Southern California. The climates are very similar and there would be a lot of possibilities for exchange of plant materials. We have invited Wes Humphrey to be here with us today to tell us what he saw in nursery production and propagation in New Zealand and Australia. So Wes, would you take over?

WHAT'S NEW DOWN UNDER

WESLEY A. HUMPHREY
U.C. Agricultural Extension Service
Anaheim, California 92805

Nursery production in Australia and New Zealand is undergoing change. Container nursery production of woody plants for landscape is rapidly coming into use and replacing field growing. One of the first items that catches a person's eye is the type of container used. Frequently seen is a heavy gauge flexible plastic one-gallon size container, in contrast to the rigid container which is typically used in nurseries in the United States. The "down under" nurseryman finds this satisfactory as he is less concerned with the problem of moving large numbers of plants considerable distances.

The advent of container production has seen the use of lightweight soil mixes being adopted as a regular practice. Arrangement of the nurseries often appears quite similar to those viewed in the western United States. Overhead sprinkler systems are installed and utilized by the nurserymen. Liquid fertilizer programs are used, but particularly in New Zealand with the major part of the production concentrated on the north island, considerable use is made of controlled release fertilizers. Rainfall in most of the areas on the north island of New Zealand (where there is considerable nursery production) may run as high as 80 inches per year with it spread out well through the year, necessitating use of the overhead sprinkler system only occasionally. With this situation, nurserymen have found the controlled release fertilizers a satisfactory method of supplying nutrients.

Sanitation appears good in many nurseries visited. The practice of steam-air treatments of the soil mix was observed at several Australian nurseries. The standard treatment with the steam-air mix is to use 140° F for a period of 30 minutes. Nurseries usually are not of the size seen in the California area, making it easier to handle the volumes of soil with the steam-air treatment; methyl bromide gas, commonly used locally, is considerably more expensive in Australia and New Zealand than in the United States. It was also observed that some nurseries use a steam-air combination for treatment of certain seeds that may carry disease organisms.

Temperatures used may vary from about 125° F to 130° F for ten minutes. Experience has indicated what specific requirements are for each of the seeds being treated, and considerable work has gone into developing such information.

Vegetative propagation is often similar to that observed in nurseries in the western United States. One major difference in the propagation of Australian native plants is to put the cutting directly into a plastic tube four inches long with a 1½-inch diameter. Some of the Australian native plants are difficult to transplant from a cutting bench to a liner pot. Putting the cutting directly into the tube and rooting it there reduces the transplanting problem and saves a step in the growing process.

This method is also used for other plants considered difficult to transplant, including several members of the protea family. Noticeable in a number of the nurseries growing woody plants was the propagation and growing on of native Australian plants. Australians are becoming much more aware of the wealth of native plant material they have, and it is being grown and used considerably more in their developed landscapes. New Zealanders also grow a reasonable range of native Australian plants and have made good use of them in their landscapes.

One finds less specialization in nurseries than typically seen in California, particularly southern California. However, the trend is for more specialization, especially so in the areas of major urban population concentration. The total market in either Australia or New Zealand is considerably less than is available to United States nurserymen and makes specialization more difficult. There is a strong interest in bringing new plants and cultivars to the attention of their customers to keep them coming back to the nurseries. Australian nurserymen have started a national plant promotion program. A plant is selected each year and promoted as the plant of the year by the national nurserymen's association.

A major difference noted is little production of what we commonly call specimen trees. A few nurserymen are beginning to produce in containers some of the larger-sized plant material. Some unique containers are being used. An unusual one was a heavy gauge wire basket with a paper liner that could easily be taken apart and removed when planting.

Both Australians and New Zealanders are most interested in what is taking place in nursery production particularly in the western United States. It seemed to me that they get somewhat the best of two worlds in that many of them are well aware of what's taking place in England and Europe as well as the United States.

PRESIDENT MAIRE: Thanks for a most interesting presentation, Wes. Are there any questions?

HUDSON HARTMANN: Wes, did you see the Waratah plant over there? Do you think it has possibilities for commercial use here on the West Coast?

WES HUMPHREY: Yes, about the Waratah plant, *Telopea speciosissima;* in the right conditions here, I think could be a winner. I could have shown you a slide of a beautiful bouquet of that Proteaceous plant. It has a beautiful, big red flower head — an excellent plant for cut flower use. It stands up just like many of the Proteaceous things, but we need more information on how to grow it. I've found that people were concerned about it having a mycorrizal relationship and yet, in talking to one of the nurserymen in the Auckland area he said, "Forget it, grow it like any other plant." They talk about it needing a high phosphate soil; he said, "Forget it, treat it like any other plant." George Rainy of the Auckland area, a very excellent nurseryman, is having good success in growing them under his conditions.

VOICE: Did you see the hybrid proteas?

WES HUMPHREY: Yes, but I don't know that we were any more impressed by those than we were by the native *Telopea speciosissima*. It seemed to me that if grown right — Wham! It really hits you in the eye.

PRESIDENT MAIRE: We always like to announce the new members who have been approved at the beginning of the meeting so they can sit in on this meeting as members. So, Jiro, as chairman of the Membership Committee, would you come up and give us a list of those who have been approved and then tell us where you are on evaluating the rest of the applicants?

JIRO MATSUYAMA: First, I would like to say to any guest here who wants to join the International Plant Propagators' Society that you can pick up a membership blank at the registration desk. Then when you get it filled out, you can turn it in to a member of the membership committee. I'll mention those on the committee so you will know who they are. Leslie Clay, Harold Clarke, Edsal Wood, Howard Brown, Gene Bacui, Ralph Pinkus, and Bob Warner — or you can turn it in to myself or to Curtis Alley. After you fill in these forms, please return them before tomorrow.

I'll call out the names of approved new members. Will you please stand?

membership committee can have a chance to process them. Then you can be accepted as a member as of this meeting. Otherwise, you'll have to wait until next year because this is the only time during the year that the membership committee meets.

To continue our program, now, we have Dr. Converse from Oregon State University, who will speak to us on viruses in strawberries.

THE PROPAGATION OF VIRUS-TESTED STRAWBERRY STOCKS

RICHARD H. CONVERSE[1]
Oregon State University
Corvallis, Oregon 97331

Small fruits are important in Pacific Coast agriculture. In 1971 strawberries ranked seventh among the crops grown in Oregon, eighteenth in California, and twenty-sixth in Washington. The strawberry industry, of course, depends on vegetative propagation of its cultivars. It is my purpose here to describe some of the procedures and problems of commercial strawberry-plant propagation on the West Coast.

Strawberry plants for the commercial industry on the Pacific Coast are grown by a few specialized nurserymen in four areas in Washington and California. There are 13 nurserymen involved, raising 1,200 acres of strawberry plants worth about $ 6,000,000 annually.

The Washington and California State Departments of Agriculture each administer their own strawberry certification programs. In both cases, the programs are designed to provide the public with adequate supplies of strawberry cultivars that are true to name, of good horticultural quality, and free from serious pests and diseases, including viruses.

Disease control has played a major role in locating strawberry nursery production where it is today in Washington and California. There are four or more viruses that seriously weaken strawberry plants and are spread by strawberry aphids on the Pacific Coast. Nurserymen have found that they cannot produce essentially virus-free stocks in the major strawberry fruit-producing areas of California, Oregon or Washington because of rapid infection of plants by the tremendous populations of virus-infected strawberry aphids present in these areas. As a result, strawberry nurserymen

[1]Research Plant Pathologist, USDA, ARS, and Professor, Oregon State University

have moved to areas where strawberries were not previously grown to raise their certified plants. The valleys of the Cascade range just west of North Cascades National Park; the Nisqually Sands area east of Olympia, Washington; the upper Sacramento River Valley in California; and the upland area southeast of Mt. Shasta at McArthur, California have all become specialized strawberry nurser-production areas. In each place, there were no commercial strawberry plantings when the nurserymen moved in.

In order to raise strawberry plants that are virtually free from viruses, however, nurserymen must also start with clean planting stock and prevent its subsequent infection by aphids.

The development of clean strawberry planting stock provides a good example of cooperation between nurserymen, regulatory officials, and research people.

Take two examples: Until recently 'Northwest' has been the major strawberry cultivar grown in Oregon and Washington. In terms of acreage, it has been one of the most extensively grown strawberry cultivars in the world. 'Northwest' was first released carrying aphid-borne viruses of the strawberry yellows virus complex. Drs. P. W. Miller and R. O. Belkengren at Oregon State University succeeded in 1963 in obtaining clones of 'Northwest' that were free from yellows complex viruses. They did this by cutting out strawberry meristems and culturing them into plants on agar. The clones thus developed were increased in screenhouses and distributed. The Washington State Department of Agriculture and the Washington State University Research and Extension Center in Puyallup have cooperated in maintaining, retesting, and distributing this stock to Washington nurserymen. Today virtually all of the 'Northwest' stock grown comes from these meristem clones.

In California a similar program was undertaken by Dr. S. H. Smith and Miss Ruth Hilton at the University of California at Berkeley to rid California strawberry cultivars of viruses by meristem culture. The work was supported by California Strawberry Nurserymen's Association. New clones of all of the major California strawberry cultivars have been produced from meristem culture. They have been shown to be free from all viruses, including pallidosis, crinkle, and mild yellow edge, three viruses that were both common and difficult to eradicate in standard California strawberry stock. Clean clones are being increased in screenhouses belonging to the California Strawberry Nurserymen's Association and have recently been put out for field increase.

Not only must strawberry nurserymen pay great attention to the quality of their nuclear planting stock, but they must also guard against reinfection of this stock by viruses and often by other diseases and pests.

Strawberry nurserymen routinely fumigate their fields with methyl bromide-chloropicrin mixtures under plastic tarpaulins or with dichloropropene under plastic tarpaulins or followed by a water seal. This eliminates nematodes and some fungus disease problems in the strawberry nursery. Thereafter, pest management consists mainly of insecticide applications to control aphids that could spread viruses in the strawberry plantings. Several systemic and contact insecticides approved by the FDA are used for this purpose. Many nurserymen prefer to rotate use among a group of pesticides to avoid building up insect resistance to any one — such as occurred in Oregon and southern Washington when the common strawberry aphid became resistant to endosulfan.

One fungus disease problem that strawberry nurserymen still have not completely solved is strawberry red stele root rot. The fungus causing this disease, *Phytophthora fragariae,* is very long-lived in the soil. Once a field becomes infested with this fungus, it cannot be safely used for strawberry nursery production thereafter. Both California and Washington have an official zero tolerance for red stele disease in certified strawberry plants. Nurserymen who find the disease in their fields can at best dig only part of these fields for plants — sometimes none at all. The selection of land thought to be free from red stele disease is a major problem for strawberry nurserymen. We need to know more about possible wild hosts of this fungus, such as *Potentilla* species, which may harbor it in previously uncultivated land.

We have spoken so far mostly about management procedures for strawberry plant production. The detection of viruses in strawberry involves unusual procedures that are of intrinsic interest to students of propagation methods.

It is an axiom among virologists that all plant viruses and mycoplasma-like diseases should be graft-transmissible. (We will lump these all under the term "viruses" hereafter.) Although some of the strawberry viruses are easily transmitted from infected to healthy plants by aphids, many strawberry viruses are transmitted experimentally only by grafting. Research workers in Europe and North America have developed a number of strawberry clones that are particularly susceptible to strawberry viruses. This work has recently been brought to a high degree of refinement by Dr. N. W. Frazier of the University of California at Berkeley. He has developed several strawberry indicator clones that will produce symptoms characteristic of the various strawberry viruses and their mixtures after inoculation. The method of inoculation now widely used in strawberry virus indexing is an ingenious petiole-insert graft technique developed by Professors Bringhurst and Voth at the University of California at Davis. Petioles of the indicator plant to be grafted are slit longitudinally, and a long spear-shaped petiole with attached terminal leaflet from the plant to be tested is inserted into this slit. The graft is then bound with self-cohering elastic tape, and the indicator plant is held for symptom development on the greenhouse bench for 2 — 8 weeks. In the past, several donor leaflets were grafted from a source plant to a single indicator plant to assure transmission. Recent work from the University of California indicates, however, that equally reliable and more rapid results can be achieved if all of the leaves are cut off the indicator plant at the time of grafting, leaving the donor leaflet to be the only leaf tissue left on the indicator.

Leaf-grafting procedures are now used by researchers to check for freedom from virus in new strawberry selections and improved stocks of old cultivars, as well as for detailed studies of the virus diseases themselves. Regulatory officials in California routinely check the virus content of sample strawberry daughter plants by leaf grafting in order to evaluate the virus freedom of the mother plants, which are maintained clonally.

As you can see, research and regulatory personnel and strawberry nursery growers are spending a great deal of time and effort in ridding strawberry stocks of viruses and keeping them that way as far as possible. It is proper for the question to be asked in closing, "Of what value are all these precautions to the commercial strawberry growers?" A number of research studies have been designed to answer this question and to demonstrate the amount of growth and yield increase that can be attributed to the use of virus-tested, certified strawberry plants. In one field study I compared growth and yield of 'Northwest' strawberry free from known viruses with those of plants naturally infected with a combination of crinkle, mottle, and mild yellow edge viruses. This combination of viruses is very common in established plantings in Oregon. We found that plants free from known viruses produced 103% more runners and yielded 51% more fruit than virus-infected plants.

Therefore, both the initial growth of essentially virus-free certified strawberry plant stock and subsequent yield from such fields can be demonstrated to be markedly increased when compared to the performance of field-run virus-infected stocks.

RICHARD SMITH: Would you describe one of the mycoplasma-like diseases and tell how you identify them?

RICHARD CONVERSE: That's almost a political question these days among plant pathologists because it's a very highly controversial field. About four or five years ago, the Japanese discovered what they feel is a new class of plant pathogenic organisms. Just where they fit in the scheme of things and how many kinds there are aren't quite clear yet. Some people feel that this group of so-called mycoplasma-like organisms belongs to a closely allied group of the already established animal mycoplasms and some of the saprophytics. There has been recent work just reported in our meetings at Mexico City that there may even be spirochete-like organisms, lacking cell walls, that are involved in this type of mycoplasm disease. This whole group of diseases usually causes deformity and yellows-type symptoms and are very often spread by leaf-hoppers. People talk about mycoplasmologists now — so we apparently have a brand new field of investigation.

PRESIDENT MAIRE: Thank you very much, Dr. Converse. Let me give you your certificate here in appreciation for your being with us today and sharing this information with us.

MODERATOR McNEILEN: To start this next session, Jay Allison of the Weyerhaeuser Company will tell us about control of freeze damage in their forest tree seedling nurseries. Jay Allison:

FREEZE-DAMAGE CONTROL IN FOREST NURSERIES

C. J. ALLISON
Weyerhaeuser Company
Seattle, Washington 98134

In 1967, the Weyerhaeuser Company established the Washington Forest Seedling Nursery. This was the first in a series of six major nursery units to support the company high-yield forest regeneration requirements. The Washington Nursery is 160 acres in size and is located about 15 miles southwest of Olympia at the south end of an open prairie. The site slopes gently to the south and has a mean elevation of 140 feet.

By 1969 the nursery had over 53 million seedlings in three age classes; 1-0, 2-0, and 2-1. In October of that year, an unexpectedly severe freeze occurred that killed or seriously damaged about 12 million seedlings, mostly in the 1-0 age class.

In September of 1970, another early freeze occurred. The 1-0 blocks were protected by sprinkling, and losses were minimal. Well capacity was not adequate to sprinkle the 2-0 beds and they were extensively damaged. Although the incidence of mortality in the 2-0 stock was low, the quality was poor and subsequent field performance of the seedlings produced was below standards.

It was apparent that, if the nursery was going to meet production objectives, a more effective means of reducing freeze-damage was needed. Before making a substantial investment for and some of the saprophytics. There has been recent work just reported in our meetings at Mexico City that there may even be spirochete-like organisms, lacking cell walls, that are involved in this type of mycoplasm disease. This whole group of diseases usually causes deformity and yellows-type symptoms and are very often spread by leaf-hoppers. People talk about mycoplasmologists now — so we apparently have a brand new field of investigation.

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It was apparent that, if the nursery was going to meet production objectives, a more effective means of reducing freeze-damage was needed. Before making a substantial investment for freeze-damage protection, a number of questions needed to be answered. Were the early freezes of 1969 and 1970 "freak" events not likely to reoccur for many years? What alternative methods of control are available? What would be the cost and the reliability of each alternative control method? Finally, what level of risk of crop loss would be acceptable?

To answer the first question, the daily temperatures from Centralia, Oakville and Olympia were compared to the four years of data collected on site at the Washington Nursery. Daily minimums correlated well with the data of the Olympia Airport, if a correction of —1.5° F was applied to account for generally lower autumn temperatures at the nursery.

Temperatures measured on clear, still nights at various levels above the nursery showed that the temperature at seedling height could be as much as 2.5° F colder than at the normal five-foot instrument level (3). Therefore, an additional adjustment of —2.5° F was applied to the Olympia data for a total difference of —4° F.

The daily mean minimum temperatures for each month at the Olympia Airport are published in "Washington Climate" by the Agricultural Extension Service (4) covering a 30-year period. The standard deviation of mean lows were obtained from the Climatological Handbook of the Columbia Basin States (2). From these data, corrected to ground level at the nursery, the probability of any given minimum temperature occuring by a certain date was derived.

The next step was to obtain meteorological data during radiation cooling periods at the Washington Nursery. Three factors were of particular interest: (1) mean minimum temperature for the whole nursery, (2) distribution of minimum temperatures over the nursery during periods of radiation cooling, and (3) the vertical temperature variation or inversion patterns. First, six minimum-registering thermometers were permanently fixed 6 inches above the ground at scattered points throughout the nursery. These were read each morning from September to November after nights of radiation cooling. The average of these six represented the nursery mean low for the night.

To obtain a pattern of low temperature distribution or "cold spots", a 100 yard by 100 yard grid pattern was laid out. This resulted in 90 data collection points uniformly distributed over the nursery. Minimum registering thermometers at these points were read after at least three nights of radiation cooling. The minimum at each point was compared with the mean nursery minimum temperature. The average differences were used to construct temperature-difference iso-therms for the nursery. Various areas were from 2½° F warmer to 4½° F colder than the mean low of the nursery as a whole. Warmer minimums seemed to occur over 1-0 blocks. Trees near the two north corners of the nursery showed a definite "shelter-belt" effect as did the building complex near the center of the nursery.

To obtain temperature inversion information a 36 foot mast was erected. Temperature-sensing diodes were located every six feet up the mast. Readings were recorded at half-hour intervals through the night. The strongest inversion measured was 8° F at the top of the mast. Cold-air cells moving down from the Mima Prairie made the strength and stability of inversions highly variable. Data on wind direction and velocity and cloud cover was also collected.

These on-site meteorological studies were made in September and October before data collection was hindered by the need to apply freeze-damage control measures. Similar data collected during the operation of control techniques was used to evaluate their effectiveness.

To make these data meaningful it is necessary to know the temperature at which freeze damage to Douglas fir seedlings will occur. This critical temperature for freeze damage changes as the trees become dormant. Temperature history, application of fertilizer, and irrigation schedules before the onset of frost danger undoubtedly influence the freeze-hardiness of the stock. The best information available at the time of this study was the work of John Alden (1). His data for Douglas fir seedlings suggests that a severe crop loss can be expected nearly every four years at the Washington Nursery unless protective measures are employed. (Figure 1)

Protection against potentially killing freezes that would occur more frequently than once in fifteen years was selected as a design criteria.

With this background it was possible to make a knowledgeable evaluation of the control measures available. The following methods were considered for their degree of protection, reliability and cost:

Oil-fired heaters	Foam blankets
Gas-fired radiators	Wind machines
Greenhouses	Various row covers
Overhead sprinkling	Wind breaks
Artificial fog	Control of nutrients and water

Greenhouses were rejected principally on cost. Fueled heaters also require a large capital investment and relatively high operating costs. Both wind machines and artificial fog depend on a pronounced low-level temperature inversion. The vertical temperature data showed that inversions over the nursery were rather weak and transitory and total dependence on either wind machines or fog would be risky.

By far the cheapest source of night-time heat was found to be the latent heat released by freezing water. It was decided to expand and modify the existing Rain-bird overhead irrigation system to provide simultaneous coverage of all 1-0 and 2-0 blocks. This required the drilling of a third well, installation of another pump, some changes to the piping system and additional thermostatic controls. Catch basins for collection of run-off water were also prepared.

The advantages of this choice were that most of the system was already in place for irrigation. It was expected to give the required level of protection (3). It could be manually or automatically operated. It is independent of temperature inversions and is unaffected by light winds. It creates no air pollution, it is quiet, and it had been successfully used to protect 1-0 seedlings in 1970.

The undesirable aspects were well recognized. Experience had shown that sprinkler heads would build up enough ice to stop rotation if the temperatures dropped below about 17° F. Prolonged operation could overtax the wells. Leaching of the nursery soil was of concern as was handling the run-off water. Sprinkling must be started at 32° F regardless of the critical temperature or line freezing can occur.

But these disadvantages were judged to be acceptable risks and the irrigation system was upgraded for freeze-damage control.

The sprinkler heads used were Rain-bird 14V-TNT quick-acting and 20E-TNT slow-acting heads with 7/64'' orifices rated at 2.6 gallons per minute at 55 psi. Sprinkler lines are 48 feet apart with heads spaced every 30 feet to give about 75 gallons per acre-minute of coverage. Three wells, with a combined capacity of over 7,000 gallons per minute, supply the system through mains ranging from 12 to 6 inches in diameter. Cross connection or isolation is possible by manually operated valves.

The first real test of the system occurred on the night of October 27-28, 1971. By 7:30 p.m. the temperature was 29° F and all three pumps had come on automatically. All 1-0 and 2-0 blocks were being sprinkled. By 2 a.m. control thermometers registered 16—18° F while the sprinkled thermometers registered 29—32° F.

Frozen sprinkler heads were first noted at 2 a.m. at the ends of some sprinkler lines. These were freed by removing the ice with the aid of propane torches. Between 2 a.m. and 5:30 a.m. the free-air temperature steadied at 15—16° F. Four men could not quite keep up with sprinkler head stoppage at the edges of the blocks. Where sprinklers stopped the temperatures within the beds dropped to 21 to 25° F. By 7:00 a.m. unprotected thermometers read 13° F. Except for end sprinklers nearly all of the heads functioned normally. The greatest frequency of sprinkler freeze-up occurred in those areas found to be the coldest in the study of minimum temperature distribution. The sun rose at 7:30 a.m. and the temperature quickly rose above freezing. Sprinkling was continued until the wet-bulb temperature exceeded 32° F.

Examination of the beds showed a 1/2 to 3/4 in. thick coating of clear ice on the seedlings Minimum-registering thermometers coated with clear ice read 27 to 32° . Near the edges of some blocks the ice had a snowy appearance. Thermometers encased in this type of ice registered from 16 to 26° F. The snowy ice was attributed to interruption of the sprinkling because of head freezing.

Sprinkling was repeated the next night but the free-air temperature dropped only to about 18° F. Sprinkler head freeze-up was much less severe and easily handled with a larger crew and the use of squirt bottles of ethylene glycol.

A week later the nursery was examined for evidence of freeze damage. Damage to lammas shoots in the unsprinkled 2-1 stock was quite apparent. A count showed damage to about % of the leader shoots. Damage to 1-0 and 2-0 stock was restricted to a thin band at the borders of the nursery and a couple of isolated spots where line failures occured. All-in-all the results were most gratifying compared to the freeze damage of the two previous years.

It is estimated that the temperature in certain areas would have dropped as low as 11° F were it not for sprinkling. Since minimum thermometers in these areas registered 29—30° F, the system performed better than expected.

Part of the success of minimizing damage in 1971 was probably due to a reduction of watering, holding back nitrogen fertilization, and applying potassium during the late summer. Still the stock was not as freeze-hardy as we would like for late October.

There were some problems with run-off after the first night due to blockages in the county road ditch. The fields and roads on the nursery were muddy for several days but never impassable. No lasting effects on soil texture or nutrient balance have been noted. And the seedlings suffered no visible damage from ice loading.

Several improvements will be tested in 1972. These include better lighting for patrolling sprinkler lines, changing the end sprinklers to segment types to increase the frequency of coverage and eliminate watering the roads, installing a wind break along the north side of the nursery to deflect cold air drainage from the Mima Prairie, and testing a row of fueled heaters along the south edge of one block to eliminate edge effects.

We are confident that the overhead sprinkling method, combined with certain cultural practices, will practically eliminate freeze damage as a dterent to meeting the Washington Nursery's production schedules in the future.

