weeds alter the normal growth patterns of crop plants when competing for water, nutrients and light. Previous studies have determined the effects of weed infestations on field crops; in corn, for example, Staniforth (6) has reported yield reductions in excess of 35% due to weed infestations.

A present, little is known of the losses in container-grown nursery stock due to weed competition. This particular study was initiated to investigate the effects of 2 weed species at various densities on the growth of *Ilex crenata* Thunb. 'Convexa' (Japanese holly) in 1 gal containers.

Materials and Methods. Cuttings of Japanese holly were planted in 1 gal nursery containers on May 1, 1971, in a medium of peat moss, pine bark and sand (1:2:1 v/v/v) amended with 4 lb/cu yd of dolomitic limestone and 3 lb/cu yd of superphosphate. Redroot pigweed (*Amaranthus retroflexus* L.) and large crabgrass (*Digitaria sanguinalis*(L.) Scop.) seed were sown in the containers and, after germination, were thinned to densities of 0, 1, 2, 4, 8, 16, and 32 plants per container. A randomized design with 8 single plant replications was employed during the study with data being collected on August 10, 1971, 100 days after initiation of the treatments.

Results. Both competing weed species, regardless of their densities, significantly decreased the dry weight of Japanese holly when the weeds were allowed to mature in the containers. No significant differences in the Japanese holly dry weight were observed as the number of competing redroot pigweed plants increased, indicating that even a single plant of this weed species was able to reduce plant production in a 1 gal container (Table 1 and Figure 1). When crabgrass was the competing weed species, an even larger reduction in size of the Japanese holly resulted, indicating that crabgrass was the stronger competitor of the 2 weed species studied (Table 1).

HERBICIDE IMPREGNATED MULCHES FOR WEED CONTROL IN CONTAINER NURSERY STOCK

Review of Literature. Herbicide impregnated mulches have been described by various researchers as a promising means for providing full season weed control in ornamental plantings (4, 5). Bing (2) employed 2,6-diclorobenzonitrile (dichlobenil) impregnated

Table 1. Competition effects from redroot pigweed and large crabgrass on 1 gal container-grown Japanese holly.

Weed density	Redroot pigweed competition		Large crabgrass competition	
	Dry weight		Dry weight	
Plants Per Container	Japanese holly	Pigweed	Japanese holly	Crabgrass
0	2.16 a[x]	0.00 a	2.33 a	0.00 a
1	1.40 b	12.56 b	1.09 b	26.99 b
2	1.53 b	14.44 c	0.85 bc	27.82 b
4	1.32 b	16.15 cd	0.93 bc	28.44 b
8	1.14 b	15.51 cd	0.99 b	27.81 b
16	1.20 b	16.31 d	0.58 c	30.34 bc
32	1.07 b	16.49 d	0.63 c	33.21 c

x/ Means in a column followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

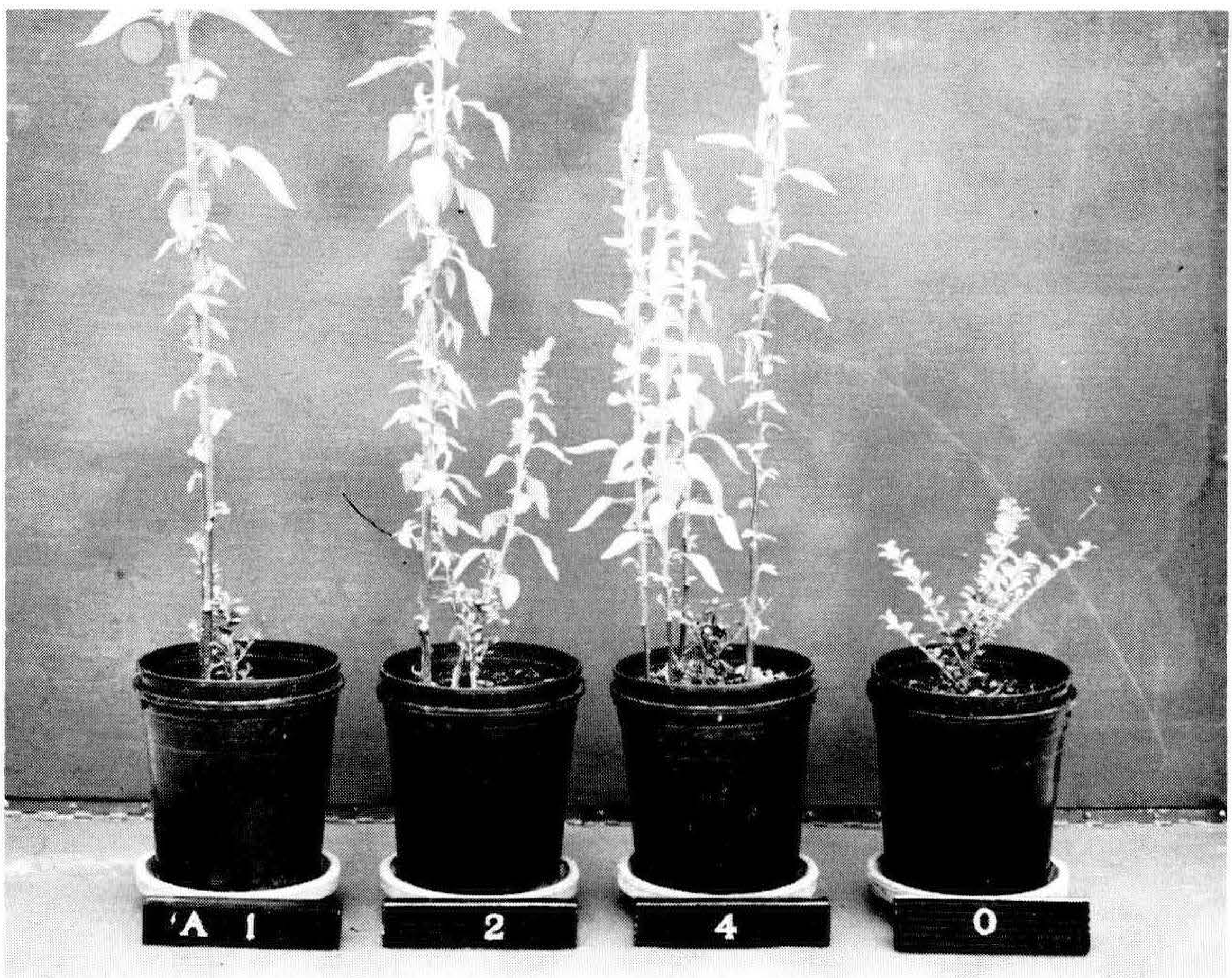

Fig. 1. Effect of various densities of redroot pigweed on the growth of Japanese holly in 1 gal containers. Left to right: 1, 2, 4, and 0 weeds per container.

mulches to achieve satisfactory weed control along highway plantings. His results indicated that ½ inch of the herbicide impregnated mulch performed as satisfactorily as 2 to 3 inches of non-treated mulch. Lanphear (5) has reported that dichlobenil impregnated mulch combinations were an excellent means for controlling weed growth in field grown nursery stock.

This study was initiated to investigate promising herbicide impregnated mulches for control of preemergent weeds in container grown nursery stock.

Materials and Methods. The herbicides were incorporated on milled pine bark mulch at several levels calculated to deliver a specific rate of active material on an acre basis (ai / A) when the mulch was employed at a depth of ½ inch. To insure uniform mixing, the herbicides in 200 ml of water, were sprayed on ½ cu ft of pine bark with an atomizer while the material was tumbling in a 1 cu ft concrete mixer. Following the incorporation of the herbicides on the pine bark mulch, the material was stored in sealed plastic bags until applied to the containers. Herbicides impregnated on the pine bark mulch in this study included: N, N-dimethyl -2, 2-diphenylacetamide (diphenamid) at 5 and 20 lb ai / A, isopropyl-m-chlorocarbanilate (CIPC) at 2 and 8 lb ai / A, dipropylthiocarbamate (EPTC) at 5 and 20 lb ai / A, isopropyl-m-chlorocarbanilate+P-chloropene-N-methylcarbamate (CIPC +PPG-124) at 2 and 8 lb ai / A, and dichlobenil at 4 and 12 lb ai / A.

Both species employed in this test, *Rhododendron obtusum* Planch. *amoenum* Rehd 'Hino Crimson' and Japanese holly were treated as individual experiments and arranged in a completely randomized design. A total of 10 treatments were included in each experiment with both mulched and non-mulched controls. All treatments were replicated 3 times with 3 plants constituting 1 treatment replicate. The study was initiated on April 9, 1970, and April 8, 1971, with data on weed control and plant size recorded 150 days after treatment application. Analysis of variance and Duncan's Multiple Range Test were applied to delineate treatment effects.

Both plant species were uniform rooted cuttings at the time the experiment was initiated and were potted in 1 gal nursery containers in a soil mix consisting of unsterilized weed-infested soil, sand and peatmoss (2:1:1 v / v / v). Following treatment with the herbicide impregnated mulches, all plants were placed in a lathhouse (50% shade) for the duration of the experiment. Standard nursery practices were employed in the fertilization and maintenance program.

The principal weed species observed during the course of this experiment were large crabgrass (*Digitaria sanguinalis* (L) Scop.), goose grass (*Eleusine indica* (L). Gaertn.), crowfoot grass (*Dactyloctenium aegyptium* (L). Richter), carpetweed (*Mollugo verticulata* L.), common ragweed (*Ambrosia artemisiifolia* L.), yellow nutsedge (*Cyperus esculentus* L.), chickweed (*Stellaria media* (L).

Cyrillo) and common yellow woodsorrel (*Oxalis stricta* L.). Visual ratings of the weed growth were employed to estimate the herbicide-mulch effectiveness, with 0 designating no control and 10 complete control.

Results. All herbicide-impregnated mulches adequately controlled the broadleaf weeds in the container-grown Japanese holly during the 1970 test. Similar results, with the exception of CIPC at the 2 lb ai / A rate, were observed during 1971 (Table 2).

In both 1970 and 1971, grass weeds in the container-grown Japanese holly were effectively controlled by the use of CIPC + PPG-124 at 8 lb ai/A, EPTC at 5 and 20 lb ai/ A, CIPC at 8 lb ai/ A, dichlobenil at 4 and 12 lb ai/ A, and diphenamid at 20 lb ai/ A. Both years, CIPC and CIPC + PPG-124 at the 2 ai/ A rates were significantly poorer in controlling grass weeds when compared to the other herbicide treatments (Table 2). During both 1970 and 1971, grass weeds were unchecked in either the mulched or non-mulched control (Table 2).

Growth of the Japanese holly was significantly reduced by the dichlobenil impregnated mulch at 12 lb ai/ A when compared to all other treatments. Significant height reductions in the Japanese holly plants resulting from poor overall weed control (i.e. excessive weed growth) were observed in the following treatments: CIPC + PPG-124 and CIPC both at the 2 lb ai/ A rate, non-mulched control, and ½" untreated mulched control (Tables 2 and 3).

Due to a poor stand of broadleaf weeds in 1970, no significant differences among the various treatments were observed on the azaleas. In 1971, all the herbicide-impregnated mulches with the exception of EPTC at the 5 lb ai/ A rate adequately controlled the broadleaf weed population in the azaleas (Table 2).

Good grass weed control in the azaleas was achieved both years with the use of CIPC + PPG-124 at 8 lb ai / A, EPTC at 5 and 20 lb ai / A CIPC at 8 lb ai / A, dichlobenil at 4 and 12 lb ai / A and diphenamid at 20 lb ai/ A. Both the mulched and non-mulched controls exhibited excessive grass weed growth (Table 2).

Dichlobenil at the 12 lb ai/ A rate caused severe damage to the azaleas both years as evidenced by the significant reduction in plant height (Table 3). The reduction in size of the azaleas when treated with EPTC at the 20 lb ai/ A rate in 1970 was thought to be herbicidal damage; however, this phenomenon was not observed in 1971. Excessive weed growth (i.e. poor overall weed control) during both years was thought to be responsible for some retardation of the azaleas when the following herbicide impregnated mulches were employed: CIPC +PPG-124 at 2 lb ai / A, CIPC at 2 lb ai / A and diphenamid at 5 lb ai / A (Table 3).

Table 2. Effects of various herbicide-impregnated mulches on the control of weeds in container-grown 'Hino Crimson' azalea and Japanese holly.

		'Hino Crimson' azalea				Japanese holly			
Herbıcıde	Rate lb aı / A	Broadleaf Weed Control[x]		Grass Weed Control		Broadleaf Weed Control		Grass Weed Control	
		1970	1971	1970	1971	1970	1971	1970	1971
Chlorpropham +	2	10 0 a[y]	10 0 a	7 7 ab	7 3 bc	9.7 a	9 7 a	5 3 b	6 3 bc
PPG124	8	9 7 a	9 7 ab	9 3 a	10 0 a	9 3 a	9 0 a	10 0 a	10 0 a
EPTC	5	9 3 a	8 0 b	9 3 a	10 0 a	9 7 a	9 0 a	8 3 a	10 0 a
	20	9 7 a	9 7 ab	10 0 a	10 0 a	9 3 a	9 3 a	9 6 a	10 0 a
Chlorpropham	2	10 0 a	9.3 ab	7 3 ab	9 3 ab	9 3 a	7.7 b	4.0 bc	5 3 cd
	8	10 0 a	9.0 ab	8 7 a	9.0 ab	9 0 a	9 0 a	8 3 a	9 7 a
Dıchlobenıl	4	10 0 a	10 0 a	9.7 a	10 0 a	10 0 a	10 0 a	8 8 a	9 0 ab
	12	10 0 a	10 0 a	10 0 a	10 0 a	10 0 a	10 0 a	9 6 a	10 0 a
Dıphenamıd	5	9 7 a	9 7 ab	9 0 a	8 0 abc	9 7 a	8 7 a	7 7 a	7 0 abc
	20	10 0 a	9 3 ab	10 0 a	10.0 a	9 0 a	8 7 a	9 3 a	9 0 ab
½" Untrtd Mulch		10 0 a	8 3 ab	5 7 b	6 0 cd	10.0 a	8.7 a	5 0 b	2 7 d
Non-Mulched Check		7 3 b	6 0 c	3 0 c	4 0 d	5 3 b	6 0 c	2 0 c	3 3 d

x/ Ratıng scale 0 = no control, 10 = complete control

y/ Means ın a column followed by the same letter are not sıgnıficantly different at the 5% probabılıty level as determıned by Duncan's Multıple Range Test

Table 3. **Effect of various herbicide impregnated mulches on the height of container grown 'Hino Crimson' azalea and Japanese holly.**

Herbicide	Rate lb ai / A	Avg. Plant Height (cm) Per Plot			
		'Hino Crimson' azalea		Japanese holly	
		1970	1971	1970	1971
CIPC + PPG-124	2	25.3 ab[x]	23.6 ab	24.4 bc	14.8 e
	8	27.5 a	26.4 a	29.1 ab	24.3 abcd
EPTC	5	28.7 a	25.5 ab	28.9 ab	26.3 abc
	20	18.7 b	24.3 ab	27.8 ab	22.1 bcde
CIPC	2	25.8 a	21.8 ab	19.6 bc	28.1 abc
	8	27.4 a	26.7 a	27.2 abc	25.4 abc
Dichlobenil	4	27.9 a	24.2 ab	23.1 bc	29.8 ab
	12	9.1 c	11.7 c	7.1 d	21.2 cde
Diphenamid	5	26.7 a	20.7 ab	29.9 ab	23.1 bcd
	20	28.4 a	24.3 ab	36.5 a	31.4 a
½'' Untreated Mulch	—	27.7 a	20.3 ab	16.9 cd	16.7 de
Non-Mulched Check	—	24.4 ab	17.7 bc	17.3 cd	14.2 e

x/ Means in a column followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

PREEMERGENT HERBICIDE APPLICATION ON CONTAINER NURSERY STOCK

Review of Literature. Information on the use of herbicides to control preemergent weeds in containers is limited at the present time. Davidson and Rees (3) found granular dichlobenil, diphenamid, and *a, a, a*-trifluoro-2, 6-dinitro-N, N-dipropyl-p-toluidine (trifluralin) safe and effective for weed control of container-grown nursery stock while 2-chloro-4, 6-bis (ethylamino)-*s*-triazine (simazine) caused injury to several test species. Similarly, Ahrens (1) observed that granular diphenamid at 5 or 7.5 lb ai / A caused no injury to 44 species of container-grown nursery stock in his study, while granular dichlobenil at rates of 4 and 6 lb ai / A caused significant damage to *Rhododendron, Cotoneaster, Cytisus,* and various *Ilex* cultivars.

Experiments were conducted at the Georgia Station during the summer of 1970 and 1971 to investigate the use of several preemergent herbicides on container-grown nursery plants.

Materials and Methods. These studies were conducted using the following container-grown species: *Rhododendron obtusum* Planch. *amoenum* Rehd. 'Coral Bells' and Japanese holly.

The seven preemergent herbicides and their rates of application employed in this study were: diphenamid at 5 and 20 lb ai / A, CIPC at 2 and 8 lb ai / A, CIPC+PPG-124 at 2 and 8 lb ai / A, EPTC at 5 and 20 lb ai / A, dichlobenil at 4 and 12 lb ai / A, trifluralin at 2 and 8 lb ai / A and simazine at 1 and 4 lb ai / A.

Both container-grown species employed in this study were treated as individual experiments and arranged in a completely randomized design. All experiments were replicated 3 times with 3 plants constituting 1 treatment replicate. The studies were initiated on April 10, 1970, and April 1, 1971. Data on weed control and plant growth were recorded 163 days after application. Analysis of variance and Duncan's Multiple Range Test delineated treatment effects.

All herbicides were applied in 1.56 gal of water (equivalent to 0.1 acre inch of water) over a 25 sq ft area with a knapsack type sprayer. The ornamental species employed in this study were uniformly rooted cuttings at the time the experiment was initiated. Within the week prior to the application of all treatments, the cuttings were potted in one gal nursery containers in a soil mix consisting of equal parts on a volume basis of unsterilized soil, milled pine bark and sand. After application of the preemergent herbicides, all plants were placed in a lathhouse (50% shade) for the remainder of the experimental period. Standard nursery practices were employed in the maintenance and fertilization program. The principle weed species observed during the course of this experiment were: crowsfoot grass, large crabgrass, goose grass, yellow nutsedge, carpweed, chickweed, common yellow woodsorrel and common ragweed. Visual ratings of both broadleaf and grass weed growth were employed to rate the effectiveness of the preemergent herbicides, with 0 designating no control and 10 complete control.

Results. Treatments which resulted in the best control of broadleaf weeds in both Japanese holly and 'Coral Bells' azaleas during both test years were dichlobenil at both rates, trifluralin at 8 lb ai / A, simazine at both rates and diphenamid at 20 lb ai / A (Table 4).

Excellent grass weed control was achieved both years on both groups of container-grown plants with the use of dichlobenil at 12 lb ai / A, trifluralin at 8 lb ai / A, EPTC at both rates, and CIPC + PPG-124 at 8 lb ai / A. In most cases, the use of herbicides did give significantly better control of both broadleaf and grass weeds than the controls (Table 4).

During both years the Japanese holly and the 'Coral Bells' azaleas were significantly reduced in size due to the application of dichlobenil at the 12 lb ai / A rate. Similarly, the EPTC at the 20 lb ai / A rate significantly reduced the height of the azaleas both years, but had no effect on the Japanese hollies (Table 5).

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Table 4. **Effects of various preemergent herbicides on the control of weeds in container grown 'Coral Bells' azalea and Japanese holly.**

Herbicide	Rate lb ai / A	'Coral Bells' azalea: Broadleaf Weed Control[x] 1970	'Coral Bells' azalea: Broadleaf Weed Control[x] 1971	'Coral Bells' azalea: Grass Weed Control 1970	'Coral Bells' azalea: Grass Weed Control 1971	Japanese holly: Broadleaf Weed Control 1970	Japanese holly: Broadleaf Weed Control 1971	Japanese holly: Grass Weed Control 1970	Japanese holly: Grass Weed Control 1971
Dichlobenil	4	9 8 a[y]	10 0[NS-z]	8 5 ab	9 0 a	10 0 a	8 7 abcde	6.7 cd	8 7 abc
	12	10 0 a	10 0	8 7 ab	10 0 a	10 0 a	9 7 ab	8 7 ab	10 0 a
Trifluralin	2	5 3 e	9 7	7 5 bc	10.0 a	9 0 a	9.7 ab	9 0 ab	10.0 a
	8	9 3 ab	10 0	8 3 ab	10 0 a	10.0 a	10.0 a	8 8 ab	10 0 a
CIPC	2	8 1 bcd	9 7	7 3 bc	10 0 a	8 8 a	6 7 f	6 0 cd	7 7 abc
	8	8.1 bcd	10 0	6 5 bc	10 0 a	10 0 a	7 7 cdef	5.5 de	6.3 bcd
EPTC	5	9 0 ab	9 0	7 8 bc	9 7 a	8 8 a	7.3 def	9 0 ab	9 0 abc
	20	8 6 abc	8 7	8.7 ab	10.0 a	10.0 a	6.7 f	9 5 a	9.0 abc
CIPC + PPG-124	2	7 3 cd	9.3	6 8 bc	8.0 a	9.0 a	7.3 def	7 2 c	8 7 abc
	8	8 2 bcd	10 0	8 7 ab	10 0 a	9 5 a	8 0 bcdef	9 3 a	10 0 a
Simazine	1	9 5 ab	9 7	5.7 cd	8 3 a	10 0 a	9 0 abcd	4.3 e	5 7 cd
	4	9 5 ab	9 3	7.3 bc	10.0 a	9.0 a	9 3 abc	5 3 de	7 0 abc
Diphenamid	5	9 7 ab	9 0	9 7 a	10.0 a	6.0 b	8.0 bcdef	7 5 bc	9 7 ab
	20	9 7 ab	10 0	9 7 a	10 0 a	10 0 a	8 7 abcde	10 0 a	6 7 abc
Control		7 0 d	8 3	3 8 d	4 0 b	7 0 ab	7 0 ef	4 0 e	3 3 d

[x] Rating scale. 0 = no control, 10 = complete control

[y] Means in a column followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test

[z] Not significantly different at the 5% probability level.