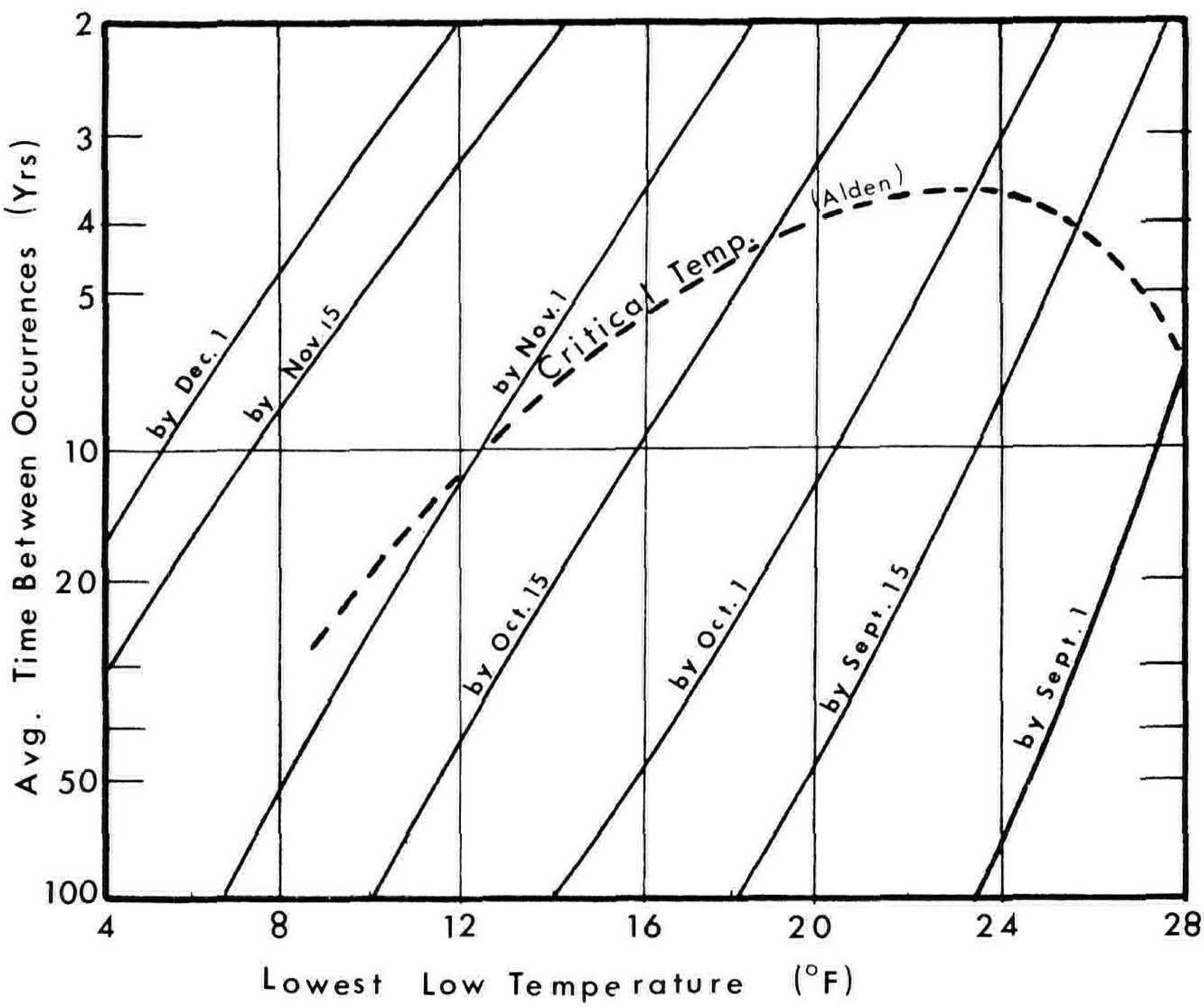

Fig. 1. Frequency of critical freeze temperatures at the Weyerhaeuser Washington Forest Seedling Nursery.

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MODERATOR McNEILEN: Thank you, Jay. Now Bob Miller from Dahlstrom and Watt Bulb Farm, Smith River, California is going to discuss the pros and cons of palletized growing of container stock.[1]

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[1] Mr. Robert Miller, Dahlstrom and Watt Bulb Farm discussed his experiences in the use of pallets for container stock.

MODERATOR McNEILEN: Our next speaker is Bill Smith, production manager at Briggs Nursery, Olympia, Washington. Bill:

PALLETIZATION IN THE PROPAGATION OF NURSERY STOCK

WILLIAM A. SMITH
Briggs Nursery
Olympia, Washington 98501

The use of pallets in the nursery industry isn't new. In fact, shipping of most nursery stock is handled on pallets at one point or another. In propagation this hasn't been the case because cuttings have been handled in solid beds or small flats. The need to develop ways of palletizing cuttings has become increasingly important as rooting costs per square foot of greenhouse space have increased greatly. The faster cuttings can be rooted and moved from the propagation bench, the lower the costs per square foot becomes. I believe a pallet system can speed up the moving process. There are many factors to consider when rooting cuttings in pallets. The size of pallet, rooting media, watering, and moving are a few. These will be outlined below in more detail. One problem that did develop, and we are still working on, is how to keep the pallets at the right height to be comfortable for the women to work at, and still be moveable.

Size of Pallet: The size of pallets for propagation is usually limited to the size of greenhouse and equipment available to move the pallets. Ease of moving the pallet in and out of the greenhouse is the main basis for using the pallet system.

After testing different sized pallets, we settled on two basic sizes. One is a 2' x 4' x 4'' pallet or box and a 4' x 10' pallet. The smaller size may not be a true pallet, but it does fill our needs within the confines of the greenhouse.

The 2' x 4' pallet holds between 450—1200 cuttings, depending upon the size, foliage, and length of time the cuttings will be in the pallet. There seems to be less heat loss from the edges of the pallet as compared to the same area utilized with regular flats. There is also less drying around the edge of the pallet as compared to a flat type system.

It takes two men to handle the pallets onto and off of the propagation bench. When we compared the amount of cuttings handled, we still found the pallet system was more efficient.

The 4' x 10' pallets that we use at the nursery are of two types: one with a 4'' side board and one that is flat. The flat type pallet is used to move flats or the 2' x 4' pallets of cuttings into a growing area from the propagation bench. We are able to put 5 of the 2' x 4' pallets on the larger pallet. In this way we can move 5000—7000 rooted cuttings per large pallet. With a fork lift this can be done quickly and efficiently.

The 4' x 10' pallet with 4" side walls is used for direct rooting of cuttings. In the direct rooting of cuttings, on the pallet system, as many as 7000 cuttings have been stuck and rooted. A good example of this is ivy cuttings. We put 5200 cuttings in the one pallet. This will give up to 5000 rooted cuttings which we can bare root or ship in the pallet.

To make the pallet system workable, a new greenhouse and special propagation beds had to be built. The new greenhouse was separated into 12' beds, which allows a 2' walkway for weeding and hand watering.

A fork lift and pallet jack are necessary to move the 4' x 10' pallets as they are very heavy. These two pieces of equipment were used mainly during the shipping season, so the propagation department was able to make use of them during the full year.

Another use of the pallet system, which we believe will be a great labor saving device, is direct rooting of cuttings in 4" pots or smaller. The nursery used this system on grapes and we were very pleased with the results.

Rooting Media: The type of soil mixes that we used this last year in the pallet system consisted mainly of sawdust and peat. With rhododendrons, the mixture was 80% sawdust and 20% peat moss. Sawdust as a rooting medium may not be the best, but for the purpose we needed, it worked quite well. In a rooting medium, we were looking for two factors:

1) good drainage throughout the 4" column and,

2) an economical medium which could be discarded after one use.

For cuttings that needed a drier mix we used 2" of sawdust on the bottom and 2" of perlite on the top of the pallet. This mixture worked well for conifers.

Watering: The watering of cuttings in the pallet system can be fairly difficult because of the number of cuttings per pallet and the number of pallets per bed area. It is very easy to mix plant material that have different water needs in the same bed. As in all propagation, water is still a variable factor between rooting and rotting of cuttings.

Results: During the past year we have become more involved with the use of pallets in propagation and have been pleased with the results. There have been failures and problems, due, mostly, to a lack of understanding of how to water the pallets. It is possible to move many thousand cuttings from the propagation bed to a growing area in a very few minutes. We feel that with the higher level of efficiency and speed by which we can handle many cuttings with the pallet system, it has been a worthwhile experiment and we plan on making use of many more pallets next year.

MODERATOR McNEILEN: Mr. Richard Bosely from Plant Systems, Mentor, Ohio, will speak to us next on overwintering structures as used in the East. Dick Bosley:

RICHARD BOSLEY: Thank you. This is the second time I've come to the Western Region meeting, the previous time being at Disneyland several years ago. I had such a fine time there primarily because of the nature of the people on the West Coast. I think they are more friendly and out-going than the more conservative Easterners, so it is very enjoyable to visit out here.

EASTERN OVERWINTERING STRUCTURES

RICHARD BOSLEY
Bosley Nursery
Mentor, Ohio 44060

Lake County, Ohio, is located along the south shore of Lake Erie and about 25 miles east of Cleveland. There are several conditions which cause a concentration of over 200 nurseries in this smallest county in Ohio. The lake has a strong influence on our weather, the great glaciers deposited a variety of soils and we are in the middle of a giant market area.

Since many of you are interested in the rhododendron, I must mention that Lake County produces 500,000 new rhododendron plants a year, according to an estimate by Dr. Hoitink of the Ohio Agriculture Research Center. Dr. Hoitink has taken quite a personal interest in the rhododendron and has done a lot of research in the area of disease prevention, for which we are all grateful. He has also been largely responsible for the development of extensive test and display gardens at the Wooster, Ohio, Center.

The Holden Arboretum, also in Lake County, is the largest arboretum in the world by a large margin and they have recently spent $100,000 dollars to develop a rhododendron collection. This was spent for developing the area alone!

Last year my father donated to the Lake County Metropolitan Park District 14 large Dexter hybrid rhododendrons. Each of these plants is unique and none of them have ever been in the trade. I am pleased that these will be available for future generations to see. These most hardy plants that Mr. Dexter developed will bloom heavily after —20° F to such an extent that you can hardly see the leaves. They are planted in a beautiful forest setting and we hope to expand the plantings in the future. The well known rhododendron breeders, Dr. David Leach and Tony Shammarello, reside and carry on their work here also.

With this background I would like to consider winter protection of container plants. If you have been a member of this Society you will find many papers on this subject in the Proceedings over the past years. It has been an evolutionary matter but perhaps the greatest turning point, for me, was a talk given by Harrison Flint (1) at the Eastern meeting of the IPPS in Mobile, Alabama, in 1967. He said in part . . "root hardiness has been measured in only a few species but in these cases roots usually have been found to be more tender than hardened stems of the same species." If you are thinking of switching from field growing to container production try to obtain this volume of the Proceedings and read the article.

At first our protection was mainly one of keeping the winter wind and sun off the plants. With the realization of Mr. Flint's fine work our structures took on the shape, size and expense of greenhouses. Today at my nursery the structures are double covered which saves about 40% on the heating bill and makes the house much more wind resistant. Each house has full electric service, piped in natural gas and a year round operating water system. The experiences I have had over the years with polyethylene has been less than good so that today I use the very best two-year film that I can get and throw it away after one winter in the hope that it will survive the high winds and bitter cold that we always get.

This past year I observed an interesting event. Most of my poly houses were covered with two layers of four mil Co-polymer white film but two houses had a variation. One had the outer layer clear and the inner white while the remaining one had the reverse. There was quite a difference in the light and heat on a bright day with these three variations. If the light meter showed 100 foot candles in the house with two layers of white it would show 200 f.c. in the one with white on the outside (clear inside) and 400 f.c. in the house with clear out and white in. There was a similar heat relationship. I don't know why reversing the two outer layers should make such a difference — but there was. Perhaps other growers can somehow use this to their advantage. The houses were oriented east and west on their long axis and were inflated with air between the sheets with about ¼ inch of water pressure.

Several years ago I realized that covering wasn't sufficient insurance that plant roots would not be injured and so heaters were installed. The units I use are furnace conversion burners used to change household coal furnaces to gas.

They are fully automatic and are controlled by a thermostat which also switches on a blower that distributes the heat through the 135 foot house. Products of combustion are retained in the house and adequate fresh air must be provided by propping the door open to prevent flame-out from lack of oxygen on cold nights. There are certain potential hazards with this heating approach and I am not suggesting that others use this method but only reporting what I have done. The system works well while keeping the cost within reason. There are many types of heaters that can be used. I find that it requires 70,000 BTU / hr / night to keep a house that is 14 ft x 135 ft, double covered, at 35 degrees when it is zero outside with a 50 m.p.h. wind blowing.

The products of complete combustion from natural gas are carbon dioxide and water vapor. If there isn't enough oxygen present the heater can then produce carbon monoxide plus unburned gas, which can cause defoliation of some crops.

The conditions we have within these winter cover structures are perfect for the spread of *Botrytis*; that is, high humidity and above-freezing temperatures. Many of the methods used in greenhouses do not work at these low temperatures but we have been using a method for several years that is very good, on at least the red rhododendrons that I grow. It is 1 lb Terraclor (75% WP) and 2 lbs. Captan (50% WP) in 100 gallons water sprayed on the plants once before they are covered and then about once a month during the covered period or as needed.

This really works but I would caution you not to use it on young growth or at elevated temperatures, such as you would have in a greenhouse. Try it on a small scale first. It appears that the Captan kills most of the organism present and then they do not seem to re-form on a surface that has Terraclor on it.

The only thing I am sure of is that we would not recognize today what we will be doing in the field of winter protection five years from now. The structures we are using now can yield about $40,000 gross crop return per year per acre covered and I expect this figure to double in five years, due to better quality crops.

I always enjoy attending the Western Region Plant Propagators' Meeting, as the people here are so very friendly.

LITERATURE CITED

1. Flint, Harrison, 1967. Winter storage of young nursery stock. *Proc. Inter. Plant Prop. Soc.* 17:344—350.

MODERATOR McNEILEN: Thank you, Dick. Now Dr. Douglas Phillips, U.S.D.A. plant pathologist from Fresno, California will discuss control of geranium rust through heat treatment. Dr. Phillips:

HOT-WATER TREATMENT OF GERANIUM CUTTINGS

DOUGLAS J. PHILLIPS
U.S. Department of Agriculture
California Marketing Research Center
Fresno, California

Postharvest, hot-air or hot-water treatment of geranium cuttings offers a high or eradicative level of control of geranium rust incited by *Puccinia pelargonii-zonalis* Doidge with only slight injury to the cuttings, (Grouet, 1965) (Phillips and McCain, 1972). Our initial work indicated that hot-water treatment at 122° F for 90 seconds also gave some control of other cutting-borne pathogens that are imnot work at these low temperatures but we have been using a method for several years that is very good, on at least the red rhododendrons that I grow. It is 1 lb Terraclor (75% WP) and 2 lbs. Captan (50% WP) in 100 gallons water sprayed on the plants once before they are covered and then about once a month during the covered period or as needed.

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Trimmed, uncallused cuttings, freshly harvested from fields in San Diego County, California were treated in water at 122° F for 90 seconds, then cooled in air or in cool chlorinated water (50 ppm C10). Control cuttings were not treated. Following treatment, cuttings were packed in fiberboard shipping boxes and held 2—4 days at room temperature before they were evaluated for disease.

In the first test, hot-water treated and untreated cuttings of the varieties Coral Seas and Electra were placed in the shipping boxes with or without a polyethylene wrapping. Table 1 shows that 67% of the non-wrapped, hot-water treated cuttings were in sound condition after 4 days, whereas only 48% of the untreated, unwrapped cuttings were sound. Wrapping markedly increased losses in both lots. The incidence of stem-end rot incited by *Botrytis* sp. was much reduced by the hot-water treatment.

In the second test, with 500 relatively "soft" cuttings of the varieties Cardinal and Apple Blossom, lots of 50 each, treated and non-treated cuttings were put into kraft paper sacks and packed into shipping boxes. Evaluation of these cuttings after 2 days indicated 30—40% injury to the small expanding leaves at the shoot tip (Table 2). However, the overall condition of the treated cuttings was good. Hot water controlled stem-end rot and produced a clean, unwilted cutting, whereas most of the untreated cuttings were wilted.

In addition to this evaluation, 300 cuttings of each variety in the second test were shipped by air to Ohio State University. Twenty-four hours after treatment, the heated and non-heated cuttings were judged to be in good condition. Cuttings from this air shipment, planted in a greenhouse, grew and developed normally.

It is not now known whether the hot-water treatment will affect vascular pathogens of geranium. The treatment does not raise the internal temperature of the cuttings sufficiently to kill these pathogens. Tests now underway indicate the bacterium, *Xanthomonas pelargonii* is not killed by the hot water, and chlorination of the hot water may be necessary to prevent the pathogen from being disseminated during the treatment. Injury might limit the use of hot water in some cases, but field-grown cuttings appear to be quite tolerant of the treatment. These tests indicate that hot-water treatment of geranium cuttings controls stem-end rot during shipping and may improve the overall quality of the cuttings, in addition to controlling geranium rust.

Table 1. Effects of hot-water treatment and polyethylene wraps on Coral Seas and Electra geranium cuttings, after 4 days at room temperature.

Variety	Heat treatment	Wrapping	Uninjured	Stem-end rot
			percent	percent
Electra	+	—	66.7 a[1 2]	7.2 a
	—	—	48.2 ab	24.1 ab
	+	+	35.7 b	41.3 b
	—	+	31.2 b	56.3 b
Coral Seas	+	—	67.2 a	2.7 a
	—	—	35.7 ab	22.7 c
	+	+	68.2 b	9.7 a
	—	+	16.5 b	69.0 b

[1]Each datum represents the mean of 4 replications of 25 cuttings

[2]Data in each block not followed by the same letter differ at a confidence level of 95 percent.

Table 2. Stem-end rot and injury of Cardinal and Apple Blossom geranium cuttings treated in hot water and held 48 hours at room temperature.

Variety	Treatment	Stem-end rot	Injury[1]
		percent	percent
Cardinal	heated	0[2]	29
Cardinal	not heated	19	0
Apple Blossom	heated	0	43
Apple Blossom	not heated	20	0

[1]Injury limited to small expanding leaves at shoot tip

[2]Each datum represents 100 cuttings.

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1. Grouet, D. 1965. La rouille du Pelargonium zonala. Traitement par thermotherapie. *Epiphyties* 16:315-331.
2. Phillips, D. J. and A. H. McCain. 1972. Hot-water therapy for geranium rust control. *Phytopathology.* In press.

Wednesday Evening Session

MODERATOR VAN VEEN: Tonight we have a panel discussion on teaching techniques in plant propagation. Howard Brown will be the lead-off man. Howard:

TEACHING TECHNIQUES IN PROPAGATION

HOWARD C. BROWN

California Polytechnic State University

San Luis Obispo, California 93401

In preparing for this presentation I tried to consider how teaching propagation in our department would differ from that done at the other institutions represented on this panel. There is probably little difference in how we handle seeds, cuttings, buds or grafts but there may be a big difference in how we motivate the students. While the technique that I will describe works well for our vocationally oriented, suburban campus, I am not necessarily recommending it for all colleges.

At Cal Poly our students in Ornamental Horticulture operate a commercial nursery and flower shop as part of their educational experience. It gives them an opportunity to propagate plants, grow them on, and market them while participating in the profits from the crops that they grow. Many of our alumni claim that production and management experience gained through our Agricultural Enterprise Program was the most valuable experience that they received in college. I know, too, that the dollar incentive is much stronger for many students than would be a mere course grade.

We encourage capable students to start an enterprise project during their sophomore or junior years. Oftentimes they will be in partnership with a student who has grown a crop previously. This gives them the benefit of the experience of a person who has been

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We encourage capable students to start an enterprise project during their sophomore or junior years. Oftentimes they will be in partnership with a student who has grown a crop previously. This gives them the benefit of the experience of a person who has been "through the mill" at least once and usually assures a market.

The heart of our operation is the Cal Poly Foundation, a non-profit corporation set up within the University to do some of the things that can't be done with state funds. The Foundation serves as banker for the Agriculatural Enterprise operations. A student must convince his advisor that he has the knowledge and initiative to complete a successful project. He then signs a contract with the Foundation, which provides the money for soil, seed, containers, etc. All of the sales are handled through the cash register in the flower shop and records are kept on all operations. Upon completion of his enterprise the student subtracts all expenses except his labor from his income. He then receives 2/3 of the profit and the other third goes to the Foundation.

If he has planned well and grown a good crop the student is likely to earn a reasonable profit in addition to making wages. If his timing is off or the market not there the most he can lose is his labor. He has still gained valuable experience.

One of our most profitable crops year after year is Christmas poinsettias in 6-inch pots. A senior student last year netted $5.27 per hour on this crop. Often a money-loser is gladiolus for cut flowers but we don't discourage this crop for a student who plans to be a flower grower. Then there is always the Mother's Day Lily — an Easter Lily that didn't make it. Instead of selling them for $3.50 a pot the operator is lucky to get 25 cents a flower from the department flower shop.

In addition to the above-mentioned crops some of our most successful student enterprises have included the following:

Miniature roses in pots	Bedding plants
Miniature carnations	Vegetable plants
Annuals in 4-inch pots	Ground covers
Novelty plants	

From a teaching standpoint the Agricultural Enterprise Program is not all sweetness and light. There are many problems, not the least of which is public relations with local nurseries and florists. The trade associations — California Association of Nurserymen and California State Florists Association have been most helpful and understanding in this respect.

Successful projects require close instructor supervision and this mostly comes on Saturday, Sunday or holidays. It requires persistence on the part of the students involved. But the rewards are great. (a) This program enables us to have at least twice as many crops for students to see and work with as compared to what we could finance on our state budget alone. (b) It provides income for students, many of whom are working their way through college. (c)

It provides real life learning experience in propagating, growing, record-keeping and sales. (d) Most important, it motivates the capable student and prepares him for employment in commercial ornamental horticulture.

Based upon thirty years of experience we believe that our Agricultural Enterprise Program is the most important tool we have in recruiting, motivating, and placing qualified graduates in our vocational field.

MODERATOR VAN VEEN: Thank you, Howard. Next is Hudson Hartmann, University of California, Davis. Hudson:

TEACHING TECHNIQUES IN PLANT PROPAGATION

HUDSON T. HARTMANN
Department of Pomology
University of California
Davis, California 95616

There seems to be an increasing interest among students in plant propagation at the University of California, Davis Campus. Enrollment in the plant propagation course was quite stable for a number of years at about 35 students per year, then in 1971 it increased to 55, and in 1972 to 80. This class is given in the spring quarter, running 10 weeks, from about April 1 to June 10. It consists of two 1-hour lecture periods and one 3-hour laboratory period per week. Several laboratory sections per week are given, depending upon the enrollment. Twenty students is the maximum per laboratory section. One-third to one-half of the enrollment has been graduate students; a sizeable percentage of the enrollment is foreign students. Various majors are represented — such as plant science, environmental horticulture, agricultural education, agricultural science and management, pomology, viticulture, international agricultural development, and botany. It is an upper division course with a prerequisite of general botany or a general plant science course.

Eighteen lectures are usually given with 2 mid-term examinations. The lectures follow the theoretical chapters in Hartmann and Kester's "Plant Propagation: Principles and Practices" (1), which is used as the text. Considerable use is made of visual aids, chiefly 2 x 2 slides, to avoid the use of time-consuming drawings on the blackboard and to illustrate situations that facilitate explanations. Reading assignments are made of many of the

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Subjects discussed in the lectures are:

(1) Objectives of course. Milestones in propagation history. Basic types of propagation in relation to meiosis and mitosis. Nomenclature terms — cultivar, clone, line, etc.

(2) Seed development, structure, viability, storage. Uses of seedlings in propagation. Methods of maintaining genetic purity. Seed certification

(3) Seed germination — hormonal and enzyme relationships. Seed dormancy — types. Embryo dormancy; hormonal relationships.

(4) Factors affecting seed germination. Phytochrome relationships. Disease control during germination.

(5) Asexual propagation, nature and importance. The clone. Juvenility. Genetic variation in clones — mutations, chimeras.

(6) Virus and mycoplasma problems in clonal propagation. Production and maintenance of pathogen-free clones. Certification programs. Plant patent law.

(7) Anatomical development of adventitious roots in stem, root and leaf cuttings. Relation of natural hormones to root initiation.

(8) Effects of leaves and buds on rooting. Rooting co-factors. Bioassays. Rooting inhibitors. Polarity.

(9) Factors affecting regeneration of plants from cuttings — selection of material, etiolation, juvenility, timing.

(10) Treatment of cuttings; use of growth regulators, fungicides and mineral nutrients. Environmental conditions during rooting: physiological effects of mist; temperature and light relationships; propagating media.

(11) Micro-propagation in aseptic culture. Uses. History. General techniques; specific procedures for various tissues.

(12) Grafting and budding. History. Reasons for using. Seedling vs clonal rootstocks.

(13) Formation and healing of the graft and bud union.

(14) Factors influencing healing of graft and bud union. Polarity in grafting.

(15) Limits of grafting; incompatibility, types and causes.

(16) Stock-scion relationships. Theories for explaining rootstock influence. Rootstocks for tree fruits.

(17) Layering. Bulbs, corms, rhizomes, etc.

In the ten 3-hour laboratory periods in this course, the work is of an applied nature, with the students learning the techniques involved in all the major propagation methods. However, the laboratory exercises are set up on an experimental basis where possible to elucidate the principles emphasized in the lectures. The laboratories are rather highly structured with materials prepared in advance for the students so that during the laboratory periods as much meaningful work as possible can be accomplished. Direction sheets are prepared for each laboratory and handed out a week in advance — with appropriate reading assignments — so that the students will be familiar with the subject material. In the first 4 laboratory periods students work in groups of two, or sometimes three.

Seeds. There are two laboratory periods on seed germination in which seven projects are done. The students essentially plant seeds in flats of germination media (the Cornell peat-lite mix) which are placed in the greenhouse; they make weekly seed germination counts for 5 weeks. A report is required for these 7 projects. The work done varies from year to year, but typically the projects used are:

(1) Effect of length of stratification period at a single temperature (41° F) on seed germination. Seeds of 5 or 6 woody species are available from which they select one. The stratification has already been done so they have only to plant the seed.

(2) Same as (1) except that the stratification time is fixed but various stratification temperatures: 32°, 41°, 50°, 68° (moist) and 68° F (dry) are used. Again seeds of 5 or 6 woody species are available from which the students select one.

(3) Seeds are soaked in various concentrations of gibberellin and combinations of gibberellin + cytokinin (compared to stratification), to demonstrate the influence of these materials in promoting germination.

(4) Seeds, such as *Cercis* and *Koelreuteria*, are planted to show the influence of "double dormancy". Various treatments are given but only those which both modify the seed coat and overcome embryo dormancy are successful.

(5) Planting of orchid seed in Erlenmyer flasks under aseptic conditions is done by each student, making use of a sterilized transfer chamber with the necessary equipment, plus a growth chamber for growing the seedlings.

(6) Seeds held under various storage conditions are planted to

illustrate the importance, with certain seeds, of storage conditions on subsequent germination. Citrus and oak seeds demonstrate this very well.

The students test all seeds before they are planted for viability, using the tetrazolium chloride test. Also samples of all seeds used in these exercises have been X-rayed by our Radiobiology Department and the x-ray photos are posted for the students to examine.

Cuttings. These are two lab periods on cutting propagation, with six projects; each student prepares reports for these projects. They vary from year to year but examples are given below:

(1) An air rooting tank is used in which cuttings of rapidly rooting species are placed, enabling the students to examine the developing adventitious roots weekly and to see the effects of wounding, IBA treatment, etc.

(2) Various growth regulators — auxin, gibberellin, growth retardent (Alar), ethylene (ethephon), cytokinin — are used for treating the base of cuttings to demonstrate the superiority of auxin in promoting rooting. The flats of cuttings are placed under mist in the greenhouse.

(3) Whole plants of various species are given to the students who make them up into various types of cuttings — root, stem, leaf, leaf-bud — all stuck in the same flat — to illustrate the various types of cuttings and to show that some types are successful and others not, depending upon the species.

(4) A project showing possible methods of reducing water loss from leafy cuttings is used by placing one group under mist, one in a closed poly frame, one in which cuttings are dipped in an anti-transpirant, and one control in the open greenhouse. Leafy grape cuttings have worked very well for this.

(5) A project illustrating the effect of leaf number in connection with IBA treatments has been very successful, using 4, 1, and 0 leaves per cutting, with and without IBA.

(6) A project with hardwood cuttings has been used with various treatments, such as wounding, IBA, boron, and fungicides. Some cuttings are inverted to show polarity effects.

Grafting. One laboratory period on root or bench grafting is done, with such material as grape on grape cuttings, pear or loquat on rooted quince cuttings and apple on apple seedlings. These are placed to callus in boxes, with the students examining some of the grafts later to note callus production in the cambial area and the healing of the union. All the material used is collected earlier and held in cold storage until needed. Both the whip graft and the machine saddle grafting, using a French-made grafting device —

see p. 431 — Hartmann and Kester (1), are used in making these grafts.

A second lab period in grafting and budding is utilized in practicing all the major grafting methods used in top-working trees. Also the T-bud and patch bud methods are practiced. Material in the proper growth stages is collected for the students to use in this work.

Following this practice lab the students have one laboratory period where they are taken to a special "student nursery" where young seedling peach and almond trees and rooted Marianna and *Rosa multiflora* cuttings and *Juglans hindsii* seedlings are available for T and patch budding. In addition, in this laboratory, seedling trifoliate orange (*Poncirus trifoliata)* trees in 2-gallon containers are available into which the students insert several buds — orange, mandarin, kumquat, lemon, etc. If these buds are successful the students are permitted to keep the plants at the end of the course.

The last grafting laboratory consists of top-working fruit trees in a special "student orchard". Five-year-old apple, pear, walnut or plum trees are used which are top-grafted to different varieties. Each student is assigned 3 trees, one top-worked by the bark graft, one by the cleft graft and one by side grafting.

The final laboratory period is utilized for a demonstration of structures and plant types used in propagation by bulbs, corms, rhizomes, stem and root tubers, runners, suckers, etc. as well as a demonstration of air layering, using *Ficus elastica* plants. This period is also used for taking counts of the rooting results from the cuttings prepared in the 3rd and 4th lab periods.

Two field trips are arranged in this course — one usually to the Oki Nursery in Sacramento, where a wide range of up-to-date nursery practices are seen. A second trip to a fruit tree nursery is made; this past year the Fowler Nursery south of Marysville, California was visited, where propagation of most species of fruit trees was observed.

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MODERATOR VAN VEEN: Thank you, Hudson. We were to have Jerry Mailman, California Department of Corrections, Soledad, on this panel but he was unable to be here. In his place, Ed Jelenfy, also a horticulturist of the same institution, will fill in briefly. Ed:

PLANT PROPAGATION TEACHING TECHNIQUES

EDWARD J. JELENFY
California Department of Corrections
Central and North Facility
Soledad, California 93960

The techniques in teaching of the Central and North Facility gardening classes are taught by separate instructors but in essence are the same.

At the Central Facility Ornamental Horticulture and Floral Work, along with landscape and general garden maintenance is taught. Seed sowing and cuttings for propagation are planted in a greenhouse under mist systems. In general, the inmate students work very much like any other plant growing establishment would operate. A number of aspects of propagation are taught, such as grafting and budding. The floral students learn various aspects one should know to enter the floral trade.

The North Facility student enrolled in Landscape Gardening is taught to properly use garden tools, along with techniques on how to grow plants, prune, bud, graft, plant bedding plants, trees and shrubs, and general garden maintenance, along with lawn care and planting.

The teaching techniques of the Department of Corrections in general is the same as in any other school teaching horticulture, with the exception of the social standing of our students.

MODERATOR VAN VEEN: Thank you, Ed. Lastly on the panel, we will hear from Jolly Batcheller, of the California State Polytechnic University, Pomona. Jolly:

TEACHING TECHNIQUES IN PLANT PROPAGATION

O. A. BATCHELLER
California State Polytechnic University
Pomona, California 91766

The foundation projects, which Howard Brown spoke of, we have also. We have similar facilities, and we work with our students in a similar manner. I think the difference in geographical location has to do a little bit with the difference in programs.

In Southern California, as I think you realize, there are approximately a thousand nurseries within a fifty mile radius of us, so

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In Southern California, as I think you realize, there are approximately a thousand nurseries within a fifty mile radius of us, so there is an opportunity for many of our students to get practical work and to work in nurseries. The demand for plants, as I think all of you realize, is very large. As a result, we, I think, do a little bit more commercial growing and selling wholesale to nurseries than does Howard: but likewise we do not advertise off the campus. We do sell to our students and to the faculty on the campus and we average about $1000 per month. Now this means a tremendous amount of production. We have about 13,000 square feet of glass; we have a five-acre growing ground; we have, I think, about 3,000 sq. ft. of lath or saran, much of which has been erected by students in class work. We have actually two courses in which propagation is presented. We have a basic horticultural course which is required of our ornamental horticulture majors; this is also an optional course for students in other majors.

We average about 50 students in the basic horticulture class, and it is given each fall, winter and spring quarters. Each class is divided into at least three laboratory periods. These labs involve considerable preparation, and planning months ahead of time in order to have plenty of proper plant material at the right stage of growth ready for each lab. I am very fortunate in having an oustanding graduate of our school as a technical assistant who handles this phase.

When one starts talking about propagating material, as has been brought out, one learns by doing. When we make cuttings, if we don't average at least 15 or 25 flats per lab, we are not doing what we should be doing.

When it comes to grafting, we do quite a lot of practice grafting because many of these students are not in the horticulture department and this may be their only opportunity to learn these techniques.

The second course in plant propagation is required of majors in ornamental horticulture and is primarily limited to such majors. Occasionally a bioscience junior or senior who has a nursery background is permitted in the class, but I discourage this because this course takes off where the basic course ends, and we don't go back to review details of the latter.

I have in prior years shown this organization the grafting models we use in class. I make these models of everything that I can, for example, for everything we do in the way of cuttings, grafts, buds, etc. I make a model at least 18 to 20 inches tall, so I can discuss this and illustrate it on the board. I have the actual plant and a large model so the students can understand. I find this is a tremendous help in teaching, because if a student can see, and if he can understand, then he can follow my conversation. But if a student can't see what I am doing and he doesn't understand, he loses interest: once he loses interest, I have lost the student. So I try very hard to use graphic means of presenting the material.

In this advanced propagation class, we go into tissue culture. Now, with a lab the size we have, we cannot do this with one station. So what we do is schedule the student's free time. It means about three or four times extra work for me because I only take three students at a time in the room where we are doing the transfers and the meristem tissue culture. It increases my load for it is a three to one type of operation, but it's very, very gratifying, due to the close individual attention. I think we are fortunate to have the type of student we seem to attract.

I'm going to digress from the matter of teaching students but I am going to talk to you about a subject that is dear to my heart, and that is teaching people. I think it's wonderful that we have 200 people here today for this, but the trouble is with us horticulturists, we talk too much to each other and not to other people. Now, we are very fortunate to be in the field we are, because we are working with living, growing things. "In nature, there are no rewards or penalties, there are only consequences." Now human beings butter each other up and say you're the greatest guy in the world and for five minutes the guy believes it, but you can't do this with plants. If you don't water them, if you don't fertilize them, if you don't take care of them, they won't respond. And this is what Howard was talking about in these projects, where the students learn this. I've had similar experiences with my students where two students take the same kind of seed in starting a project and one comes out with a tremendous crop, the other comes out with a complete failure. They have learned from the experience.

I think many people, including California's governor, are sort of mad at educational institutions: I think people point at education or at institutions and say, "you're not doing a good job." And I ask each of you at this time, to point your finger at something, will you? Just each of you take a look at your hand as you point at something. Just hold up your hand and look at it. Will you look and see that three fingers are pointing back at you.

This is a story I tell when I work with scouts. I also tell it to students and to parents. It's the story of the scoutmaster walking along a mountain trail with his troop. They pause for a rest under the shade of a shrub. As the scoutmaster is sitting there, he notices a small chrysalis on one of the branches. He calls it to the attention of the scouts. "Look, scouts, here is a chrysalis; this is a butterfly in the making." He said, "You know, I've never seen one of these things break out of the chrysalis and I'm going to take this home with me." So he very carefully cut the twig and, as all scoutmasters are prepared, he had a little box with some cotton wool to put it in. He wrapped it up and he took it home. He placed it on the kitchen table where he could watch it very closely. One Saturday, and he was very glad it was Saturday, he noticed that the thing was beginning to move, so he quickly got on the phone and he called the scouts. He said, "Look, fellows, this thing is beginning to come out and I want you to come over and see it." So the scouts came over and they gathered around and pretty soon, sure enough, there was a twisting action of this chrysalis and suddenly it cracked. You could see the wings beginning to emerge. Well, it's a slow process. So he called his wife and said, "Dear, I want your tweezers and a pair of nail scissors." Very carefully he cut part of the chrysalis that was exposed, not touching the butterfly. Soon he had the butterfly out of the chrysalis — and apparently undamaged. So the boys had seen the butterfly come out of the chrysalis and they went home. But the scoutmaster watched that butterfly during the day and that night the butterfly had not changed. It was still hanging from the chrysalis with its wings helpless beside its body. Two days later, it died, and dropped on the floor. So the scoutmaster got in touch with an entomologist and he said, "What happened? Why did this chrysalis die? He said, "I'm positive I didn't touch it — I know I didn't touch it What happened?" The entolmologist said, "You killed it." He said, "How could I have killed it? Was it the temperature of the house? Was it diseased? "No," the entomologist said, "you killed it, because you see, a butterfly is first a caterpillar and then it goes into this chrysalis, where 90% of the body fluids are in the thorax or the body. It is the struggling, the twisting, the turning, the effort, that forces these fluids from the thorax into those helpless wings to fill them out to make it possible for the butterfly to fly." And so to you parents, to you horticulturists, to you teachers, don't make it too easy, because that is one of the problems of education today. There are too many people, I believe personally, who shouldn't be in college. They don't want to be there but the parents want them to be. I think it would be better if some of them were working to learn the value of effort. Don't make it too easy. Make it tough. Thank you very much.

TED VAN VEEN: Thank you very much, Jolly. Do we have any questions that you'd like to ask of these four people at this time? If not, we'll go on, but I do want to hand out these certificates of appreciation.

Next we will have Bill Curtis and his perennial Question Box. Are you ready, Bill?

WILLIAM CURTIS: Sometimes you have quality and sometimes you have quantity. Tonight we have quality but we don't have very much quantity.

How do you get a new plant accepted? I think every one of us has been through that. We see something good, we pick it up in some other part of the country, we bring it home with us, and we have a hard time getting the public to accept it. Who wants to answer the question as to how we go to work and get a particular plant into the hands of the public, into the hands of the architect, into the hands of the landscapers so that we can produce it and make some money. *Who wants to answer this question? There ought to be a dozen answers.* Dr. Clark, you've introduced a number of new rhododendrons. How do you go about getting rhododendrons accepted?

HAROLD CLARKE: I haven't introduced any new rhododendrons, but I'd say the first thing is to be sure you have a plant that's better than anything else.

WILLIAM CURTIS: Well, that's one answer. Go ahead, Joe.

JOE KLUPENGER: I always felt, Bill, that if a new plant is to get propagated in quantity, first send out sample plants all over the country where you know this plant will survive, for tests. Get it out before the public, get good color pictures, get its characteristics, get all the information you can on it and get it out into many areas and to as many people as you can and, by doing that, I think those who have developed this plant will have very successful stories to tell.

We can look at the rose growers; you will find that many of the patent roses have been handled in that way. But I think that anything, whether a tree or shrub or any plant material that you know surpasses those in the same field, the same area, the same type of plant should be handled this way. Take for example, we have a new Pfitzer-Tam-juniper that was developed right here in our area quite a few years back but as far as I could see, there's never been any promotion of it. The man who owns that plant, if he would propagate it and get it scattered out into all the zone areas where it will grow, he would find that he can get it accepted by the general public.

ED JELENFY: Just plain advertising; for example, a number of years ago there was the black rose of Germany. If some of you old timers remember, they sold thousands of them even though it wasn't any good, just by heavy advertising.

WILLIAM CURTIS: Right now, there is on the market a new *Pieris* the North Willamette Valley Experiment Station has developed and we're all wondering, when it gets the acid test, what's going to be the final results. I would put it out now into the hands of a number of nurserymen; these nurserymen will evaluate it and the time will come when we will know whether it's a plant that is going to go over big and everybody will be able to accept it and sell it. So there are a number of ways that you can get a plant introduced. *Sunset* magazine is very helpful if you have something unusual. I know in this area the editor from Seattle will come down to your place and take pictures and write an article about it. It is possible for an unusual plant to get introduced to the trade through *Sunset* and lots of people read *Sunset* magazine.

EUGENE BACUI: Bill, there's one method I didn't hear mentioned; that's with the architects. Contact architects, especially with ornamentals. It just takes a few to like it and put it into a good landscape job or on a big important work and your plant is sold.

WILLIAM CURTIS: The next question is: What is the proper way to make a cutting for the best rooting? Who wants to answer that? There are several ways to make cuttings — different woods, and different materials that have to be cut differently. Who wants to answer this? Dr. Brown? You supervised the making of a good many thousand cuttings among your students; would you answer this question? The way you would want to make a cutting so it would root the best.

HOWARD BROWN: I think, Bill, you just have to narrow this down a little bit to the kind of plant. Because certainly some things are going to root very well from hardwood cuttings. Others are going to take softwood cuttings; and, of course, the location of the basal cut can have quite an influence on rooting in some kinds of plants, too. I think you'd have to know which kind of a plant you're talking about.

WILLIAM CURTIS: Who wrote this question? Have you a particular plant in mind?

JOE KLUPENGER: I'm talking about hardwood cuttings. As we look around over the past years, we find so many ways the cuttings are taken off, at a 20° or 45° angle; some cut 90° across the end of the cutting. Some wound halfway up one side or for ¾ inch or ½ inch. Some wound both sides. This seems to be pretty general among all woody cuttings. I wonder if there has been any work done on hardwood cuttings as to which is the best method to make the wound on a cutting to get the best rooting. Has there been any work done experimentally to find exactly what is the best way to make the cuttings.

ED SCHULTZ: There is lots of information on early work done with cuttings in making the basal cut in relation to the nodes. The cutting that has prominent nodes is most likely to root at a node, because here is the place that natural storage of foods is concentrated. In making cuttings that you don't know anything about, the most likely place for it to set roots is at the nodes, so a basal cut just below the node is considered ideal. The angle of cut depends a little on your conditions. With mist I don't think it would make any difference whether you cut square across or at any angle. If your conditions are similar to those under which the old time nurseryman propagated, in which he watered the cuttings himself, chances are the longer the angle of the cut the more likely there will be a surface that is exposed to water — the greater surface exposed to water in the medium. So an angle cut would be very important — if you don't have an automatic watering system. But, as far as angle of cut, some work at Texas A. & M. University was done with pruning shears versus sharp knife versus dull knife, along with different positions on the cutting end. The conclusions were that the sharp knife at an angle in which you increase the base at twice the length of a straight cut was about ideal. You shouldn't have too long a sharp point that could be bent over and make an opening where decay could get started.And yet, you should have an angle cut that makes it easy to stick the cutting and to give a cut surface exposed to moisture in the medium. This also allows more hormone — in that study they were using powdered hormones — to coat the cut surface.

WILLIAM CURTIS: Many years ago, when I worked for Franz Krusky—and I don't think he ever read about this work — that is the way he explained it to us. I think that stands pretty true today. Dr. Clarke, though, has a different method for making rhododendron cuttings. He uses the pruning shears and he whacks them off at the base with the shears and he cuts the extra leaves off with the same pruning shears — real simple. I asked him how they rooted and he said, "good." So since then, when Dr. Clarke gave a talk and was asked that question, at our meeting at West Lynn, Oregon (1963), we've always made our cuttings with pruning shears, and I couldn't see any difference in rooting. Just a straight cut. Anybody else wish to comment on this question?

JOE KLUPENGER: Cuttings with no visible nodes; now with plant material as camellias it is very easy, but when you get into wood that has no visible nodes or bud eyes showing on the stem, what do you do?

WILLIAM CURTIS: Does anybody have the answer to that? Well the first article that I read about wounding was when I first went to work for Franz Krusky; it mentioned that if you wounded and then dipped your cutting in hormones, you could use a longer cutting. We made very short rhododendron cuttings. We had the darndest time to hold the cutting in the medium because we didn't have stem enough. That's the way Pop Krusky rooted them. But when we started using a hormone and wounded the cuttings with the wound on the side, we made longer cuttings and we had less problems rooting. So now we make a cutting about 2½ to 3 inches long and we wound it heavily with a pair of pruning shears. But rhododendron doesn't have visible nodes like you find on a deciduous magnolia or some other plant. Mr. Bosley, here, he is an expert on rhododendrons. How do you make your rhododendron cuttings?

RICHARD BOSLEY: With the shears, just slice it down the sides.

WILLIAM CURTIS: We have a man, Ted Van Veen, who wrote a book about rhododendrons; he must have all the answers. Ted.

TED VAN VEEN: Well, its just what you said about rhododendron cuttings. I think it's a matter of experience. Cuttings should be 2½" to 4" long, and with the hormone powder that we use, they root beautifully. I remember a couple of years ago when one of our fellows who normally doesn't make cuttings came in one afternoon, and there was some odd things to make, he made some six inches long. I stuck them in, just out of curiosity, to see what would happen and they did not root very well; in other words, we have just too long distance from the top to the bottom of the cutting. I think they just did not root because they were too long. Where the happy medium is on rhododendron cuttings, I don't think anyone really knows.

BRUCE BRIGGS: Well, I would have to go along with Howard Brown to a certain extent, although, I believe, you have to consider also the effects of your mix, your media, how you handle the cuttings, etc. Let's look back to 10 or 12 years ago in the Plant Propagators' Proceedings to an article on grape cuttings. It amounted to extensive work on hardwood cuttings cut with sharp shears, scissors, clippers, and a saw. Results were that the saw was the best because there was a certain amount of wounding. You had a ragged cut. So here, again, it may be the way the cuttings are handled. So I don't think you could say any one way is the best; it is only when the method is best under your conditions.

DAVE ADAMS: Some of the work done at the University in the last few years indicates that there are probably many more things that are a darn sight more important than how the cutting is made, although I grant we did not look at this particular problem. But when we start getting into leaves, the number of leaves, and flowers versus no flowers and all the other factors, then they become much more important than how long the stem is.

WILLIAM CURTIS: Another question. Is the superiority of the German pine seed a matter of elevation, or a matter of uniform stand, or different strain?

EDSAL WOOD: That was *Pinus sylvestris.* There is no question that the seed of the German strain germinated more quickly; they put on more growth than the French strain. Don't ask me why, I never grew them before in my life until last year so I don't really know. They just performed a lot better.

WILLIAM CURTIS: Ed, did you bring a package of those cartridges that you plant the seedling in? I understand there's a larger size being developed and I wonder if you'd cover that a little bit with the group here. They were quite interested in them as a means of maybe using it for greenhouse crops.

EDSAL WOOD: Here is the one we came up with. This was the original without the hole in the bottom. Believe me, don't do it. Put the hole in the bottom. You won't get the root curling. This is the larger one that we're going into. This is 2½ inches by 10 inches. We will transplant the plugs from that into the larger one. They come out as individuals. Shaped the same way with the hole in the bottom. You can space them wherever you want to, about 140 per square foot. You can space them every other one, every third one, or whatever space you need for whatever plant you're growing.

WILLIAM CURTIS: Anything about costs?

EDSAL WOOD: Not yet These are the first ones off the die. They haven't come up with production costs. I'm assuming they will be about 6 cents apiece. We figure on using them for about five years. So that cuts the cost . . . . . This we developed primarily for Noble fir Christmas trees because we want to shoe-plant them out of a tractor and this will fit a three inch shoe. That's the reason we came up with 2½ inches by 10 inches. We need to put the root ball far down because this land is non-irrigatable. We don't have enough water up there to plant the Christmas trees so we've got enough depth to get down to normal soil mixture and hold them until the plant has a chance to regenerate its root system and carry itself. They are all tapered so they should slip out just like the plugs do. You are welcome to come up and take a look at them.

I'm glad to see we are catching up with California. It's just a matter of transposition. They have a thousand nurseries in fifty miles; we have fifty nurseries in a thousand miles.

WILLIAM CURTIS: Do you use any nutrients in the sawdust you root rhododendrons in? This is for Bill Smith.

BILL SMITH: Last year, no; this year, yes. We are now using about 10 pounds dolomite and 3 pounds superphosphate per cubic yard.

WILLIAM CURTIS: Do you prefer cedar sawdust?

BILL SMITH: I don't know really, Bill. We haven't decided yet.

WILLIAM CURTIS: I'd like to ask one of these experts here what is the difference in the chemical composition of cedar and redwood sawdust? Are they similar? Is there much difference between them? I know they use redwood a lot in California for rooting or they use it in their rooting mixture. Has any work been done on this subject? Have you tried anything, Dr. Brown?

HOWARD BROWN: We haven't done any analysis but we know that for years people tried to avoid redwood sawdust or redwood chips because of tannic acid, and then in recent years it has been used very extensively. Is Don Dillon here this evening? Or Fred Real? Don? You've had some real fine experience on this.

DON DILLON: You know, it's terrible; we got so many roots we couldn't get them separated from the mix, so we stopped using it.

HOWARD BROWN: I think rate of decomposition is one of the main reasons many of our growers stay away from sawdust. We avoid the fir sawdust because it does decompose rather rapidly; it involves a nitrate tie-up. Redwood, on the other hand, breaks down much more slowly. I know when the cut flower growers, particularly San Lorenzo Nursery in the Los Angeles area, started using redwood sawdust in their soil mix for chrysanthemums and carnations, just because it was being used successfully in Northern California, they found they had to go into a very severe leaching program in order to remove the tannic acid, or some other harmful substances, from the redwood sawdust before it could be used. After that, it was quite satisfactory. About 1/3 of their soil mix was this particular material.

AL ROBERTS: Some work at Oregon State with cedar and redwood showed that the volatile water soluble oils in cedar could be leached out in piles fairly rapidly through an Oregon winter, or putting them under sprinklers. But these oils are very toxic to plants, even in packing materials, for several months until they are leached out. I don't think the tannins, Howard, are as much a problem as some of these other materials that we are certain have toxic properties.

VOICE: The best way to eliminate the essential oils is to steam sterilize for half an hour. When I use cedar, I steam sterilize. It drives the oil out and that solves the problem.

HOWARD BROWN: I'd like to add here that several of our students and staff members have been working closely with the Sequoia Forest Products Company in Visalia, California. The objective is to get a lightweight medium for growing plants in four inch pots. This would be for plants as miniature carnations, salvia, marigolds, petunias, etc. In order to increase the water holding capacity, the fertilizer holding capacity, and cut the weight, they used a number of different mixtures of various organic materials. One of the most satisfactory mixes we're using right now is a composted redwood sawdust, 50%; 30% perlite; and 20% Canadian peat. And then, of course, we adjust the pH through the addition of dolomite lime and fortify it with nitrogen, phosphorus, and potassium. This does make a very lightweight mixture that holds moisture and fertility for a long period of time and it induces a very good root system. When we raised it up to 75% sawdust, then we got into trouble. So about 50% seems to be the maximum we can use. A number of the growers in our area are using this mix now even for various other potted plants.

AL ROBERTS: Further with the toxicity of cedar material is the fact that in some of the piles where they were leaching them through the winter, they weren't careful about the run-off and they actually could kill trout in the streams this material was running into. So there are some real toxic properties in it, but apparently they are water soluble and easy to leach out.

WILLIAM CURTIS: I remember a number of years ago, there was injury with some bare root trees that were shipped. You know in this country they used to, I suppose they still do, use a shingle tow around the roots of bare-root trees and there were some quite severe injuries. Now I don't remember why for that particular reason but there was some injury from shingle tow in bare-root trees that were shipped East.

We have one final question unless someone else has another question.

VOICE: I don't know what shingle tow is.

WILLIAM CURTIS: Well, shingle tow is the sawdust that really isn't sawdust, but is something like excelsior. You know what excelsior is? Shingle tow has the same formation of excelsior but it comes from cedar when they saw shingles. The type of a blade they use runs out shavings that is similar to excelsior; and they call it shingle tow. It's a rip-saw and it goes the length of the grain. They use it in cars for shipping nursery stock — in boxes, and so on.

We have one final question: "I am having trouble in rooting *Juniperus scopulorum* 'Pathfinder'. What are the practices being used?" Is anybody rooting this juniper? That's one of the upright ones. I always grafted when I was growing them.

IVAN STRIBLING: I'm having all kinds of trouble with it. I still haven't solved the problem. We get a fair percentage, but that's it.

WILLIAM CURTIS: Anybody else have a comment on this item? I know Rudy Wagner always grafts them and he does a real good job of grafting.

BRUCE USREY: We are rooting them in January or February in an outside mist bed with bottom heat at 65° F for six weeks, then resetting them with 3,000 ppm into indolebutyric acid after sticking them in this way in 1,000 ppm IBA and along about June or July we get 80 or 90% rooting. It's all done in the open air outside in the full sunlight (in Southern California).

WILLIAM CURTIS: Did all you people who want to grow 'Pathfinder' juniper follow that? I think I'm going to graft mine. I think it would be cheaper.