Table 5. Effect of various preemergent herbicides on the height of container grown 'Coral Bells' azalea and Japanese holly.

Herbicide	Rate lb ai / A	Avg. Plant Height (cm) Per Plot			
		Coral Bells azalea		Japanese holly	
		1970	1971	1970	1971
Dichlobenil	4	29.7 abc[x]	34.0 ab	14.6 cde	24.4 a
	12	25.5 cde	11.1 c	3.5 f	5.3 b
Trifluralin	2	28.2 abcd	34.6 ab	20.2 bc	25.7 a
	8	24.6 cd	27.2 b	17.7 cd	22.7 a
CIPC	2	29.7 abc	37.2 a	11.6 de	21.4 a
	8	23.8 d	36.3 ab	15.3 cde	22.1 a
EPTC	5	28.2 abcd	33.4 ab	14.9 cde	18.5 a
	20	1.9 e	1.9 d	17.9 c	20.7 a
CIPC + PPG-124	2	23.9 d	41.1 a	16.6 cde	21.6 a
	8	25.3 bcd	36.0 ab	17.6 cde	28.8 a
Simazine	1	28.0 abcd	43.3 a	11.3 e	21.6 a
	4	31.3 a	41.3 a	14.2 cde	24.4 a
Diphenamid	5	31.6 a	42.2 a	27.2 a	23.1 a
	20	30.6 ab	42.2 a	25.3 ab	19.2 a
Control	—	25.0 bcd	38.7 a	15.0 cde	18.2 a

x/ Means followed by the same letter are not significantly different at the 5% probability level as determined by Duncan's Multiple Range Test.

ARIE RADDER: How long did you get control with the materials you were using?

TOM FRETZ: We were still getting pretty good control with most of the materials at the end of 75 days, but some of the materials were beginning to break down.

ARIE RADDER: We have been using Trifluralin for a number of years now and we find that it has a longer residual action than any of the other materials we have tried.

DICK AMMONS: Would there be any merit to spreading your mulch out on a driveway and spraying it with Trifluralin and then using it to mulch the cans?

TOM FRETZ: We haven't done this, but other workers have done similar things such as mixing the Trifluralin with the mulch. You do, of course, get some weed control from the mulch itself. I don't incorporate my Trifluralin, but I do use a water seal; that is, water is applied immediately after applying the Trifluralin.

RALPH SHUGERT: I want to emphasize your statement concerning the difference in the cost of control between grasses and broadleaf weeds. Having chemically weeded seed beds for the past 10 or 12 summers, I have found that costs are tremendously higher when attempting to control grasses. Dacthal in my opinion is a tremendous help in grass control, but what Dacthal would do in cans I don't know since I have had no experience with it.

TOM FRETZ: We have tests in which we are using Dacthal. We have used it at tremendously high rates, but I cannot say that I am very well pleased with it; thus far it has been very erratic and others that I have talked to have found the same thing.

MODERATOR FLEMER: Our next paper also deals with container growing and it concerns lightweight media for containers. It will be presented by one of our old stand-by members, Mr. Harvey Gray.

LIGHT WEIGHT MEDIA FOR CONTAINER GROWING OF ERICACEOUS PLANTS

HARVEY GRAY

State University of New York
Farmingdale, New York

The production of containerized woody plants with the desired soil mixes is a major operation. If the plants to be marketed in containers could be grown in a medium in beds, properly spaced, much of the labor might be reduced. Plants grown in beds are easier to care for, particularly in regard to watering and fertilizing. The following remarks are made with these points in mind.

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DICK AMMONS: Would there be any merit to spreading your mulch out on a driveway and spraying it with Trifluralin and then using it to mulch the cans?

TOM FRETZ: We haven't done this, but other workers have done similar things such as mixing the Trifluralin with the mulch. You do, of course, get some weed control from the mulch itself. I don't incorporate my Trifluralin, but I do use a water seal; that is, water is applied immediately after applying the Trifluralin.

RALPH SHUGERT: I want to emphasize your statement concerning the difference in the cost of control between grasses and broadleaf weeds. Having chemically weeded seed beds for the past 10 or 12 summers, I have found that costs are tremendously higher when attempting to control grasses. Dacthal in my opinion is a tremendous help in grass control, but what Dacthal would do in cans I don't know since I have had no experience with it.

TOM FRETZ: We have tests in which we are using Dacthal. We have used it at tremendously high rates, but I cannot say that I am very well pleased with it; thus far it has been very erratic and others that I have talked to have found the same thing.

MODERATOR FLEMER: Our next paper also deals with container growing and it concerns lightweight media for containers. It will be presented by one of our old stand-by members, Mr. Harvey Gray.

LIGHT WEIGHT MEDIA FOR CONTAINER GROWING OF ERICACEOUS PLANTS

HARVEY GRAY

State University of New York
Farmingdale, New York

The production of containerized woody plants with the desired soil mixes is a major operation. If the plants to be marketed in containers could be grown in a medium in beds, properly spaced, much of the labor might be reduced. Plants grown in beds are easier to care for, particularly in regard to watering and fertilizing. The following remarks are made with these points in mind.

Experience and observation have proven that a soil mix high in organic matter and with a fair amount of clay has several points in its favor. Increased water holding capacity reduces the frequency of irrigation and a reduction of fertilizer loss. This is most important when containerized plants are on display for sale. A growing medium containing some soil classified as loam, possessing 20 to 25% clay, permits the roots of certain container-grown plants to make ready entry into the surrounding soil when planted in the landscape. Also the clay fraction of the loam soil serves in holding exchangeable ions of nutrition.

This is a report on a procedure to modify a loam consisting of 25% sand, 50% silt and 25% clay, in order to make a soil mix lighter in weight, retentative of more water, and possessing a favorable oxygen content. Such a mix is intended to produce ericaceous plants which would be dug and transferred, after one or two seasons of growth, to containers for marketing. Beds are prepared under pipe frame structures, the structures to be covered with plastic film for winter protection. When the plants have reached the desired size they are transferred during the cold of the winter. Portable oil heaters may be used at containerizing time to eliminate the light crust of frozen growing medium as well as for the comfort of the workers.

After a series of trials and calculations the existing loam in the growing structures are prepared to have equal parts of loam, sphagnum peat, sawdust or wood chips and perlite. The beds are first prepared with a rotovator and tilled to a depth of 2 inches of the firm soil. The amendments are added in 2 inch layers. A bed consisting of 1000 square feet will be dressed with:

Sphagnum peatmoss	20 bales (6 $ft.^3$)
Sawdust or wood chips	6 $yd.^3$
Perlite (supercoarse)	30 bags (4 $ft.^3$)
Dolomitic limestone	100 lb.
Superphosphate	100 lb.
Long lasting fertilizer (21-15-15)	25 to 30 lb.

FERTILIZER FORMULA:

Magamp (7-48-6)	15 lb.
Ureaform (38-0-0)	40 lb.
Di-ammonium phosphate (21-53-0)	15 lb.
Potassium nitrate (13-0-44)	15 lb.
Muriate of potash (0-0-60)	15 lb.

The soil additives are blended into the tilled loam with the rotovator at least twice for a good blend. Care should be taken not to till into the base soil any deeper than the original 2-inch cut. Such a mixture when settled should produce a 6-inch light weight medium.

Roots of ericaceous plants will not grow into the loam below the prepared strata. This makes it possible to dig and shape the plant ball to fit an 8-inch Zarn #350 plastic container. If the ericaceous plants are to be placed into larger containers with greater depth, the bed would be prepared to a greater depth with an increase in the amounts of soil additives. Sometime during the soil mix preparation in the beds, the area should be sterilized with either Vapam or methyl bromide. Course, deep-rooting plants, such as cotoneaster or pyracantha, quite likely would not adapt to this program.

All species of ericaceous plants, whether propagated by seed or cuttings, do not produce plants of equal size nor form in the same time period. For this reason some plants may reach marketable size earlier than others of the same batch of seedlings or cuttings. At containerizing time all plants are put in containers except the culls. Those plants which are not marketable will be carried on for another growing season in the containers.

The system outlined here is adaptable to seedling propagated plants of *Leucothoe, Oxydendron* and *Pieris,* as well as rooted cuttings of small leaf rhododendrons, such as *R. carolinianum* and its hybrids, *R. ferrugineum, R. myrtifolium* and *R. obtusum* forms, as well as the deciduous azaleas.

Experience in the growing of ericaceous plants from seed proves the value of early seed sowing and using light media, such as equal parts of shredded sphagnum peat and vermiculite, #4 grade. To make one bushel of mix add:

Dolomitic limestone	3 tbsp.
Superphosphate	3 tbsp.
Di-ammonium phosphate (dissolved in 1 gallon of warm water)	1 tbsp.

When this seed sowing medium is used, there will be the least amount of root disturbance in the pricking off of well-spaced seedlings from the seed flats.

The seedlings are pricked off into 3-inch square plastic pots when the plants have two or three leaves and are large enough to handle. The square pots are placed in trays made with 1 x 2 inch turkey wire bottoms, and then filled with the growing-on medium. Growing-on light weight mixture:

Shredded sphagnum peat	1/2 $yd.^3$
Perlite (propagation grade)	1/2 $yd.^3$

continued

continued

Dolomitic limestone	2 lb.
Superphosphate	2 lb.
Long lasting 21-15-15 fertilizer	1½ lb.

It is suggested that rooted cuttings and seedlings be induced to make rapid growth during February, continuing on until early June when they are planted out in beds. This is possible by sowing the seed late in December and making use of night temperatures of 72° to 75° F. Subjecting seed and germinated seedlings to a longer day of 18 hours is suggested. Rooted cuttings may be treated in a similar fashion; however, the plants will respond best when subjected to 40° F. during December and January in order to break bud dormancy.

MODERATOR FLEMER: Thank you very much, Harvey. We will have time for only one question.

DICK BOSLEY: Have you observed any difference in the ability of the plants that survive when you plant them from your soil mix to native soils?

HARVEY GRAY: There is a problem with the roots not wanting to move out of these lightweight soil mixes into the surrounding native soils, but this soil mix retains about 20% soil and I think it is a breakthrough in overcoming this reluctance for roots to grow out into the existing soil.

MODERATOR FLEMER: This concludes this morning's program.

FRIDAY AFTERNOON SESSION

December 3, 1971

The session convened at 1:30 p.m. in the West Ballroom. President Tom Pinney, Jr. served as moderator.

MODERATOR PINNEY: Our first speaker this afternoon is Mr. Bill Morsink from the Shade Tree Research Laboratory at the University of Toronto. He will speak on a subject which many of you have requested. The title of his paper is "Mist Propagation of *Acer saccharum*".

MIST PROPAGATION OF SUGAR MAPLE

(Acer saccharum Marsh.)

W. A. G. MORSINK

Shade Tree Research Laboratory
Faculty of Forestry
University of Toronto, Ontario

Trials on mist propagation of sugar maple have been in progress since 1968 in Toronto, Ontario, as part of the "Superior Shade Tree Programme for Ontario" (6). Procedures on vegetative propagation have recently been reviewed (1). Softwood cuttings (15 cm) of sugar maple collected in June have been rooted with varying success, using IBA and mist (2, 3, 4, 5, 8). Little information was available on the precise effect of auxins, length of cuttings, base diameter and a number of other questions. A number of small exploratory tests were carried out over the last 4 years to gain information on mist propagation of this species.

The rooting medium was a 2:1:1 (v / v / v) mixture of sandy loam top soil, vermiculite, and peatmoss, sterilized at 82° C.

Collection of cuttings. Juvenile softwood cuttings taken in the middle of June in Dorset, Ontario, rooted between 65 % and 89 %. At this time cuttings had fully elongated bottom leaves while the apical meristem was in full growth. Cuttings taken in the middle of May decayed under the mist.

Cuttings were severed with clippers or the cuttings were broken at the base of softwood growth. The effect of dividing one shoot into two cuttings is shown in Table 1; the thicker cuttings rooted better, and there was a slight improvement in rooting of the top parts as compared to bottoms.

Table 1. Effect of base diameter on rooting of sugar maple softwood cuttings (30 cm).

Ave. Base Dia. (mm)	Number of Cuttings	Percent Rooted	
		Bottoms	Tops
3.5	300	36	39
4.5	200	45	66
5.5	100	73	75

Cuttings were collected from stump sprouts which varied in length from 10 to 90 cm. These shoots were very vigorous and rooted without application of auxins, and were classed as juvenile (7). Cuttings also rooted from the lower crown part of selected sugar maples without the use of auxins, but the percentage of rooting varied from tree to tree.

Auxins. Softwood cuttings (15 cm) containing terminal buds were basal-dipped with 0.1, 0.4 and 0.8% of IBA in talc and 25, 50 and 100 mg / 1 of IBA in distilled water for 1 minute, each group containing 50 cuttings. Rooting did not improve with any of the treatments as compared to the controls with 60 to 80% rooting. When concentrations of IBA in distilled water were increased to 1000, 5000, and 10,000 mg / 1 for a 10 second dip, softwood cuttings—varying in length from 15 to 55 cm—all decreased their rooting to 20% as compared to 80% for controls.

Wounding of softwood cuttings by slicing lightly on the base appeared detrimental (Table 2) to rooting, with or without the aid of auxins.

Table 2. Effect of wounding on rooting of softwood cuttings (15 cm) treated with IBA (100 cuttings per group).

Treatment	Percent Rooted	
	Unwounded	Wounded
Control	64	55
0.1% IBA *	64	48
0.4% IBA	53	33
0.8% IBA	33	40

* Commercial preparation in talc powder.

Effect of base diameter and terminal buds. Softwood cuttings (35 cm) were graded into 3 base-diameter classes, each containing 200 cuttings. Terminal buds were removed on half the cuttings in each group. The effect of terminal buds in controlling auxins appears nonexistent (Table 3). The effect of base diameter (Table 3) on rooting is slight.

Combination softwood-hardwood cuttings. The purpose was to root long shoots. A series of juvenile cuttings collected in June, ranging from 15 to 120 cm was divided into control and treatment lots. All groups, except for softwood controls (15 cm), contained a combination of softwood on wood—from one or more previous years. All cuttings remained green under mist for about 4 weeks, after which the longest, followed by the shorter lengths, died successively without rooting. The control (15 cm) and 35 cm combination cuttings rooted (Table 4). IBA treatments had no effect. Bottoms of the large cuttings became infected.

Table 3. Effect of wounding on rooting of softwood cuttings (15 cm) treated with IBA (100 cuttings per group).

Average Base Dia. (mm)	Percent Rooted, with Terminal Bud	
	—Intact	—Removed
3.0	86	86
4.0	88	89
5.5	91	90

Table 4. Effect of cutting length on rooting of softwood-hardwood combination cuttings (100 cuttings per group).

Type	Size (cm)	Percent Rooted	
		Control	Treated *
Softwood	15	65	62
Soft-hard	35	23	14
Soft-hard	55	0	1
Soft-hard	90	0	0
Soft-hard	120	0	0

* 1 minute dip in 25 mg / 1 of IBA in distilled water.

Finally, juvenile softwood cuttings 15, 35, 55, 65 and 75 cm long were sorted into thick and thin cuttings. Cuttings 35 and 55 cm long rooted between 75 and 89 %; cuttings longer or shorter rooted less. With 15 to 55 cm lengths, thick cuttings rooted better than thin cuttings.

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MODERATOR PINNEY: Mr. Morsink tells me he will be with us tonight for the Question Box and so I will allow only one question at this time.

VOICE: What has been your experience in over-wintering these rooted cuttings?

BILL MORSINK: We have been trying many different treatments, with and without heating cables, and to date the best treatment has been without heating cables but with a heavy mulch of oak leaves. This has given us about 75% survival.

MODERATOR PINNEY: Thank you very much, Bill.

The next gentleman on our program is no stranger to any of us; he is Dick Bosley and he is going to talk to us concerning rhododendron mythology. This ought to be an interesting subject so I will turn the program over to Richard.

RHODODENDRON MYTHOLOGY

RICHARD W. BOSLEY

Plant Systems
Mentor, Ohio

In the 25 years that I have been in the business of growing hybrid rhododendrons I have been exposed to many expert opinions both in person and through programs and publications—such as those of the Plant Propagators' Society. I have appreciated these ideas as they have been useful in expanding my knowledge and often enabling me to produce a better product. Two years ago I left the nursery I had been associated with for most of my life to start my own nursery which is called "Plant Systems". I would like to share some revelations I have had, regarding one hybrid rhododendron, 'Nova Zembla', during these 2 years and how these experiences compare with the myths to which I have been exposed.

I do not wish to imply in any way that the experiences that others have had were not valid because I am sure they were. I would also like to suggest that what worked for me may not work for another person or for another plant.

To give a little background regarding the crop environment, the plants were potted into ½ bushel baskets in a medium composed or 70% ground bark, 15% coarse sand and 15% peat. They were subject to constant feed through the whole growing season. Soil and leaf samples were taken every 3 weeks during active growth in order to keep the nutrition at a near optimum level at all times. Irrigation was supplied as needed, 1½ inches of water being given each watering. There was no manipulation of day length or night temperatures.

Multiple Vegetative Bud Breaks. For years I had understood that if the rhododendrons were not given a "rest", that the number of vegetative breaks would be few. My experience is that the rhododendron will probably grow continuously for several years with generous breaks. In the middle of this past growing season I found that the common number of breaks was 3 to 7 and some were as high as 10 to 12. This was not following a rest but after 2 months of growing; so I suspect that multiple breaks are more a function of nutrition, temperature, moisture and humidity.

Continuous Growth. Rhododendrons normally grow in flushes rather than continuous growth, as azaleas, but under the near optimum conditions this past spring I observed our rhododendrons cycling into continuous growth instead of flushes.

Close Packing. I was assured that my crop was spaced much too close (the baskets were touching but not nested). Experience showed that the interior plants were superior to the edge plants. Again I would like to stress that this may not be true at all under different conditions or other cultivars.

Nutrition. All the nutrition these plants received, from me, was in the inorganic form. Some would suggest that if you don't use this or that organic form of feed the plant will not do well. I used ammonium nitrate, potassium nitrate, diammonium phosphate, magnesium chloride, and iron. All were applied through the electronic injector.

Soluble Salt Levels. It is generally agreed that rhododendrons are a "low feed" crop; I would agree in principle, but I would like to cite some extremes I have experienced. You must use caution in taking one person's raw data and using it in your own situation. This past summer I sent identical samples to two different laboratories and found nearly a 300% difference in the reporting of two elements. If you hear figures, check them with **your** laboratory and under **your** conditions before committing a crop.

This past year I had some *Rhododendron* 'Nova Zembla' plants growing in poly bags in pure peat. I was starting to get some foliage burn, indicating high salts and, therefore, sent in soil samples and found the approximate soluble salts to be : 8,000 (ECA 3.6). This is a level far above that which I would have believed the plants could survive, but they did, once I applied 4 feet of water. There has been little recognition of the fact that soils vary greatly in nutrient retention; what might be an optimum level in pure peat would certainly kill a plant in Lake County, Ohio, soil. Any laboratory should relate their soil report data to the exchange capacity of that medium.

Phosphon Persistance. Most of us growing rhododendrons have played with growth retardants during the past few years. One of the materials that has often been mentioned is Phosphon. It has been suggested that once the plant has been transplanted that, as new roots penetrate the new soil, plant growth will return to normal. This is not true, at least for me, and any person buying a Phosphon-treated plant may find the dwarfing persisting for a number of years.This may not be bad but I prefer less persistant chemicals for growth regulation.

Night Temperatures. The greenhouse industry mentions night temperatures as separate from day temperatures in the culture of most of their crops. It is seldom mentioned in the nursery industry. I have found that the rhododendron is much more responsive to 65° F minimum night temperature than it is to night lighting and temperature control requires much less fuss and expense than light control. I am not knocking night lighting because I use it too, but when it comes to growth stimulation don't overlook the effect of night temperatures.

Root Rot Disease. Stress has been put on root rot (water mold) disease control in nursery crops. It was probably first recognized in connection with rhododendrons but it affects many nursery crops. We have been having this problem for as long as there have been nurseries but it became less of a problem since the much better drainage of field soils was putting the disease organisms at a disadvantage. As soon as we shifted to container growing and set containers on black plastic the organisms at last had the free moisture they needed to survive and spread. The shortness of the soil column in a pot tends to cause a wet zone at the bottom, which large or multiple pot holes will not correct. Use a well drained mix and never let free water stand around the base of a pot — even during irrigation. This is a much better root rot control than all the chemicals.

Budding Rhododendrons. There has been a lot published about how to encourage bloom bud formation on rhododendron plants; I suppose the surest method is wait until it is 7 years old! Little is known *about the budding mechanism and not much more is known about why* certain things work—sometimes. I would like to know a lot more about why the plant forms a vegetative bloom, or a bloom bud, and when this determination is made. I find that many of the techniques that growers have used in the past either don't work all the time or are very dangerous in regard to the possibility of root injury. If you injure the roots this becomes the path into the plant that the root rots take. The throttling of plant growth should be possible with chemical growth regulators rather than the usual method of water withdrawal. This would maximize food production while allowing cell size regulation.