I want to make one comment about growing or rooting *Magnolia grandiflora*. You know we spoke about taking cuttings at the eye or the nodes, so on, like that. Through the years, I've made quite a few cuttings of *Magnolia grandiflora* and I've always found that I had best luck by taking cuttings with a "heel". Now I know they say that's old-fashioned and it's all baloney. But I think if there is something there that will help you so you will get better rooting percentage, why not use the "heel"? So we've always taken "heel" cuttings. I always tried to have sufficient stock in the field so I could go into my two-year-old plants, because such plants in the field have a tendency to send out side branch right down close to the ground. If they aren't too vigorous, you can get a cutting with the heel from an inch to six or eight inches long. Then we wound them, use Hormodin 3 and put them in sand, or sand and perlite; we use high bottom heat, up to 85° F. But we don't take the cuttings until the tip, the bud tip, has fully developed. I have found that in many cases if we take the cutting before this tip has developed and is firm, sometimes we lose it. Then we get a "dog-leg", and get a tree that's awkward-shaped. But if we take the cutting when the tip has matured, we won't lose it and get a nice straight tree. We go in the field with a sharp knife and sever this cutting right close to the trunk and get, of course, a little bit of the old wood. Now magnolias, as you know, are pithy. They have a hollow stem with pith in it. My understanding has been that anything with a pith was difficult to root. So if you take magnolias with the heel you get away from that pith.

Any other questions?

VOICE: What time do you do it, Bill?

WILLIAM CURTIS: We generally take them along in November — maybe about the middle. But you can take them whenever the tip has firmed up so it's not growing anymore. I think if you look at the plant along in November, you see what I mean. If you take them now (September), they are soft and are growing and something could happen. It's real soft tissue — fungus could get in, and you could lose it. The tip will die or, quite frequently, if we get a frost this time of year (September), on magnolias you'll invariably lose the tip, at least on many of them. If you grow a plant from a cutting like that, you get a "dog-leg". But generally those cuttings from down below, underneath, do not get frosted. We always take the material after the tip has developed and we get very good results.

BRUCE BRIGGS: I have one question that I put in the Question Box to Dick Bosley. I'd like to ask in regard to the foot candles on the white poly. The question would be this: Why did you get higher light intensity through the white poly than you did through the clear? What time of day did you measure the light intensity?

RICHARD BOSLEY: I measured it about 10 a.m. I measured it at right angles to the film, about three feet away. The interesting thing was not the specific levels but the relationships.

BRUCE BRIGGS: Then you had more light with the white poly than you did the clear. You had 400 against 100 f.c.

RICHARD BOSLEY: Where the white was on the outside, and the clear on the inside there was an intermediate level; when the clear was on the outside and the white on the inside, there was the highest level.

BRUCE BRIGGS: What was the reason?

RICHARD BOSLEY: I don't know. Somebody suggested that certain wavelengths come through the clear and can be converted to different wave-lengths which would go on through the white. But where the white was on the outside, the initial wave-length was reflected. I don't know.

BRUCE BRIGGS: Now the other thing, was there any moisture on the film, because of the relationship of film. Water can decrease the light and water will form on the film under certain conditions; but this didn't bother?

RICHARD BOSLEY: Somebody else asked me about the moisture, I don't know.

ANDY LEISER: You mentioned the heat was higher with the clear on the outside and the white on the inside than it was with the reverse situation. This is your greenhouse effect . . . it would be somewhat the same with the visible wave-lengths.

PAUL ADAMS: What is the best way to stratify Mazzard cherry seeds for spring planting?

IVAN STRIBLING: We store the seeds when they come in fresh. We maintain them in plastic bags through the winter at about 34° F. Then we start our moist stratification around January and carry it for about three months, then plant in the spring and we get good results. We also put the seed through a warm stratification period before the cold. At 70° F; this seems to increase the germination of Mazzard seed. That is a fairly short period; if I recall, it's about three weeks at 70° F and then we follow that with moist, cold stratification between 34° and 40° F for the remainder of the three months.

THURSDAY MORNING SESSION

PRESIDENT MAIRE: Before I turn the program over to the Program Chairman, I would like to acknowledge a couple of new guests that we have with us from the Eastern Region this morning — Al Fordham and Al Martin. Would you stand up and let the people see you? You've arrived and we're glad to have you with us. I'm not sure whether Otis Kenyon from Sherman Nurseries in Iowa City, Iowa, is here. Is he here in the room now? Yes. Glad you're with us too. Now here is your Program Chairman.

TED VAN VEEN: Well, we have a good crowd this morning. We have a full program. To start off today, Dick Joyce has kindly accepted the job of Moderator. Dick is with Joyce Nurseries in this area. He is one of our fine young nurserymen; we have a whole crop of young nurserymen coming up in this area. Dick, I'll turn this over to you.

DICK JOYCE: It gives me real pleasure to welcome you to the second session of the Western Region Plant Propagators' Society Meeting and I know the program this morning is going to be beneficial and educational and will certainly give you something you can take back and utilize.

To start our program this morning we have one of the leading nurserymen and certainly one of the most reputable from the Portland area to be our first speaker. J. Frank Schmidt, Jr., has been 34 years in the nursery business. He's the president of J. Frank Schmidt and Son Nursery in Troutdale, Oregon, and president of the Milton Nursery Company in Milton Freewater, Oregon. They are farming all together in the vicinity of 1200 acres. He is a past president of the Oregon Association of Nurserymen. His father, with Avery Steinmetz and Mr. Brownell, started the Portland Wholesale Nursery Company years ago. He is going to be discussing shade tree propagation this morning. Mr. Schmidt:

SHADE TREE PROPAGATION

J. FRANK SCHMIDT, JR.
Troutdale, Oregon

Most of the trees we propagate are cultivars, a few are selections but both groups are clones propagated by budding or grafting. Two or three, such as oaks, are grown from seed and continued on their own roots. Our annual routine starts with land preparation.

One year of constantly worked bare fallow eliminates weeds. A year of repeated cover cropping with appropriate fertilizer restores the organic matter and nutrient level in the soil. In early fall we apply lime and dolomite and plough down the last cover crop. In March the following spring we disc or plough the ground, whichever is appropriate, for the particular soil type or season — apply fertilizer as dictated by soil tests, and work the soil up to a nice crumbly condition. In early April we plant seedlings of: — green ash, birch, cherry, apple, hawthorne, honeylocust, linden, laburnum, Norway and red maple, mountain ash and plum. These become the root stocks on which we bud or graft. The oaks, grown from specially selected seed are not budded. London plane and cistena plum are grown from cuttings and so do not require budding.

The newly planted seedlings are kept free of weeds by cultivating and herbicide spraying throughout the summer. We irrigate when necessary to develop a good stem and root system and flow of sap. In August we cut buds from the various cultivars and selections in our stock blocks and insert these into the stems of the seedlings with the exception of the three mentioned above.

With the exception of weed control, re-budding or grafting in February trees that didn't take, not much more happens culturally until early the following March. We then cut the seedlings off just above the bud, which is about 2" above the ground line, shred up the prunings and broadcast them and an application of fertilizer appropriate to the field and crop.

We have found that the caliper of the tree which develops from the bud inserted the previous August is directly related to the nutrient level in the soil and plant sap at the time the bud breaks. No deficiency then can be made up by extra feeding later on though, of course, later feedings will be necessary in most cases.

Cultural practices during the spring and summer involve weeding, watering and cultivating the soil, staking, tying, shaping and pruning the trees, watching for pests and diseases and spraying to control them. Further steps in our cycle are harvesting, grading, storing, selling and shipping, which are important because they are more vital than anything else we do. So much of the year's work in our trees depend upon understocks. Producing these is a separate operation that follows its own routine.

Well ahead — two years at least — planting plans are made. On this basis seeds are ordered or harvested at the proper time. The seeds are properly stored after they are received. Some are dried and stored in closed containers at room temperature. Others are kept slightly moist in a cooler and a few are frozen.

Seed coat dormancy can be overcome by hot water or by treating with acid or in an abrasive drum. Embryo dormancy can be overcome by chilling or by chilling and warming a couple of times to simulate seasonal changes. The important thing is to ready the seed so that it germinates promptly after sowing. Sowing some seed in the fall and some in spring often results in at least one lot escaping untimely frosts which kill even hardy seedlings if it catches them in the cotyledon stage. Sowings are usually made on beds 4 feet wide, with sawdust used to cover the seeds.

From the time of germination we have found the ideal stimulant to be "fertigation" rather than applying dry fertilizer and irrigation by turns. By adjusting a liquid mixture the first applications should be as gentle as a tear and the danger of burning eliminated. The reason for fertilizing seedlings at all is to get them up to optimum size, ¼ inch, for most kinds. This is quite difficult in one season.

While this group may be more interested in the techniques and finer points of propagation than in the business end of it I decided to conclude with a few figures. We plant about 600,000 seedlings a year. We sell about 400,000 trees. Seedlings cost $100—150 per thousand if you buy them — more if you raise your own. Budding costs about 4.0 cents per tree — not counting the bud. It takes one steady employee per 10,000 trees but we report on over 100 people who make more than the minimum.

Wages and salaries add 75 cents to the cost of a tree, truck and tractor fuel 2 cents, insurance 6½ cents, sprays and fertilizers 7 cents, social security taxes take a 12 cent bite from the nursery and a 12 cent bite from the employee plus other overhead expenses per tree. These are a few of the out-of-pocket expenses. The cost of land, buildings, machinery and the use of capital are not included although, of course, they must come out of the selling price of the tree.

DICK JOYCE: Our next speaker is Harry Lagerstedt, who will be talking about winter grafting of walnuts, *Juglans regia*. He is now a USDA research horticulturist working out of Oregon State University at Corvallis and is responsible for research with nut crops in Oregon. Dr. Lagerstedt.[1]

DICK JOYCE: Are there any questions?

VOICE: I was trying to write down the factors that promote callus growth in walnuts. Would you repeat these?

HARRY LAGERSTEDT: It is 82° F as far as temperature goes, and then you have to have moisture — where there is no

[1]Dr. Lagerstedt discussed his experimental work in grafting of the Persian walnut in Oregon.

moisture there is no life. And aeration, which involves oxygen, and a lack of light, and a lack of pressure at the union. These are the five things.

HUDSON HARTMANN: Harry, how about patch budding walnuts in the nursery row in late summer. Is that successful in Oregon?

HARRY LAGERSTEDT: No, it is not. It has been tried but we have very poor luck. There is just no take.

HUDSON HARTMANN: It's a common practice in California for nurserymen to make some slanting cuts around the trunk of walnut trees close to the ground so the bleeding takes place there instead of around the graft union. Was this used here ?

HARRY LAGERSTEDT: No, these slanting cuts at the base have not been used. I know that a lot of Eastern amateur walnut growers do this, too. It's common practice in California. This drilling of a hole through the trunk has worked very nicely for us and we can continue to graft even during quite severe bleeding.

HUDSON HARTMANN: Another thing, what rootstock do you now recommend for walnuts in Oregon?

HARRY LAGERSTEDT: We grow grafts solely on a rootstock called Manregian. It is a *Juglans regia*, or Persian walnut, which was located in Manchuria. So they've combined the Manchurian and the *J. regia* to make the rootstock name, Manregian. If we graft on the black walnut in Oregon, ultimately we wind up with "black-line," which is a breakdown at the graft union. So we're limited to this particular rootstock. Actually, we have very few walnut nurserymen in Oregon and I think it is a rather risky business.

VOICE: Has Carpathian stock been used much?

HARRY LAGERSTEDT: Carpathian rootstock has not been used. There were some tests made around 1952 to 1954 comparing a large number of rootstocks for walnuts and out of this, the Manregian rootstock was the one that was chosen and we stay with it pretty much.

VOICE: Have you done some work on budding and grafting filberts?

HARRY LAGERSTEDT: Yes, my primary effort is with filberts. I have done a great deal of work with this. Budding is practically impossible with filberts. We've had a great deal of trouble. As soon as we get a very small piece of tissue, it seems to dry out and we just cannot maintain it. Even if it looks like we get a take with a filbert bud, whether it is our rainy winters or whatever it is, by spring we have nothing. Now we can graft filberts. It has been a hit or miss thing, but I think through some of our efforts we're up maybe 85 or 90% in commercial filbert grafting. However, it is not a common practice in Oregon. There is no nurseryman doing this at the present time. We are extending this practice to nurserymen by going out into their nurseries, planting out rootstocks and doing the grafting for them to show them and carry them along. But one of the problems with filbert grafting is that there is no accepted rootstock at the present time, another whole problem.

VOICE: How about Turkish hazel nuts?

HARRY LAGERSTEDT: Well the Turkish hazel nut has been used but when you grow our primary variety, Barcelona, on Turkish hazel, after about 20 years or so, production declines. So Turkish hazel nut has not found a great deal of favor as a result. It is an excellent rootstock as it does not sucker, which the European hazel does. We are now crossing the European and the Turkish hazel to try to come up with a happy compromise.

HUDSON HARTMANN: How is the propagation of filbert by leafy cuttings under mist working out?

HARRY LAGERSTEDT: This can be done roughly between June 15 and July 15. We find the critical thing is that the terminal must be growing. If the terminal bud has set, all we get is callus and no roots. Now, we put so much water on these cuttings that we tend to rot out the lateral buds and at the end of the propagating season, we wind up with a rooted stick. We have no growing point; this has been our biggest problem. We're trying to control the mist so we have enough mist to keep the cutting alive yet not rot out these lateral buds. We can root them, however, about 60 to 65% consistently. IBA is essential for this.

VOICE: You might try to use some air pressure with the water to produce a fine, foggy mist.

HARRY LAGERSTEDT: To reduce the quantity of water. Yes. Well, that's a very good idea. I appreciate that. We went the other way using a Solatrol to try to just put just barely enough mist and try to control it rather than use just a straight mechanical control.

DICK JOYCE: Our next speaker this morning will be discussing the propagation of dogwood. Les Clay is a graduate of the University of California, 1956; he's been in the nursery business since then and is mainly interested in cutting propagation. He lives in Langley, B. C., Canada. At this time we would like to welcome Les Clay talking on the propagation of dogwood. Les.

PROPAGATION OF DOGWOODS

LESLIE K. C. CLAY
Les Clay & Son Ltd.
Langley, B. C., Canada

Dogwoods may be propagated in a number of ways. As my prime interest lies in the propagation of dogwood by cuttings, I will briefly touch on the other methods first.

Seeding. Species such as *Cornus nuttallii* and *Cornus florida* are best raised from seed which should be gathered in early fall just as the colour begins to change. Best results are generally obtained if seed is sown in early fall in rows or prepared beds outdoors and covered with a thin layer of sand. No further winter protection is required. The seed should germinate evenly in the early spring, producing a good stand of 15 to 24 inch seedlings by the end of the first season. If the seed cannot be planted in the fall and must be stored for spring planting, stratification is required to break dormancy. With spring-sown seed, germination is patchy; in some cases the seed may lay dormant and come up the following year.

Layering. *Cornus alba* and varieties, *Cornus florida* varieties, *Cornus kousa,* and *Cornus stolonifera* and varieties may all be produced by layering. Stock plants for layering should be headed back rather severely to promote the growth of a large number of shoots suitable for layering. The shoots are layered in a circular pattern out from the stock stock. The shoots are bent down, given a slight twist, and pegged securely with the terminal portion of the shoot rising at right angles to the ground, then covered with 3-4" of soil and left until the following spring by which time the layers should be rooted. They are then separated from the stock plant and field planted.

Grafting. One year *Cornus florida* seedlings are used as understock. These are potted in the fall and allowed to become established in the pot. Prior to grafting, the understock (preferably about pencil thickness) is cut back to a stump several inches in length. The scion, of at least two nodes and approximately six inches in length, (preferably from older basal growth) is placed on the understock by means of a side graft. Cotton twine or grafting tape is used to secure the scion to the understock after which both should be dipped in molten wax. The new grafts should be placed in a cool house to permit slow callusing, which forms a stronger union than if the plants are allowed to callus quickly at higher temperatures.

Budding. *Cornus florida* seedlings used for understock are planted out in field rows prior to growth commencing in the spring. By mid-summer the seedlings should be of sufficient caliper and well enough established to permit budding. A "T" cut is made as close to the ground as possible and the bud inserted and bound in place with a budding strip. Care should be taken not to bud while the growth is too succulent, with too great a sap flow, else the inserted bud may flood out. The following spring, the top of the understock is cut off 2 to 3 inches above the bud. The young shoot as it develops may first be tied to the stub of the understock, then later staked to protect it from wind damage. The union between the bud and understock during the first growing season is very weak and unless staked the bud may be blown off by a strong gust of wind. Any shoots developing from the understock should be removed. Varieties grown in this manner are *Cornus florida* 'Rubra' and cultivars, *Cornus nuttallii* 'Goldspot' and *Cornus* 'White Wonder' (*Cornus nuttallii* x *Cornus florida*). *Cornus florida* 'Rubra' will make 2 to 3 foot plants the first year, while *Cornus nuttallii* 'Goldspot' and *Cornus* 'White Wonder' will produce lightly branched whips of 3 to 5 feet in length.

Cuttings. Many dogwoods propagate easily by cuttings. The cuttings are taken in late June and July and placed in flats containing a medium of 1/3 sand, 1/3 peat moss, and 1/3 coarse perlite. The cuttings are 4 to 6 inches in length and are cut just below the bottom node. Lower leaves are removed prior to hormone treatment. On species such as *Cornus alba* and cultivars and *Cornus stolonifera* and cultivars, we use Seradix No. 2 powder (0.3% IBA). The flats of cuttings are placed on bottom heat at 72° F and under intermittent mist controlled by a moisture leaf. These varieties root easily within a three week period and if immediately potted or set in the field will put on considerable growth by fall, making 8 to 12 inch plants. Tip cuttings of the current season's growth are used; however, if the shoots are long enough, sub-terminal cuttings may also be used, as these root just as easily and make bushier plants. With varieties such as *Cornus florida* and cultivars and *Cornus kousa*, cuttings are made in the same manner as above with the addition of a wound ½ to ¾ inch in length on one side of the stem prior to hormone treatment. These varieties are treated with Seradix No. 3 powder (0.8% IBA) or Jiffy Grow diluted 1:5. Where Jiffy Grow is used the cuttings are given a quick dip to the depth of the wound. Rooting, while somewhat slower than *Cornus alba* and *Cornus stolonifera* cuttings, will be in evidence within 5 to 6 weeks. With these varieties I have found it better to let the cuttings go dormant in the flat prior to potting. If potted prior to fall dormancy we have had difficulty in getting the potted liners to break into growth in the spring whereas, if potted after they become dormant no difficulty has been encountered. In fact, a large number of *Cornus florida* and cultivars even produce flower buds and flower prior to coming into growth. Some of the results we have achieved are shown in the following table.

Table 1. Results obtained in rooting cuttings of various dogwood species and cultivars.

Variety	Cuttings	Hormone Treatment	Number Rooted	Percent Rooted
Cornus alba 'Elegantissima'	1,260	Seradix No. 2	1,230	97.7
Cornus alba 'Gouchaulti'	1,440	Seradix No. 2	1,394	96.8
Cornus alba 'Variegata'	200	Seradix No. 2	196	98.0
Cornus stolonifera 'Flaviramea'	300	Seradix No. 2	295	98.3
Cornus florida	300	Seradix No. 3	239	79.6
Cornus florida 'Rubra'	290	J. G. 1:5	227	78.3
Cornus florida 'Cherokee Chief'	290	J. G. 1:5	217	74.8
Cornus florida 'Sweetwater'	390	Seradix No. 3	264	67.7
Cornus florida 'White Cloud'	290	J. G. 1:5	186	64.1
Cornus kousa	200	Seradix No. 3	109	54.5
Cornus kousa 'Chinensis	300	J. G. 1:5	193	64.3
Cornus 'White Wonder'	60	J. G. 1:5	4	6.6
Cornus nuttallii 'Goldspot'	120	J. G. 1:5	0	0.0
Cornus contro-versa 'Variegata'	60	J. G. 1:5	0	0.0

While the results obtained were not subjected to statistical analysis, I think some differences appear within the *Cornus florida* and cultivars and *Cornus kousa*. Jiffy Grow gave slightly more consistent results. The rooting response of *Cornus* 'White Wonder' (*Cornus nuttallii* x *Cornus florida*) was slight with only 4 rooting out of 60 cuttings and then with poor quality roots. No rooting was obtained on either *Cornus nuttallii* 'Goldspot' or *Cornus controversa* 'Variegata'. However, this may have been the result of poor timing as these cuttings were taken in late July.

VOICE: When you layer, do you wound the layer or do anything to it?

LES CLAY: Well, for the varieties that we have used, no wounding was required.

VOICE: What type of growth do you get from your cuttings of *Cornus florida* Rubra and things like that after you root them?

LES CLAY: We find that taking them from cuttings, we get a good saleable plant in three years. It's about comparable to a two-year-old budded plant that's had two years of growth. But the overall picture is that you still have to grow the understock for one year so it makes the total plant age three years also. Now another interesting thing that we found with a lot of these *C. florida* varieties is to let them go completely dormant prior to potting; by the following spring, when they start to grow, many will have flower buds and will come into flower before they start vegetative growth. It looks rather odd to go into the house and see a bench full of small plants three or four inches tall, all covered with flowers.

AL ROBERTS: Do you get strong orthotropic growth; that is, upright growth, from these rooted cuttings like you would get from a strong bud?

LES CLAY: I think the growth is maybe a little slower than from budding but we do develop a fairly straight stem.

DICK JOYCE: Our next speaker, Ivan Arneson, grows fruit trees, shrubs, deciduous azaleas, and various understocks. If you want to see a nursery where things are not just grown, but they are manicured, then his nursery is the place to go. Ivan Arneson:

PROPAGATION OF CERTAIN FRUIT TREE UNDERSTOCKS

IVAN ARNESON
Arneson Nursery
Canby, Oregon

My first experience in growing trees in the nursery involved the use of seedlings as practiced by most nurserymen at that time. Back in the 1940's Dr. Al Roberts brought in some of the East Malling apple understocks from England and naturally I became interested in them. I started with the East Malling and later on used the Malling Merton apple stocks, the quince 'A', and the Mazzard 'F-12-1' cherry. Since, we have added St. Julien plum, filbert and Provence quince, as well as cherries, and pear stocks.

The suggested way to propagate these was by layering in stool beds. A lot of experimenting was done in the years following to

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The suggested way to propagate these was by layering in stool beds. A lot of experimenting was done in the years following to determine the best way to propagate these. I will try to elaborate on some of the procedures.

To get a bed fast we planted the stools about 1½ feet apart then staked them down at about a 45° angle with wire. As the side limbs grew they were covered with dirt or sand. Later sawdust was found to be a better medium than dirt. A mistake that was sometimes made was to graft these new stocks on a nurse root thus permitting the spread of virus. Sometimes I found trees that looked different than the stock it was supposed to be so I would rogue these out. I am glad I did as other growers found a mixture in some kinds later on.

It is a good practice to level the soil some to aid cutting and keep the stools even. If there are insects or diseases in the ground it is best to fumigate. I have used Terramycin or Morsodren as a drench just before or after planting cherry stocks. In the winter we now plant the trees 2" to 4" apart using small trees about 2/16" to 3/16" in diameter. Rows can be planted from 40" to 5'. We are using 4' rows for most of our plantings. Sawdust can now be used to cover the new plants to induce rooting and hold the moisture near the plant. Little needs to be done until cutting time in winter except water, cultivate, and spray.

INSECT AND DISEASE PROBLEMS

Insects

1. Woolly apple aphid (*Eriosoma lanigerum*). Parathion was recommended and worked quite well, but aphids are stubborn and would stay in the ground. A Parathion emulsion works better. We have also tried Cygon.
2. Eriophyid mite in apples. Lime sulphur is good for new plantings, but for young growth we use Kelthane with good results.
3. Apple leaf skeletonizer (*Anthophila pariana*). This is seldom a problem; any good spray for chewing insects should work.
4. Nematodes. This has never been a problem with us. We think it is partly due to using clean sawdust as a mulch.
5. Strawberry root weevils (*Brachyrhinus* Spp.). These are easily kept under control but to eradicate is something else. Ten pounds (a.i.) of Aldrin, or DDT and Aldrin, or Lindane (or BHC) as the weevils emerge in May are the best treatment we have found. A second application may be necessary if a later brood emerges. We used a liquid Lindane once and got burning of the plants.

Diseases.

1. Leaf spot of quince (*Coccomyces hiemalis*). Cyprex gives good results. See that it is put on in time.

2. Powdery mildew (*Podosphaera leucotricha*). In apple, Karathane should do the job. The last two years we have used Parnon.
3. Viruses. Use virus-clean stock if you can get it.
4. Crown gall (*Agrobacterium tumefaciens*). A very stubborn bacterial disease that is almost impossible to eradicate, especially in the cherry stool beds. For cherries use clean ground and clean plants. We have used Terramycin and Morsodren as a drench either before or just after planting. Our new plantings show no galls. In the older plantings we rogued any plant that showed galls, treating the area around with Terramycin or Morsodren. Lately we are trying such things as Terramycin, Bacticin, Morsodren, Clorox, and Elgetol. Almost no galls have appeared where Bacticin or Elgetol have been used.
5. Root rots. With as much water as is used to induce rooting, decays could develop below the sawdust. A copper compound is effective. Collar rot has not shown up in our area.

CARE OF ESTABLISHED STOOL BEDS

In the spring of the year, after danger of frost, the sawdust (about 1" to 2" deep) should be removed from the crowns of the stools. Parathion for aphids could be used now. As the stools begin to grow one should follow with sawdust covering the new shoots to 3" to 4" of the top. Keep this up until the plants are covered from 6" to 9" from the crown. At the same time see that enough water is used to keep the sawdust wet, especially near the plant. Keeping the sun off and using reasonable amount of water seems to induce rooting the most. Too much water can cause poor rooting. In the Willamette Valley we feel we have good climatic conditions for rooting. Cool, damp, fall weather will add a lot of roots to the stools.

After removing the stools we cover the plants an inch or two to avoid freezing; this will be left until the sprouts begin to grow in the spring. Timing is critical. If opened too soon they freeze. If too late the stools will be damaged.

MACHINERY USED IN GROWING UNDERSTOCKS IN STOOL BEDS

Machines to apply sawdust have been constructed all the way from worked-over manure spreaders to well-planned hoppers with spreaders and levelers.