Plant Breeder. The plant breeder in the future will be the one responsible for at least a portion of production cost reduction for the grower. At the present time I screen rhododendron varieties that show potential to see if they will respond to accelerated growing methods. If they do not meet the growth criteria the plants will be rejected no matter how well they may look as an adult. This approach is common in the pot-mum industry and is coming to the nursery business.

It seems as though the more we learn the more there is to know. There are still many things about plant functions that we do not understand and it looks like the future of the Plant Propagators' Society will be an exciting one.

CASE HOOGENDOORN: Dick, I have been admiring the plant you have on display and it's beautiful, but isn't the bud set on that new growth rather soft and immature?

DICK BOSLEY: Yes, but the buds are still forming. As sometimes happens in our area we had 50° F nights during the first two weeks of August which caused buds to set. For the next three weeks or so, we had night temperatures of 60° to 70° F and new growth occurred; when that growth matured, buds set on it. The buds will not be damaged since the temperature in the houses is never allowed to fall below 35° F during the winter. I believe it is important to supply a plant to the market without either leaf or bud damage.

MODERATOR PINNEY: Thank you very much, Dick. You always give an interesting talk and the name of your organization, "Plant Systems", indicates that you have thought through the entire operation pretty thoroughly before putting it into practice. Dick has aptly indicated that we cannot take a piece of information out of context and apply it haphazardly to our own system.

Our next speaker is Mr. Fleming from the Horticultural Research Institute of Ontario, and he is going to tell us about Baycovin, which is a new experimental material for sterilizing propagating media.

BAYCOVIN—AN EXPERIMENTAL MATERIAL FOR STERILIZING PROPAGATING MEDIA

R. A. FLEMING

Horticultural Research Institute of Ontario
Vineland Station
Ontario, Canada

Baycovin, more properly known in research as DEPC, or the diethyl ester of pyrocarbonic acid, has been used as a sterilizing agent for the preservation of fruit juices both fermented and nonfermented. It has shown anti-fungal properties when used as a post-harvest dip on strawberries (3), and is also toxic to a wide spectrum of microorganisms, including mycelial fungi which affect greenhouse crops.

A characteristic of the chemical is that it hydrolyzes readily to carbon dioxide and alcohol. The possibility of using the material as a sterilizing agent for greenhouse soils or plant propagation media seemed of interest and utility in view of its toxicity to fungi and the fact that its use would not give rise to residue problems as do other biocidal materials.

Baycovin or DEPC was first manufactured by Farbenfabriken Bayer A.G., Leverkusen, Germany. Its solubility in water is 0.6%, and in 96% ethyl alcohol 50% with hydrolysis. Baycovin is harmless to humans under most conditions of use (2), but should be handled with care. Eyes should be protected at all times, and washed well with water if any of the material has contacted them. Wash exposed skin with soap and water immediately and change clothing on which concentrated liquid is spilled. As it is a volatile chemical, allow good air circulation during application where vapors may arise.

The chemical should be stored in closed bottles in a cool place. In the concentrated form, gloves and face masks should be worn when handling, as with other agricultural chemicals.

MATERIALS AND METHODS

To ensure uniform mixing, Baycovin was dissolved first in 95% ethyl alcohol, then suitably diluted with water. In all tests, the chemical was applied with a watering can.

Initial tests using the material were made on unsterilized soils taken from fields known to contain soil-borne fungal diseases of several types. Seeds of tomato, lettuce, salvia, kochia, alyssum, bellis and nemesia were planted in random rows in the unsterilized field soil. These plants were selected as ones commonly propagated in flats and susceptible to damping-off diseases. Seeds were planted in the soil 24 hours after drenching and immediately before drenching.

Rates of application of Baycovin to the seed flats were 1000 ppm and 2000 ppm. Follow-up treatments were applied 9 and 16 days following the initial treatment on some flats to determine the effect of the material on growing seedlings.

RESULTS

From the standpoint of disease control, 2000 ppm drench applied prior to seed planting was most satisfactory. Salvia appeared to be stimulated in growth. At 1000 ppm lettuce and tomato appeared to be stimulated. However, the supplementary treatment, whether at 1000 or 2000 ppm appeared to retard growth somewhat without affecting the health of the plants.

Post seed-planting drenches were almost as effective in disease control, though some slight damping-off disease occurred with the 1000 ppm treatment. In all cases control or untreated flats showed a high incidence of damping-off disease.

Samples of the soil used in the drench treatments were cultivated in petri plates under laboratory conditions. No treatment revealed rapid growth of moulds and bacteria. The populations were reduced proportionately to the concentration of Baycovin used, 100 and 200 ppm being inhibitive, and 500 ppm restricting growth almost entirely. Other tests at 1000 and 2000 ppm showed similar reduction in microbial counts.

Molin *et al.* (3) showed that lethal concentration of DEPC for various genera of fungi varied from 100 ppm for *Botrytis cinerea, Aspergillus niger* and *Fusarium* to 500 ppm for *Trichoderma*. In this laboratory, the amount of DEPC required to inhibit growth of plant pathogens (1) was also seen to vary. For example, a *Verticillium* species responsible for wilt of tomatoes was inhibited by 100 ppm, an isolate of *Diplocarpon* (strawberry leaf spot) did not tolerate 200 ppm, while growth of *Fusarium* was inhibited markedly at 500 ppm.

In commercial greenhouses, suitable atomizing units are available for injecting DEPC (suitably dissolved in ethyl alcohol) into a stream of water for use in a watering program or as a soil drench treatment. In research, or for special purposes requiring only small amounts of soil, DEPC can be emulsified first in a small amount of ethyl alcohol then diluted with water to the required volume. Experimentally DEPC costs about 5 cents per gallon, which is minimal considering the cost of steam and the related costs of labor and equipment.

Tests using Baycovin as a drench on propagating benches consisting of 60% perlite, 40% peat by volume proved quite successful. No statistical report is available yet, but from the practical standpoint, excellent results were obtained. *Taxus* and *Juniperus* cuttings were drenched in the bench with no injury to the cuttings. The incidence of rot on the portion of the cutting in the rooting medium was reduced to almost zero. An untreated section of the same bench containing similar material showed a fairly high incidence of rot. The propagating medium had been in constant use for 2 years.

Tomato seedlings transplanted to *Verticillium* and *Fusarium* inoculated soil grew well where Baycovin treatment preceded planting, but showed some incidence of disease where treatment followed transplanting. Plants were not affected by the treatment but apparently the disease entered the plant in the period following transplanting and before treatment (2 or 3 days).

DISCUSSION

Greenhouses represent large commercial investments and are major sources of agricultural revenue. These crops include not only fruits aand vegetables but ornamental crops such as flowers and nursery stock. Soil sterilization, imperative if the best yields are to be obtained, continues to be one of the most time-consuming tasks related to production, and is accomplished now by fumigating or steam treatment or a combination of both. Rarely is bacteriological sterility ever achieved nor, for the most part, is it necessary since basically the purpose of the treatment is to reduce the fungal pathogens to the point where the activity of the surviving organisms does not adversely affect the germination, growth and later development of seeds and seedling plants.

Emphasis continues to be placed on the synthesis of new biocides for use in both primary and secondary industries. These new biocidal products are initially developed and introduced to serve very specialized roles in the protection of one or several closely related products. However, it would seem reasonable that sometimes a material primarily designed as a fungicide for field applications might also be useful for other purposes, e.g. as a mould inhibitor in damp cellars of breweries and wineries or in warehouses of canning plants. Similarly, DEPC originally introduced for the beverage and food industry is shown here to be of value in another production area. Greenhouse operators and plant propagators might profitably use this chemical not only as described above but in other ways where temporary reduction of soil fungi is desirable.

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MODERATOR PINNEY: Is Baycovin commercially available?

R. A FLEMING: Yes, the material is available through Stauffer Chemical, or Pfizer Chemical, or any place that sells supplies for home winemakers.

MODERATOR PINNEY: What diseases will this material control?

R. A. FLEMING: Baycovin apparently controls all soil-born diseases. We especially like the easy application of this material.

MODERATOR PINNEY: The next speaker is no stranger to this group; he comes from Minnesota and this afternoon will tell us about "The Storage of Conifer Scions and Cutting Material"; Mr. Dick Cross.

STORAGE OF CONIFER SCIONS AND CUTTING MATERIAL

RICHARD E. CROSS

Cross Nursery, Inc.
Lakeville, Minnesota

In the area where we have our nursery in Minnesota most conifer propagation is done during the winter months. If it were possible I would start in November and December, but because of pressures from tree and shrub digging and from Christmas business, it is usually about the first of the year before we get into greenhouse propagation.

Quite a few years ago, when I was new at making cuttings and grafts I read all the material I could find on the subject of propagation. I was under the impression I should take cuttings and scions and use them in a very short time, certainly within several days. This would be fine if we were in a mild climate where we would be able to go to the field and take fresh propagation materials daily.

About 6 years ago I began to wonder about the difficulty we were encountering in gathering cuttings and scions in January, February and March to get fresh material for our use. Also some winters there was winter damage to the cuttings, showing up after these later cut materials were used and put in the greenhouse benches.

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Cross Nursery, Inc.
Lakeville, Minnesota

In the area where we have our nursery in Minnesota most conifer propagation is done during the winter months. If it were possible I would start in November and December, but because of pressures from tree and shrub digging and from Christmas business, it is usually about the first of the year before we get into greenhouse propagation.

Quite a few years ago, when I was new at making cuttings and grafts I read all the material I could find on the subject of propagation. I was under the impression I should take cuttings and scions and use them in a very short time, certainly within several days. This would be fine if we were in a mild climate where we would be able to go to the field and take fresh propagation materials daily.

About 6 years ago I began to wonder about the difficulty we were encountering in gathering cuttings and scions in January, February and March to get fresh material for our use. Also some winters there was winter damage to the cuttings, showing up after these later cut materials were used and put in the greenhouse benches.

As I thought about this difficult situation, with frosted hands and frozen feet, I could not help but feel that we needed a change in our procedure. I decided to try something different. The next fall in late November I cut about 30 bushels of cuttings for a trial experiment; most of them were junipers, *Thuja* and *Taxus* with several varieties of each. They were cut with pruning shears about 6 to 8 inches long and packed in bushel baskets, 500 to 800 cuttings per basket depending on the kind. They were then taken to our old root cellar and placed on the floor; they were left in the baskets until used.

The temperature in this root cellar ranges from 32° to 35° F during the winter months with no cooler or fans running. I am careful not to get these stored conifer materials wet with the hose. If possible I do not take them while wet. If they are wet when taken, I dump the baskets and dry them somewhat, before leaving them for long periods of time. Occasionally I do moisten the floor of the cellar and packing materials around other shrubs that are also stored there. This is to keep a high humidity level in the entire cellar.

The results with the cuttings were good; they were better than winter-cut materials. Some we kept 3 months and longer and they still turned out very well. We did this for several years with cuttings, but were still trying to gather "fresh cut scions" for juniper grafts as the good book said. Then in the winter of 1968-'69 we went out to gather scions in late December. There had been several storms just previously. We got down in the nursery with much effort and found just a little of the tops of the upright junipers sticking out of 4 feet of hard-crusted snow drifted solid between the rows. Three of us shoveled all afternoon to dig out rows and cut icy scions; we also broke up some tree tops. We spent several days trying to get a few thousand scions. I said enough of this, never again.

So the next fall in late November we also cut our juniper grafting scions, stored them in baskets and held them like our cuttings. We could not get as many in the baskets because of the larger size. They run about 350 to 500 scions per basket. We kept a good record of the grafts made from stored scions, and the results again were better than previously when they were winter-cut.

Last year some were held until March 6th. These were stored 3 months and 1 week and the graft results overall were over 90% on our 8000 juniper grafts. I have tried storing 18 varieties of junipers and can see no difference in any of them if they are free of blight and dry when put away. On making the cutting or graft, I do like to make a fresh cut and remove a small piece from the bottom.

I have also cut and stored scions of some pines and spruce varieties. These were not held as long a time but were used after about 4 weeks. The success ratio was as good as newly-cut materials.

In our northern climate we have found this to be a better way to handle cuttings and scions than the "fresh cut" method and our results have proved it so.

I do not wish to say that these procedures are all totally original. I have seen one other nursery in our area store cutting materials. Also our good member, Jim Wells, as far back as 1955, in his book on propagation mentions the making of arborvitae cuttings, storing them in sphagnum moss for 6 weeks, then planting them when they were callused in March. However, these above two methods are different than the ones we use.

CASE HOOGENDOORN: Do you cover these baskets with poly?

DICK CROSS: No, I leave them open but, as I mentioned, there is a dirt floor in the cellar where I store them and though I do occasionally moisten the floor I am careful not to get any water on the cuttings. I tried wetting them one time, but I had trouble so I haven't done it again.

DICK AMMON: What experience have you had taking frozen scion wood?

DICK CROSS: My experiences have not been good. I prefer to collect the materials when temperatures are above 20° or 25° F.

JIM WELLS: When I was out at Dundee, we did quite a bit of storing cutting material and I had a room which was much as you described except that it was above ground and we never had one bit of trouble with material stored in it. It was kept at about 32° F and materials were held there for up to 2 months. I have also tried storing some materials in refrigerator at 33° F; in darkness they begin to deteriorate after about 2-2½ months.

CASE HOOGENDOORN: We have taken cuttings which are frozen, but we bring them in and dump them in a tub of water to thaw them out; it seems to work satisfactorily.

MODERATOR PINNEY: Thank you very much, Dick. Our next speaker is Richard Zimmerman of the U.S.D.A. We have had the privilege of hearing some of Dr. Zimmerman's cohorts at previous meetings, but today he is going to talk to us about shortening the juvenile phase in crabapple seedlings.

SHORTENING THE JUVENILE PHASE IN CRABAPPLE SEEDLINGS

RICHARD H. ZIMMERMAN

Agricultural Research Service
U.S. Department of Agriculture
Beltsville, Maryland

Seedlings of pears and apples, in common with those of many other tree species, have a juvenile phase lasting 4-5 years or more. This long period before the seedlings flower is a major hindrance to rapid progress in tree breeding programs, which require several seedling generations for success. This is especially true for the U.S. Department of Agriculture program to develop high quality pears resistant to fire blight. In order to develop methods for shortening the juvenile phase in pears, it became clear that we needed to understand better the nature of juvenility and its relationship to flower initiation. From a review of the literature, it also seemed clear that such research must be done with seedling trees since vegetatively propagated trees do not always respond to treatments in the same way as seedlings.

Pear seedlings are difficult to use in juvenility studies because of their genetic variability and because they are rather difficult to keep in active growth in the greenhouse for extended periods of time. However, some species of flowering crabapples were suited for this research because they are fairly closely related to pears and because they form seedlings by apomixis. This is a process by which seeds develop without fertilization so that the resulting seedlings are genetically identical. Five species of apomictic crabapples were tested for suitability and one, the tea crabapple (*Malus hupehensis* (Pamp.) Rehd.), was selected for the experimental work. The research went through several phases. At the beginning, growing conditions for relatively rapid flower initiation in tea crabapples were defined. Then methods were developed to bring them into flower and finally the growing conditions were continuously improved to shorten the time to flowering

For defining the basic conditions for tea crabapples to flower, three treatments were used (2). Seedlings transplanted to the nursery from the greenhouse 10 weeks after germination were about 1 m tall after two growing seasons. Seedlings grown in the greenhouse for 8 months, then hardened off and given cold treatment for 5 months before being returned to the greenhouse for another 6 months were nearly 2 m tall after two growing seasons. Seedlings grown continuously in the greenhouse for the same length of time (19 months) were nearly 4 m tall. Plants grown in the field had many long lateral branches. Those grown in the greenhouse for two seasons had a few long lateral branches which developed during the second season in the greenhouse. Those grown continuously in the greenhouse had only one or two short spurs. All the plants were transplanted to a permanent field location after the second growing season.

All the seedlings grown continuously in the greenhouse flowered after the second growing season and continued to flower every year thereafter. One-third of the seedlings grown for two seasons in the greenhouse flowered after the second growing season but it took four growing seasons before all flowered. None of the nursery-grown seedlings flowered after the second growing season, 20 percent flowered after the third season, and all flowered after the fourth season. From this experiment, it was clear that the juvenile phase could be shortened by growing the seedlings to get tall plants as quickly as possible.

The next step was to have the crabapples flower in the greenhouse. Seedlings were grown in the greenhouse for 10 months by which time they were more than 3 m tall. They were then hardened off, defoliated and given cold treatment for up to 10 weeks. The plants were returned to the greenhouse and were in bloom within 1 month, only 13 to 14 months after seed germination.

To eliminate having to move the plants to cold storage, I then tried using growth regulators on greenhouse-grown seedlings to induce buds to grow without chilling. Cytokinins, gibberellins, and mixtures of the two, were applied to buds with or without removing the leaves from the seedlings. After numerous trials, I found that a mixture of the cytokinin PBA (6-benzylamino-9-(tetrahydropyran-2-yl)-9H-purine) and gibberellins 4+7 applied in a lanolin fraction was most effective. Currently I am using 2000 ppm of PBA plus 250 ppm of GA_{4+7}. Using this technique, crabapple seedlings have had flowers open 9½ months after seed germination.

How are the crabapples grown to get this rapid flowering? In the greenhouse, seedlings are started in 2¼ inch peat pots and then are transplanted to 4", 6", and finally 8" plastic pots as necessary to prevent checking of growth by transplanting. During rapid growth, the plants are fertilized twice a week with a 20-20-20 water-soluble fertilizer (1.7 g / 1) but this is reduced to once a week when the plants are nearly full-grown. Supplemental lighting is used so that the plants are always under long-day conditions. Seedlings grown in this way will be 1 m tall in 20-21 weeks. They grow at the rate of 2 cm per day from the time they are 60-80 cm tall and maintain this growth rate for up to 20 weeks. Seedlings have been as tall as 3.5 m in 11 months.

Even more rapid growth can be achieved if the plants are started in growth chambers and moved to the greenhouse later. Standard growing conditions are a 16-hour photoperiod with a light intensity of 2000-2500 foot-candles, temperatures of 25° / 18° C. (77° / 64° F.) light / dark, and 65 percent relative humidity. The plants are fertilized with a dilute solution of 20-20-20 water-soluble fertilizer (0.1 to 0.25 g / l) up to 5 times per day. Seedlings grown in these conditions will be 1 m tall in 13-14 weeks and will be 3 m tall in 7½ months.

Earlier experiments (1, 3) showed that even more rapid growth can be attained when additional CO_2 is introduced into the growth chambers. About 2000 ppm CO_2 seems to be adequate but the temperature must be increased to 30° / 24° C. (86° / 75° F.) light / dark and additional fertilizer and water are necessary. Preliminary results indicate that seedlings should be able to attain a height of 1 m in 10-11 weeks.

On the original seedlings grown in the greenhouse, the transition from the juvenile to the mature phase took place at a height of 1.8-2.0 m above the cotyledonary node. As the growing conditions have gradually been modified and improved so that the plants grow more rapidly, this transition has taken place somewhat lower at a height of 1.5-1.6 m. If the plants are started in the growth chamber for up to 20 weeks, this height is reduced to 1.3 m. However, the first flower is formed at around node 75 whether the seedling is grown in the greenhouse, started and grown in the growth chamber before going to the greenhouse, or started in the greenhouse and later transferred to the growth chamber for varying periods of time. It now seems that the node number is a better estimate of the site of the transition from the juvenile to the mature state than plant height.

We now have a test plant which can be used as a tool to study the delicate process of transition from the juvenile to the mature state within a reasonably short period of time. It also provides us with readily identifiable leaf and flower buds in which we can study the chemical changes associated with the transition and hopefully discover those responsible for flower initiation. At the same time, nurserymen can adapt these growing techniques for production of seedling trees.

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BILL FLEMER: Would the maturity of a crabapple seedling be hastened by taking the leader and training it over into a horizontal position?

DICK ZIMMERMAN: No, we find that the best thing to do to hasten the flowering of seedlings is to get it to grow as rapidly as you can, as long as you can. Any procedure which checks the growth of the seedling will, in turn, delay the flowering of the seedling.

MODERATOR PINNEY: U.S.D.A. has certainly been a big help to us in our birch program and if any of you ever get to Beltsville, Maryland, you should certainly make it a point to stop in and see some of the interesting things they have going there.

Our next paper is a substitute for the paper listed on your program since the gentleman who was to present that paper has hurt his leg and will not be with us. The paper which will be given is by W. G. Ronald and W. A. Cumming. The work to be reported was done while Mr. Ronald was at the research station in Morden, Manitoba though, more recently, he has been spending some time at the University of Minnesota. The paper will be read by Mr. Herman Temmerman. under whose technical direction the experiments were carried out.

COMPATIBILITY AND GROWTH OF COLUMNAR EUROPEAN ASPEN ON POPLAR ROOTSTOCKS[1]

W. G. RONALD[2] AND W. A. CUMMING

Canada Department of Agriculture
Research Station, Morden, Manitoba

Hardwood or softwood cuttings of most poplars root easily with the exception of white poplars and aspens which belong to one section of the genus *Populus*. White poplars generally propagate easily by softwood cuttings and with more difficulty by hardwood cuttings; both softwood and hardwood aspen cuttings generally root poorly. Under natural conditions the aspens regenerate quickly from root suckers and seed.

Columnar European aspen (*Populus tremula* L. 'Erecta') is a valuable columnar clone that has proven difficult to propagate. Many attempts, by the authors, to root softwood cuttings have resulted in

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[1]Contribution No. 104 of the Canada Department of Agriculture, Research Station, Morden, Manitoba

[2]Present Address: Department of Horticultural Science, University of Minnesota, St. Paul, Minn 55101, U.S.A

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less than 10% success. Despite its value as a hardy upright poplar for northern areas, propagation failures have prevented wide commercial acceptance of this clone.

Propagation failures have stimulated research into aspen clonal propagation by greenwood cuttings (1), adventitious etiolated cuttings from root cuttings (1, 3) and tissue culture (5, 6). While these techniques have been successful with some clones, most utilize facilities not readily available to commercial propagators. The use of budding or grafting has apparently been little used for aspen propagation. Nelson (4), in a recent rootstock survey, recorded four reports of poplar grafting. Three reports concerned white poplar and aspen propagation; none recorded the propagation of columnar European aspen. One report recorded the use of *P. nigra* L. 'Italica' as a rootstock for *P. alba* L. 'Pyramidalis'. The existence of a *P. tremula*-*P. trichocarpa* L. graft was also recorded by Bortitz (2). These two rootstock-scion combinations, between two sections of the genus, indicate that intersection compatibility exists.

A propagation method based on the use of clonal rootstocks has definite merit in aspen propagation. The use of rootstocks would avoid persistant suckering evident in plants on their own roots. The development of clonal rootstock recommendations could apply in forestry for perpetuating and testing superior aspen clones. The basic requirements for a clonal rootstock are easy rooting ability and compatibility with the grafted or budded selection. This paper reports on the use of 8 clonal rootstocks and 1 seedling rootstock for clonal propagation of columnar European aspen.

MATERIALS AND METHODS

Budding. The first propagation attempt was made in August, 1968, when 10 buds were placed on rooted cuttings of Brooks #6. Early evidence of bud-rootstock union suggested that further testing was merited, using a wider range of rootstocks. In 1969, hardwood cuttings were prepared of Brooks #4 and #6 hybrids, *P. canadensis* Moench. 'Serotina de Selys', *P. deltoides* Marsh. var. *occidentalis* Rydb. 'Dakotah', *P. nigra* L. 'Thevestina', *P. acuminata* Rydb. and Manchurian poplar (*P. songarica* unknown). Cuttings were planted in early May for subsequent use in August budding. Seedling rootstocks of native *P. tremuloides* Michx. were obtained and tested in 1969. In 1970 five rootstocks that rooted well in 1969, were retested. T-budding was done early (August 8-12) and late (August 20-25) to test for ideal budding date. Ten rootstocks were budded on each date in all clones showing a high rooting percentage.

Grafting. Whip and tongue grafts of 7 cm (3") scions and 15 cm (6") unrooted hardwood cuttings of Brooks #4 and #6 were tested. Ten grafts in 1970 and 40 grafts in 1971 were made with each rootstock.

Completed grafts were stored in peat moss at 2° C until planted in nursery rows. At the end of the growing season the whip height and diameter at 12" above scion-rootstock union were recorded for both budding and grafting experiments.

RESULTS AND DISCUSSION

The combined results of rootstock rooting, bud take and bud growth in 1969 and 1970 are presented in Table 1.

Rooting of understocks. All clones rooted over 60% except 'Dakotah' which was tested only in 1969. This clone proved difficult to root in other trials carried out at Morden. The two Brooks clones rooted over 90% making them highly desirable as rootstocks.

Budding Date. The late August budding date produced superior stands. The later date appeared to produce better callusing around the inserted bud. Even with late August budding in 1969, a tendency was noted for some buds to commence fall growth.

Table 1. Results of two seasons of budding trials with columnar European aspen

Rootstock	Percent Rooting	Percent Bud Take: Early August Budding	Percent Bud Take: Late August Budding	Growth: Height (meters)	Growth: Diameter (cm)
Brooks # 4	94 2	36	75	2 3	1 65
Brooks # 6	95 2	52	88	2 3	1 67
P canadensis 'Serotina de Selys'	63 3	20	79	Incompatible	
P deltoides var *occidentalis* 'Dakotah'[y]	30 0	z	100	2 2	1 60
P songarica	76 6	None	None		
P nigra 'Thevestina'	76 6	15	40	1 2	81
P acuminata [y]	80 0	20	46	Incompatible	
P tremuloides [y]		20	26	2 4	1 89

[y]tested one year only

[z]not budded due to limited rootstock

Compatibility and Growth. Three clones proved unsuited as rootstocks. *P. acuminata* and 'Serotina de Selys' produced satisfactory bud stands but all whips died after reaching about 1 m in height during the first growing season. Manchurian poplar did not produce a successful union in two years of testing. Brooks #4 and # 6, 'Thevestina' and 'Dakotah' clones and seedling *P. tremuloides* proved compatible for two or more years. Due to poor rooting of 'Dakotah', testing of this clone was discontinued. Subsequent growth and compatibility indicate that further testing of related cottonwood clones is merited. 'Thevestina' rootstock has resulted in smaller whips than other compatible combinations which may be indicative of delayed incompatibility. *P. tremuloides* proved compatible and produced large whips. This species, closely allied to *P. tremula*, may have a limited use in propagation. However its tendency to sucker, seedling variation, and difficulty in obtaining rootstocks would appear to rule out its usefulness. Brooks #4 and #6 clones produced high bud stands and good growth. These rootstocks have not exhibited undesirable suckering tendencies. The whips from 1968 budding have continued to grow well for 3 years.

Grafting. The results of grafting scions to hardwood cuttings are presented in Table 2. This technique has merit as it may be a faster, less expensive operation. It is possible to produce a plant in 6-7 months using this method. A second year of growth resulted in well-branched plants 2 m or more in height. This is the first apparent record of the use of this method for aspen production.

Table 2. Grafting results obtained with columnar European aspen

Rootstock	Year	Percent Graft take		Height (meters)	Diameter (cm)
Brooks # 4	1970	40.0	1 yr	1.3	.95
″			2 yr	2.1	2.54
″	1971	12.5		0.4	.60
Brooks # 6	1970	20.0	1 yr	1.6	.97
″			2 yr	2.3	2.54
″	1971	47.5		0.4	.55

CONCLUSIONS

This study has indicated three rootstock-scion compatibility relationships: non-successful unions, incompatible unions and compatible unions. The most promising rootstocks on the basis of rooting, compatibility and growth are the two hybrid poplar selections Brooks #4 and Brooks #6. These two clonal rootstocks appear useful for the following reasons:

1) The problem of obtaining root pieces of columnar European aspen followed by subsequent propagation of new plants from root pieces or etiolated cuttings from root pieces is overcome.

2) They can result in well grown whips within one season of growth either by budding or grafting.

3) The suckering problem can be overcome by their use.

4) They preserve the clonal characteristic of columnar European aspen.

Research into a wider range of rootstocks and tests with scions of the two native North American aspens, *P. tremuloides* and *P. grandidentata* Michx., is currently in progress. Suitable clonal rootstocks could result in a much wider use of these interesting aspen species.

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MODERATOR PINNEY: Our next speaker is Chiko Haramaki, a personal friend of mine and a very interesting fellow who will be telling us about tissue culture of gloxinias.

TISSUE CULTURE OF GLOXINIA

CHIKO HARAMAKI

Department of Horticulture
The Pennsylvania State University
University Park, Pennsylvania

Gloxinia, *Sinningia speciosa,* does not come true when propagated by seed and new plants of a given cultivar are primarily obtained by leaf cuttings and occasionally by stem cuttings. This research was undertaken to see if gloxinia could be propagated by tissue culture and if so, would it be possible to rapidly multiply it under controlled conditions. During the last few years a number of herbaceous plants have been propagated by tissue culture, such as asparagus (13), carnation (1, 4), cattleya (11), chrysanthemum (5, 6), cymbidium (7, 12), dahlia (8), iris (2), potato (9), rhubarb (14), and strawberry (3).

This study was done in cooperation with Dr. Toshio Murashige who graciously invited me to work in his well-equipped, tissue-culture laboratories at the University of California, Riverside.

In the preparation of the plant the shoots were cut back to the tuber when it was found that all of these shoots were reproductive. The ideal stage for taking vegetative shoots was when the new shoots were from 4 to 5 cm long. The shoots were rinsed with tap water to remove any

Table 1. Murashige and Skoog's High Salt Medium.

Chemical	Conc. mg / l
NH_4NO_3	— 1650
KNO_3	— 1900
$CaCl_2 \cdot 2H_2O$	— 440
$MgSO_4 \cdot 7H_2O$	— 370
KH_2PO_4	— 170
Na_2-EDTA	— 37.3
$FeSO_4 \cdot 7H_2O$	— 27.8
H_3BO_3	— 6.2
$MnSO_4$ $4H_2O$	— 22.2
$ZnSO_4$ $4H_2O$	— 8.6
KI	— 0.83
$NA_2MoO_4 \cdot 2H_2O$	— 0.25
$CuSO_4 \cdot 5H_2O$	— 0.025
$CoCl_2$ $6H_2O$	— 0.025

continued

continued

Other constituents included

i-inositol	—	100	adenine sulfate	—	0-80
kinetin	—	0-30	$NaH_2PO_4 \cdot H_2O$	—	0-170
IAA	—	0-10	thiamine.HCl	—	0.4
IBA	—	0-3	sucrose	—	30,000
NAA	—	0-10	Bactoagar	—	6,000-10,000

debris and the lateral leaves were cut off. The 10 to 15 mm long trimmed shoots were placed in an antioxidant solution until they were ready to be disinfected in a 5% liquid chlorine bleach solution for 5 minutes. The shoots were then rinsed several times with a sterile antioxidant solution. In the transfer chamber a 1 to 2 mm apical section of the shoot tip was excised and placed in the culture tube. Axillary buds from large shoots were tried but it was found that they tended to oxidize too rapidly.

The medium used was the Murashige and Skoog (10) high salt medium adjusted to pH 5.7.

The cultures were placed under standard conditions of 25° C with 16 hr of 100 ft-c of Gro-lux illumination per day.

A number of apical shoot tip experiments were conducted, among them a variation in concentration of different auxins, kinetin concentration, photoperiod, and light intensity. Other experiments were conducted on rooting shoots from these cultures *in vitro* and then transplanting them into pots.

Effect of NAA Concentration. Experiments were conducted on the effect of varying NAA concentration on the growth of excised gloxinia shoot tips. Tables 2 and 3 show the results of these experiments, 2 and 6 months, respectively, after the cultures were started.

Table 2. Effect of NAA Concentration on the Growth of Excised Gloxinia Shoot Tips (Kinetin, 10 mg/1).

NAA (mg/l)	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots
0.0	15.0	2.0	0
0.1	9 1	2.3	0.6
0.3	2.3	0	0
1.0	2.2	0	0.8
3.0	1.3	0	9 8
10.0	0.3	0	2.8

The number of usable shoots for rooting was highest where there was an absence of NAA and decreased as NAA concentration increased. The cultures tended to be all callus as the NAA concentration increased, although callus was present in all cultures.

Table 3. Effect of NAA Concentration on the Growth of Excised Gloxinia Tips (Kinetin, 2 mg/1).

NAA (mg/l)	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots
0.0	101.3	2.9	320.9
0.1	34.4	3.4	219.3
0.3	81.6	2.0	309.7
1.0	22.5	1.8	187.5
3.0	15.6	0.4	143.0

After 6 months the cultures also tended to have the most usable shoots where there was an absence of NAA and least where it was the highest.

Effect of IAA Concentration.

Table 4. Effect of IAA Concentration on the Growth of Excised Gloxinia Shoot Tips.

IAA mg/l	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots
0	11.6	2.0	43.0
0.1	108.4	4.2	322.4
0.3	57.6	1.7	182.7
1.0	34.3	1.0	113.3
3.0	86.3	6.7	260.2
10.0	18.5	2.0	53.3

The IAA concentration was varied from 0 to 10 mg/l and after 5 months it was noted that the cultures with the largest number of usable shoots had 0.1 mg/l of IAA, (Table 4).

Effect of Kinetin Concentration.

Table 5. Effect of Kinetin Concentration on the Growth of Excised Gloxinia Shoot Tips (IAA, 0.1 mg/1).

Kinetin (mg / l)	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots
0.0	1.0	0.3	5.7
0.3	1.2	0.7	5.2
1.0	3.3	1.2	5.5
3.0	5.0	1.2	8.4
10.0	68.8	6.6	168.0
30.0	229.3	17.3	225.8

The number of usable shoots, tubers and roots per culture increased as the concentration of kinetin in the medium increased. The cultures without kinetin had little or no growth and were approximately 5-10 mm wide. The original explant was readily visible in these cultures and the foliage was reddish green. As the concentration of kinetin increased the plant size also increased. The cultures with 30 mg / l of kinetin were approximately 25 x 65 mm and had green foliage.

Effect of Photoperiod. The excised shoot tips were grown under treatments from continuous darkness to that of continuous light with increments of 4 hr of light between each treatment. The cultures under total darkness were etiolated. The shoots were white and elongated with small yellow leaves; the callus was large and white. The cultures with 8 hr or less of light still showed some signs of etiolation such as their elongated stems and small leaf blades. As the length of the photoperiod increased the leaves tended to be thicker, stouter, larger and darker.

Effect of Light Intensity.

Table 6. Effect of Light Intensity on the Growth of Excised Gloxinia Shoot Tips.

Light Intensity (ft-c)	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots	Callus Present
0	9.8	1.0	0	10 / 10
30	52.1	2.4	51.8	10 / 10
100	49.1	3.6	91.8	6 / 8
300	17.0	1.4	100.1	0 / 9
1000	1.2	0.3	0	0 / 10

The cultures growing without light were etiolated. The leaf blades were small (1 x 1.5 mm) and yellowish-green and there was a larger amount of tuber-like callus which was a translucent, whitish-yellow.

The plant and leaf size increased up to 300 ft-c of light and leaf color darkened with an increase in light intensity. Some of the newer leaves were quite large (20 x 25 mm) but the average leaf blade was 12 x 12 mm. The cultures under 1000 ft-c of light had small (1.5 x 2 mm), yellow or purple-brown leaves and had very little growth. Callus was present in all of the cultures growing without light and at 30 ft-c, but was absent in all of the cultures growing under 300 and 1000 ft-c of light.

Rooting of Cultured Shoots. Shoots 5-10 mm in length were transferred to media with varying concentrations of IAA (Table 7).

Table 7. Effects of IAA on the Rooting of Cultured Gloxinia Shoots.

IAA (mg / l)	$\bar{X}$ No. of Roots
0.0	6.6
0.1	7.8
0.3	11.9
1.0	14.9
3.0	11.0

The cultured shoots growing in the medium with 1 mg / l of IAA had the most rooting after 3 weeks.

Effect of Plant Part on Rooting. It was found that a single node section of a cultured shoot rooted and grew as well as an entire cultured shoot (Table 8) when transferred to a rooting medium.

Table 8. Effect of Plant Part as a Propagule.

Plant Part	$\bar{X}$ No. of Shoots	$\bar{X}$ No. of Tubers	$\bar{X}$ No. of Roots
Shoot	2.3	0.4	12.7
Single Node	2.1	0.6	22.9

After 4 weeks the cultures from the single node sections had approximately the same number of shoots and tubers but had a decidedly larger number of roots.

Effect of Transplanting Treatments. Rooted cultured shoots were removed from the culture tubes after 4 weeks. The shoots were well rooted and were approximately 25 x 30 mm in size. The agar which was attached to the roots was carefully removed. The rooted shoots were transplanted in either a 1:1 peat and perlite soil mix or a 1:2 peat and vermiculite soil mix in peat pots. The transplants were placed in either an 80% shade saran tent, 4 mil polyethylene sheet tent, or under intermittent mist. All of these treatments were in shaded greenhouses. The plants were examined 2 weeks after transplanting (Table 9).

Table 9. Effect of Humidity Control and Soil Mix on the Growth of Transplanted Cultured Gloxinia.

Treatment	No. of Plts. Trans-planted	No. of Plts. Dead	Plant Injury *	Plt. Width (mm)
Saran shade				
— peat and perlite	10	0	0	40.0
— peat and vermiculite	10	0	0.4	42.0
Polyethylene tent				
— peat and perlite	10	1	0.5	51.1
— peat and vermiculite	10	0	0	50.0
Intermittent Mist				
— peat and perlite	10	0	0.8	26.5
— peat and vermiculite	10	0	1.0	33.5

* 0—no injury, 5—dead.

The plants under the saran shade in both soil mixes had good green color, were low and flush to the soil and were well rooted. The plants under the polyethylene tent all looked good, but were taller and spindlier than those under the saran shade or intermittent mist. The leaf color was a slightly lighter green. The plants were well rooted. The plants under the intermittent mist had fair to good growth but the leaves were dotted with small black necrotic spots. The plants were also well rooted. The soil mix used didn't appear to have any affect on the growth of the gloxinias.

Selected and desirable cultivars of gloxinias can be rapidly multiplied by the use of tissue culture. With the use of Murashige and Skoog's high salt medium plus other constituents it is possible to culture the shoot tip apex to produce large numbers of shoots. These cultured shoots and nodes will root readily. They are easily transplanted to artificial soil mixes under conditions of low light intensity and high humidity. It is possible to obtain 500 or more plants from a single shoot tip culture by using both shoots and single node sections.

Cultured plant parts can also be repeatedly recultured in a high shoot producing medium, thus increasing many fold a highly desirable cultivar of gloxinia in a short length of time.

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MODERATOR PINNEY: Unfortunately, we are out of time and so we will have no questions directed to Chiko. I do want to thank all of the speakers; they had interesting papers, they were well presented, and we kept right to the schedule. At this time I will turn the program back to you, Bill.

MODERATOR FLEMER: Once again, thanks to the participants of the Speaker-Exhibitor Symposium and to you, President Pinney for serving as moderator.

We will move on now to a subject to which I feel many of us in this Society pay too little attention, and that is the methods of keeping cost records in propagation. We do have an expert to talk to us on that subject; Ralph Shugert of Spring Hill Nurseries.

RALPH SHUGERT: Before I present my paper, I wish to take the prerogative as President of the International Society to extend to our members an invitation, and I have asked Editor Stoltz that this invitation be placed in the Proceedings of this meeting.

Williamsburg, Virginia's Colonial Capital, is only about 40 miles away. Many of you have visited Williamsburg. Others who have not are, no doubt, familiar with the restoration of Williamsburg to its 18th century appearance by Mr. John D. Rockefeller, Jr. The fame of Williamsburg, its historical heritage, buildings, gardens, craft program, collections of antiques, and research program are widespread.

Though perhaps not often thought of as such Williamsburg, including the campus of the College of William and Mary, is a vast arboretum containing one of the most outstanding collections of plant material in this country. This expanding collection utilizes, in the historic areas, only plants native to the region or known to have been introduced before 1800. The collection of native southeastern woody plants will soon include virtually all of the trees, shrubs, and woody vines native north of peninsular Florida. Outside the historic areas a wide variety of modern plant material is cultivated and much of it is labeled. Many plants used in Williamsburg are at their northern limits and are quite unfamiliar to most northern visitors. Many unusual plants are growing on the William and Mary campus including large specimens of *Sequoia sempervirens* and, perhaps, the largest Metasequoias in the U.S. The collection of boxwood is outstanding. Dr. J. T. Baldwin, Professor of Botany at William and Mary College is one of the world's leading authorities on *Buxus*.

All in all, the results of horticultural experimentation and introduction, whose roots go back over 300 years awaits you in Williamsburg. Bob McCartney, on behalf of the Colonial Williamsburg Foundation and its Department of Landscape Construction and Maintenance, extends to each of you an invitation to visit Williamsburg before you leave for home.

METHODS OF KEEPING COST RECORDS IN PROPAGATION

RALPH SHUGERT

Spring Hill Nurseries, Inc.
Tipp City, Ohio

When I first started thinking about this very important topic, I was almost certain that there would be very, very few references in past volumes of our Proceedings. My, how mistaken I was! At the Eighth Meeting of our beloved Society, Henry Weller (5) told us that being aware of the cost of production, and doing something about it, is just as important to the nurseryman as the "know-how" of propagation. Then in 1962 in Cincinnati, Ohio, George Oki (1) traveled from Sacramento, California to share with us the importance of daily, weekly, monthly and annual records. When you review this outstanding paper, you can see appended to the paper the various forms that George uses at his outstanding nursery. Apparently there were some members stimulated by this report because the following year, in my hometown of St. Louis, Missouri, there was a round table discussion entitled "Cost Control in Propagation" (3). The recorder of this discussion, Wayne Lovelace (a former co-worker of mine), tells of the interest in our topic of the afternoon and some data recording techniques. The next step in research finds us in Sacramento, California—this time the guest of George Oki as we tour his nursery and we learn more about his IBM equipment (4). It is apropos to quote Ed Kubo's comments at this meeting when he said, "The only logical way to improve our efficiency and reduce our cost of production is to keep comprehensive records". And this, my friends, is the key phrase...comprehensive records! Then finally, in 1966 at that beautiful meeting in Newport, Rhode Island, our good friend, Jim Wells (6), presented all of us with a formula of taking our direct labor cost and multiplying by four to arrive at a total plant unit cost. There are several nurserymen in this room today who have, and are, using those words to good advantage. So we have gone back through some of our own previous Proceedings and, indeed, we have had a considerable amount of discussion pertaining to costing in propagation.

Now, what about today, and are cost records really important? Does it really make any difference how much it costs us to root a *Taxus* cutting? You know, as incredible as it sounds, there are nurserymen—although I hasten to say none in this room—who price their plants from competitors' catalogs! The thought has passed through my mind, from time to time, if some poor soul used four or five typographic catalog errors as a guidepost, he would be bankrupt at the end of the season! I have shown the ridiculous in hopes to reach the sublime—the exact per unit cost of each and every plant we produce! If anyone in this room today thinks that this is an impossibility, they are unequivocally incorrect! This will cost money, rather like the old saw that one must spend money to save money. The expenditure, or the increase in overhead, will come about from the key in determining unit costs and that key is keeping accurate, careful records, and the realistic evaluation of those records.