Removing the sawdust and cutting the finished product is time consuming and expensive. At first, hand clippers or loppers were used; now circular saws mounted on wheels or tractors have been used with satisfaction by some propagators. A single mower type of sickle or a double sickle is used by some with equal satisfaction. A chain saw with a thin bar is a fast cutter, but leaves the tree a little ragged. Most of these require that the ground be level and the stools even in elevation. I am sure other machines are used and the field is wide open for those with a mechanical mind to develop more.

CUTTINGS

We have used only what we consider easy-rooting hardwood cuttings such as 'Myro 29C', 'Marianna 2624' and '4001', quince, and 'St Julien A.' These are taken in December or January and put in the ground as soon as we can after cutting. As a rule, no hormones have been used. We used Benlate on 'St. Julien A' with good results.

In closing let me say that one of the most frustrating problems is to have a stool bed well established and then find that the demand has changed to another stock. This is a good challenge to the young at heart to stay in the propagating business.

TED VAN VEEN: This section of the meeting will be moderated by Bruce Briggs. Bruce, as you know, is our International President and we always enjoy having him at the meetings. Bruce, will you take over now?

BRUCE BRIGGS: Thank you, Ted. It's always an honor to participate in the meetings. I appreciate being asked to moderate this session. I would like to recognize the many students that we have here today. Some of you professors who are here, if you get a chance, don't hesitate to go over and talk to them because these students may be our future nurserymen. So make them welcome.

So let's get started on our "Chemical Aids to Propagation." First of all, we have with us Dr. Charlie Pfieffer. Charlie is from a background of nursery work. He went on later to become a professor at Washington State University. Later he left this field and is now with the Soil and Plant Laboratory. We are certainly indebted to have Charlie working in our profession. We need his help badly and we appreciate every bit of it. He's going to talk on water quality. Charlie:[1]

BRUCE BRIGGS: Thank you, Charlie. I'm sure you remember on the tour yesterday afternoon at Wood's Nursery we looked at all those small tubes in the greenhouse containing Douglas fir seedlings. Ed Wood is fortunate to have a lady who lives there and she must

[1] Dr. Pfeiffer discussed the relations of water quality to propagation and plant production.

work there 24 hours a day. She takes care of the place when Ed is gone which must be a lot of the time. But anyway, she is real fortunate to be able to work there with Ed. She is going to talk on the use of penetrants and what they are doing with them. Louise Zachry:[2]

BRUCE BRIGGS: Thank you very much, Louise. Our next speaker here is from Hazel Dell Gardens, Canby, Oregon. We have Myrtle Fish, who will talk on supplemental hormone applications. Myrtle:

SUPPLEMENTAL HORMONE APPLICATIONS

MYRTLE FISH
Hazel Dell Garden Nursery
Canby, Oregon

I have been asked to tell of my experiences in propagation and what I have learned through the years. I have had very good teachers in starting out. Ray and Irene Burden were very patient as I was learning. It has been a lot of fun and hard work. I have found, though, that there is more to propagation than just powdering the cuttings and sticking them. Along with bottom heat in the bench and watering, it all makes for good rooting; at least that is what I keep telling myself. We do have our losses, which makes us try harder the next year. Most cuttings root quite readily, but we do have some stubborn ones, at least they have been for me. We do a lot of experimenting with Jiffy Grow and the combination of Jiffy Grow and Hormodin powder.

Camellias usually root quite readily, although there are a few that are quite hard to root, as we root between 80 and 90 different varieties; there are always a few that are either slow to root or will not root at all. After putting them in with No. 3 Hormodin powder, we let them set for six weeks, then spray with a light application of Jiffy Grow 1:5; too heavy an application will retard the root growth.

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In this case, the roots come out about ¼ to ½ inch long and are very thick looking. They do not grow longer, they just seem to sit there; so a light application is very important. There are some varieties that always root quite readily so I usually just skip over them. The very hard to root varieties are put in with No. 3 Hormodin and let set until they start callusing, then we pull them up, remove the callus and put them back with No. 3 Hormodin again. The second time they root excellently. I have tried using a solution of Jiffy Grow, but haven't found one that produces better results. I do believe one should do his own experimenting before trying this solution on a large scale.

We have experimented with *Arbutus unedo,* as it has been a problem to root. We found that by taking the soft tip cuttings in the spring and putting them in with No. 3 Hormodin powder, under mist, they have done very well. Another hard-to-root plant is Parney cotoneaster. I use Jiffy Grow, 1:5, on these cuttings. This seems to do a pretty good job and we get many more roots.

By using mist spray in the summer time, we have found that many cuttings, which we had been rooting in the fall and winter, do just as well and sometimes better. When starting out using mist, we used the electronic leaf type, but found we were getting too much chemical build-up on the bars from the water, so we switched to a time clock, which works very well.

I was having trouble rooting kinnickinnick, not getting a high enough percentage; another propagator told me how he was rooting it. Now we use a Jiffy Grow solution of 1:7 and stick into bands with a medium of 2/3 sand and 1/3 peat. We stick two cuttings to a band. When rooted, they are ready to sell. This way they do not have a set-back as they do when they are taken up and potted. This saves a lot of work and time which is most important in greenhouse work, as every one knows. Pachysandra, which is easy to root, is another ground cover we put in pots to root, saving the time to pot them.

Each year the rooting process of the different cuttings is different; one never knows just how things will turn out. I can say I am certainly surprised at the results. That is what keeps things interesting, when propagating. There are so many things to take into consideration when trying to decide why this or that cutting didn't root. It could be the condition of the plant the cuttings were taken from, such as a winter injury compared to a good healthy plant. There are numerous things to watch for and then one doesn't always know the answer.

Magnolias are one of my favorites, when it comes to rooting. They are not hard to root, except a few varieties. The deciduous ones are put in under mist in the summer time with No. 3 Hormodin powder. It is very important when taking the cuttings, not to let the tips dry out. We keep them damp at all times. Evergreen magnolias are started in November or December. For the few varieties of deciduous magnolias that do not root, we graft. This is very interesting work and is done in February. We use rooted cuttings as understock, as this gives a superior root development later.

Viburnum davidii cuttings are easy to root with No. 2 Hormodin powder, but have tried Jiffy Grow 1:9 solution and found that the roots are much heavier and the cuttings also root quicker.

Photina glabra and P. x *fraseri* have been quite a problem in the past as they are hard to root; usually we could root only 1/3 to 1/2 the first time, then we restrike them. I used No. 3 Hormodin powder and a solution of 1:5 Jiffy Grow and sprayed the leaves, hoping this would cause rooting; it showed some results but not enough to be encouraging. We decided then, to use a combination of different solutions of Jiffy Grow and Hormodin powder. I used four different solutions, straight Jiffy Grow — Jiffy Grow 1:5 — Jiffy Grow 1:9 and No. 3 Hormodin powder—and Jiffy Grow 1:7 and No. 2 Hormodin powder. The first and second solutions did not help, but the third solution (Jiffy Grow 1:9 with No. 3 powder) caused rooting with a good heavy root system. This took approximately four weeks, whereas with No. 3 powder alone, the cuttings were in the bench for eight weeks with nothing but large calluses and very few roots. On that experiment, we used 1,000 cuttings each of *P. glabra* and *P.* x *fraseri*; out of the *P.* x *fraseri* we potted 836 and the *P. glabra,* 902. We were quite happy with the results. Whether this will work for us every year remains to be seen.

In one of our propagation houses, we use electric cables, so the heat is distributed evenly throughout the bench; the other house is heated with hot water, so one end of the bench is cooler than the other. This makes a difference with some cuttings as to the strength of powder to use. The cooler bench will take a stronger powder, so when putting in juniper cuttings I must watch the hardness of the cutting as well as where they are going to be placed. We use all three strengths of Hormodin on juniper, depending on the cutting and where it goes in the bench.

BRUCE BRIGGS: Thank you very much, Myrtle. I was delighted to hear that you also received a response to the amount of hormone in relation to the temperature. We ran into this a few years ago. In the morning it's cold, possibly 60° F and in the afternoon the hormone liquids you're dipping into might be 80° F. There is a big difference in the temperature of the liquids. So it is a big factor.

The next speaker we have works at Bill Curtis' Nursery — Linda Rumgay. Bill has been good enough to let her go to many short courses and she has worked up through the channels too. She went to work with Bill and actually I'm not sure who is the boss there now. Anyway, Linda:

HORMONE POWDER MODIFICATION

LINDA RUMGAY
Wil-Chris Acres
Sherwood, Oregon 97140

The topic, "Hormone Powder Modification" includes the very effective "H.P.M. Formula" which is the basic point for the information that is to be presented. At Wil-Chris Acres we have been using the following formula for rooting cuttings:

Hormodin No. 3	— 10 ounces
Benlate	— 1 ounce
Indolebutyric acid	— 5 grams (2 heaping tsp.)

These component parts are put together and shaken for 20 minutes to insure thorough mixing. For absolute mixing that has been used effectively place the ingredients in a container that can be put on a paint shaker. Expansion is involved in this blending, however, so be prepared with extra space in the container for fluffing. It is understood that Hormodin No. 3 does have a high IBA level already but our "H.P.M. Formula" gives yet another boost of indolebutyric acid.

Below is a summary of our research results:

I. Deciduous plants, such as *Euonymus alatus* 'Compacta'

A. In 1970, out of a flat of 150 cuttings, 75 rooted giving 50% rooting.
B. In 1971, H.P.M. was used; out of a flat of 150, 135 rooted, giving 90% rooting.
C. We have tried cuttings also from such plants as quince and the deciduous magnolias, *M. stellata, M.* x *soulangeana, M. liliflore* 'Nigra', *M. s.* 'Rubra', and *M. s.* 'Rustica Rubra'.

II. Rhododendrons.

A. Rhododendrons treated with H.P.M. showed a better root system.
B. We root the hardier rhododendrons — many varieties from A to Z, 'America' to 'Nova Zembla'.

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II. Rhododendrons.

A. Rhododendrons treated with H.P.M. showed a better root system.

B. We root the hardier rhododendrons — many varieties from A to Z, 'America' to 'Nova Zembla'.

1. Some varieties we are propagating are:

'America'	'Kluis Sensation'
'Anna Rose Whitney'	'Lamplighter'
'Mrs. Betty Robinson'	'Mrs. Tom H. Lowinsky'
'Blue Peter'	'The Hon. Jean Marie Montague'
'Chionoides'	'Scarlet Wonder'
'Cosmopolitan'	'Scintillation'
'Dora Amateis'	'Unique'
'Gomer Waterer'	'Virginia Richards'
'Jingle Bells'	'Vulcan'

2. Other varieties include:

'Bowbells' — which is difficult to root in some years but the problem was taken care of with H.P.M. very well.

'Mrs. C. B. Van Ness' — There was a problem in rooting this one, but then again, this variety is always difficult.

'Nova Zembla' — this would be classified as extra good as it roots well and heavily.

'Virgo — in reference to this variety, the newer white one from Canada gave problems in rooting.

3. The time must be right when you take rhododendron cuttings. This means that the wood should **not** be hard. 'Blue Diamond' rooted 98% with H.P.M. as opposed to 75% rooting in a flat of cuttings taken later, but given the same treatment with H.P.M.

III. Camellias.

Camellia cuttings always root very well for us, but we were very objective. When it came time to pot the cuttings we were very analytical and did detect what appeared to be a stronger root system with H.P.M. treatment.

IV. Pieris.

A. In the different types of Pieris there appeared a better root system with H.P.M. treatment. It seemed to separate the weak from the strong. Perhaps it may be more accurate to say that the strong were stronger and the weak — died! Even in the light of this, there were only two flats of re-strikes, where before we had as high as 15.

B. 'Valley Rose' cuttings showed 85% rooting for us the first year we worked with them. These were new from the North Willamette Valley Experiment Station, Aurora, Oregon. We also stuck 3,000 'Flamingo', with 2,400 rooting, giving us a rooting percentage of 80.

V. Broad-leaved evergreens.

A. I wish to give *Magnolia grandiflora* cuttings an "Oscar"; they merit this award because they responded beautifully to H.P.M. They were the best ever.

B. Dwarf laurestinus, *Leucothoe,* and *Andromeda polifolia* never have presented problems in rooting, but a better, more extensive root system was produced with the H.P.M. rooting mixture. (By the way, even conifer cuttings react favorably to H.P.M.)

VI. Huckleberry (*Vaccinium ovatum*).

A. In former years there was 75% rooting as opposed to 95% with the use of H.P.M. We wish to note, however, that we must be cognizant of the fact the seasons are different each year and that rooting percentages will show a wide variance due to this.

VII. *Pyracantha* 'Watereri' and *Pyracantha* 'Red Elf'

Last year was the first time we used H.P.M. formula on these plants and due to the late sticking they responded in a negative manner; in fact, they died.

VIII. *Ilex crenata* 'Convexa'.

These rooted as readily as always, just as do *Viburnum.*

IX. *Viburnum.*

Among the viburnums we rooted are *V. burkwoodi, cinnamomifolium,* and the extra responsive *davidii.*

X. *Cotoneaster dammeri* 'Lofast'

and the other types of cuttings that root easily, were literally killed by the use of the extra IBA in the H.P.M. mixture.

All in all, the "H.P.M. Formula" is excellent in the areas prescribed and does effectively and efficiently root cuttings of certain plants which, in turn, expedites the needed growth resulting from the early rooting. However, it does have its negative areas and drawbacks. Temperature and water are always paramount items. We recommend 75° F bench temperature and 10 degrees less air temperature, although we realize that it is not always possible to obtain this.

BRUCE BRIGGS: Thank you, Linda. Well, we've had hormone powders, then liquids, and now we're going to see what happens. What about herbicides? Do they help rooting or do they hinder rooting and as we go along we should look at all our chemicals; and I'm not sure where we're going. We've got so many we're using now. Maybe this is the confusion. But, anyway, to talk on this, we have with us Dr. Bob Ticknor. If you remember yesterday, we went on a tour to his Experiment Station. Bob is in charge of the Horticulture Division at the North Willamette Valley Experiment Station, Aurora, Oregon. He is with the Oregon State University, Horticulture Department. Without further ado — Bob Ticknor to talk on herbicide effects on rooting. Bob:

EFFECTS OF SEVERAL HERBICIDES ON PROPAGATION OF FOUR ORNAMENTALS

ROBERT L. TICKNOR
Oregon State University
Aurora, Oregon 97002

Abstract. Cuttings of *Calluna vulgaris* 'Aurea', *Cytisus purgens, Ilex crenata* 'Howard,' and *Thuja occidentalis* 'fastigiata' (T. o. Pyramidalis) obtained from container grown stock plants which had received ten herbicide treatments were propagated. Only the *Calluna* showed a statistically significant difference in rooting

Review of Literature

In a talk to the Connecticut Nurserymen's Short Course (1), Dr. John Ahrens reported "none of mentioned herbicides affected rooting of cuttings taken from treated plants when the herbicide was used at the label rate." The herbicides mentioned were: Amiben, Betasan, Casoron, Chloro IPC, Dacthal, Dymid, Enide, Eptam, Princep, and Treflan.

In a previous report (2), I mentioned that several herbicides did not influence the rooting of *Juniperus sabina* 'Tamariscifolia'.

Materials and Methods

Cuttings of *Calluna vulgaris* 'Aurea' — golden Scotch heather, *Cytisus purgens* — Provence broom, *Ilex crenata* 'Howard' — Howard Japanese holly and *Thuja occidentalis* 'Fastigiata, — pyramidal arbor-vitae,were taken from container-grown stock plants which had received four applications of herbicides during a two year period. Ground fir bark was the mix in which the plants were grown. The herbicide treatments and the rates at which they were used are shown in Table 1.

Three replicates of 10 cuttings selected at random were used with each species for each herbicide treatment. Following applications of Hormodin No. 3, the cuttings were inserted into screen bottom flats filled with perlite, or peat-perlite 1:1 in the case of heather, on January 18, 1972. Bottom heat was maintained at 70° F with a minimum air temperature of 45° F. The cuttings were lifted and the rooting results recorded as the root systems of each species became large enough for transplanting. The date of recording was February 29 for the heather, March 1 for the broom, May 2 for the holly, and May 6 for the arbor-vitae.

Results and Discussion

Rooting results based on a rooting index value of 5 for a heavily rooted, 4 for a medium, 3 for a light, 2 for a callused, and 1 for a dead cutting are shown in Table 2. No significant difference caused

Table 1. Herbicides applied to container-grown stock plants.

Trade Name	WSSA Common Name or Chemical Name	Lbs. Rate Per Acre
Amiben 2EC	Amiben	2
Bladex 80W	2-(4-Chloro-6-Ethylamino-S-Triazin-2-Ylamino)-2-Methylpropionitrile	½
Bladex 80W	2-(4-Chloro-6-Ethylamino-S-Triazin-2-Ylamino)-2-Methylpropionitrile	1
Kerb 50W	N-(1,1-Dimethylpropynyl)-3,5-Dichloro-benzamide	1
Check		
Kerb 50W +	N-(1,1-Dimethylpropynyl)-3,5 Dichloro-benzamide	1
Princep 80W	Simazine	1
Princep 80W	Simazine	1
Casoron 4G	Dichlobenil	3
Lasso 4EC	Alachlor	3
Falone 4EC +	2, 4 Dep	4
Enide 50W	Diphenamid	4

by the application of herbicides to stock plants was found in the case of *Cytisus purgens, Ilex crenata* 'Howard' or *Thuja occidentalis* 'Fastigiata'. Rooting index values both statistically better and worse than the check were recorded with *Calluna vulgaris* 'Aurea'. Cuttings taken from plants treated with Amiben, 2 lbs/A; Bladex, ½ lb/A, and Casoron, 3 lbs/A rooted better than those taken from the untreated check plants. Cuttings taken from Lasso, 3 lbs/A, or Princep 1 lb/A treated plants rooted poorer than those from the check plants.

Casoron is the herbicide most often suggested as decreasing the rooting percentage. In this experiment, *Calluna* cuttings taken from Casoron treated plants actually rooted better than those taken from the check plant.

Herbicides applied to stock plants can influence the rooting of cuttings taken from them. However, not all herbicides or plant species will show this effect.

Table 2. Root index values[1] for cuttings of four plant species given 10 herbicide treatments.[2]

Herbicide and Rate (aia)		Calluna vulgaris 'Aurea'	Cytisus purgens	Ilex crenata 'Howard'	Thuja plicata 'Fastigiata'
Amiben	2	45.0 *	34.0	40.7	35 0
Bladex	½	45.7 *	35.7	39.0	32.3
Bladex	1	39.3	32.7	40.0	30.7
Kerb	1	40.3	36.3	38.7	38.3
Check		38.7	33.7	43.3	40.7
Kerb + Princep	1 1	44.0	36.7	39.7	34.1
Princep	1	32.3 *	31.0	39.0	40.7
Casoron	3	43.7 *	34.0	0	38.3
Lasso	3	32.3 *	32.7	39.7	36.0
Enide + Falone	4 4	33.3	34.0	40.7	37.3
LSD 5% *		5.5	N.S.	N.S.	N.S.
LSD 1% * *		7.9			

[1]Root index value: 5 heavy roots, 4 medium, 3 light, 2 callused, 1 dead
A value of 50 would indicate 10 heavily rooted cuttings.

[2]Average of three 10-plant replications.

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1. Anon. 1972. Pest control tops program in Connecticut. *Amer. Nurs.* 135(7):15, 52-63.
2. Ticknor, R. L. 1965 The effect of herbicides on the rooting of juniper cuttings. *The Plant Propagator* 12(1):8.

BRUCE BRIGGS: Thank you, Bob. Now we'll get down to the real good part, the Question and Answer period. Andy, you had your hand up. Do you want to start it off?

ANDY LEISER: I just missed the amount of bicarbonate in that table you gave, Charlie, on the neutralization of bicarbonated gas in a thousand gallons. What was the figure on the bicarbonate?

CHARLIE PFEIFFER: One milliequivalent per thousand gallons.

EDWARD JELENFY: Linda, will HPM separate out or will it be suitable for use for the next day. Or how do you do it. Do you mix it again?

LINDA RUMGAY: Just the first time. That's all you need to do. You just continue to use it until it's finished.

BRUCE BRIGGS: On that, Linda, you mix it for twenty minutes. Do you consider this necessary to get a good mix? Fine, O. K

WILLIAM CURTIS: For this "HPM", as Linda calls it, we've got to thank Ted Van Veen for the start of this. I have never been one to change around much if I had pretty good luck, I leave it alone. I've been rather conservative. About two years ago we were talking to Ted and he told me what he was doing; and this is Ted's formulation. We mix this up and we leave it alone until we use it. Now, we get Hormodin 3 in an eight ounce tin. We take ten ounces of Hormodin 3 and put it in a fruit jar, also the Benlate,. We put this all in a fruit jar and then we shake it for twenty minutes. Or, as has been suggested that you take it to a paint store and they will shake it for you. Perhaps a quart can that you seal real tight may be better. If you shake it to get it well mixed it will fluff up. You can't put it into the same size vessel because it has a tendency to fluff way up and you've got twice as much after you shake it as you had before. We take a small amount and put it in a small vessel to dip our cuttings in, like you would with Hormodin 3 or any other powder. This came originally from Ted Van Veen but now Ted has another modification. Ted, do you want to add to this? He's got the latest dope.

TED VAN VEEN: Well that's basically what it is, Bill; we modified it only to the extent that we're putting a slight portion of boron into it this year and, offhand, I can't remember the amount.

GEORGE RYAN: I have another question on that, Bill; is this straight IBA or did I understand that you already diluted it?

WILLIAM CURTIS: It's been diluted in talc and it's fifty per cent Fifty per cent IBA, What did we pay this year? Seventy-five dollars for 100 grams.

ED SHULTZ: When I buy IBA it comes in a granular form and I use a mortar and pestle to grind it up. Now when you had this mixed with talc did you have this put through an alcohol solution in order to bring it into a solution and then mix with talc?

WILLIAM CURTIS: We get the mixing done for us by Miller Chemical Company. Evidently they take the crystals and dissolve it in alcohol just like the directions tell you to do, then they add the talc and regrind it. And it's fine, the same kind of texture as Hormodin 3. So I suppose they use the same grade of talc so you don't have any separation. If you use a coarser talc, or a finer talc, then you would have, perhaps, a separation.

RICHARD BOSLEY: I have a question regarding the use of Benlate. There are some reservations in the East regarding Benlate. I wonder if you have tried other fungicides?

WILLIAM CURTIS: "You can't beat success." You know the old saying. We've had excellent results with Benlate. But that's the only place we use Benlate — on cuttings. We only use it once because we were told it has inhibiting factors in regard to root growth. We use Captan. We don't use a second application of Benlate.

BRUCE BRIGGS: Charlie Pfeiffer, I believe there was some work in the greenhouse where they used Benlate in rooting and also I believe there was a breakage point not to use it over a certain strength. Do you wish to comment, Charlie?

CHARLIE PFEIFFER: This was on rooted cuttings of chrysanthemums and pot mums. At six ounces they got burning. But at three or four ounces to a hundred gallons, there was no problem. If you follow the rate that is on the package I think, in the experience of some of the growers, there may be burning.

BRUCE BRIGGS: Has anyone else had experience with Benlate and what strength would it inhibit the rooting? Is there any comment? Bob.

ROBERT TICKNOR: Several of the growers in this area are using Benlate as a dip for cuttings before they put them in the bench. Last year we tried some of this and we also had Benlate in the mix. It was 10% of 50W. So there was about 5% of actual Benlate in the hormone mix. And when we doubled up with the dip before and the Benlate afterwards, we had poorer rooting than not including the Benlate. I don't know whether there is any particular advantage in our system for using Benlate as a pre-dip; but I know a lot of growers have and have rooted things that they haven't rooted before. So, again, there can be a particular group of disease organisms or whatever is around the place that can make a difference.

JOHN EICHELSER: We used Benlate this year on Exbury azaleas; we dipped our cuttings in the Benlate and then used it later over the bench. And, so far — we're just taking them off now — but we're having the best take we've had in several years.

HAROLD CLARKE: Last year we dipped all our cuttings in

Benlate. We put them into a tub of Benlate solution and we also used it as a spray over the cuttings in the bench — and we had very good results Next, about this HPM formula, George Ryan here just figured it comes to about 1 5% indolebutyric acid. Several years ago we tried 2% for certain rhododendrons. We got considerable injury and burning and it seems to me it's getting pretty close to that concentration. The question I was going to ask Bob, are there any other fungicides you can mix in the hormone? We have used some Captan. We also used Arasan originally very well.

BRUCE BRIGGS· Thank you. Going back for some information to bring you up to date. At the Eastern Meeting, there was documented work showing that Benlate did stimulate rooting when used alone. I believe this was on Kwanzan cherries, I'm not sure. It was definitely proved that it did stimulate rooting.

TED VEN VEEN: As long as we're on that subject, George's calculation is correct. It is 1½% IBA. There are a few varieties of rhododendrons that will show some burning if they are taken quite early; we take our cuttings starting the first of July, so we do have some tender things We have a list of varieties that we don't use the full strength on; so you will get some burning at that rate. But later in the season — we do take some in October and November also — they seem not to burn. I think it's just a matter of the succulence of the cutting.

DON DILLON: I want to question whether other materials could be used in the hormone mix; we have used IBA with talc and Fermate. Fred, do you remember how much was in it?

FRED REAL: I let the druggist take care of that

DON DILLON: We have ours compounded at the local druggist and its's in the Proceedings of some years back when we presented our paper on twig grafting. I can get the information but I think Fermate came out as a recommendation of the Soil and Plant Lab, actually as a additive to the hormone treatment.

RICHARD BOSLEY· I want to ask Dr. Pfeiffer about chlorination of pond water. How much chlorine, what equipment?

CHARLES PFEIFFER: Basically a sufficient amount of chlorine to react with the organic matter that is in the water: this will vary anywhere from 4 to 5 ppm. As long as there is about 1 ppm residual; the exposure time should ideally be about ten minutes. Frequently, about five minutes is about all you can achieve. But ten minutes is considered the ideal time for exposure: and this will help tremendously in controlling water mold organisms.

RICHARD BOSLEY· How do you tell how much remains in the water?