When I mentioned to Bill Snyder that I was presenting a paper on this topic, he asked if I could take one specific plant and cost it out all the way. Bill, I wish I could, but at Spring Hill Nurseries we haven't reached the exact unit cost at this date. Our plans for the immediate future include, among other things, a card which is shown in Figure 1. This card shows the following: a Block Number and a specific plant (Product) within that unit block. *Materials,* which would include things such as spray and fertilizer used in that block. *Task Performed,* the labor used in the maintenance of that particular plant. *Equipment Used,* this, of course, would be tractor, mower, spray rig, etc. *Labor Uses,* this column will show the name of the employee, the hours worked and, of course, his hourly rate; and the final item on the card shows *Planting and Harvesting,* the number of plants planted, the number of plants dug, and the *Amount* column to correspond with this. With this card, we are hoping to update our existing program. At present, we have 23 job classifications which include the various office breakdowns. This information is affixed to the daily time card and, as our payroll goes to the computer for fulfillment, we are also able to get a dollar breakdown, by the computer, as to the amount of dollars spent in each numbered classification. Since we are primarily a retail mail order nursery, this information can give us, among other things, an exact cost-per-order, the function of that order, the variable direct-labor costs year to year. We can take this information and attribute back to catalog costs an exact dollar and cents figure. In other words, we know exactly the cost of shipping an order to the tenth of a cent.

The reason we are going to enlarge upon our existant system is that we wish more information than we are presently receiving. Whether we will get down to the point of knowing exactly what each perennial, for example, might cost us is problematical. But we do think that we can, through better record keeping, justify a decision as to whether we should grow a particular plant or purchase it on the market.

In discussing this paper with our Comptroller, Mr. Vincent Hinde, he made the comment that he feels there are quite a few nurserymen today who are "living on their depreciation". It is his belief that once we start the more detailed costing techniques, we can then, after perhaps a 5 year period, come up with a history of specific plants. We also will be able to justify the costs of problem plants, and this will allow management to decide whether the plant should be grown locally or whether we should abandon that particular plant and have it grown for us on contract.

The history of the nursery community shows that successful nursery owners normally have somewhere in their organization an individual who has an intuitiveness which enables him to make a decision as to the growing or buying of a particular plant. It has been said that the cost of maintaining records and data will not justify the means. We have heard this philosophy uttered at various I.P.P.S. meetings, and there is some discussion pertaining to this virtually every year during the Question Box Session. My personal belief is that if we could come close to an exact cost in a particular block of plants, we will have the battle won. An interesting theory was presented which was labeled the "Barberpole" method of record keeping. This would merely be the setting of four posts in a block of any plant, and from the time the ground was prepared for planting through the final harvest, all functions within that particular block were noted on a card affixed to one of the poles. This is certainly not very sophisticated, but if everyone working within the confines of those four poles would jot down the information, you certainly would come up with an excellent per-unit cost factor. If someone would be interested in following this through, it might be one of many points to take home from this meeting because it certainly could be set up in an unsophisticated manner, but the information would be available.

I would mention again that the importance of the record cannot be underestimated. This is not a procedure that is going to be reconciled in a one year period, because I believe that a history is extremely important. Unfortunately, everything must have a starting point and if costing is important to you as an integral part of your profit picture, then you must start and there would be no better time to start than January 1. From that date on, every function performed by every employee of your nursery is recorded daily, weekly, monthly and, of course, annually. Records are meaningless unless they are evaluated. You can have volumes and volumes of paper but unless it is evaluated it means nothing.

In preparing this paper, I contacted several Society members and I would at this time like to acknowledge a letter and form received from Peter Orum of the D. Hill Nursery of Dundee, Illinois. Peter said that certainly costing can be obtained and he also added and I quote, "The big question is how to get the figures into the accounts and that is what is difficult". He also pointed out that one of his tasks this winter is to work out a usable system for getting the square foot price into his cost accounting. I believe that he has a very workable plan and one that would be of great benefit.

There isn't a formula that one can use (other than the formula that Jim Wells has reported, which I alluded to earlier). I think in many operations if a formula could be determined, this certainly would be ample. The value of the record and its evaluation is paramount. I wish that I could give each of you a formula that you could take home and apply very simply to your operation but it is an impossibility.

In summing up I think there are a few basic steps which one must take if he wishes to explore the costing techniques in his personal nursery operation:

1. From the date you decide on a program, you must record every employee's function throughout the day. It is not too difficult to derive fixed costs, such as the typical overhead expenditures of taxes, water heat, light, etc., but we must have a labor breakdown, knowing what our direct labor costs are. If we do no more than derive a direct labor cost and multiply by a factor, such as Jim Wells has done, we are at least on the right track.
2. If we then wish to explore further, we can take our direct labor, convert it to individual blocks of plants and, dependent upon the efficiency of your record keeping technique, follow through to an individual unit plant within that particular block.
3. It is not necessary in a modest nursery operation to have this information computerized. Naturally, the computer will save many man-hours of time, but if one is not presently using the computer for payroll, inventory control, or sales information, then the data can be assimilated by hand as part of an office technique. In some cases this could well mean one more office employee for the year who would be devoting perhaps 80 percent of his time to record evaluation.

We are in an era today, and it will increase rather than decrease over the next decade, where we must have available to us more information as to profit and loss. The day of looking at the bottom line of a financial statement and determining whether we made a profit or a loss is not sufficient. I urge all of you to do what you can in evaluating your individual nursery program to determine the direction in which you go. It is ridiculous for members of the nursery community to operate year in and year out on a 2, 3 or 4 percent net return on their investment. Life is too short for this type of venture.

Throughout this paper the name of George Oki has arisen several times, and I would like to quote him one last time in a statement which he made last year at our joint meeting in St. Paul, Minnesota (2). George said the following:

> "Profit-mindedness is an absolute necessity for success and the good executive is constantly aware of the need to keep costs down and production and sales up. He thinks, decides, and acts to the end that the company will earn a fair profit—a fair return on the capital that has been invested in it so that the company can continue to operate, grow, and expand."

This, ladies and gentlemen, is the end result of accurate records properly evaluated. As calloused as it may sound, we are all in

Block ____________________

Product ____________________

Date ____________________

MATERIALS

	TYPE	AMOUNT
1		
2		
3		
4		
5		

TASK PERFORMED

1 ____________________

2 ____________________

3 ____________________

EQUIPMENT USED

	TYPE	TIME
1		
2		
3		

LABOR USES

	NAME	HOURS
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

PLANTING – HARVESTING

	TYPE	AMOUNT
No Planted		
No Dug		

Foreman ____________________

Fig. 1. Card system used by Spring Hill Nurseries to keep records on cost of production.

business for one reason and that is to make a profit. We cannot do this without accurate, meaningful cost data. We can do it and every one of us in this room should do it.

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MODERATOR FLEMER: Thank you very much, Ralph. I, for one, will be looking forward to next year's Proceedings which will carry copies of the forms you described for record keeping. There will be no time for questions at this time, though you can put them in the "Question Box" to be answered tonight.

No doubt, you have all received releases from the U.S.D.A. and the National Arboretum describing new plants being developed there. The National Arboretum is very actively concerned in a woody plant breeding program and the man largely responsible for many of the successes is Dr. Donald Egolf who is here this afternoon to describe and show us slides of many of these new cultivars.

THE EVALUATION AND PROPAGATION OF NEW CULTIVARS DEVELOPED AT THE U.S. NATIONAL ARBORETUM

DONALD R. EGOLF

U.S. National Arboretum
Agricultural Research Service, U.S. Department of Agriculture
Washington, D. C.

The U. S. National Arboretum, Washington, D.C., has become a major center for the development, evaluation, and distribution of woody ornamental cultivars. A new cultivar may arise as a selection from a seedling population derived from introduced seed, a naturally occurring or induced mutant, or a hybrid resultant from controlled pollination. The early hybridization work of B. Y. Morrison, who produced the vast array of Glenn Dale azaleas (18); and of O. M. Freeman, who produced *Magnolia* x 'Freeman' and 'Maryland' (11, 17), has been expanded in the last 15 years to encompass a major shrub breeding project and more recently a tree breeding project. From these research programs some 40 cultivars have been introduced and numerous seedling selections made which will yield superior shrub and tree cultivars in the future.

The development of a new cultivar by hybridization requires not only a minimum of 8-10 years for a shrub and many more years for a tree, but also a great expenditure of funds. Briefly, the current procedure of cultivar introduction into the nursery trade, and subsequently to the consumer, is as follows:

1) Hybridization, seedling production, and initial seedling selection research is conducted at the U. S. National Arboretum.

2) The seedling is propagated and sent to cooperators in other geographic regions for evaluation under a Standard Memorandum of Understanding for Evaluation of Potential New Cultivars of Ornamental Shrubs and Trees.

3) Propagation stock of the seedling selection to be introduced is distributed by the National Arboretum under number or cultivar name to cooperating wholesale propagation nurseries for volume stock increase under a Standard Memorandum of Understanding for Increasing the Planting Stock of Vegetatively Propagated Stock.

4) The selected plant is given a cultivar name that is registered and published, and official release made by the Plant Science Research Division of the Agricultural Research Service, U. S. Department of Agriculture

5) After stock increase, publicity in the form of brief, factual information is released by the National Arboretum to the trade journals.

6a) The cultivar is released for distribution by cooperating wholesale propagation nurseries to other wholesale and retail nurseries.

6b) The cultivar is distributed by the National Arboretum to cooperating arboreta, botanic gardens, and research institutions.

7) When a cultivar is listed in at least three retail nursery catalogs, the A.R.S. Information Div., U.S. Department of Agriculture, distributes press releases to publicize the merits and the availability of the cultivar to the consumer.

PROPAGATION OF NEW CULTIVARS

With few exceptions, the cultivars released to date by the National Arboretum are readily propagated utilizing softwood or semi-hardwood cuttings under mist as would be standard propagation practice for the species. However, a few comments would be in order for several of the cultivars.

The crape-myrtle cultivars are easily propagated by softwood, hardwood, or root cuttings. Softwood cuttings will root under mist in 3 weeks. Hardwood cuttings can either be rooted in the usual manner in cold frames in late fall and early winter, or placed horizontally on the propagation media in a warm greenhouse in mid-winter to vegetate. When the young shoots that form abundantly along the hardwood cutting are several inches long, they are removed and handled as softwood cuttings. The same hardwood cutting will produce a sequence of shoots that can be periodically removed and rooted.

Hibiscus rosa-sinensis 'Vulcan' and *H. syriacus* 'Diana' can be readily propagated by cuttings or grafting, but if grafted on stock of the same species, a salable plant will be produced more quickly. Mature wood will root, but will take much longer and will not produce as vigorous a plant as softwood cuttings.

The magnolia cultivars are best propagated by softwood cuttings, but success is dependent upon the condition of the cutting. *Magnolia* x 'Freeman' is more readily propagated from cuttings taken from immature plants. The deciduous magnolia cultivar cuttings are best taken very soft before the terminal bud has set. The softwood cuttings under interrupted mist will root in 6-8 weeks.

Pyracantha x 'Mohave' and 'Shawnee' both root readily and can be propagated by softwood, semi-hardwood, or hardwood cuttings. 'Mohave', in particular, is easily propagated and rapidly produces vigorous plants.

In general, the viburnum cultivars are best propagated as softwood cuttings under mist in early summer. If the cuttings are rooted early and kept under long days of at least 18 hours from mid-July until a second flush of growth has been produced, they will have a well established root system and sufficient growth to over-winter in cold frames. Late season propagations result in plants that will not have growth hardened to withstand freezing and must be over-wintered in a cool greenhouse. *Viburnum* 'Mohawk' and 'Cayuga' can be readily propagated only when growth is very soft and before the terminal flower buds have been initiated. These two cultivars can be satisfactorily over-wintered if given long days to maintain the rooted cutting in vegetative growth until the second flush of growth.

DESCRIPTIVE COMMENTS OF NEW CULTIVARS

A brief description of each of the cultivars released by the U.S. National Arboretum follows. The N.A. number refers to the National Arboretum accession number, and the P.I. number refers to the plant introduction number assigned by the New Crops Research Division of the Agricultural Research Service. The hardiness zone of each, as indicated after the P.I. number, is based on the Plant Hardiness Zone Map, U.S.D.A. Misc. Publ. No. 814. All color designations are according to the Royal Horticultural Society Colour Chart, 1942 and 1966. Additional descriptive botanical details may be located in the original reference citation indicated after each cultivar name. (The following cultivars were illustrated with Kodachrome slides):

1.) *Hibiscus syriacus* L. 'Diana' (Egolf) *Baileya* 17(2):75-78. 1970. N A 32224. P.I. 347257. Zone 5.

'Diana' is a triploid from a cross of a tetraploid seedling with white petals and red eye spot and a heavily ruffled diploid white seedling selection made in 1963 It is being introduced because of its waxy, heavy textured, wide spreading, up to 6-inch diameter, ruffled, pure white flowers that remain open for more than one day; heavy, dark green leaves, dense branching; and compact, upright growth habit Since 'Diana' is a triploid, there is little or no seed production The majority of the flowers drop immediately after withering with the result that flower bud initiation is never inhibited, and the plant continues to flower freely until autumn 'Diana' in 8 years has developed into a dense, upright shrub that is now 8 feet high and 6 feet wide

2.) *Hibiscus rosa-sinensis* L. 'Vulcan' (Egolf) *Baileya* 14(2):47-49 1966 N A 28178 P I. 315886 Zone 9b

'Vulcan' resulted from a cross of *H r-s* 'Fire Chief' x *H.r-s* 'Mason Red' made in 1963. It is a subtropical shrub of medium upright growth, with thick, leathery leaves Flowers are 5-7 inches in diameter, blood red (Blood Red 820/1, Blood Red 820), with yellow (Yellow Ochre 07/1 to Chrome Yellow 605/1) reverse that does not fade; of excellent form and substance; and persistent for more than a day except in extreme heat. It has grown well in sun or shade Plants grown outdoors produce flowers and leaves somewhat smaller than when grown in the greenhouse 'Vulcan' is a semi-tropical plant which can be grown only in areas similar to Florida and Southern California where *H. rosa-sinensis* is hardy

3) *Ilex crenata* Thunb 'High Light' (Kosar). *Proc. 37th Mtg., Holly Soc. Amer.* P 5 1964 N A. 16473. P I. 316588 Zone 6.

'High Light' is a male selection from a branch mutation of *I. c* 'Microphylla' made in 1956 by W. F. Kosar. The cultivar may be distinguished by its broadly pyramidal growth habit, boxwood-like textured foliage; dark green leaves, 1 inch long and ⅜ inch wide, and twiggy branching that gives the mature plant a billowy appearance. The plant is as hardy as *I. c.* 'Microphylla'. During the past 15 years at the National Arboretum the cultivar has grown to 13 feet in height and 11 feet in width The plant with the aspect of boxwood is best used as a specimen in the landscape.

4) *Ilex* x 'John T Morris' (Skinner). *Proc. 31st Mtg., Holly Soc Amer.* P. 11 1961 N A 12201 P I 267825 Zone 7a

'John T Morris' is a male selection from a cross of *I. cornuta* Lindl. 'Burfordii' x *I. pernyi* Franch. made in 1948 by H T. Skinner at the Morris Arboretum, Philadelphia The rich, glossy, dark green, leathery leaves, which are 1¼-1¾ inches long and 1 to 1½ inches wide, have 5-7 deep lobes ending in stiff spines The original plant, now 15 feet high and 12 feet wide, has a symmetrical, conical growth habit It is suitable for the small residential garden and hedges

5) *Ilex* x 'Lydia Morris' (Skinner). *Proc. 31st Mtg , Holly Soc. Amer.* P 11 1961 N A. 12202 P I. 267824 Zone 7a.

'Lydia Morris' is a female selection from the same cross as 'John T Morris' The cultivar has abundant ⅜ inch diameter, cardinal red (Orange Red 34A to 33A) berries that ripen in November and persist until mid-winter and are spectacular against the glossy, dark green leaves The original plant has a symmetrical, conical growth habit that is 12 feet high and 8 feet wide

6) *Ilex* x 'Accent' (Kosar) *Proc. 41st Mtg , Holly Soc. Amer.* P 13 1966 N A 28260. P I 329154 Zone 7a?

'Accent' is a male selection produced by the hybridization of *I. integra* Thunb x *I. pernyi* Franch. by W. F Kosar in 1960 The cultivar is a single-stemmed, evergreen shrub of narrow, conical growth habit with dark green, fine textured foliage. The leaves are elliptic, ⅝ to 1¾ inches long and ⅝ to ⅞ inch wide, with 3 to 4 soft small spines on each margin. In 11 years the plant has grown to 8 feet in height and 3 feet in width It was introduced as a pollinator for 'Elegance', as well as for an accent plant in the landscape.

7.) *Ilex* x 'Elegance' (Kosar) *Proc. 41st Mtg., Holly Soc Amer.* P. 13 1966. N A. 28261 P I 329153 Zone 7a?

'Elegance' is a female selection from the same F_1 seedling population as 'Accent', with similar foliage and growth habit The cultivar has fruit ⅜ inch in diameter that ripens as early as October to red (46B). The original plant in 11 years has grown to 8 feet high and 2 feet wide

8.) *Ilex* x 'Oriole' (Kosar). *Proc. 41st Mtg., Holly Soc. Amer.* P. 13. 1966. N.A. 28322. P.I. 329156. Zone 7a.

'Oriole' is a female selection made by W. F. Kosar in 1956 from an F_2 population resulting from a sibling cross of an F_1 *Ilex myrtifolia* Walt. x *I. opaca* Ait. hybrid produced by H. T. Skinner in 1949. The cultivar is a compact, slow-growing, fine-textured, red fruited plant. The thick, leathery leaves that resemble *I. myrtifolia*, are 2 to 2¾ inches long and ½ to ⅝ inch wide with 3 to 4 small spines on the upper half of each leaf margin. The fruit is 7/16 of an inch in diameter and bright red (Red 46B to Orange Red 33A). The original plant has attained a height of 5 feet and a width of 6 feet in 15 years.

9.) *Ilex* x 'Tanager' (Kosar). *Proc. 38th Mtg., Holly Soc. Amer.* P. 12. 1965. N.A. 28323. P.I. 329155. Zone 7a.

'Tanager' is a female selection of the same origin and of similar growth habit to 'Oriole'. It differs in that the fruit is more like *I. myrtifolia*; 5/16 of an inch in diameter; bright red (Red 45A to Red 40A); and more exposed on the branches. The original plant is a globose shrub that in 15 years has grown to 6 feet high and 7 feet wide.

10.) *Lagerstroemia indica* L. 'Catawba' (Egolf). *Baileya* 15(1):8. 1967. N.A. 28861. P.I. 316671. Zone 7b.

'Catawba' is a selection from a cross of *L. i.* 'Dwarf Purple' x *L. i.* 'Light Lavender' made in 1960. The abundant, compact inflorescences are borne on terminal and lateral branches over the entire plant from late July to September with scattered recurrent flowering. The dark purple (Violet Purple 733/1) inflorescences are complemented by the glossy, dark green foliage. The glossy, thinly coriaceous foliage is resistant to mildew, and in autumn turns a brilliant orange-red. Growth habit is compact and globose that in 11 years has grown to a height of 10½ feet and a width of 11 feet.

11.) *Lagerstroemia indica* L. 'Cherokee' (Egolf). *Baileya* 17(1):1-2. 1970. N.A. 30167. P.I. 326427. Zone 7b.

'Cherokee' resulted from a cross of *L. i.* 'Hardy Red' x *L. i.* 'Low Flame' made in 1960. The cultivar is introduced because of its brilliant red (Red Purple 63A) florets that begin to open in late July and maintain a good recurrent display through September. The compact panicles are borne in abundance on terminal and lateral branches over the entire plant. The red flowers are complemented by the dark green, glossy, thinly coriaceous leaves. The compact plant in 11 years has grown to a height of 8 feet and a width of 7½ feet.

12.) *Lagerstroemia indica* L. 'Conestoga' (Egolf). *Baileya* 15(1):8-10. 1967. N.A. 28862. P.I. 316672. Zone 7b.

'Conestoga' resulted from a cross of *L.i.* 'Alba' x *L.i.* 'Low Flame' made in 1960. This selection has consistently produced abundant, long-tapered inflorescences that arch gracefully outward each season The flowers, which open lavender (Phlox Purple 632/2, 632/3, and lighter on the same inflorescence) and change to pale lavender, produce a multiple-colored inflorescence Flowering begins in mid-July before most crapemyrtle cultivars are in flower and continues over a period of 2 months. The heavy foliage is only slightly susceptible to mildew. 'Conestoga' has an open growth habit that in 11 years has grown to a height of 10 feet and a width of 14 feet.

13) *Lagerstroemia indica* L. 'Potomac' (Egolf) *Baileya* 15(1):10-12 1967. N A 28863. P.I 316673 Zone 7b.

'Potomac' was selected in 1962 from an *L. indica* seedling population treated with colchicine Each season the cultivar has consistently produced abundant flowers which begin to open in mid-July with recurrent bloom until October. The flowers, in large, terminal panicles, are clear medium pink (Phlox Pink 625/1). The dark green, leathery leaves are highly ornamental, with only slight mildew susceptibility late in the season The vigorous, upright growth habit indicates that the plant will develop into a large, tree-like specimen In 12 years the plant has grown to a height of 15 feet and a width of 13 feet

14) *Lagerstroemia indica* L 'Powhatan' (Egolf) *Baileya* 15(1).12-13. 1967 N A 28864 P I. 316674 Zone 7b.

'Powhatan' resulted from a cross of *L.i.* 'Dwarf Purple' x *L.i.* 'Light Lavender' made in 1960. The light lavender (Imperial Purple 33/1 with base slightly darker) flowers begin to open in late July and continue to provide a good display until late September The glossy, thinly coriaceous leaves are highly tolerant to mildew 'Powhatan' is a dense, globose plant that in 11 years has grown to a height of 10½ feet and a width of 10½ feet.

15) *Lagerstroemia indica* L 'Seminole' (Egolf) *Baileya* 17(1)·2-5. 1970. N A 30166 P I 326426. Zone 7b

'Seminole' resulted from a cross of *L. i.* (hardy pink) x *L. i.* 'Low Flame' made in 1960. 'Seminole' was introduced because of its clear, medium pink (Red Purple 67B, base 59C to lighter shade 64D) flowers that begin to open in mid-July with recurrent bloom until October The dense, dark green leaves are thick, leathery, and highly ornamental. The dense, globose plant in 11 years has grown to a height of 8½ feet and a width of 8½ feet.

Magnolia

The eight deciduous magnolia cultivars are all sterile F_1 triploid selections that resulted from hybridization of *Magnolia stellata* (Sieb. & Zucc.) Maxim. and *M. lililfora* Desr The cultivars all are multiple-stemmed, deciduous shrubs with a rounded or erect growth habit, 7 to 12 feet in height. The growth habit and flower color approaches that of *M. liliflora*. The flower color and number of tepals per flower may vary from year to year, depending upon environmental conditions All flower later than the *M. stellata* parent and thus tend to escape damage by spring frosts. In the hybrids varying degrees of fragrance have been inherited from *M. stellata*.

16) *Magnolia* x 'Ann' (Dudley & Kosar). *Morris Arb. Bull.* 19(2)·28. 1968. N.A. 28344. P.I 326570 Zone 6.

'Ann' resulted from the hybridization in 1955 by Francis deVos of *M. l.* 'Nigra' x *M. s.* 'Rosea', as did the cultivars 'Judy', 'Randy', and 'Ricki'. 'Ann' commences flowering in early to mid-April and is the earliest to flower of the eight cultivars of this series The erect, tapered flower buds are red purple (71A) at the base, grading to lighter red purple (70B) toward the apex The flowers are 2 to 4 inches in diameter with 6 to 8 erect tepals, purple (75D) on the inside surface, red purple (72B) on the outside surface, grading into lighter red purple (74D) at the apex and margins The original plant in 16 years has grown 7 feet high and 5 feet wide.

17) *Magnolia* x 'Judy' (Dudley & Kosar) *Morris Arb. Bull* 19(2):28. 1968. N.A. 28345. P.I 326571. Zone 6.

'Judy' (*M. l.* 'Nigra' x *M.s.* 'Rosea') is the slowest growing of the series, and flowers in mid- to late April. The erect flower buds are red purple (71A to 70A) The small flowers are 2 to 3 inches in diameter, with 10 tepals, with the inside surface of the tepals creamy white (155A) and the outside surface red purple (70B fading to 70C and 70D). In 16 years the original plant has attained a height of 7 feet and a width of 5 feet.

18.) *Magnolia* x 'Randy' (Dudley & Kosar). *Morris Arb. Bull.* 19(2):28. 1968 N.A. 28346 P I. 326572 Zone 6.

'Randy' (*M.l.* 'Nigra' x *M.s.* 'Rosea') is extremely floriferous and flowers in late April. The pointed flower buds are red purple (71A) grading to lighter red purple (72B) above the middle. The flowers are 3½ to 5 inches in diameter, star shaped, with 9 to 11 tepals, with the inside surface white (155D) and the outside surface red purple (72A or 73A to 72D or 73D). The original plant has a height of 9 feet and a width of 10 feet.

19.) *Magnolia* x 'Ricki' (Dudley & Kosar). *Morris Arb. Bull.* 19(2):29. 1968 N A 28347. P.I. 326573. Zone 6.

'Ricki' (*M.l.* 'Nigra' x *M.s.* 'Rosea') is erect and flowers in late April. The long, slender flower buds are red purple (71A to 73A through 73C). The flowers are 4 to 6 inches in diameter, with 10 to 15 tepals, often twisted, with the inside surface either white (155D) or stained purple (71A to 75D), and the outside surface red purple (74C or 61B) at the base fading to purple (75A through D) or red purple (74C and D). The original plant in 16 years has grown to a height of 11 feet and a width of 6 feet.

20.) *Magnolia* x 'Betty' (Dudley & Kosar). *Morris Arb. Bull.* 19(2):26. 1968. N A 28348 P I. 326574 Zone 6.

'Betty' resulted from hybridization of *M. l.* 'Nigra x *M. s.* 'Rosea' by W F. Kosar in 1956. It flowers in mid- to late April. The pointed and sometimes curved flower buds are red purple (71A) with some fading at the apex (73D and 74D). The flowers are large, up to 8 inches in diameter, with 12 to 19 tepals;

white (155D) on the inside surface and the outside surface grading from greyed purple (187D) at the base to a red purple (73D and 74D) at the apex. The original plant in 15 years has grown to a height of 10 feet and a width of 9 feet. 'Betty' is an outstanding cultivar with large flowers borne in abundance.

21.) *Magnolia* x 'Susan' (Dudley & Kosar). *Morris Arb. Bull.* 19(2):26-27. 1968. N A. 28350 P I 326575 Zone 6.

'Susan' resulted from a cross of *M.l.* 'Nigra' x *M.s.* 'Rosea' by W. F. Kosar in 1956. It flowers in mid- to late April. The erect flower buds are red purple (71A, 72A) grading into lighter red purple (71B) at the apex The fragrant flowers are 4 to 6 inches in diameter, with 10 to 15 twisted tepals, red purple (74D) on the inside surface, and the outside surface deeply colored with varying gradations of red purple (70A, 72A and B or 73C, 70C and D, 73D, 74C and D) The original plant has a height of 7 feet and a width of 7 feet. 'Susan', with its smaller stature and abundant flowering, is an outstanding cultivar

22) *Magnolia* x 'Jane' (Dudley & Kosar). *Morris Arb. Bull.* 19(2):27 1968 N.A 28349 P.I. 326576 Zone 6.

'Jane' resulted from a cross of *M. l.* 'Reflorescens' x *M. s.* 'Waterlily', made by W F Kosar in 1956 It flowers in early May and is one of the last to flower in the series The slender, erect flower buds are red purple (71A) grading to lighter coloration (74C and 74D) The flowers are very fragrant, cup shaped, 3½ to 4 inches in diameter, with 8 to 10 tepals, white (155D) on the inside surface with the outside surface grading from a red purple (78B or 73A) at the base into a light red purple (73D and 74D) at the apex. The original plant in 15 years has grown to a height of 12 feet and a width of 8 feet.

23) *Magnolia* x 'Pinkie' (Dudley & Kosar) *Morris Arb. Bull.* 19(2):27 1968. N A. 28351. P.I. 326577 Zone 6.

'Pinkie' resulted from hybridization of *M. l.* 'Reflorescens' x *M. s.* 'Rosea' by W F Kosar in 1956 It is the latest of the series to flower in early to mid-May The blunt flower buds are red purple (70A) at the base, grading to lighter red purple (70D) along the margins and apex. The flowers are cup shaped, 5 to 7 inches in diameter, with 9 to 12 broad tepals, white (155D) on the inside surface and the outside surface pale red purple (73A, 74D) at the base to almost white at the apex In 15 years the original plant has grown to a height of 8 feet and a width of 9 feet

24) *Magnolia* x 'Freeman' (Hyland). *U.S.D.A. Plant Inventory No. 169*·274 1967 N A 7717-3 and 12203 P I 277263 Zone 7

'Freeman' is a selection of *M. virginiana* L. x *M. grandiflora* L. produced by hybridization by O M Freeman in 1930 and 1931 The cultivar is a single-trunked, evergreen tree, densely branched, of relatively narrow, columnar growth habit The leaves are thick, leathery, elliptic to oblanceolate, 4 to 6 inches long and 1¼ to 2½ inches wide, resembling those of *M. grandiflora*. The cream-white, cup shaped, 5 inches in diameter flowers have a strong lemon fragrance Flowering occurs with a major flush during May and June, followed by a second but lesser flush of flowers during August The 40-year-old plant is now 41 feet in height, with a trunk girth of 12 ½ inches d.b h and branch spread of 19 feet

25) *Magnolia* x 'Maryland' (Meyer) *Newsletter Amer. Mag Soc.* 8(1)·8-9 1967 N A 7717-6. P I 358717. Zone 7.

'Maryland' (*M. v.* x *M. g.*) is of the same origin as 'Freeman'. The cultivar has a wide spreading growth habit. A 15-year-old plant of 'Maryland' is now 20 feet high with a 14-foot breadth. 'Maryland' has a hardiness range similar to *M grandiflora*.

26) *Malus sieboldii* (Regel) Rehd. 'Fuji' (Jefferson) *Amer. Hort. Mag.* 47(1):22-24. 1968. N.A. 2073. P I. 325156 Zone 5.

The horticultural merits of *Malus sieboldii* 'Fuji' were recognized by Roland M Jefferson in 1968 The origin of the cultivar is unknown. The parent plant at the U S Plant Introduction Station, Glenn Dale, Maryland, is approximately 40 years old and 28 feet tall with a spread of 46 feet The abundantly produced flowers are greenish-white (157D) with occasional traces of red purple (66D), and have the 8 to 10 inner petals loosely clustered in an erect anemone-like arrangement The yellow (Greyed Orange 63A) fruit is approximately ½ inch in diameter.

27). *Metasequoia glyptostroboides* Hu and Cheng 'National' (deVos). *Amer. Hort. Mag.* 42(3) 174-177 1963. N.A. 10920 P.I. 286608. Zone 5

'National' was selected from a seedling population of over 200 plants grown from seed (P I. 161688) received in 1948 from W. C. Cheng, the Arboretum, National Central University, Ting Chia Chiao, Nanking, China, through arrangements made by the Arnold Arboretum. The cultivar has a narrow pyramidal growth habit and compact branching. The original tree in 23 years has a trunk girth of 16 inches d b.h. and is 58 feet tall and 24 ½ feet wide. 'National', like the species, is a deciduous conifer with bright green summer foliage that turns an attractive copper-red in the fall. With age the lower trunk becomes attractively buttressed

28). *Pyracantha* x 'Mohave' (Egolf) *Baileya* 17(2)·79-82. 1970. N.A. 32225. P.I. 347258. Zone 6.

'Mohave' resulted from a cross of *Pyracantha koidzumii* (Hayata) Rehd. x *P. coccinea* Roem. 'Wyatt' made in 1963. 'Mohave' was selected for attractive fruit that ripens early and remains ornamental until mid-winter; foliage that is heavy, dark green, and semi-evergreen to evergreen; dense, upright branching; and resistance to fire blight and scab. The fruit is firm, waxy, and dark orange red (Orange Red 32A) as it ripens in mid-August, changing to red orange as the season advances. Bird damage has been insignificant, or none, while other cultivars have been stripped of fruit The original plant is now 8 years old; has a height of 13 ½ feet and a width of 16 feet. Since it has been hardy to —5° F., it can be expected to survive wherever *P. coccinea* and its cultivars are grown. The upright growth habit makes the plant adaptable for specimen, hedge, or espalier landscape use. 'Mohave' was awarded a Certificate of Preliminary Commendation by The Royal Horticultural Society (England) Floral Committee in 1971.

29) *Pyracantha* x 'Shawnee' (Egolf) *Baileya* 14(2).61-63 1966 N A. 28179 P I 315887 Zone 7b

'Shawnee' resulted from an F_2 seedling selection of *Pyracantha* 'San Jose', which is considered to be a spontaneous hybrid of *P. koidzumii* (Hayata) Rehd. and *P. fortuneana* (Maxim) Li. 'Shawnee' was selected for abundant inflorescences of glossy, clear yellow to light orange (Cadmium Orange 8 to Orpiment Orange 10) fruits that have an ornamental effective period of up to 7 months; semi-persistent foliage; dense branching; and resistance to fire blight and scab. The original plant has a height of 9 feet and a breadth of 10½ feet. Bird damage to the fruit has been insignificant, or non-existent, while other nearby pyracantha plants have been stripped of fruit

30) *Viburnum* x *rhytidophylloides* Sur 'Alleghany' (Egolf) *Baileya* 14(3).108-109 1966 N.A 28865 P I 316675 Zone 5b.

'Alleghany' was selected from an F_2 *V. rhytidophyllum* Hemsl. x *V. lantana* L 'Mohican' seedling population in 1958 Plants have very dark green, coriaceous leaves; abundant inflorescences, resistance to bacterial leaf spot, hardiness, and vigorous, dense, globose growth habit The foliage, which tends to be decisuous to semi-persistent, is intermediate between the parental species It is smaller than *V. r.*, and is more leathery than *V. l* The rugose, coriaceous leaves are resistant to leaf spot and are highly ornamental The abundant, yellowish-white flower inflorescences in May are effectively displayed above the dark green foliage. For several weeks in September and October the fruit becomes brilliant red (Currant Red 821/1) as ripening advances to black at maturity In 13 years the original plant has attained a height of 10½ feet and a spread of 11 feet.

The cross, *V. r.* x *V. l.*, was previously made in Holland to produce *V* x *rhytidophylloides* 'Holland', and by Henry Tubbs of Willowwood Farm, Gladstone, New Jersey, to produce *V.* x *rhytidophylloides* 'Willowwood'. 'Alleghany' has smaller, more persistent leaves and a more compact growth habit than the latter two cultivars Although 'Alleghany' is hardy to Zone 5b, in more severe climates the naked flower buds may be winter-killed

31). *Viburnum dilatatum* Thunb 'Catskill' (Egolf) *Baileya* 14(3) 109-111 1966. N A. 28866. P.I. 316677 Zone 5b.

'Catskill' is a dwarf growing *V. dilatatum* seedling selection made in 1958 from plants raised from seed obtained from Japan 'Catskill' was selected for the compact growth habit; smaller and rounder leaves; and good autumn coloration. The compact, wide spreading growth habit has been constant. The smaller, dull, dark green leaves, which are more nearly round than on most *V. d.* plants, assume good yellow, orange, and red fall coloration The creamy-white inflorescences are produced in mid-May on new growth. The dark red (Brick Red o16 to Currant Red 821) fruit clusters, which are dispersed over the plant, ripen in mid-August and provide a display until mid-winter The original plant, now 13 years old, is 5 feet high and 8 feet wide

32) *Viburnum x carlcephalum* Burk ex Pike 'Cayuga' (Egolf) *Baileya* 14(1):27 1966. N A 28180. P I. 315888 Zone 5b.

'Cayuga' is the result of a backcross made in 1953 of *V. carlesii* Hemsl. x *V. x carlcephalum* Burk ex Pike (*V. carlesii* x *V. macrocephalum* Fort.). 'Cayuga' is distinct in producing abundant inflorescences with pink buds (Rose Opal o22 / 1) that open to white flowers in late April; compact growth habit; and medium textured foliage, with tolerance to bacterial leaf spot and powdery mildew. The leaves, which are less susceptible to bacterial leaf spot and powdery mildew than those of *V. carlesii*, are a darker green, smaller and not as coarse as those of *V. x carlcephalum*. In the autumn the foliage turns a dull orange-red. Although the inflorescences of 'Cayuga' are smaller than those of *V. x carlcephalum*, their greater numbers present a mass effect and a more ornamental plant. The flowers open from one side of the inflorescence in such a way that nearly all inflorescences have pink buds accenting the white, waxy flowers. 'Cayuga' is a compact, spreading, deciduous shrub to 5 feet high. Plants have been hardy as far north as Ithaca, New York.

33) *Viburnum dilatatum* Thunb. 'Iroquois' (Egolf). *Baileya* 14(3):111-112. 1966. N.A. 28867. P.I. 316678. Zone 5b.

'Iroquois' resulted from a cross of two *V. d.* selections made in 1953 The cultivar was selected for large, thick textured, dark green leaves; abundant inflorescences of creamy-shite flowers; large, glossy, dark scarlet fruits, and dense, globose growth habit The heavy textured foliage is ornamental at all seasons, glossy green in summer, and orange-red to maroon in autumn. In mid-May the inflorescences transform the plant into a mound of creamy-white The glossy, red (Orient Red 819 to Cardinal Red 822) fruits are larger than those on most *V. d.* plants The flat, wide spreading fruit clusters contrast well with the dark green leaves. The fruit, which ripens in late August, persists after the leaves have fallen, and often the dried fruits are in abundance in mid-winter if not eaten by birds earlier The original specimen is 9 feet high and 12½ feet wide

34). *Viburnum x burkwoodii* Burk. & Skip 'Mohawk' (Egolf). *Baileya* 14(1):27-28. 1966. N.A. 28181. P.I 315889 Zone 5b.

'Mohawk' resulted from a backcross of *V. x burkwoodii* (*V. carlesii* Hemsl x *V. utile* Hemsl.) x *V. carlesii* made in 1953 The cultivar was selected for the dark red (Currant Red 821 / 2 to 821 / 3) flower buds which open to white petals with red-blotched (Currant Red 821 / 3) reverse, abundant inflorescences, strong, spicy clove fragrance; compact growth habit, and foliage resistant to bacterial leaf spot and powdery mildew The brilliant red flower buds appear several weeks before the flowers begin to open, and extend the effective ornamental period of the plant to several weeks rather than a few days as with other *V. c.* types The strong, spicy clove fragrance is very pleasant and a noteworthy attribute of 'Mohawk'. The glossy, dark green leaves, which turn a brilliant orange-red in autumn are highly resistant to bacterial leaf spot and powdery mildew. The original plant is a compact shrub 7 feet in height with spreading branches to 7½ feet. 'Mohawk' has been hardy as far north as Ithaca, New York In colder regions the plant may survive, but the naked flower buds may be frost damaged.

35). *Viburnum lantana* L 'Mohican' (Egolf) *Baileya* 14(3):112-115. 1966. N A. 28868 P I. 316679. Zone 4.

'Mohican' was a seedling selected in 1956 from a population grown from *V. l.* seed received from Poland. The plant, as deciduous shrub, was selected for compact growth habit; thick, dark green leaves, fruit that turns orange-red and maintains an effective display of 4 or more weeks, and resistance to bacterial leaf spot The creamy-white flowers and expanding pale green leaves appear together for a week in late April-early May. The orange red fruit (Jasper Red o18 to Blood Red 820) begins to ripen in early July and remains effective for 4 or more weeks, whereas fruit on other *V. l.* plants pass rapidly from orange to black The original specimen in 15 years has grown to 8½ feet high and 9 feet wide.

36). *Viburnum* x 'Oneida' (Egolf) *Baileya* 14(3):115-117. 1966 N A 28869 P I 316676 Zone 5b

'Oneida' resulted from a cross of *V. dilatatum* Thunb. x *V. lobophyllum* Graebn made in 1953. This deciduous shrub was selected for the abundance of flowers in May and sporadic flowers throughout the summer, the glossy, dark red (Fire Red 15/1 to Cardinal Red 822) fruit that persists until late winter, and the thin textured foliage that turns pale yellow and orange-red in autumn; and upright growth habit with wide spreading branches. Because of the two or three sporadic flowering periods, abundant fruit is produced that ripens in August and persists on the plant until mid-winter The original plant has grown to a height of 10 feet and a width of 9½ feet.

37) *Viburnum sargentii* Koehne 'Onondaga' (Egolf) *Baileya* 14(3) 117-119 1966 N A 28870 P.I. 316680 Zone 5.

'Onondaga' was selected from a selfed population of *V. s.* in 1959. 'Onondaga' may be distinguished by velvety, pubescent, dark maroon (Erythrite Red oo27) young leaves that maintain a maroon tinge when mature The dark maroon foliage is evident as soon as the buds expand and is distinct until the leaf matures The plant will produce a greater foliage display if pruned to induce dense branching. The inflorescences, composed of creamy-white sterile and fertile flowers, are effective against the maroon foliage. The sparse, red (Orient Red 819 to Chrysanthemum Crimson 824) fruit ripens in September and contrasts well against the foliage. The smaller stature, up to 6 feet high, is less than half the size of most *V. s.* plants and provides a plant adaptable for smaller properties

38) *Viburnum sieboldii* Miq. 'Seneca' (Egolf) *Baileya* 14(3):119 1966. N.A. 28871. P.I. 316682. Zone 5b

'Seneca' resulted from a self-pollination of *V s.* The plant was selected for the abundant, large, pendulant inflorescences of firm red fruit on red pedicels which persists on the plant up to 3 months before turning black and falling. The massive, creamy-white panicles are produced in May-early June as the young foliage unfolds The panicles are supported on stout, spreading branches that are picturesque at all seasons. The pendulant, multiple-colored clusters of orange-red (Indian Yellow 6/2 to Jasper Red o18, ripening to Blood Red 820) fruit are spectacularly displayed above the coriaceous, green foliage. Birds normally eat the fruit of *V. s.* before it has matured, leaving only the red pedicels which provide an ornamental display. However, the fruit of 'Seneca' is very firm and is not devoured by birds even when the fruit becomes fully ripe Although 'Seneca' is tree-like and has attained a height of 14 feet and a width of 13½ feet, the plant can be trained with several branches from the base and kept as a large spreading shrub This cultivar will undoubtedly equal in size plants of the species and be as much as 30 feet with gnarled trunk

39) *Viburnum sargentii* Koehne 'Susquehanna' (Egolf) *Baileya* 14(3) 120 1966 N.A 28872 P I. 316681 Zone 5

'Susquehanna' was selected in 1959 from a seedling population raised from seed obtained from Japan The plant was selected for the heavy branched, corky trunk, coriaceous, dark green foliage; abundant flowers and fruit; and upright growth habit *V s* as commercially grown usually is not the true species, or it may be an inferior form of the species The large inflorescences of sterile and fertile creamy-white flowers are produced on the new growth and provide an effective display for a week in late May. The large clusters of fruit are yellow-green (Yellow Ochre o7 to Burnt Orange o14) during the summer, ripen to glossy, dark red (Capsicum Red 715 to Currant Red 821) in September, and remain on the plant until mid-winter The sturdy, corky branches are attractive for landscape use either when covered by the large, glossy leaves, or when the plant is dormant, exposing the corky, fissured trunks. The original specimen, now 12 years old, is 15 feet high and 16 feet wide The cultivar is ideal for park planting but not suited to the small home garden.