CHARLES PFEIFFER: Ask Bruce, he's the one who has had experience in that

BRUCE BRIGGS: Normally if you chlorinate water, unless it vaporizes or goes out through the air, or goes out into the soil or something, the chlorine will remain there and it disappears only in reacting with the bacteria and the fungi that are in the water The indicator we use gives parts per million on a color scale — the same as the cities use. So what you do is to take the water that you have, put this in and add a little chemical to it and then you get a certain coloring. Then you can tell the parts per million, by this little meter, of free chlorine. Anytime you want, you can check it. What we do — we may have as high as 4 or 5 ppm at the pump — then when it finally reaches the destination, when it's ready to go on to the field, we again check it and it will be over 1 ppm — this is all. The difference between where it goes in at the pump and the area where it goes out on the field is consumed in the process; it was in the pipe, killing the fungus or bacteria in the water.

Yesterday it was mentioned, I believe, on tissue culture, using chlorine as a disinfectant. There were comments coming from the East last year in regards to *Phytophthora*. It was said to be very bad for us to keep dipping cuttings into a bath of water since we would be recontaminating cuttings because the water would contain things that we normally wouldn't kill with Benlate or with Captan, and so on — that we were doing harm. We always felt in the West that if we used Clorox the water would remain clean. So two years ago, we checked ourselves out. Because, they said, the chlorine in 20 minutes would all be gone in this bath. So we used the city indicator which we normally use and we found if we use Clorox, as it comes out of the bottle, not calcium chloride as is used in dairies, the chlorine will remain high all day long. It does not deteriorate in the water; so it stays there active as a disinfectant.

DOUGLAS PHILLIPS: I've been using chlorine a little bit on peaches and geraniums; one thing that has been pointed out to me is that the pH of the solution is very important. We're actually dealing with the active hypochlorite ion and the important thing is to have a pH at a point near neutral, because if it's alkaline, it is not active. If it's acid, it goes off too fast and you can have very rapid loss of activity of the hypochloride ion when it's put into an acid solution. What most of the people that I've been associated with strive for is a pH near 6.8 or 7. That is one of the factors.

I want to mention, too, that some of the fungi that I have been working with, particularly *Monolinea* — if it's adhering to the surface of a particle or a fruit, or something like that, it may take concentrations up to 100 ppm in order to get the kill. Another factor that is very important is the temperature. If you're dealing with cold water you get very poor kills at relatively high concentrations.

BRUCE BRIGGS: Very good. One other thing you might consider. If you are running an injector system and use calcium nitrate as your liquid form, you lose your chlorine immediately because the chlorine breaks down. So unless you inject a different kind of element between when you inject the chlorine and when you put the fertilizer in, you will have no free chlorine because the calcium will chemically react with the chlorine and you immediately lose it.

HAROLD CLARKE: I'd like to direct a question to Louise Zachry. I'm not sure you mentioned your rooting hormone, your basic one.

LOUISE ZACHRY: Well, our hormone, generally speaking, is the old Jiffy-Grow solution.

BRUCE BRIGGS: I'm surprised that we don't have more confusion. I feel that we get more uniformity of results with a liquid. Louise, would you care to comment. You used both powder and liquid hormone preparations. How do you feel about the results from powder versus liquid?

LOUISE ZACHRY: Well, our results seem to be better with the liquid so I'll have to go with the liquid. We've tried both and used them in different strengths and so I still say we have to go with the liquid at this time.

BRUCE BRIGGS: We have not heard anything about rutin today; is anyone working with this? This is involved in some of the work that Dr. Tukey did back East. It was an interesting project. I know there must be a lot of work going on. How about it?

EDSAL WOOD: In some liquid trials we're trying right now, rutin is in it; it was done just this summer and it's all under mist. So far we can see absolutely no advantage at all from rutin under these conditions on succulent material.

ED JELENFY: A while back there was something mentioned about penetrants. Does somebody care to comment on just exactly what it is. What do you mean by the word?

BRUCE BRIGGS: A penetrant is something that will move a product within the plant. So, in other words, we want something that will translocate that product elsewhere within the plant. Like DSMO; it was, and still may be, one of the best ones we have.

HARRY LAGERSTEDT: Referring to Louise's talk — she mentioned using DSMO at 10 per cent. That sounded awfully high.

EDSAL WOOD: DSMO is put in the hormone stock solution at 10%.

BRUCE BRIGGS: O.K. Now, what strength are you running down to?

EDSAL WOOD: Well, you use about a one to ten dilution of the stock solution penetrant. The big advantage of the two new pharmaceutical penetrants has been that we can cut, for instance, on our normal Jiffy-Grow, where we used a one to five, now we cut it to one to ten. We don't get the damage because our concentrations aren't as high. But we actually get better penetration and better rooting from the use of these penetrants. That is their purpose, of course, to carry in lower concentrations, almost half — right down the line. We cut our hormone strength by half.

ANDY LEISER: Would you name the new penetrants again, Ed.

EDSAL WOOD: Tetrahydroferberil. It is impossible to get it any place I know except England. These came out of a pharmaceutical research lab. They were working with DSMO as a topical application. They found they could use this without the ill effects of DSMO and accomplishing the same thing. The other is dimethylacetamide.

GEORGE RYAN: These are now available from chemical suppliers here.

BRUCE BRIGGS: What strengths of penetrants are in your solutions?

EDSAL WOOD: I think it's five per cent.

BRUCE BRIGGS: O.K., fine. That would be the total of each, one or the two combined?

EDSAL WOOD: We're trying to separate them out now and see which one does the best.

BRUCE BRIGGS: If you remember last year in California; it came up in discussion — they were using one per cent DSMO as the carrier. Now, where is your point of danger, if there is any danger; this is always a question. Harry.

HARRY LAGERSTEDT: I would like to comment on this. Eight or nine years ago, when DSMO first came out, we used it with IBA in class projects with about thirty different types of plants. If it worked at 0.1%, 1,000 parts per million, you're on the high side; we found a variation of results. With a few plants we seemed to get some response and in a few plants, we got injuries. So I think that you would first go below 1,000 ppm and then just experiment.

Another group that we've become acquainted with over the past few years are the research people operating near Centralia, Washington with one of our very large forestry firms, the Weyerhaeuser Company; they have been doing some very fine work in forestry improvement. One of the problems, of course, all the geneticists and tree improvement people have is getting their super trees into seed orchards and so on and this has gotten the forester into the problem of grafting and so on with which horticulturists have been involved for many years. This has not been without its problems for them. To me, as a horticulturist, this problem they have run into is one of the most fascinating things I've seen in my many years in forestry; it is the fact that many of these Douglas firs will not accept their own seedlings as rootstocks. No one has been able to satisfactorily explain to me why this is. In other words, 30 or 40% of their super trees, when grafted back on their own roots, will develop incompatibility problems. But we've had the opportunity to get acquainted with Bill Webb here at Weyerhaeuser's research group and have met with him several times and today he's come down to talk to us about compatible and incompatible understock in forestry. Bill, we appreciate your coming to share with us what you have here today.

COMPATIBLE UNDERSTOCK IN FORESTRY

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Weyerhaeuser Company has embarked upon a program of tree improvement aimed at increasing wood yield per acre on its lands through forest tree breeding. In a classic breeding program this means choosing a number of superior trees of seed-bearing age within our wild stands of timber, and genetically duplicating them by grafting to develop *seed orchards* designed to provide seed improved over that now collected from average trees in the wild. These seed orchards must produce consistently over a period of 30 years or more in order to meet reforestation schedules that call for planting new trees within one year of logging.

As you are aware, certain of our major tree species, notably Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) are inconsistent grafters, showing strong clonal variation in stock-scion compatibility.

Incompatibility not only kills a number of our grafts, but will obviously interrupt and delay seed production unless steps are taken to overcome or circumvent it. If we eliminate grafting then we must sacrifice the advantages it offers to the seed producer:

A. *Gains in time through:*
   1. Early flower production for continuation of the breeding program.
   2. Early seed production for forest regeneration.

B. Gains in orchard management through the development of dwarfing rootstocks.

For our first generation of seed orchards we have accepted the use of grafting in propagating our clones. Therefore, in order to meet our seed production goals and, incidentally, to provide a broad genetic base for our program, we must guarantee the long-term productivity of our orchards through the development of understocks compatible with our plus trees.

In the rooting of compatible stocks, two basic methods could be used:

1. Scions of many clones can be grafted onto one rootstock.
2. Each rootstock can be grafted with scions from one plus tree clone

We have chosen the second method in order to:

— shorten the time to propagation of compatible stock in quantity

— give us the option to select from a broad rootstock base.

Here is the course we follow. Initial grafts of Douglas-fir are made from our "plus" trees onto seedling rootstocks which had their seed origin in the same area as the plus tree.

These rootstocks at the age of two years are each grafted with two scions from the same plus tree clone in accordance with the procedure developed by Dr. Don Copes for compatibility testing (1).

All grafts are later screened to identify those showing no visual symptoms of incompatibility. These are tested by Cope's destructive technique in sufficient numbers to isolate at least one compatible rootstock for each clone. Special attention is given to clones that are poor grafters. Compatible scion-stock combinations are then duplicated by rooting the rootstock and re-grafting to fill in the ranks depleted by delayed incompatibility. In Douglas-fir this depletion of incompatible grafts and replacement with proven compatibles continues through a period of 7 or 8 years where large numbers of clones are involved. At present we have rootstocks which are compatible with 350 of our plus tree clones, or approximately ½ of those in our Douglas fir seed orchards.

Obviously we would like to have a stock which is universally compatible with all our plus tree clones, stimulates flowering, controls height growth, and is free from susceptibility to pathogens and extremes of climate.

LITERATURE CITED

1 Copes, D. L 1967. A simple method for detecting incompatibility in 2-year-old grafts of Douglas-fir. *U.S. Forest Service Research Note*, Pacific NW Forest & Range Experiment Station.

AL ROBERTS· I'm sure we're all impressed with the sophisticated approach that both Bill's group here and Jim's are taking on these very serious problems in forestry. I think these two talks have served as sort of an introduction for our next topic and that's the matter of rooting these cuttings. I think you can see why horticulturists with their experience in the rooting of cuttings and so on might have become involved in this phase of interest to forestry at the present time. Over the past five years, through a grant from the Hill Foundation we've been able to devote quite a bit of time to the rooting of Douglas-fir at Oregon State University and we feel that this has great application to our propagation of conifers in the nursery trade in general.

Someone mentioned students yesterday and that we welcome these students. I'd like to introduce a few that are here today from Oregon State; at least they're supposed to be. Would you students stand up?

The one who will speak to us now is Dr. Kim Black. I noticed in the program, Kim, they didn't add that Doctor title to your name. He just freshly hatched and I'm sure it's important to him to have that prefix added to his name. Dr. Black finished his research program this spring and has done a fine piece of work. I am pleased that he was willing to come over here from Idaho to present this material to you We've had a lot of good graduate students in the past but he's one of the best. Kim is going to share with us just a portion of his work, particularly along the line of the selection of the shoot and its origin in relation to its rootability and so on. I think some of this material may be a review to some of you but I'm sure you're going to find some new material mixed in with this. Kim, we're pleased to have you this morning.

THE INFLUENCE OF SHOOT ORIGIN ON THE ROOTING OF DOUGLAS-FIR STEM CUTTINGS

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Abstract. The influence of collection date on the rooting of Douglas-fir was reported by Roberts (14) at an earlier meeting of this group.

Results reported here show the importance of additional factors in the selection of cutting material. Depending on genotype, cuttings of juvenile trees under nine years of age had the potential for rooting 100%, declining rapidly after this age to less than 5% between ages 14 and 24 years. Genotypic differences in cutting rootability were greatest among the physiologically older trees. Rejuvenation of rooting in old trees and clones was achieved by shearing and successive propagations. Comparisons of sheared and non-sheared portions of old trees showed the rejuvenation effect to be localized in the sheared portion. Cutting ramets established from old clones produced cuttings which rooted 40% compared to 6% from grafted ramets and 3% from the ortet Crown position (cyclophysis) had little influence on the rootability of shoots from trees under 24 years of age. Branch order positions (topophysis), however, were important in cutting selection, with first order lateral (large), and second order terminal positions rooting better than first order terminal, first order lateral (small), or second order lateral cuttings.

Douglas-fir, (*Pseudotsuga menziesii* [Mirb.] Franco), is the most important timber species in North America. It is also one of the best soft woods of the world. Nearly 30% of the commercial forest land in the West carries stands in which Douglas-fir predominates. Most of this timber area is on the Pacific Coast, mainly in the very productive area west of the Cascades, but Douglas-fir stands are also widespread in the Rocky Mountain states. This represents approximately 37,352,000 acres or 7.3% of the total forest crop in the U. S., and almost 25% of the saw timber produced, by far the most important species (6). It is also considered a leading timber species in Canada, where it is a native, and in other countries, where it has been introduced.

It is one of the most important Christmas tree species in those regions where it is adapted. Large Christmas tree plantations are common in the Pacific Northwest. These facts show the importance of this species in meeting the soaring demands for wood products by a growing population and expanding economy.

In maintaining a supply equal to the demands for this species, there is a need in forest genetics, forest management, including

Christmas tree management, for methods of propagating clonal lines of superior phenotypes and genotypes of Douglas-fir on their own roots. This would avoid problems of rootstock-scion incompatibility and rootstock influences common to grafted materials presently used in forest tree improvement. These trees would be useful in site performance evaluation, the establishment of seed orchards, and conceivably in the future for forest and Christmas tree plantations. One need only look at the advancements made with horticultural plants by asexual propagation to see the potential with such an important timber, ornamental, and Christmas tree species.

Large scale propagation of many woody plants from cuttings is a relatively recent development. Prior to 1930, only the "easy-to-root" species and cultivars were so propagated. The discovery by Thimann and Went (18) that naturally occurring auxins contribute to root initiation led to the use of synthetic auxins in rooting many "difficult-to-root" species.

The conifers have been considered by some to be among the most difficult species to root (17). However, some conifers, largely ornamental forms used in landscaping, have been considered by others to be more or less easy-to-root (8).

The forest conifers which have been most widely studied and propagated from cuttings include *Pinus radiata* (2, 5, 9, 19), *Picea abies* (3, 4, 7), *Pinus densiflora* (10, 11), and other species in the genus *Pinus* (12).

There has been a growing interest by foresters throughout the world in tree improvement through various means of vegetative propagation. Grafting scions from select trees onto chance seedlings has been the most common procedure for seed orchard establishment with difficult to root species. An obstacle to the wider use of rooted cuttings has been the inconsistent results obtained and lack of knowledge concerning the many factors which interact and contribute to the rooting potential of these species. Progress in forest tree improvement must rely heavily on the identification and understanding of factors which contribute to the rooting of cuttings, because grafting and budding techniques have been plagued with poor graft unions, incompatibility and rootstock influences. Grafting is not generally suited to the economic mass production of forest planting stock. The current interest in propagating forest species from cuttings has provided the research incentive to clarify the principles involved in rooting specific species.

Success in rooting Douglas-fir has been inconsistent and progress slow. Research has not been sufficiently detailed to obtain basic answers. However, research has shown the feasibility of rooting this leading timber species (1, 14, 15).

These studies were conducted to determine quantitatively how rooting potential of Douglas-fir is influenced by genotype, tree age, shearing, successive propagation, crown level (cyclophysis) and branch order position (topophysis). These variables have been shown to be important in the rooting of other conifers (5, 3, 4, 7).

MATERIALS AND METHODS

Age. Age effects were studied using a factorial experiment with five seedling trees in each of the four age classes (5, 9, 15, 26 years), and six sampling dates over a two-year period. A minimum of twenty cuttings per tree was sampled on each date.

Rejuvenation. Rejuvenation in rooting potential of old trees was studied using the following approaches:

a) Old sheared trees in two age classes, 25-28 and 35-42 were compared with the non-sheared trees used in the age study. Again five trees in each class were sampled with the number of cuttings per tree, collection dates, and treatment of cuttings the same for both studies. The trees used in these two experiments were growing in the Willamette Valley, Oregon, but were not necessarily of the same seed source or growing at the same site.

b) The effects of shearing on rejuvenation were studied further by comparing sheared and non-sheared portions of the same old trees ranging in age from 25 to 56 years. Three samples of 20 cuttings each from sheared and non-sheared portions of eight different trees were taken on two dates during 1971-1972.

c) The effects of successive propagations on rejuvenation of rooting potential was studied by comparing cuttings from clonal material representing: (a) the parent ortet, (b) grafted ramets of the ortet, and (c) rooted ramet cuttings. These plants were all growing in the same area, (b) and (c) in the David T. Mason seed orchard near Sweet Home, Oregon, and (a) in the forests near Sweet Home. Twenty cuttings were sampled from each source on two dates during 1971-1972. Five clones ranging in age from 25-84 years were included in this study. Rejuvenation resulting from successive propagations was further evaluated by comparing cuttings from 15- to 25-year-old seed orchard understock plants with three-year-old rooted cuttings of these same clones. Eleven clones with samples of 20 cuttings from each source, placed in the rooting bench on two dates, were included in the study.

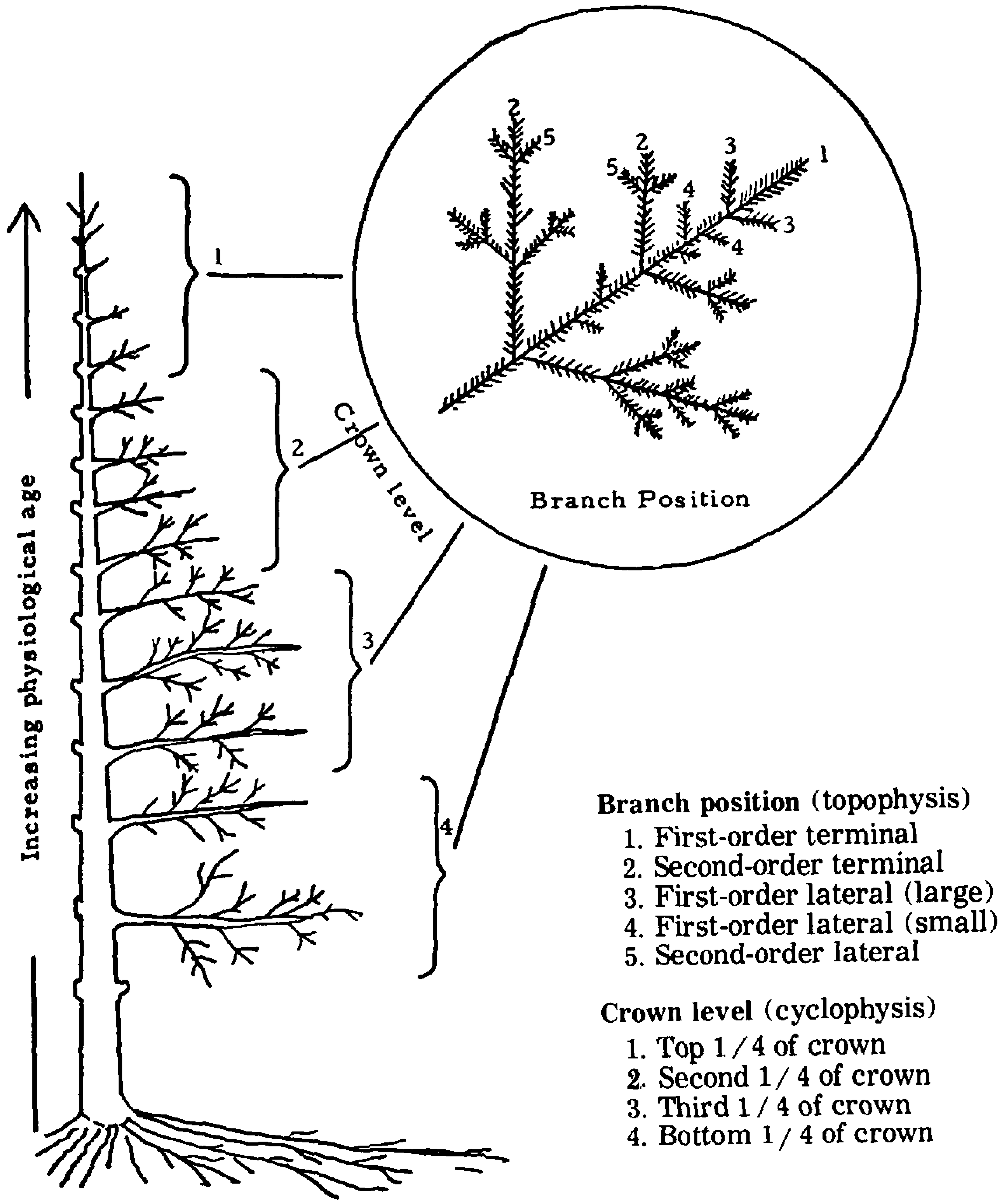

Fig. 1. Topophysis and cyclophysis. Diagram showing the physiological age levels and branch order positions used in this study.

Genotype and Position. Genotypic and positional effects were studied using a factorial experiment with cuttings selected from at least five trees in each of four age classes (4, 8, 14, and 24 years), two branch order positions (terminal and lateral), and four crown levels (Fig. 1). Five samples of ten cuttings from each position of each tree were included in this study during 1970-1972. Each sample was analyzed separately.

Branch order effects were studied in more detail by comparing shoot rootability within five branch orders of three 9-year-old, field-grown trees. Branch order positions compared were (1) first order terminal, (2) second order terminal, (3) first order lateral (large), (4) first order lateral (small), and (5) second order lateral. Three samples of ten cuttings from each position of each tree were analyzed in this experiment.

RESULTS AND DISCUSSION

Aging. Rooting potential decreased with increasing age of the seedling trees at all dates sampled. However, the results indicate that the decline in rootability of Douglas-fir may not be as rapid as in some other conifers.

Up to 100% rooting was common in the cuttings from trees up to 9 years of age. Rooting declined rapidly at tree ages beyond 9 years, and reached a very low level (less than 5% at all sampling dates), at 24 years. This decline in rooting does not appear to be due to the onset of flowering, since no evidence of strobili could be observed in the 15 year old trees or any of the younger trees used in this study. Only the 24-25 year age class showed any evidence of cones or cone development.

Root quality was better and the rate of root development was faster in younger trees. Cutting mortality before and after rooting was less and the amount of extension growth was greater in cuttings from younger trees. (Table 1).

Rejuvenation. Various criteria have been used to distinguish between the juvenile and adult stages. "Most authorities consider that the greater ability of cuttings to root is most closely associated with juvenility" (13). Significant rejuvenation in rooting and growth potential occurred as a result of shearing.

a) *The Rejuvenation of Rooting by Shearing.* At all sampling dates the 24-28 and 35-42 year old sheared trees, some of which had numerous strobili in the crown, rooted better than the 24-year-old, non-sheared trees. Cuttings from the 24-28 year old sheared trees generally rooted better than those from the 14 year old non-sheared trees, but not as good as those from the 8 year old class (Table 1). Shearing also improved root quality. The rate of root development was significantly faster in cuttings from sheared trees, being comparable to the much younger, non-sheared trees. Bud break occurred sooner and cutting mortality was lower in cuttings from sheared trees, again reflecting the rejuvenating effect of shearing. (Table 1).

Table 1. The effects of age on the response of cuttings from different age classes of non-sheared and sheared trees.

Tree age (yrs)	Dec. 1, 1970 C.S.[a]	Aug. 1, 1971 N.S.[a]	Dec. 1, 1971 N.S.	Dec. 1, 1971 C.S.
		Percent rooting		
Non-sheared				
4	55.2	6.3	57.0	67.5
8-9	62.7	23.0	35.3	45.5
14-15	21.5	2.5	9.5	19.8
24-25	4.7	1.9	0.8	0.8
Sheared				
24-28	45.2	2.0	11.2	26.0
35-42	15.3	1.0	14.0	6.0
LSD .05	5.8	4.3	3.4	3.15
		Percent of rooted cuttings of good quality		
Non-sheared				
4	12.0	14.0	49.0	61.0
8-9	57.0	24.0	42.0	27.1
14-15	15.0	0.0	16.0	11.4
24-25	0.0	0.0	0.0	0.0
Sheared				
24-28	18.0	25.0	15.0	6.1
35-42	18.0	0.0	11.0	6.7
		Percent bud break in bench		
Non-sheared				
4	61.5	0.0	55.0	98.9
8-9	59.4	0.0	5.8	49.0
14-15	43.0	0.0	13.3	99.0
24-25	8.0	0.0	0.0	38.8
Sheared				
24-28	67.0	0.0	8.0	70.4
35-42	45.0	0.0	26.0	84.8
LSD .05	6.4	0.0	11.0	1.97

Continued

Table 1. (Continued)

Tree age (yrs)	Dec. 1, 1970 C.S.[a]	Aug. 1, 1971 N.S.[a]	Dec. 1, 1971 N.S.	Dec. 1, 1971 C.S.
	Dead cuttings in the rooting bench			
Non-sheared				
4	0.0	24.3	3.8	0.0
8-9	7.5	12.0	11.8	5.5
14-15	16.8	12.0	21.8	1.0
24-25	27.0	17.8	1.8	0.5
Sheared				
24-28	19.3	48.5	11.6	2.8
35-42	30.7	33.5	1.2	13.2
LSD .05	7.5	8.1	9.3	2.0
	Alive callused unrooted cuttings			
Non-sheared				
4	21.5	16.8	34.3	6.3
8-9	15.7	40.0	46.5	46.5
14-15	39.9	59.0	66.3	75.0
24-25	50.1	54.5	96.0	98.5
Sheared				
24-28	33.0	26.0	67.2	71.0
35-42	53.0	57.5	74.4	78.0
LSD .05	10.8	11.9	15.1	6.0
	Percent mortality of rooted cuttings			
Non-sheared				
4	7.0			
8-9	11.6			
14-15	16.8			
24-25	44.0			
Sheared				
24-28	14.0			
35-42	31.7			
LSD .05	17.3			

[a]N.S. — non-stored cuttings
[a]C.S. — cold-stored cuttings

A comparison of the rooting potential of cuttings from sheared and non-sheared portions of the same tree confirmed the possibility of rejuvenating old clones by shearing, and revealed the localized nature of the response (Table 2). In each of the eight trees, there was significantly better rooting in cuttings from the sheared portions of the tree. Even more significant perhaps was the greater number of trees that proved rootable when cuttings were taken from the sheared portions of the tree.

Table 2. Percent rooting of cuttings from the sheared and non-sheared portions of the same old trees. Values are the average percentage rooting of 20 cuttings from each portion of eight trees (320 cuttings).

Sample (Date and cold) storage	Sheared portion	Non-sheared portion	LSD .05
	(%)	(%)	
Aug. 1, 1971	9.3	1.2	7.0
Dec. 1, 1971	10.0	3.8	6.1
Dec. 1, 1971 [a](C.S.)	20.0	9.4	11.2

[a]C.S. — Cuttings stored for 60 days at 0 ± 1° C.

b) *Rejuvenation Effects of Successive Propagation.* — Cuttings from cutting ramets rooted significantly better than cuttings from grafts or cuttings from the parent ortet of the same clone (Table 3). With the five clones included in this study and sampled December 1, 1 percent of the cuttings from the parent, 9 percent from the grafted ramet, and 45 percent from the cutting ramet rooted. Cuttings from only one of the parent trees rooted, while those from three of the grafted trees and those from all five of the cutting trees rooted. Since these trees were all growing in the same area under similar environmental conditions and represent comparisons within clones, it was evident that the cutting ramets were rejuvenated.

While it can be concluded that rooting and root quality decreased with age of the ortet, there is considerable evidence that old clones can be rejuvenated by heavy shearing, and successive propagation. Cuttings from established cutting ramets show the greatest potential for rejuvenation, even for clones up to 84 years from seed. Genetically identical trees (clone) with identical chronological age appear to be quite different physiologically, as evidenced by the increased rooting potential of cuttings from grafted and most particularly of cutting ramets. Cutting ramet plants show more juvenile morphological characteristics, such as differences in needle and bud form and lack of lower production, than the ortet or grafted ramet trees.

Table 3. A comparison of the rooting potential of cuttings of the same clone but from different sources. Values are percentage rooting.

Harvest date	Ortet	Source of cuttings: Grafted ramet	Source of cuttings: Cutting ramet	LSD .05
	(%)	(%)	(%)	
A. Ortet versus grafted ramet versus cutting ramet (average of five clones).				
Dec. 1 Non-stored	1.0	9.0	45.0	10.3
Dec. 1 Cold-stored	7.0	6.0	48.0	12.0
Feb. 1 Non-stored	0.0	2.0	26.0	4.1
B. Ortet versus cutting ramet (average of 11 clones).				
Dec. 1 Non-stored	12.7		39.5	8.3
Dec. 1 Cold-stored	9.0		36.0	17.7

Genotype. Throughout these studies, genotype was observed to be a most important factor affecting cutting rootability. Trees growing side-by-side under apparently identical environmental conditions, and of the same chronological age, showed extreme variability in rooting potential (Table 4). These differences were not as great in younger trees as older ones. This confirms the findings reported earlier (16) that seedling differences in rooting potential become more exaggerated with age, and suggests that the aging process proceeds more rapidly in some genotypes.

Crown Level and Branch Order. No significant differences were noted in rooting potential of cuttings from different crown sections (Table 5). These results are different from those generally reported for this and other species (3, 5, 7). Randomly selected cuttings from terminal and lateral positions gave no significant

Table 4. Percent rooting of cuttings at different harvest dates over a two-year period for individual trees of different ages.

Clone	Age (yrs)	Dec. 1 '70 CS[a]	Feb. 1 '71 NS[b]	Aug. 1 '70 CS	Dec. 1 '71 NS	Dec. 1 '71 CS	Feb. 1 '70 NS	Mean
		Date and treatment						
		Number of cuttings / clone						
		80	20	80	80	80	20	
young	4	55	53	6	57	68	95	55.6
30	8-9	35	87	50	31	68	80	58.4
31		56	40	15	5	44	90	58.4
32		55	73	10	36	36	40	41.6
33		73	60	0	51	14	40	39.6
34		95	67	40	53	74	90	69.7
55	14-15	24	20	0	2	24	20	15.1
56		3	7	0	0	8	10	4.5
57		9	0	0	0	8	50	6.0
58		42	27	0	33	20	30	25.4
59		30	53	12	11	40	50	32.8
61	24-25	3	0	5	1	1	10	3.3
62		0	0	0	0	0	0	0.0
63		16	0	5	1	1	0	3.9
64		0	0	0	0	0	40	6.7
65		6	0	0	1	3	20	1.5

Continued

Table 4. (Continued)

Sheared								
45	24-28	49	23	0	20	18	40	25.0
46		25	3	5	8	22	30	15.5
47		57	43	0	24	58	0	30.3
48		41	43	5	4	30	0	20.5
49		44	20	0	0	2	0	11.0
40	35-42	5	0	1	8	0	0	2.4
41		6	0	0	22	2	0	5.0
42		10	3	0	6	2	0	3.5
43		33	37	3	8	4	0	14.1
44		16	50	1	26	22	30	24.2
Mean		30.2	27.2	6.1	15.8	21.8	29.4	

LSD .05 date and cold storage = 4.44
LSD .05 clone = 7.9

CS = cold storage for 60 days at 0 ± 1° C.
[b]NS = non-stored

Table 5. **Rooting, mortality and growth of Douglas-fir stem cuttings from terminal and lateral branch positions. Four samples of 10 cuttings x 4 levels x 4 age classes x 5 clones per age.**

	Dec. 1, 1970 cold-stored		Aug. 1, 1971 non-stored		Dec. 1, 1971 non-stored		Dec. 1, 1971 cold-stored	
	terminal	lateral	terminal	lateral	terminal	lateral	terminal	lateral
Total rooting (%)	30.2	40.6 [a]	8.4	6.6	24.5	26.7	39.9	26.8
Percent of rooted cuttings good quality	29.2	40.6 [a]	23.0	0.0 [a]	37.5	43.0	50.0	29.5
Percent of cuttings callused unrooted	26.0	44.5 [a]	42.7	43.1	55.8	65.6 [a]	55.5	70.1
Percent of cuttings dead in rooting bench	18.2	8.8 [a]	16.4	18.2	19.8	3.7 [a]	3.0	0.5
Percent cutting mortality six months after rooting	30.0	14.0 [a]						
Shoot growth the summer following rooting (cm)	9.3	7.2 [a]						

[a]Differences due to branch order position significant at .05 level.

Table 6. **Rooting, mortality and growth of Douglas-fir stem cuttings from different crown positions. Four replications of ten cuttings x 2 branch order positions x 4 age classes x 5 clones per age are included for comparison. Differences due to crown positions are not significant at .05 level. Values are in percent rooting.**

	Dec. 1, 1970 cold-stored				Aug. 1, 1971 non-stored				Dec. 1, 1971 non-stored				Dec. 1, 1971 cold-stored			
Crown level[a]	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Total rooting	27	24	30	33	12	10	9	9	21	27	26	29	32	30	31	41
Callused unrooted	26	30	40	32	40	38	32	29	58	58	66	62	57	69	68	57
Dead in bench	21	14	6	10	13	16	14	23	14	10	5	5	5	1	0	1
Bud break	49	41	43	41	0	0	0	0	12	18	26	20	67	75	71	71
Good rooting													47	33	55	40

[a]Level 1 — top ¼ of crown
Level 2 — second ¼ of crown
Level 3 — third ¼ of crown
Level 4 — bottom ¼ of crown

differences in rooting with any of the age classes studied (Table 6).

The more refined study of five branch order positions revealed that random selection of terminal and lateral cuttings is inadequate for determining the influence of branch order on rooting. A comparison of five positions (Fig. 1) showed that cuttings from position two and three (first order lateral—large and second order terminal), rooted best on the three winter sampling dates (Fig. 2). Cuttings from positions four (first order lateral—small) and five (second order lateral) were least vigorous and gave the poorest rooting. Root quality was also best in cuttings from positions two and three.

By combining the terminal and lateral cuttings of this study into separate categories, the differences due to position are erased. These results show the necessity for identifying branch order position in comparing terminal and lateral cuttings.

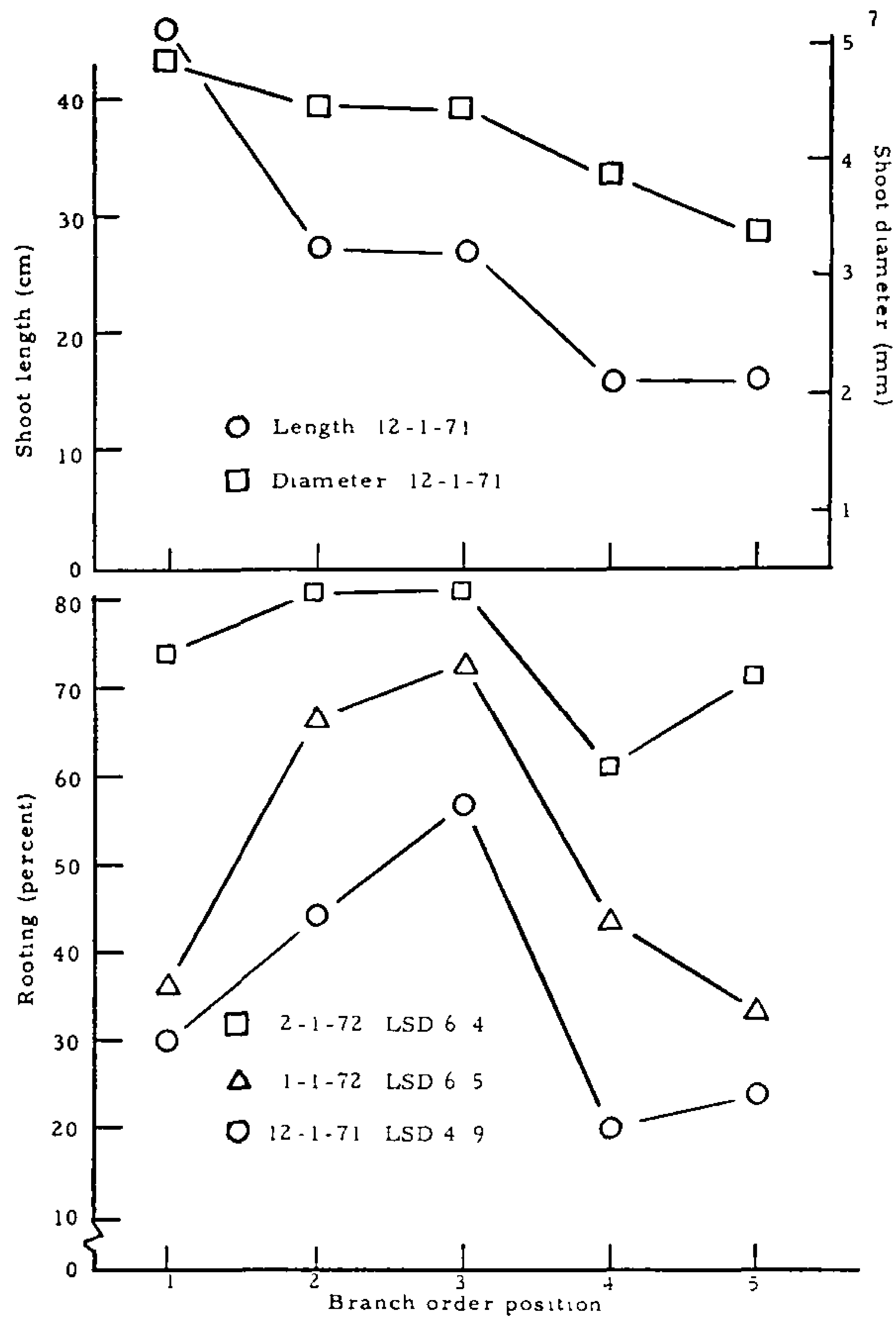

Fig. 2. **Shoot size (above) and percent rooting (below) of cuttings from different branch positions in nine-year-old Douglas-fir trees (Fig. 1). Dates given are harvest dates.**

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AL ROBERTS: The utilization of this, as all three of our speakers have brought out—the rooting of cuttings—is centered primarily around assisting the geneticist in establishing seed orchards. The four Douglas fir trees that Kim showed you in the picture looked like four peas out of a pod; this was a photo I took at Johann Kleinschmidt's place at Lower Saxony in Germany where they've got fifty years of work behind them on this. Now I think those trees were 10 or 15 years old. He has Douglas fir there that are 25 years old and they are tooling up to grow spruce in Germany which is a principal European timber source. They're tooling up rapidly; he says within a few years they will have most of the spruce planted, in his area anyway, from cuttings. Of course, the Japanese have done a lot with *Retinospora* and one or two other species. But it does show the trend and the necessity for lots of this kind of work.

KIM BLACK: The foresters are interested mainly for two reasons. (1)Seed orchard establishment with select clones, and (2) forest site performance evaluation using clonal lines.

The Christmas tree growers are interested for another reason. Seedling Douglas fir require considerable shearing. Some self-branching bushy trees could be propagated vegetatively as clonal lines as cuttings, eliminating the need for shearing.

BRUCE BRIGGS: What effect did light have upon the curvature?

KIM BLACK: Thank you. I meant to comment on it. I worked with light, put the cuttings in tubes and produced, by providing an opening on the side, an opening on the top and so on, and it produced no effect. Our work with plants grown in tubes with some open on the top and others on the sides revealed that unidirectional light produced no phototropic response in Douglas fir. Research on this species in France has shown that the phototropic response is lost by seedlings after three or four years. Apparently the cutting ramets I was working with were physiologically older than four years because they didn't respond to light.

BRUCE BRIGGS: Another question, have you obtained small juvenile trees that you also could shear heavily? Did this help to increase their rooting ability?

KIM BLACK: I didn't try that; the only thing I did on shearing was to sample these trees that had been heavily sheared and I can't tell you for sure how long they had been sheared. I wish I could say that you could go into the forest and cut the tree heavily for two or three years and get this rejuvenation effect; I don't know how long it will take to reproduce this juvenility —or rejuvenation in rooting potential.

AL ROBERTS: I would like to clarify Kim's comments about rejuvenation, and we're stretching this term a little bit — calling this rejuvenation. Because usually we think of rejuvenation as going back to the basal portion of the original seedling and picking up some mysterious factor there that you can't get this from adventitious buds but we have yet to find what we could identify as an adventitious bud on a Douglas fir.

KIM BLACK: We've argued about this juvenility term, rejuvenation, for two years and I hold to Robbins' concept in an article in *Plant Physiology*. He makes a statement there and I quote him, "Most authorities," this is the way he puts it, "agree that one of the most identifiable features of juvenile trees is their rootability." Now there's a lot of other things you could look at. You can look at shape of bud and shape of leaf, leaf morphology of all types — lots of other things physiologically. But if they'll root, in my book, they're juvenile. Because that's very characteristic of juvenile trees, so I'm using it that way.

AL ROBERTS: Of course, the other camp traditionally has used the mature form, or the flowering form, as the first indication of maturity.

VOICE: What was your optimal hormone treatment?

KIM BLACK: I used Jiffy-Grow which includes 5% IBA, and 5% NAA, and boron. I wasn't interested in studying the effects of hormone. I used a 10% quick dip of Jiffy-Grow through all my studies.

BILL WEBB: We all noticed, I think, the difference in root development around the axis of the callus ball. What's your assessment in regard to the age of the cutting and also clonal differences?

KIM BLACK: I noticed that on cuttings from old trees there is more of a tendency to form a big callus ball before rooting occurs. Often on young clones, roots will develop on the cutting without much callus evident. On some of these old clones you'll get a very large hard callus ball before the root emerges. So in partial answer to your question, it may be because of this large callus ball that rooting is difficult on these old clones. Why, I don't know.

BILL WEBB: The question really was how do you get the best quality of rooting? You know, in many cases, you get roots out one side the callus ball; this is obviously not desirable from the standpoint of future growth for that tree. It may grow well but, for instance, in an alpine situation it may be susceptible to wind throw and other problems. What do you see is the way of getting around this?

KIM BLACK: I really can't answer that. I wasn't evaluating the location of the root on the cutting as I took the data so I really don't have any information on it that I could back up with data. I do know that wounding did not help. I tried wounding the cutting up and down the sides and compared with controls I got just as good a rooting without wounding. I think with wounding, you have more of a tendency to get roots up along the wound rather than at the base. But I really can't answer your question.

ANDY LEISER: You mentioned the callus on the older cutting. Did you examine the callus; was it real soft callus material or was it an entirely different material under the outer layer of callus?

KIM BLACK: It appeared to be quite consistently callus throughout.

ANDY LEISER: The reason I asked, we were doing some work with pine which also callused. It looked like callus but when we peeled it off, it was a lignified material that actually made the callus ball.

AL ROBERTS: One thing we've observed over the period of years we've been on the Douglas fir is the fact that the callus increases in volume progressively as we go through the season; by midwinter we get tremendous callus development from the same clone.

Very recently, in fact a week ago, our next speaker, Dr. Mel Westwood, participated in a symposium at the University of Minnesota at the national meetings of the American Society of Horticultural Science where they considered various aspects of growth regulator chemistry. His topic there was the influence of these materials on rooting in plants and so today he has agreed to come up here and discuss this matter — the use of growth regulators and the rooting of cuttings of various woody plants. So we should have a very interesting discussion, Mel:

USE OF GROWTH REGULATORS IN ROOTING CUTTINGS OF WOODY PLANTS

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Rooting of cuttings is dependent upon interrelated genetic, environmental and chemical factors. Genetics controls such factors as the presence of pre-formed root initials and potential kinds and levels of endogenous rooting substances. Chemical balance is regulated internally by the interaction of genetics and environment but is subject to change by exogenously applied chemicals. The infinite number of possible combinations of genetic, environmental and chemical factors affecting cuttings, both pre- and post-severence, has led to some confusion regarding the importance of specific factors for rooting. This review considers briefly the role of growth regulators in rooting but with the interactive effects of genetic type and environment considered concomitantly. Only sample references are given along with books and review papers which include many additional references (2, 11, 12, 20).

Historical. In 1880 a rhizogenic substance was postulated to be produced in leaves and translocated down the stem to promote root formation (Sachs, 33)). Later Zimmerman and Hitchcock (41) reported that ethylene and other unsaturated gases would stimulate adventitious roots. Thimann and Went (37) established that auxin (indoleacetic acid or IAA) is a principal rooting hormone. Then the synthetic auxins indolbutyric acid (IBA) and napthalene acetic acid (NAA) were found to promote rooting (42). An added factor, rhizocaline, was proposed by Went (39), which is produced in the leaves and moves down the stem, where, with auxin it causes roots to form. During the decade which followed many works reported were empirical ramifications of auxin timing and concentration and post-severence treatments for best rooting (2).

Polarity in Plants. Plants and cuttings exhibit strong polarity, both in the position of roots and other organs (19) and in the strong basipetal transport of auxin and other rooting substances (39). Kawase (19) showed that basipetal centrifugation enhanced the polarity of both leafy and leafless cuttings. However, this increased polarity did not uniformly increase rooting. Rooting was increased in some species, decreased in some and was similar to controls in other species. Such variability possibly explains why inverting cuttings improves rooting in some types and reduces it in others.

Nutrition. Balanced mineral nutrition generally results in better rooting than when a deficiency exists, except that low nitrogen often aids rooting by a resulting carbohydrate buildup or possibly by reducing cytokinin levels. Zinc deficiency seems to reduce IAA levels by reducing tryptophan synthesis (12). Tryptophan is needed for IAA synthesis.

Juvenility. Juvenility in plants was reviewed in detail by Ali (1) He found that pear species resemble others in rooting better as juvenile than as adult cuttings and that juvenile tissues contain the same level of DNA but less RNA than adult tissues. This infers the blockage of "flowering" information transfer in juvenile forms. Not only does the non-flowering state aid rooting (34), but juvenile plants contain more rooting cofactors than adult ones (14) So called "rejuvenation" by repeated shearing of adult mother plants (5) may improve rooting by suppressing flower initiation and by changing the auxin balance rather than causing a return to the true juvenile state.

Seasonal Differences. Seasonal influences can alter the effects of growth regulators on rooting (29) and may explain many of the contradictory results reported. Higdon and Westwood (15) and Ali (1) found that IBA-treated hardwood cuttings of pear rooted well only if the buds were in rest. But Fadl and Hartmann (9), in a different climate, found that active pear buds of easy-to-root 'Old Home' promoted rooting with IBA while disbudding reduced rooting. However, disbudding the hard-to-root 'Bartlett' increased rooting potential. The effect of bud activity in these tests is inconclusive because effects of wounding were not separated from bud removal. Howard (16) reported that enhanced rooting of IBA treated plum cuttings was not related to bud activity but to wounding *per se.* Stimulation occurred either by bud removal or by internodal wounding. Wounding causes ethylene synthesis which is known to stimulate rooting (8). In a seasonal study of Douglas-fir rooting, IBA aided rooting in December and January but equal rooting was obtained in February and March without IBA (31). Little rooting occurred during September and October when buds were in rest. Bud removal reduced rooting but IBA treatment sometimes restored the capacity of disbudded cuttings to root. Lek (24) found that, depending upon the season and stage of growth, active poplar buds stimulated, and dormant ones inhibited, development of pre-formed root initials. Any general statement regarding the role of buds in rooting must account for the separate effects of wounding and disbudding, state of dormancy, the presence or absence of leaves and whether the stimulus is to growth of pre-formed root primordia or to *de novo* root initiation.

Growth Regulant Effects. Besides auxins (IAA, IBA, NAA, 2,4-D), other growth regulators such as gibberellic acid (GA), cytokinins, abscisic acid (ABA), ethylene and possibly traumatic acid may affect rooting. Both GA and cytokinins inhibit root formation (12). In some cases the growth inhibitors ABA (4,7) and succinic acid-2, 2-dimethylhydrazide (SADH) (10,30) improved rooting. ABA may act as an auxin synergist and a GA antagonist, but does not affect kinetin-induced inhibition. The synthetic regulator 2-chloroethyl trimethylammonium chloride (chlormequat) in contrast to SADH, reduced rooting of herbaceous cuttings (30). Skene (35) found that chlormequat-treated grape vines had a higher level of cytokinins in bleeding sap than did controls, which may explain the chlormequat effect. Cytokinin inhibition does not affect amino acid levels in rooting pea stems as does ethionine-induced inhibition (18). Lagerstedt (22) reported that the cytokinin, kinetin, inhibited rooting but was required for budding of begonia leaf disks, and a proper balance between auxin and kinetin was needed for both bud and root regeneration. Some IBA-treated *Prunus* cuttings increased rooting when treated with adenine sulfate while other varieties so treated were unaffected or showed reduced rooting (32). Menhenett (27) concluded that rooting of begonia induced by adenine sulfate was by supplying a nutritional source of N, because it did not produce a cytokinin response. Both 2,3,5-triiodobensoic acid (TIBA) and a morphactin improved rooting of 3 herbaceous species in which the latter failed to antogonize a GA_3-induced inhibition (21). Leshem et. al. (25) reported a gonadotropin-like plant constituent which improved rooting of stems. It may act by depressing GA synthesis or by altering the peroxidase system which affects IAA levels in the plant.

Rooting Cofactors. Rooting cofactors which, with auxin, aid rooting have been reported. Hess (14) found 4 such rooting factors in juvenile *Hedera helix* which were not present in adult plants. Cofactors were reported in evergreen species during late fall to late winter at which time rooting was best (23). Several cofactors of a complex phenolic nature have been reported for fruit species of the rose family (6,9,26). Tukey and Lee (38) found that misting of leafy cuttings not only changed the C/N ratio and delayed dormancy, but also increased rooting cofactors. Rooting cofactors must interact with or accompany auxin to stimulate rooting, hence they work like Went's hypothetical rhizocaline. A possible link between anthocyanins and rooting of cuttings was reported (3), but a comparison in Oregon by the author (unpublished) between cuttings of a red-leafed mutant of 'Bartlett' pear and its green-leafed parent indicated no benefit of the pigment to rooting.

Other Factors and Interactions. The following also affect rooting: method of auxin treatment, etiolation, day-length, host plant treatment and position and type of cuttings used. Howard and Nahlawi (17) found that rooting of hardwood cuttings was inhibited if they were dipped too deeply in high concentration IBA solutions. The application of IBA to the bark somehow inhibited rooting of the callus base. Westwood and Brooks (40) showed that a low concentration IBA soak was superior to high concentration quick dip for pear cuttings. Etiolation of stems improves rooting by increasing the amount of rooting cofactors and by otherwise changing the physiology of the stem (13). Short-day photoperiods aided rooting of *Bryophyllum* (28). Several stock plant treatments, such as girdling, use of a dwarf rootstock and a horizontal position of medium-sized rather than large cuttings improved rooting of pear (15). Also, difficult-to-root varieties rooted well even without IBA if they were inarch grafted to an established tree (15).

From this discussion we see that the role of growth regulators in rooting may change depending upon the genetics of the species and the specific environmental conditions imposed upon it. The balance of biochemical factors required for rooting probably remains constant, but this balance may be achieved by different internal or external means at different seasons of the year.

SUMMARY

The balance between auxin and other constituents in plant tissues controls organ formation and is the basis for rooting of cuttings. This balance may be achieved by various combinations of genetic, environmental and chemical factors. The following facts are important to an understanding of the role of growth regulators in rooting: 1. Budding and rooting are strongly polar, as is the basipetal movement of auxin and rooting cofactors in plants. 2. Nutritional deficiencies usually hinder rooting. 3. Juvenile tissues contain more rooting promoters than adult tissues and lack flower buds which inhibit rooting. 4. Whether bud activity or auxin treatment aids in rooting depends upon 2 and 3 above and the season in which the cuttings are taken. 5. GA and cytokinins tend to inhibit rooting while ethylene, ABA and morphactins may improve rooting. Such synthetics as SADH, chlormequat and TIBA give variable responses. 6. Both environment and genetic makeup affect the kind and amount of rooting cofactors. These cofactors appear to be phenolic compounds which interact with auxin to stimulate rooting. 7. Other factors such as stock plant girdling, photoperiod, etiolation, IBA dipping technique, positional effects and maturity of cuttings may affect rooting.

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AL ROBERTS: Thanks, Mel, for a most informative presentation. Any questions?