Availability of New Cultivars

The Plant Science Research Division of the Agricultural Research Service, U.S. Department of Agriculture, has no plants of the cultivars introduced by the U.S. National Arboretum for sale. A limited number of plants for propagation purposes have been distributed to cooperating arboreta, botanic gardens, research institutions, and wholesale propagation nurseries for evaluation and stock increase. As the cultivars are commercially propagated, they will become available to the retail nurseries, and consequently to the consumer.

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MODERATOR FLEMER: It should be apparent that the National Arboretum has an extensive breeding program encompassing a number of genera. If you have never taken the time to go to our National Arboretum, I think you will find it is a great treat to any plantsman.

Continuing on with our emphasis on new plants I will turn the podium over to Al Fordham for our session entitled "New Plants—Slides and Descriptions".

MODERATOR FORDHAM: I believe all of you are familiar with the way this section of the program is run, and the usual stipulations are pertinent here. With this in mind, I have a short paper which will preface this section of the meetings which has to do with some of the many variants of Canadian hemlock and their propagation.

CANADIAN HEMLOCK VARIANTS AND THEIR PROPAGATION

ALFRED J. FORDHAM

Arnold Arboretum
Jamaica Plain, Massachusetts

When reproduced from seeds, both in nature and in cultivation, some conifers give rise to many seedlings which are quite unlike the parent plants. These variants, which originate as mutations, generally retain their characteristics when propagated vegetatively. Canadian hemlock (*Tsuga canadensis*) is an excellent example of a conifer which produces seedlings that vary widely in genetic make-up.

Some idea of the extent of variation in Canadian hemlock is brought out by the fact that through the years the Arnold Arboretum has received plants or propagating material of 280 clones. They were discovered in the woods or in nursery rows by contributors who considered them worthy of perpetuation at a botanical institution. A search of the Arboretum's records reveals that hemlock variants were being received in the infancy of this century-old organization. Some were named and others, as is the case with many received more recently, simply bore descriptive notations such as, "dense form", "dense pyramidal", "variety", etc.

Canadian hemlock variations deviate from normal by being slow growing, globose, pendulous, pyramidal, contorted, spreading, fastigiate, prostrate, etc. Some have leaves that differ in size, shape, color or arrangement on the branches. Combinations of these various characteristics are not uncommon. An upright plant may have dark leaves while a globose plant may be slow growing.

Canadian Hemlocks Found in the Wild. Where did this wide diversity of plant forms come from? Many were discovered and brought from the wild by observant people. Frank Abbott of Saxon River, Vermont has been a hunter, fisherman and woodsman throughout his long life. While traveling in the New England woods he has collected plants or propagating material of numerous Canadian hemlock mutations. Searches made in the wild by Joseph B. Gable of Stewartstown, Pennsylvania have also led to many new discoveries. Each of these collectors assigned numbers to his finds. Some have since been named. Many, however, have no formal cultivar names and are designated only by the original collector's numbers.

Through the years, Henry Hohman of Kingsville Nurseries, Kingsville, Maryland has propagated the Abbott and Gable material together with many selections of his own and made them commercially available. All told he has assembled 84 Canadian hemlock cultivars. In an effort to insure perpetuation Mr. Hohman has thoughtfully donated specimens to botanical institutions.

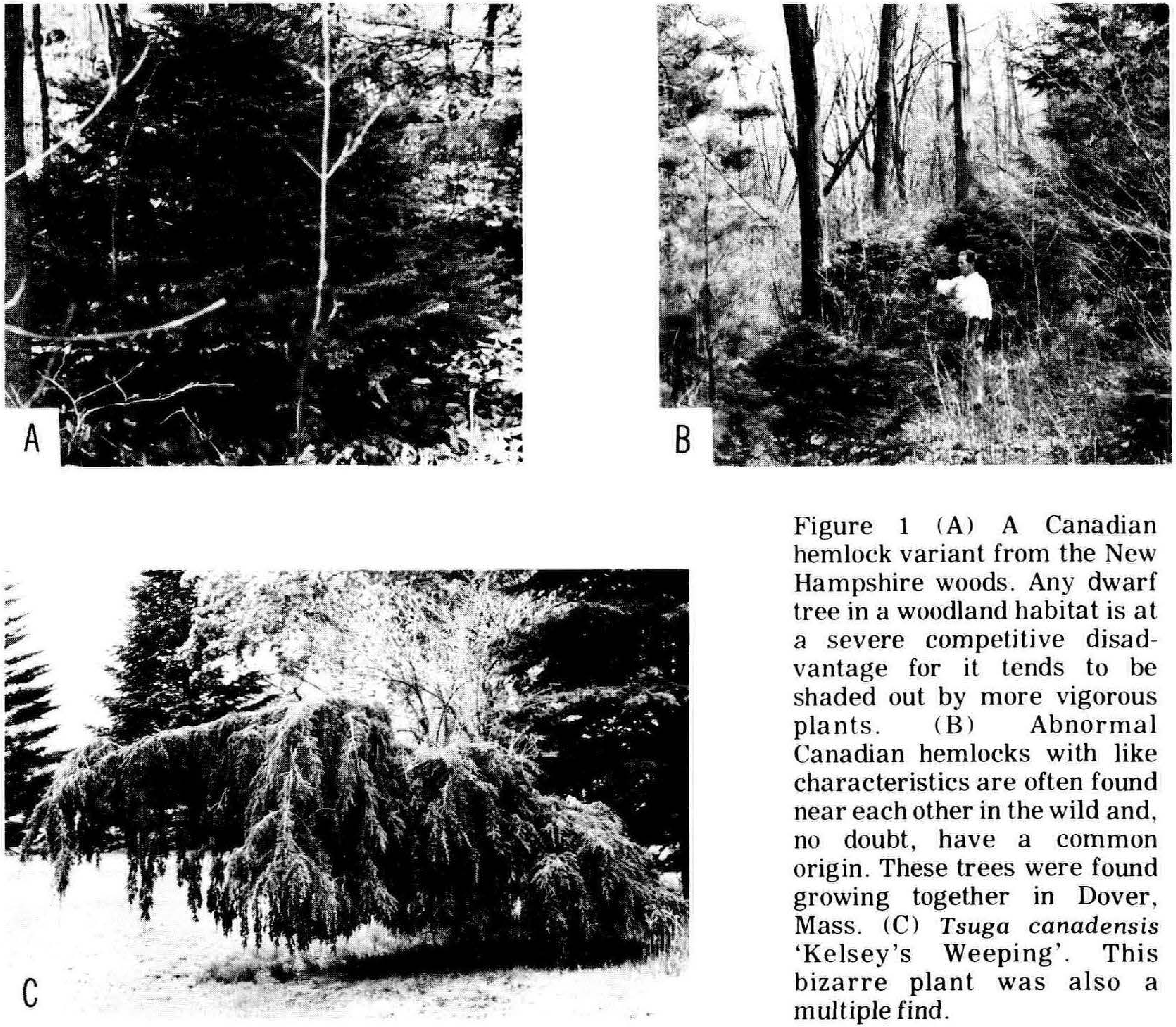


Figure 1 (A) A Canadian hemlock variant from the New Hampshire woods. Any dwarf tree in a woodland habitat is at a severe competitive disadvantage for it tends to be shaded out by more vigorous plants. (B) Abnormal Canadian hemlocks with like characteristics are often found near each other in the wild and, no doubt, have a common origin. These trees were found growing together in Dover, Mass. (C) *Tsuga canadensis* 'Kelsey's Weeping'. This bizarre plant was also a multiple find.

Figure 1A shows a Canadian hemlock variant found in the New Hampshire woods. It is slow growing, and has small needles which are darker than normal in color. Any dwarf or slow growing conifer in a woodland habitat is at a severe competative disadvantage for it tends to be shaded out by more vigorous plants. Canadian hemlock seedlings however, have the ability to survive and develop in deep shade under conditions where seedlings of other conifers would perish.

Abnormal Canadian hemlocks with like characteristics are often found near each other in the wild and, no doubt, have a common origin. Similar phenomena have been reported frequently in the literature. The plants shown in Figure 1B all exhibit darker than normal leaf color and slow rates of growth. Nine were found growing together in woods at Dover, Massachusetts. A bizarre form called *Tsuga canadensis* 'Kelsey's Weeping' (Figure 1C) was also a multiple find.

Figure 2A shows two trees of particular interest that grow in front of a residence at Sherborn, Massachusetts. The house was at one time the town post office. The trees are estimated to be 150 or more years old. Their positions indicate they were planted as a pair. In those days there were few if any nurseries in the area and it was common practice to carry plants from the woods for landscape use. It seems probable that the trees in question were from that source. One is normal in character and is now approximately three times taller than the other. The slow growing form is unusually dense due to short internodes and a closely set arrangement of the leaves which are darker than normal in color. Its lower branches are gone but those that remain present a perfect pyramidal shape.

Another slow growing form found in the woods along a Connecticut roadside is shown in Figure 3. The plant is about 12 feet tall and perhaps 100 or more years old. It survives despite competition from other trees and the dry impoverished soil in which it grows.

Vegetative Propagations from Witches'-Brooms. Canadian hemlock variants have also originated as vegetative propagations from witches'-brooms. Several now under observation at the Arnold Arboretum show similarity. All are vase-shaped with hollow centers.

Variants Found in Nursery Rows. Nurserymen, when transplanting seedlings, ordinarily discard plants of small size and select the largest of the seedling lot. Recent interest in dwarf plants has led to a demand and some nurserymen now put aside these mutations for further observation. John Verkade of Verkade's Nursery, Wayne, New Jersey, has selected many Canadian hemlocks for this purpose. From these he has chosen some very nice diminutive forms which have recently been registered.

When visiting the Weston Nurseries, Hopkinton, Massachusetts, some years ago, we looked at a block of plants which clearly illustrated the wide variation to be found in Canadian hemlock. All plants which appear in Figure 2B are different. They show variation in growth habit, growth rate, needle color and needle arrangement. Mr. Edmund Mezitt, of Weston Nurseries, commented that these plants were received as small seedlings from one source and are of similar age.

Figure 2C shows one of the original Sargent hemlock plants which is growing in Brookline, Massachusetts. Seedlings from this were started at the Arnold Arboretum in 1965. Fifty-four percent of the offspring are prostrate and increase in diameter at the rate of two feet per year. Another prostrate cultivar, called 'West Coast Spreader', produces annual growth 21 inches long and therefore increases at the rampant rate of 42 inches per year.

Long lists of cultivars available from a few special nurseries emphasize the wide diversity to be found among Canadian hemlocks. Joel W. Spingarn of Baldwin, New York, shows 68 cultivars in his current catalogue, while Lane Ziegenfuss of Hillside Gardens in Lehighton, Pennsylvania, lists 132.

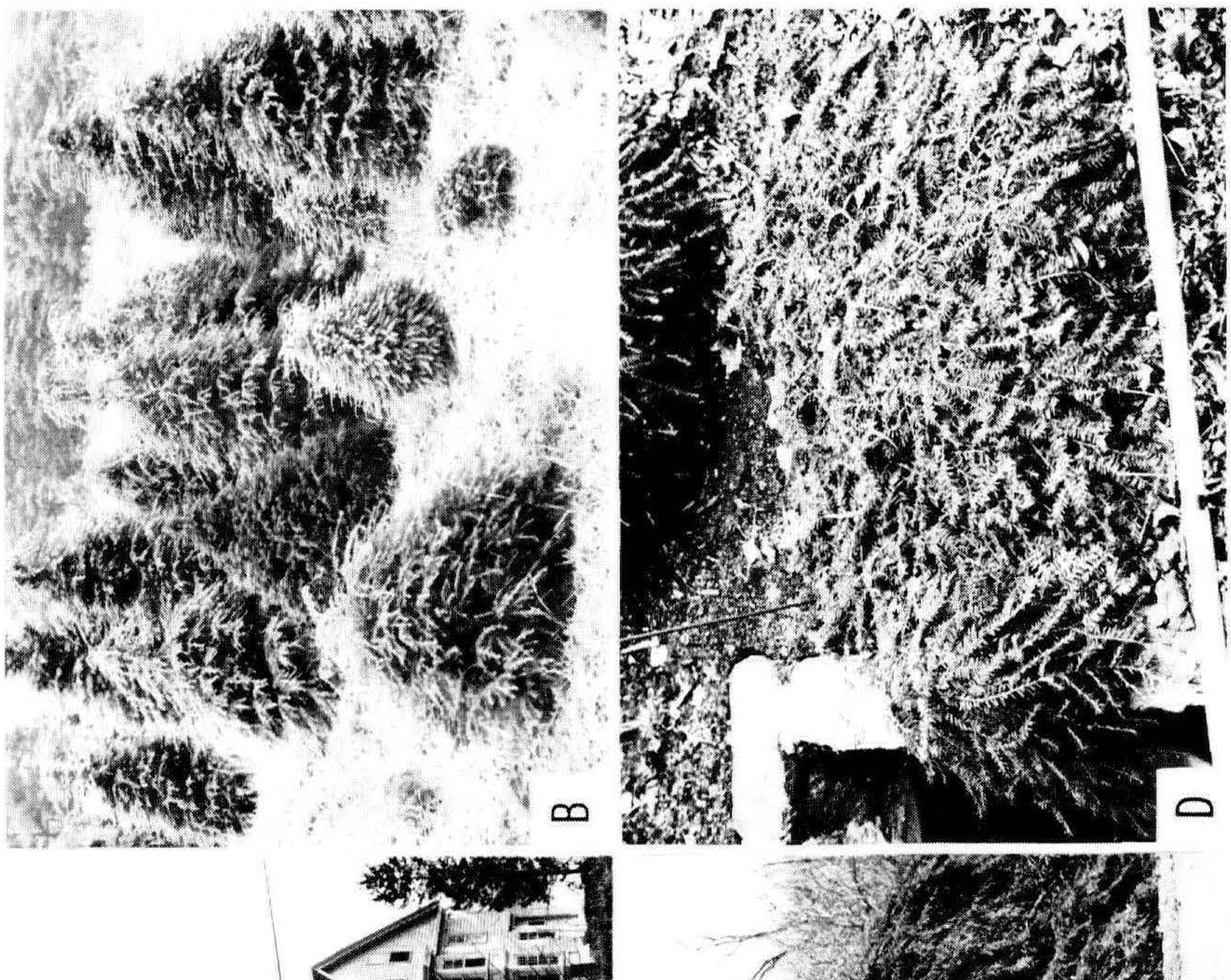
At the Hemlock Arboretum in Philadelphia, Pennsylvania, the late Charles F. Jenkins, the owner, attempted to assemble all the various forms of Canadian hemlock. His collection is reputed to have contained 190 specimens when he passed away in 1951 and the project was discontinued. Little did he realize that such a collection might have involved thousands of plants.

As would be suspected in a subject exhibiting such wide natural variation, a great many forms of Canadian hemlock are similar. Although discovered and collected from widely separated locations, many appear identical. Considering the frequency with which new forms arise it is doubtful whether any possible good can come from continuing to name new variants unless they are particularly different or unusual.

Propagation of Canadian Hemlock. In the past it was customary to propagate Canadian hemlock cultivars by grafting. In fact, *Tsuga canadensis* was considered a suitable understock for all other *Tsuga* species. However, we have experienced instances of incompatability when abnormal hemlocks were grafted on their own species.

Overgrowth of the scion or girdling, brought about by circling roots which arose on understocks established in small pots, can both lead to failure of the plants either shortly after grafting or in subsequent years. Therefore, we now propagate these subjects only by cuttings.

Cuttings, consisting of two or more growth flushes, are taken in autumn (October, November). A five-second dip, using IBA plus NAA at 5,000 ppm each, has proven the most satisfactory root-inducing substance. The cuttings are placed either on an open greenhouse bench


A
B
C
D

or in polyethylene chambers. In either case a high percentage of rooting can be expected.

Figure 2D shows a specimen of *Tsuga canadensis* 'Cole' growing at the Gray & Cole Nurseries, Ward Hill, Massachusetts. It is about 3 feet in diameter and 4 inches tall. Henry C. Cole found this cultivar near the base of Mount Madison in New Hampshire. Cuttings taken from it root easily. Cole described an incident where he took prunings from a plant he was moving and stuck them into the ground in the shade of a nearby plant—all initiated roots.

Fig. 3. This slow-growing *Tsuga canadensis* tree was found in dry impoverished soil along a Connecticut roadside.

A definitive study of the Canadian hemlock problem has been undertaken by Dr. John Swartley of Ambler, Pennsylvania. His extensive knowledge of the subject should provide a guide to those interested in naming new variants and thereby help to bring order out of chaos.

Figure 2 (opposite page). (A). A residence at Sherborn, Mass. Two Canadian hemlocks were brought from the woods for landscaping about 150 years ago and provide dramatic evidence of difference in growth rate. (B) Canadian hemlocks at the Weston Nurseries, Hopkinton, Mass. The seedlings, which came from one source, show remarkable variation. (C) One of the original Sargent hemlock plants located in Brookline, Mass. (D) *Tsuga canadensis* 'Cole', found at the base of Mount Madison, New Hampshire, is easily propagated from cuttings.

MODERATOR FORDHAM: Bruce Briggs would like to show us some slides of a new yellow rhododendron.

BRUCE BRIGGS: Dave Leach mentioned this rhododendron yesterday and it is called 'Hotie'. We released this plant this past year. You will notice it is a deep yellow and it keeps its color when the flower opens fully; many of the yellows have a tendency to fade. One of the first things you people here wanted to know is how much cold will it take; this I cannot answer except to say that a few years ago we had a cold snap in December and this plant was one of the very few which came out with a perfect truss. I believe it will be as hardy or hardier than 'Goldsworth's Yellow'. It propagates very easily. We were very happy to find a yellow which propagated easily. Its habit of growth is very compact; it makes many breaks, and grows a little larger than 'Unique'. Its leaves are long and dark green. It has about the same rate of growth as x 'Cunningham's White'.

MODERATOR FORDHAM: Thank you, Bruce. Next Tony Shamarella has a slide he would like to show.

TONY SHAMARELLA: This is the hardiest blood-red azalea that I know of. It is about 7 years from seed. It is being introduced with the name 'Red-Red'.

I also have a group of Yakusimanum hybrids in a range of colors. These plants will bud well at 2 years of age and, as with all of the Yakusimanum hybrids, they are fairly resistant to root rot diseases. They are mostly in colors of which the ladies can't seem to get enough. I hope to introduce these in the fall of 1972 and they will carry various names such as 'Yahoo King', 'Yahoo Queen', 'Yahoo Prince'. There will probably be four or five clones introduced.

MODERATOR FORDHAM: Joe McDaniel has some slides he would like to show.

JOE McDANIEL: I have talked at previous meetings about both hackberries and magnolias. Today, I have slides showing a hackberry and a magnolia species both native farther south, but thriving in and around Urbana, Illinois, and some selections of both which appear worthy of clonal propagation as good shade trees for Zones 5 and 6.

SOME SELECTIONS OF CELTIS LAEVIGATA AND MAGNOLIA ACUMINATA

J. C. McDANIEL
705 S. Busey Avenue
Urbana, Illinois

Celtis laevigata. When I lived at Nashville, Tennessee I decided that the commonest deciduous tree there, at least in the older parts of town, was probably the Sugarberry or Mississippi Hackberry, *Celtis laevigata*. Though the common eastern hackberry, *C. occidentalis,* also occurred there, the southern species probably outnumbered it 100 to 1. It is also common, I see, on streets and woods borders here in eastern Virginia and many other parts of the South, as far as southern Florida and southwestward at least to Monterrey, Mexico. In the Mississippi and Missouri Valleys, it grows wild as far north as Hannibal, Missouri and Quincy, Illinois. Botanical manuals, such as Rydberg's "Flora of the Prairies and Plains of Central North America" list it for southeast Kansas.

C. laevigata is prevalent in the southern third of Illinois, though not native around Urbana. There at the upper edge of Zone 6a, *C. laevigata* trees from at least two sources have proved hardy over a period of 15 years, and with us show enough advantages over most of the *C. occidentalis* to suggest their wider use there and in comparable climates at least a half zone north of where *C. laevigata* occurs wild. The biggest local planting was made by Wandell's Nursery of Urbana, around the parking lots adjacent to Lincoln Square. Mr. Wandell tells me that his liners came originally from Hess' Nurseries, formerly located at Wayne, N. J., which is well north of the Virginia distribution given in "Gray's Botany" (1950) for this species in the eastern states. Whatever their original seed source, these Lincoln Square seedling trees looked good enough to me that I had selected some for clonal propagation. I learn now that Wandell's has independently selected some for increase and that they should be available in another year or two.

General advantages of *C. laevigata* over the native *C. occidentalis* at Urbana include freedom from the hackberry witches'-broom disease, a more refined or distinguished growth habit, a smoother gray bark which is more attractive, and less insect damage to its foliage, which remains green until frost. With us, there seems to be no nipple-gall infestation, with subsequent fall migration of the midges, which can get into houses and be a brief but sharply felt nuisance. At Cairo, Illinois, and here in Virginia there are some smaller leaf galls on *C. laevigata,* but apparently not the nipple galls of *C. occidentalis*. At Urbana, *C. laevigata* has fruited only sparingly, in contrast to the condition at Nashville, where it supports large flocks of migrating robins for several weeks each year.

The hybrids that occur naturally between sugarberry and common hackberry sometimes, as at Forest Park in St. Louis, include F_1 or F_2 individuals which are witches'-broom susceptible. One grafted cultivar already in the trade (William Flemer's 'Magnifica') was patented as a hybrid of these two, but is not witches'-broom susceptible, so far as I know. We have not yet tried it at Urbana.

Not diseased, but genetic mutations are two instances of what might be called broomy, dense branches on *C. laevigata* trees. Don Shadow has one at Winchester, Tennessee, and I photographed another at Vincennes, Indiana recently. These might be worth grafting on standards for novelty trees of slow growth.

I'd agree with Hartmann and Kester, who say that clonal propagation is probably best for hackberries, to obtain uniform growth. I've budded *C. laevigata* successfully on *C. occidentalis,* and the Chinese *C. sinensis* on both *C. occidentalis* and *C. laevigata.*

Magnolia acuminata. Catesby, the colonial naturalist, painted a white flower for the cucumber tree, and was followed in his error by the younger Michaux in the early 1800's. We know now that its flowers are never white, but can be a good yellow in one form. A less well known fact is that other trees of it have good yellow color in the fall.

Bright fall color is not one of the several attributes usually mentioned for our hardiest American Magnolia, the cucumber tree, *M. acuminata.* One writer in 1913 found the newly fallen leaves to be about the same color as "owl's feathers" (species unspecified). Donald Wyman ("Trees for American Gardens") is among authors who do not credit it with autumn color interest, and for most specimens he is right. Dull brownish color does prevail at leaf senescence on most *M. acuminata* seedlings, but not all of them. For several years I have been watching some old trees of this species planted about 75 to 100 years ago in Champaign County, Illinois, and at least four of them do regularly turn yellow before frost brings the leaves down. Scion wood is available to propagators who would like to upgrade their *M. acuminata* in this respect.

M. acuminata 'Philo' was previously registered primarily because it is exceptionally self-fruitful, but it also turns conspicuously yellow, so it has two things going for it beyond the species average. The original tree, on the John F. Keeler farm near Philo, Illinois, is a large one, estimated at about 100 years old. It has annual crops of seeds, though standing some five miles from any other pollen source.

The Allison clone, another of about equal age, at the old Allison mansion in Tolono, Illinois, also may be self-fruitful, but grackles damage most of its fruits before maturity, and it does have a younger tree within ½ mile that could cross pollinate it.

Two others, at Savoy and Urbana, are fully fruitless unless cross pollinated. The Dunlap clone at the former Senator Dunlap nursery near Savoy is particularly late vegetating in spring, and matures its seeds (if crossed) as early as the second week in August. The Busey clone, an old tree in Urbana, has the very wide spreading branches sometimes seen on old specimens of this species. In 1971, it colored ahead of a large ginkgo that is one of its tree companions at the old Busey mansion between Elm and Green streets. All four clones are comparatively early maturing, and should be adapted where other less colorful cucumber trees are now grown, north through Zone 5, at least.

Some American nurseries, and Treseders' Nurseries (Truro) Ltd., at Truro, Cornwall, England, have previously grafted from *M. acuminata* 'Philo' and the Dunlap clone. Scions of these and the other two fall coloring clones will be available in season. It should be mentioned that all four clones have the greenish, inconspicuous flowers typical of *M. acuminata*. For yellow flowers, we can still graft or bud from *M. acuminata* forma *aurea*, or selected clones of the smaller *M. a.* var. *cordata*. I have not yet seen yellow magnolia flowers and yellow autumn foliage on the same tree, but by cross-breeding, we may ultimately achieve that combination.

MODERATOR FORDHAM: Harry Hopperton has a couple of plants he'd like to tell us about.

HARRY HOPPERTON: Here is a picture of *Corylus duplex*. This plant has a very nice dense growth habit and I think it has possibilities. Another plant, *Corylus calurna* is one I think we are overlooking too often; perhaps we should be using it instead of some of the honeylocusts. It has a very interesting branching habit.

MODERATOR FORDHAM: That concludes the new plants portion of the program, and I turn the meeting over to Bill Flemer.

BILL FLEMER: Thank you, Al, for your usual fine job. This completes the program portion of today's meetings.

FRIDAY EVENING SESSION

December 3, 1971

PLANT PROPAGATORS' QUESTION BOX

The question box session convened at 8:00 p.m. in the West Ballroom. Dr. Bill Snyder served as moderator.

MODERATOR SNYDER: We have several questions here, and though we seem to be few in number this evening what we lack in quantity we will make up for in quality. Many of these questions are directed to specific individuals and if they are not present, we will set near Savoy is particularly late vegetating in spring, and matures its seeds (if crossed) as early as the second week in August. The Busey clone, an old tree in Urbana, has the very wide spreading branches sometimes seen on old specimens of this species. In 1971, it colored ahead of a large ginkgo that is one of its tree companions at the old Busey mansion between Elm and Green streets. All four clones are comparatively early maturing, and should be adapted where other less colorful cucumber trees are now grown, north through Zone 5, at least.

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BILL MORSINK: We sterilized the soil in which they are stuck at 180° F and this is very important. If we do not sterilize the soil we get only about 20% rooting, whereas with sterilized soils using the right size cuttings we can get up to 90% rooting.

MODERATOR SNYDER: Do you treat the cuttings in any way with a fungicide?

BILL MORSINK: I tried a few of these materials, but I found that the sugar maple is extremely sensitive to many of these fungicides. I did mention that the softwood on top of hardwood cuttings became infected at their base, but I have not determined what the fungus is as yet.

MODERATOR SNYDER: This question is for Tom Pinney and reads, "I've been having trouble obtaining good stands of *Betula alba* (= *B. verrucosa*) from seed. Would you outline your seed treatment for this genus?

TOM PINNEY: Immediately after collecting the seed we check the germination. We germinate them under high temperature in the greenhouse using a germination box with bottom heat from cables and we run the temperature up to probably 80° F. We may add light and mist but this is not always necessary—it's primarily temperature, which is critical. Germination occurs in 7 days and one should be able to prick them off in 21 to 28 days maximum.

Some seed lots in some years will give very poor results and since we collect sufficient seed we can be choosey, we just throw poor lots out. It is possible that stratification or some other procedure might improve the germination of these poor lots, but we prefer not to fool with them. We store the seed over winter or from year to year by placing them in plastic bags and holding them at 34° F.

MODERATOR SNYDER: It has been reported from California that methyl bromide fumigation under certain conditions can cause a nutrition problem. Has anyone experienced this problem and is there a solution?

JOHN ROLLER: I have heard of the problem and it seems to be the formation of nitrites in the soil.

TOM PINNEY: John, I don't believe this is all of the problem; it may be the cause of some of it due to killing the nitrifying bacteria. The information which has filtered back to me is that there is a definite stunting effect which appears to be tied up with the micronutrients, and is not solely a nitrogen problem. This has been happening with some of the fruit understocks.

BRUCE BRIGGS: There was also some work where crowngall was present and, after fumigating with methyl bromide, the crowngall became a lot worse in the fumigated soil. This could have been caused by killing some organism which was keeping the crowngall in check. Along these same lines I'm wondering if perhaps the methyl bromide fumigation may be killing off the mycorrhiza and the stunting results because the plant can no longer pick up the nutrients it needs.

MODERATOR SNYDER: Has anyone encountered a toxic exudate given off by the roots of one crop that will affect another crop on this soil? I am aware of the black walnut situation.

BILL FLEMER: I believe it was Ed Rex at Rutgers who found that English ivy used as a bedding plant or ground cover in beds of ericaceous plants give off some substance which gradually reduces the growth of rhododendrons, azaleas or mountain laurel and he thinks it is a toxic exudate.

RON GIROUARD: There is a recent publication entitled, "Biochemical Interactions Among Plants," which contains summaries of special reports and formal papers presented at a University of California symposium in 1968. Copies of this publication can be obtained by writing to:

National Academy of Sciences
Printing and Publishing Office
2101 Constitution Avenue
Washington, D. C. 20418

MODERATOR SNYDER: Thank you for that information. I do know that there is a very toxic material in buckwheat seeds and hulls. If this material is incorporated into the soil it will cause a reduction in root growth, but the material is water soluble and will leach out readily.

DAVE BAKKER: There is a list available from Boskoop which gives information about plants which are compatible for successive plantings.

Undesirable Nursery Crop Rotation[4]
(From: Horticultural Guide, 1965.
Netherlands Government Publication)

CROP	INCOMPATIBLE CROP
Apple	Pear-Roses [1]
Azalea	*Calluna-Chamaecyparis-Clematis-Erica-Rhododendron-Taxus*
Buxus	Azalea-*Hydrangea-Rhododendron*

continued

continued

Calluna	Azalea-*Chamaecyparis-Clematis-Erica-Rhododendron-Taxus*
Chaenomeles	*Malus*
Chamaecyparis	Azalea-*Calluna-Clematis-Erica-Rhododendron-Taxus*
Clematis	Azalea-*Calluna-Erica-Rhododendron-Taxus*
Crataegus	*Cotoneaster*
Dicentra	*Lonicera* (Climbing form) *Ribes*
Erica	Azalea-*Calluna-Chamaecyparis-Clematis-Rhododendron-Taxus*
Fagus sylvatica[1]	*Picea*
Ligustrum	*Hydrangea* (Needle Conifers)[2]
Malus (Flowering Crab)	*Chaenomeles*
Pear	Apple-Roses[1]
Picea	*Taxus*
Pinus	Azalea-*Clematis-Hydrangea-Magnolia-Rhododendron*
Pinus[1]	Fruit trees (Bacterial root (knot) gall)
Populus	Current (Red-Black) Fruit Trees[3] *Ribes-Sambucus*
Prunus laurocerasus	Azalea-*Clematis-Hydrangea-Magnolia-Rhododendron*
Rhododendron	Azalea-*Calluna-Chamaecyparis-Clematis-Taxus*
Sambucus	Gooseberry
Syringa	*Clematis*
Taxus	Azalea-*Calluna-Chamaecyparis-Clematis-Rhododendron*

[1]Crop grown for a long period, over 5-6 years

[2]*Picea, Pinus, Pseudotsuga*, etc.

[3]Apple, Pear

[4]Editor's Note. Dave Bakker supplied the above information by mail after the meetings.

MODERATOR SNYDER: Jim Wells, this morning you mentioned using Paraquat for weed control in your nursery. What strength do you use and how is it applied?

JIM WELLS: I'm going to have to ask one of my young men to answer that for you, is Clive here?

CLIVE DEEBLE: We are using Paraquat at 3½ fluid ounces in 4 gal of water. We don't measure the spreader sticker very accurately. We simply use one capful per 4 gal.

JIM WELLS: We apply the material from knapsack sprayers with a flat spray nozzle. The material is sprayed right along the ground and it does require great care.

JOERG LEISS: I would comment that the new formulations of Paraquat have a spreader sticker in it and so you do not have to add it.

PAUL BOSLEY: Paraquat is a wonderful material but you must respect it. It will do for you just about what the old torch burners used to do. We use a 3 gal nozzle with an engine sprayer but you must be careful not to get the pressure so high that you get drift because this material will burn any green tissue it hits. One man can do a tremendous job of weeding using Paraquat during the summer. We caution the worker to wear appropriate protective clothing and not to smoke or drink without washing thoroughly first.

BRUCE BRIGGS: Concentration studies with Paraquat were run in our area and it was found that on hot dry days you could get by with as little as a ½ oz/gal, but on cool days you had to go up to 1 oz/gal in order to get good kill. The addition of spreader-sticker increased the kill on weeds which were hard to kill but did not help on easy-to-kill weeds.

MODERATOR SNYDER: John Roller, someonw wants to know if you broke the callus off of the cuttings before resticking them?

JOHN ROLLER: Yes, I did, on the 'Burkii' and the 'Maneyi'.

MODERATOR SNYDER: Can pine such as Austrian and mugho be grown continuously without a dormant period? Since no one is volunteering any information, I will cite some experience I've had attempting to grow them under 8, 12, 16, 20 and 24 hour photoperiods without cold treatment. Under all photoperiods the plants died within one year if they were not given a cold treatment. Has anyone else had experience with these plants?

Al Fordham, would you go over your procedure for rooting hemlock?

AL FORDHAM: We take cuttings from 2 to 3 year old wood, and though we have tried many mixtures of auxins and fungicides, the quick-dip method with IBA and NAA has proven superior. We usually use sand and perlite as the rooting medium and the cuttings are stuck in late autumn either on an open greenhouse bench or under poly. It doesn't seem to make much difference.

MODERATOR SNYDER: What is the origin of *Populus nigra* 'Thevestina'?

JOERG LEISS: This plant comes from Morocco and we have found it to be very susceptible to canker. It grows very much like *P. nigra* 'Italica' although it is a little faster growing; we grow both of them.

MODERATOR SNYDER: Dick Cross, how do you root the 'Moonglow' juniper?

DICK CROSS: We take the cuttings in the fall, treat them with Hormodin No. 3 and stick them in a sand medium; about 70% will be rooted by March or April. We remove the callus on those not rooted, stick them back in the bed and almost all of these will root. We find 'Moonglow' to be the best globe-type.

MODERATOR SNYDER: Has anything been done further on the treatment of cuttings in a centrifuge to bring the natural hormones to the base of the cuttings?

RON GIROUARD: The original work was done by Kawase and recently he has reported that ethylene is being released during the centrifugation process. Kawase is of the opinion that it is the ethylene causing the rooting; plant physiologists do class ethylene as a plant growth regulator.

MODERATOR SNYDER: Leonard Savella, I have several questions for you; however, I think I can put them all together and simply ask you to outline your procedure for rooting pink dogwood, time of year, type of wood, etc.

LEONARD SAVELLA: We take the cuttings about June 6, which isn't too important. The main thing is that the new growth be about 5 to 6 inches long. Take the material into the greenhouse and make the cuttings, leaving just two sets of leaves on them; they should root in about 6 weeks. After they are rooted I prefer to put them in a 2¼ inch clay pot using the same medium that they were propagated in and then I stick them right back under the mist. In about 1½ weeks we see root action and it is then that we take them out of the mist. Just before winter sets in I put them in a small pit, cover the pots with about 1 inch of medium and cover the tops with 4 to 6 inches of salt marsh hay, which is kept very thin so that light can get down to the stem and the medium. Then the pit is covered with sash and that's all there is to it. About the middle of the next June they're set out in beds. I've heard lots of people say they don't transplant on their own roots, but I don't agree with this; I think they transplant very well.

ED LOSELY: Have you noticed any clonal differences in the root hardiness of your pink dogwoods?

LEONARD SAVELLA: No, we haven't. I think that as long as you choose acclimated plant material you won't have any trouble.

MODERATOR SNYDER: Bill Flemer, how do you handle your pink dogwood and Japanese maples?

BILL FLEMER: We've given up softwood cuttings of both of these items. We have lost many blocks of pink dogwoods on their own roots while those grafted on white dogwood seedlings would show no damage. Several years ago we had a block of Japanese maples in plastic houses in containers and we had a very severe winter. When spring came we lost a good number of these and every one that was lost was on its own roots. We feel that they're not as hardy on their own roots, in our Princeton area, as when they are grafted.

CASE HOOGENDOORN: I had a similar experience with some 3 year old *Biotas. (Thuja orientalis)*. During a severe winter all of those on their own roots were killed. The grafted ones were badly hurt but they weren't killed and did eventually grow out of it.

MODERATOR SNYDER: A grower in central Ohio can't get *Ginkgo biloba* liners to grow. They die either the first or second season. Can anyone offer any advice?

RALPH SHUGERT: This could be a problem of having a non-acclimated seed source.

BILL FLEMER: One other possibility is that this plant is very susceptible to herbicides when young—especially the dinitro herbicides.

MODERATOR SNYDER: Joe Cesarini, what is your after-care for grafted pines and spruces?

JOE CESARINI: We have fiberglass houses and the grafts are placed in these and left standing up. We heal them in with peatmoss or a peat moss and perlite mixture, just covering the union. We do not use sash or plastic over them, but on warm days we do syringe them and if it is hot we may have to syringe them several times. Once they start to grow we gradually cut the understock back and remove the peatmoss from the union.

MODERATOR SNYDER: Case, when do you take *Prunus* x *cerasifera* 'Thundercloud' cuttings and how do you root them?

CASE HOOGENDOORN: We take cuttings in the middle of July, treat them with a hormone and stick them in sand in an outdoor mistbed.

KNOX HENRY: We're using a little different procedure. We're sticking softwood cuttings about the 10th of June with 75° F bottom heat in the greenhouse and having excellent results. We're also having fairly good results rooting hardwood cuttings in the fall.

MODERATOR SNYDER: Does anyone know what the hardiness of *Pyracantha* 'Mohave' is?

JOHN ROLLER: It is reportedly hardy to —5° F.

MODERATOR SNYDER: How do you keep chickweed from growing in containers in the fall?

JIM WELLS: Casoron will control it.

MODERATOR SNYDER: Dick Bosley, do you leave your irrigation system set up in your storage houses and use them overwinter? Also, are all of your water pipes plastic?

DICK BOSLEY: Yes, the system is pressurized and is kept on, but generally the winter drying is so spotty that I use hand watering. Most of the pipe is plastic, but the fittings are metal.

MODERATOR SNYDER: Do you think there is hope for rhododendrons or azaleas for homeowners in western Ohio?

DICK BOSLEY: I assume they are referring to the alkaline soil condition and I would say yes if they are properly planted using sulfur and other materials to take care of the alkaline condition.

MODERATOR SNYDER: Have you had any experience which showed that container-grown nursery plants do not root well into garden soil when transplanted?

DICK BOSLEY: This is a problem which needs considerable study. I feel that we have to use a highly organic mix to successfully grow container plants. Some instructions on how to plant container plants might help. I also believe the use of wetting agents might help because water doesn't like to cross an interface.

MODERATOR SNYDER: Mr. Hancock, why do you consider it necessary to remove burlap covers during nights or cloudy days?

LESLIE HANCOCK: I am reminded of an answer Bill Curtis once gave. He said "When I see a good thing, I stick with it" and that's the only reason I can give you. I get excellent results using this system; I've used mist systems along side of it and the cuttings are always far superior under the burlap covers.

MODERATOR SNYDER: What was the rate of Benlate which caused the injury to the plants in the west?

BRUCE BRIGGS: I believe they are referring to the poinsettia work and they found injury at 8 oz / 100 gal on poinsettia. This rate caused damage to the ends and some stunting. They found they could get just as effective control with 3 oz / 100 gal without getting damage to the plants.

MODERATOR SNYDER: Joerg Leiss, should tree peony grafts be lined out in the field in the spring or kept in the cold frame for a year and a half?

JOERG LEISS: We keep them in the cold frame until the fall of the following year, peonies only make roots in the fall so there is no point in planting them out in the spring.

MODERATOR SNYDER: Would Mr. Ravestein please explain his experiences in irrigating rhododendrons and azaleas during the winter months.

JOHN RAVESTEIN: We put some plants in containers in a plastic house during the winter and when it gets real cold I go in and irrigate them. If water is not frozen it has to be at least 32° F so if the temperature goes down to say 8° F outside and I water the plants in containers (and I really soak them) the temperature will rise. The temperature in the can will gradually start going down and about 10 days later I'll water them again. One section of plants did not get water and when spring came these were all dead. The others were all in good shape.

E. STROOMBEEK: Since John told me about this, I've been trying it and every 3 or 4 weeks I take a couple of plants out and let them thaw out and thus far they appear to be in perfect shape. If I take out a can which is saturated with water and one that has not been watered, the one which is saturated will thaw out first. I'm still following this program of winter watering and so far it looks very good.

JOHN HAVIS: I am very interested in this information, but would like to have a clarification. Can you do this watering when the temperatures in the house are very cold, say below 20° F or even 10° F or do you have to have a mild day when the temperature in the greenhouse has risen to above freezing?

JOHN RAVESTEIN: We try to time the waterings at about 3 to 4 week intervals. The irrigation is usually done when the temperature is 27° F to 28° F outside. I have kept some records of the temperatures outside, inside, and in the can and, shortly after watering, the difference between night temperature and day temperature will only be 6° to 8° F in the can but when we get about 3 weeks away from the irrigation time, the temperature in the can may go down as low as 18° F during the night and get up to as high as 28° or 29° F during the day. The watering maintains a more uniform temperature in the can.

MODERATOR SNYDER: With more and more container stock being grown in the Northeast and being protected with poly through the winter, disposal of these vast quantities of plastic has become quite a problem. With the tightening of pollution laws, burning is frowned upon and garbage dumps and land fills in our area refuse to accept this material. Do our members have any suggestions on how to dispose of it?

HUGH STEAVENSON: One fellow I know had a very simple solution to this. He simply wraps his stock in it and sends it to the other fellow.

RALPH SHUGERT: To add to Hugh's comment, we take it off of the house and put it back on pipe or paper rollers and use it to line our shipping boxes.

VOICE: Why not use it in the soil mix?

BRUCE BRIGGS: If you leave it out in the sun for a while, a shredder will shred it up very nicely for use in a soil mix.

MODERATOR SNYDER: Has anyone used calcined clay for potting mixes or as a propagating medium?

KNOX HENRY: This past summer we used it for a rooting medium for softwood cuttings. We compared peatmoss, perlite, sand (1:1:1v/ v) with peatmoss, perlite calcined clay (1:1:1v/ v) and we found very little difference between them.

ARIE RADDER: We mixed it with peatmoss and tried to root rhododendrons in it, but it did not perform very well because it has a very high pH.

RALPH SHUGERT: I believe there is a report on this material in Volume 16 of the Proceedings.

MODERATOR SNYDER: That completes the questions in the Question Box and I now turn the program back over to our President.

PRESIDENT FLEMER: I wish to thank you all for your participation in this session of the Question Box and I now declare this meeting closed.