HUDSON HARTMANN: Mel, in the experiments you described on rooting pear hardwood cuttings you referred to "callusing" the cuttings. Perhaps it would be useful to describe this in more detail.

MELVIN WESTWOOD: Well, in every instance, when we did the callusing we treated the cutting either with a quick-dip or a slow soak of IBA. This was with freshly cut cuttings; then we placed them in plastic bags in moist conditions and placed them at 60° to 65° F. This permitted the callus to develop following IBA treatment, usually taking about two weeks. We would watch them and as the small root primordia would begin to show a protuberance from the edge of the callus plate then we would either plant them or put them in a cool place (35° F. storage) to keep them from growing. If the roots extend very much beyond a centimeter or so, then they're very difficult to plant and you usually lose them in the transfer.

AL ROBERTS: Any more questions? Any for the other speakers?

MELVIN WESTWOOD: I might mention, since Dr. Black talked about shearing and rejuvenation that certainly there are a number of rooting factors that are benefited by this reinvigoration. At a conference back in St. Paul last week people involved in juvenile physiology from around the world met and tried to plan for working groups in this area — an international working group. It was generally agreed that the only way that we could avoid confusion in the literature on juvenility was to retain one of the original definitions — that a juvenile plant is not capable of flowering. There is a period too, which we called the transition period or stage in which the plant flowers but with difficulty. It doesn't flower as much or with the same kinds of treatments that induce flowering in the fully adult stage. I think much of the confusion may be in dealing with this transitional stage But the true juvenile form we say is not capable of flowering. Then there are all the other characteristics, some of which Dr. Black mentioned this morning.

FRIDAY AFTERNOON SESSION

TED VAN VEEN: Dave Adams, our moderator this afternoon, came from Oregon State where we got to know him a number of years ago. We are happy to have Dave Adams back with us this afternoon. Dave, will you take over now?

DAVE ADAMS: Thank you very much, Ted. I'm certainly happy to be back and be a part of your organization as one of your newest members. This afternoon we'll have a group of selected short topics. We have with us first today, Dorothy Dickson, from the Chehalis Rare Plant Nursery, Chehalis, Washington. They grow trees and shrubs and, as she tells me, various very unusual plants. They don't like the usual things up there. They've got all the oddball materials. But today she's going to talk to us primarily about primulas. Mrs Dickson:

THE PROPAGATION OF PRIMULA

DOROTHY DICKSON

Chehalis Rare Plant Nursery

Chehalis, Washington 98532

The propagation of primula is a big subject, impossible to cover even in an hour presentation, since there are about 700 known species and 350 species have been in cultivation at one time or another

I will talk only about a few of the more common kinds and give you a glimpse of a few of the others. Here, we call all primula, primroses but only the acaulis type, one flower to a stem, is a primrose. The polyanthus, with a cluster of flowers on top of a stem, is the most common commercial primula in the United States.

The easiest to grow are the Juliae hybrids which are crosses of the species, *P. juliae*, a low creeping plant which is not a prolific bloomer, with species of the acaulis or polyanthus type. These crosses produce mainly magenta-colored flowers. It takes two or three generations and the infusion of some of the bright colored primroses and polyanthus to achieve the color range of our modern "Julies". The further away from the species to obtain new colors, the more we lose the desirable plant qualities of hardiness and low growth.

A first generation cross of *P. juliae* was red jack-in-the-green. We introduced it as 'Jay-Jay'.

Primula are generally propagated from seed, or by division foi named clones. If you are particular as to color and type, seed from hand-pollination is best, but with no guarantee.

At the Chehalis Rare Plant Nursery, we plant our seed in four-inch square plastic pots, or in deep flats, using a sterile open mix that drains well. We plant from December to April, covering each pot or flat with a cotton cloth to prevent the seed from washing or blowing away and to keep the birds from eating them. We place the pots or flats outside on benches, exposed to full weather, until germination.

After germination, we move them to a shaded area and water with a fog nozzle Transplanting is attempted when the first pair of true leaves have developed. If we miss this stage, we find it is better to wait until the plant has developed some heavy secondary roots

Transplanting during the in-between stage results in high losses, sometimes a total loss We usually transplant the seedlings into flats before moving them to the growing bed or to individual pots

Other quite common types of primula are *P. auricula, P. denticulata, P sieboldii* and candelabras

Division is a method of propagation that can be used with all primula. It is a way to increase outstanding plants and the only way for named plants

Different species have different times which are best for dividing. Primroses, polyanthus, "Julies", and *P. auriculas* divide best in the spring, right after flowering, or in early fall at least two weeks before frost New roots are active at this time. The candelabras, *P. sieboldii* and other species that go dormant in the winter, divide best just as they start to grow in the spring.

P. denticulata can be increased by root cuttings. The rare petiolaris primulas can be increased by leaf cuttings. The petiolaris are still rare because their seeds lose viability very quickly. They must be planted while still green before the seed coat hardens. At our nursery, we were fortunate in obtaining, by airmail, a green seed capsule of *Primula calderiana,* one of the petiolaris group. Within 15 minutes after arrival this July, it was planted and under the mist.

Primula scapigera is a typical petiolaris primula.

DAVID ADAMS: Thank you very much, Dorothy, for bringing us all up to date on what is in the primula field and what we can expect in the future.

Our next speaker today is Bob Whalley. Many of you know Bob. He has had quite a background in plant propagation at the Whalley Nursery here in the Portland area. They, of course, propagate literally everything under the sun out there but Bob today is going to talk to us about rhododendrons and how they are handled at the Van Veen Nursery. Bob Whalley:

SANITATION IN RHODODENDRON PROPAGATION

ROBERT WHALLEY
Van Veen Nursery
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Sanitation. Where does it begin? When should it stop? I feel it is essential to consider the journey of one cutting from a stock plant to a landscape planting. See if its attitude is that sanitation should be hospital conditions or garbage heap. Should present conditions at your nursery be compromised?

My name is 'Nova Zembla'. Genus *Rhododendron*. Because of my growth habit, my hardiness factor, and my red flower color, I am an exploited variety. It seems I grow well in many locations in the Eastern and Midwest regions of the U.S.A. because of my flower bud survival rate. I propagate comparatively easy and my color is demanded as a highlight for gardens and landscapes in the spring. Northwest nurseries grow me into a semi-mature shrub in 3 years. Then I am shipped in cool fruit or beef carrying refrigerator trucks to Eastern cities — but I am getting ahead of my journey —

In breezy fields of the Willamette Valley I grow lush and bushy. Then July arrives and I get trimmed — reduced — thinned — plucked from field plants. Any larger stock plants are humiliated by being stripped of their newly grown cover. These plants are struggling anyway because usually they are imported from afar and planted in any space available. With the best of intentions they are planted close together to be moved later. Most humans, being limited to seeing only a few things to do each day seem to forget that each stock plant relishes plenty of space for expansion and good air circulation. My growth is very specialized and each branch a limb of beauty — to be admired.

My efforts in growth are appreciated by a few of the garden pests unless a seasonal insecticide spray is applied. Aphids can cause some very mottled looking and stunted growth and leaves. Many times this can cause the same effect as a late frost. There are a few airborne fungi that can move into the neighborhood and give my stems and foliage some problems. *Botrytis* and *Phytophthora cactorum* are the two most commonly recognized. So when the new summer growths are harvested I begin life anew in a healthy or weakened state. Studies are being conducted to determine what levels of nutrients should be stored in my leaves before I am separated from my mother plant. If I am given all the proper conditions of growing, then my chances of rooting are very good. Even the cleanliness of the clippers that cuts me from the stock plant should be cleaned daily. Tools should be soaked for 5 minutes or more in a solution of 50:1 diluted LF-10 after the pitch and gummy residue accumulated from new growths has been cleaned off — clippers along with knives, scissors and any tools that are used in the processing of my fellow cuttings. I usually am harvested during day by being cut and stored in sacks. I should be kept cool and moist as soon as possible after separation from my parent plant. If plastic bags are used, it is critical to keep them out of the sunshine because the heat builds up in them very quickly. After the bags are emptied, they should be hosed off, inside and out. Burlap sacks should be soaked in a 50:1 concentration of LF-10 each time after they are used.

I and my companions are brought into one house that is used to store us until the following day. We are dumped onto empty rooting beds that have had saran shade cloth stretched tight over them. We are bathed with a flooding stream of water and the shade cloth allows the excess water to drain so we will not lie in a puddle of water over night. This house is used for all cuttings to be stock piled so we will not be bringing any of our problems to the other rooting houses. The next morning I am awakened by a man with a basket who collects us and carries us to a table in the preparation area. Extra leaves are pulled off; remaining leaves are cut so about 66% of my leaf surfaces are left. Then a bath in a combination of Benlate, Dithane M-45 and Malathion is given to us. We set out on frames that are covered with saran shade cloth and we are allowed to dry — at least until the excess moisture is gone. While I am drying I have a chance to look around and see that the trimmings from that day are bagged and the floors are kept as clean as possible. At the end of the day I can hear sweepings and the whole area being picked up and put in order. I hear "tales" that cutting preparation areas can be overlooked for cleanliness, floors unswept and stems and leaves scattered around the edges, tables unwashed, tubs of solutions left uncovered, tools dropped onto dirty surfaces after they have been dipped in LF-10, and sacks and boxes allowed to accumulate, piled or stacked which collect dust plus all the scattered trimmings that can hide under them. This area is as critical as the next. The whole chain of cleanliness can be broken if one step of processing is neglected.

When we are sufficiently dry our stems are cut with a diagonal cut and the side is wounded with an inch slash so my cambium is exposed. The open cut is dusted with Hormodin No. 3, which has been boosted to about 1.5% IBA, and Benlate has been added to the powder. Two rounded teaspoons of 50% IBA are added to one 8 oz. can of Hormodin No. 3 and one oz. of Benlate is also added. This is mixed with a beater in a bowl or churned for five minutes in a plastic bag. Some of my cousins are susceptible to being burned at such a high rate of IBA so they will be dipped in Hormodin No. 3 with just Benlate added. After my stem is powdered I am dropped into a cardboard box that is lined with a burlap sack that has been soaked in LF-10 (50:1). I am stored in a cool room and await the end of the day when I will be dumped on top of the bed I will develop my roots in. Here I stay for the night. The next day I am "stuck" along with thousands of my companions into the bed of peat moss (60%) and perlite (40%)medium. If my sense of smell is acute enough I detect that some preparation of cleaning the greenhouse I am in has taken place before I arrived. Actually if I could smell the formaldehyde that was used as a contact sterilant I doubt if I could survive. The humans in charge applied a gallon of formaldehyde to a house about 15 by 70 feet. The house had been thoroughly washed and soaked with water prior to the application. Application was with a siphon on a hose bib — dilution rate 15:1. The house had been closed for 48 hours and then opened and the mist system turned on since this is the best method of getting formaldehyde to evaporate. After a week the humans could no longer smell any trace of the chemical so they painted the wooden side boards with copper naphthenate (8% diluted with paint thinner) and then the medium was mixed on a clean black top pavement surface and placed in the beds. The medium was leveled and the edges pressed but not packed or pounded firm. I really prefer developing my callus and root system in a comparatively loose medium so I have maximum drainage and air is allowed to flow through the medium. As I am telling you this, I am wondering if all the tools (shovels and smoothing boards) were cleaned that handled the medium. Hmmm. Soildusto or BHC is lightly dusted over the surface of the bed and watered in. Paths are sprayed with 200:1 rate of LF-10.

So I sit in the greenhouse bed day after day developing my callus, bathing in the overhead mist system, and eventually my roots become sufficiently large after 6 to 8 weeks. I have heard that there is a system that sterilizes the water that is pumped through the mist system. The growing house I will be going into has had its ground beds treated with methyl bromide (1 lb. per 100 sq. ft.) during the warm summer days. New peat moss is added, the beds leveled and anyone is reprimanded for stepping in the beds until they are empty again. I get to rest my roots in a bed of peat moss and enjoy a few months of rest. Occasionally I am given enough water to encourage my roots to extend and look for some nutrients that have been added to the peat moss. Three pounds of dolomite (fine grind) and superphosphate (also fine) plus 3 oz of fritted trace elements are added to 50 sq. feet of bed space or about one cubic yard of peat. February 15th begins the growing process. I am being fed custom mixes of "foliage feed". Actually I feel that very little food is absorbed through my leaves. The bulk of the water soluble food is washed down into my root system. Every two weeks I am fed until I am sent out into the world to grow into a year-old liner, or a two, three or four year landscape specimen. Each time I am moved the soil conditions should be evaluated by a soil test before I arrive and then adjusted as levels of nutrients and trace elements are indicated as being too low or too high. Lath houses and fields should be prepared for cleanliness prior to my moving into them. Soil sterilants should be used to clean up soil and airborne disease problems but used with discretion so that the same material is not indiscriminately used year after year.

My conclusion is that I, as *Rhododendron* 'Nova Zembla', along with all my brothers, sisters, cousins and far-flung relatives do so much better with the proper clean attitudes expressed around us at each stage of my growth and development. Yes, a kind word, a positive thought verbalized in my direction will encourage me to mature and bloom. I respect, thrive, and survive so much better under the best sanitary conditions all along the various stages of my development and growth.

DAVID ADAMS: Our next speaker today is Richard Smith from the Rod McLellan Company, South San Francisco. This company, as you may know, handles cut flowers and orchids; and Richard tells me they are also selling fertilizers and prepackaged soil. This is an item that I have noticed around the country that more and more companies, large and small, are getting into — handling of prepackaged soil. Even my own parents, who just have a very small place, find that they make quite a bit each year just packaging up their soil mix and selling it to the local gardeners. Richard runs the Rod McLellan propagation laboratory and, of course, they do a great deal with orchids. Today he will speak to us on orchards and orchids propagation. Richard Smith:

ORCHID PROPAGATION BY IN VITRO CULTURE TECHNIQUES

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The orchid industry has been a pioneer in commercially applying *in vitro* culturing of plants as a means of rapid propagation. Since Knudson's (1) work in the 1920's nearly all new hybrids are products of laboratory culturing of rudimentary embryos. Hundreds of millions of orchid seeds are germinated aseptically in growing flasks each year in our laboratory alone. Continual selection of seedlings throughout the years to flowering eliminates plants with undesirable growth or flowering characteristics.

Rapid clonal propagation was impossible until George Morel (2), while attempting to free a cymbidium of virus by culturing the shoot tip, noticed that the isolated piece of tissue seemed to revert to the seedling protocorm stage and proceeded to divide into a clump of 3 or 4 identical structures which eventually became plants. He continued his research on the so-called method of "meristem culture," applying it to many other orchid genera, so that during the 1960's many orchid labs around the world were clonally propagating orchids by his techniques.

In this paper I shall attempt to explain the seedling and meristem techniques used in my lab for the propagation of orchids.

SEXUAL PROPAGATION

A ripe orchid pod may contain up to 500,000 seed. Under natural conditions the pod splits and the seed are dispersed by the wind, lodging on trees or on the soil. Most seed die for lack of proper germinating conditions or are killed by pathogens, so that perhaps only 1 to 10 in a million seed survive to become mature plants. Under favorable circumstances a mycorrhizal relationship develops between the young seed and a host fungus.

The seed consists of a thin, nonliving seed coat and a rudimentary embryo of from 50 to a couple hundred cells. There is no endosperm. Relatively few fat and protein globules within the cells represent the extent of stored food reserves. Mineral and carbohydrate reserves are nil.

During germination the embryo swells into a rotund structure called a protocorm, developing hair-like absorbing organs called papillae. The first leaf emerges from the top of the protocorm and the first root soon follows. New shoots and roots are produced and eventually the bloom spike 3 to 7 years later.

Commercially, all crosses are controlled by manual cross-pollination, and the seed is collected rather than let fly in wind currents. Pollination is effected by smearing pollen on the stigmatic surface of an emasculated flower. If the pollen is compatible the flower collapses within 72 hours. Generally, fertilization of the ovules takes place about 90 days after pollination. In 9 to 12 months the pod is mature. It is split open and the seed collected on onion skin paper A microscopic examination for embryos gives us an estimate of the amount of viable seed. Wrapped in thin paper, the seed can be stored up to 6 years in a refrigerated dessicator.

Preparatory to seed sowing, sterile formula must be made in culturing bottles. Orchid literature abounds with seed germinating formulas, but all have sugar, minerals, water and a gelling agent such as agar. In addition, depending upon the requirements of the genus, other substances may be added, such as vitamins, hormones, protein hydrolysates and fruit homogenates Formula is distributed into 32 oz. French square bottles, capped with mercury-treated cotton and a metal cap Bottles of formula are sterilized in large pressure cookers for 15 minutes at 15 psi and then allowed to cool on their sides

A portion of the seed is decontaminated for 10-20 minutes in a vial of filtered calcium hypochlorite (10 gm / 150 ml) to which has been added a few drops of diluted wetting agent. A sterile cotton plug drenched in 5% Clorox helps to collect the seed in the bottom of the vial by filtering off the sterilizing solution. In a sterile transfer chamber, the seed is scooped out of the vial with a sterile spatula and is plated in a bottle of formula. By another method of seed sowing, called green-podding, a ripe pod is surface decontaminated in 5% Clorox, cut open with a sterile scalpel and the seed is spread directly onto the sterile formula Germination is apparent in a couple months, and by the fourth to sixth month after sowing, the small plants must be thinned out and reflasked to another bottle.

A year after sowing, the seedlings are large enough to be removed from the bottles and are flatted in 0 to 1/8" grade white fir bark. They remain in the flat about one year and then are potted into 3" pots with 1/8 to 1/2" grade bark After another year they are shifted into 4" pots with 1/4 to 1/2" grade bark and the plants are staked and tied. Some *Cattleya* orchids bloom in the 4" pot stage, in their fourth year The potting mixture and procedures of growing seedlings outside bottles varies for the different types of orchids.

VEGETATIVE PROPAGATION

Prior to the last decade the only way of increasing a clone was by division of the parent plant This was very slow because a plant produces only one or a few new growths every year. People desiring divisions of valuable plants had their names on long waiting lists

With the advent of "meristeming" the hobbyist has access to quality clones at a cost a fraction of the value of the original plant. The flower grower benefits by being able to crop color and quality in quantity to meet peak seasonal demands.

In our lab we are currently meristeming *Cymbidium, Cattleya, Miltonia, Oncidiums, Phalaenopsis* and a few other genera. Formula preparation involves the same sterile procedures as with seed sowing, except that most of our cultures are proliferated in flasks of liquid formula rather than on gelled formula.

I shall use *Cymbidium* to typify the procedures. An actively growing vegetative shoot is excised with a sterile knife to avoid virus infections. The outer leaves are stripped away to reveal the bulb-like growth at the base of the shoot. This portion, having large axillary buds and a shoot tip, is soaked in 5% Clorox to decontaminate it In a sterile case under a stereoscope, the axillary buds and shoot tip are cut off and dipped in 1% Clorox, then into liquid formula in culturing flasks. Tissue swells at its base in 4 to 6 weeks of culturing on rotating wheels. These protuberances, which resemble seedling protocorms, are cut off and subcultured. Every 3 to 4 weeks the pieces have enlarged enough, 4 to 8 fold, to be resliced We can produce 10,000 pieces from one shoot in 6 to 8 months

When production figures are met, cutting stops and the pieces are arranged on solid formula just as seedlings are reflasked. In 8 months leaves and roots are well developed and the young mericlones are removed from the bottles and flatted.

Mericloning has been greatly simplified here. There are methods of subculturing the tissue, such as slicing techniques, timing and special formula, which are beyond the scope of this paper Certain orchids, such as *Paphiopedilum,* have been recalcitrant in culture so far. Many other problems remain to be solved in successful *in vitro* culturing of orchids.

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DAVID ADAMS: I suppose you could hear the wheels turning out there while Dick was talking. Some of these very difficult-to-produce rhododendrons and so forth that are bringing six, eight, ten, and 25 dollars per plant. If you had a set-up of this type where you could grow many, many thousands a year, what might happen to the market?

RICHARD SMITH: You may be interested in the cost figures on this. From the time of meristeming, they cost us about 20 cents a plant The major cost of growing the orchid is then the years after that we spent bringing them to flower. A typical seedling costs us about five cents a plant to produce.

DAVID ADAMS: Thank you. There are a lot of crops in which we could take a real long look at this method of propagation. To start a new daffodil, for example; once you have one flowering, it can take as many as 10, maybe even 15 years before it can be put on the market with sufficient stock to expect a large volume of sale. What could we do with type of culture. They've done it with asparagus, they've done it with orchids, there are many crops for which we know it's possible, it's just a matter of working out the techniques We want to thank you very much, Mr. Smith, for an excellent presentation

Our next speaker today is going to be talking to us about grapes. As many of you have heard, grapes have become more and more popular here in the Willamette Valley. Mr. Charles Coury from the Coury Nursery near Forest Grove, Oregon is going to talk to us about grape production, both in the field and in greenhouse culture. Mr Coury [1]

DAVID ADAMS: Next we have Jiro Matsuyama with us Mr Matsuyama has grown up in the nursery business They grow trees and shrubs primarily at their nursery and today he's going to talk to us about a plant that we don't normally think of growing in this area but again it could be something we could move up along the Pacific Coast maybe on up into Seattle. I don't know if it would be hardy that far north or not. Jiro Matsuyama is going to speak to us today about the propagation of *Bignonia*. Jiro:

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[1]Charles Koury described the propagation methods now being used for grapes in the Willamette Valley, Oregon.

PROPAGATION OF PHAEDRANTHUS BUCCINATORIUS (BIGNONIA CHERERE), BLOOD RED TRUMPET VINE

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Phaedranthus buccinatorius (*Bignonia cherere*) is an evergreen vine that climbs by tendrils, with leaves of two oval or oblong leaflets, 2 to 4 inches long. Clusters of large 4 inch long trumpet-shaped flowers stand well out from the vine. The color of the flower is orange-red with a yellow throat, which turns bluish-red with age. The flowers appear in bursts throughout the year whenever the weather is warm.

Phaedranthus buccinatorius is a subtropical vine which withstands temperatures as low as 20° F. In the interior valleys of California it should be planted in a protected place. Along the south coast area of Santa Barbara county it is used extensively on high walls and along fences; it blooms most of the year with lots of bright color.

To propagate *Phaedranthus buccinatorius*, I used two types of cutting wood from outdoor and indoor grown mother stock plants. The outdoor mother plant has thick, dark, leathery leaves. The indoor mother plant has thin, tender leaves which are lighter in color, with tender stems. The young hardened wood below the tip was used — about 4 to 6 inches long with 2 to 3 nodes.

I separated the cuttings (outdoor and indoor) into three groups for hormone treatment — Jiffy Grow No. 2 (combination of 3—indolebutyric acid and naphthaleneacetic acid). One group was dipped in 1,000 ppm, another in 5,000 ppm, and another in 10,000 ppm. Each group was divided into 5 and 10 second dips, and dipped ½ inch of the base. The cuttings were then put into flats filled with a medium of vermiculite and Sponge Rok, 1:1. The flats were placed on a bench with bottom steam heat of 65 to 70° F. Watering was done by a 5-minute mist system with 3-second durations.

In the first group which is 1,000 ppm, with 5-second dip, the indoor cuttings callused in 12 days and the outdoor in 17 days. In 5 weeks roots started to appear on the outdoor, but the indoor took 6 weeks. In 7 weeks one cutting out of 75 of the indoor group had rooted, 49 callused, 25 had no callus, with two lost from leaf drop or other causes. The average number was two roots at 2½ inches long.

In the 5,000 ppm, callusing time for the indoor group for 5-second and 10-second dip was 12 days. For the outdoor it was 20 and 22 days. Rooting for both dips was 5 weeks. In 7 weeks the 5-second dip had one cutting rooted (indoor) — the outdoor had 11. In the 10-

second dip it was reversed. For 5-second dip, 51 cuttings had callused for indoor, and 36 for outdoor. In the 10-second dip it was reversed. Twenty had no calluses for indoor, and 26 for outdoor in the 5-second dip. In the 10-second dip, 18 had no callus for indoor and 19 for outdoor. Three were lost for the 5-second dip indoor and two lost for outdoor. For the 10-second dip, ten were lost for indoor and four for outdoor. The average number of roots for 5-second dip indoor was one at 1 inch, for outdoor it was two roots at 2 inches. For 10-second dip indoor, the average number of roots was 1½ at 2½ inches, for outdoor one root at 1 inch.

In the 10,000 ppm group callusing time for indoor and outdoor, 5-second and 10-second dip, was 17 days. Rooting time for 5-second dip indoor was six weeks, outdoor was four weeks. For 10-second dip indoor and outdoor it was five weeks. In seven weeks 5-second dip indoor had five rooted, outdoor had 12. The 10-second dip indoor had 7 and outdoor had 6. For 5-second dip indoor 48 had callused, outdoor had 25 callused. For 10-second dip 58 had callused for indoor, 37 for outdoor. Indoor 5-second dip had 22 no callus, 19 for outdoor. The 10-second dip indoor had ten no callus, outdoor had 16. There was no loss for indoor cuttings for both 5-second and 10-second dip; 24 were lost for 5-second dip outdoor and 16 for 10-second dip outdoor. The average number of roots for 5-second dip indoor was one at 2 inches, for outdoor it was two roots at 2½ inches. For 10-second dip indoor the average number was one at 3 inches, for outdoor it was two at 2 inches.

The last group was experimental — to determine if dipping 30 seconds at 10,000 ppm would burn the cuttings. The results were better than expected. For indoor callusing time was 12 days, 22 days for outdoor. Indoor rooting took 5 weeks and 6 weeks for outdoor. Both indoor and outdoor had only one rooted, but 61 had callused for indoor. There were no losses. For indoor there were two rooted at 3 inches long.

In this experiment, 1,000 ppm and 5,000 ppm, outdoor grown cuttings in 5-second dip, started vigorous top growth in about one week. In the 7th week 1,000 ppm had three 12-inch long runners while 5,000 ppm had three 10-inch long runners. Top growth on both groups did not seem to have any effect on the rooting.

Propagating *Phaedranthus buccinatorius* usually takes at least three months. I have found from past experience that as long as the cutting callused, roots followed. Leaf droppings should be removed as soon as possible to avoid fungus problems. The average cutting has two to four roots and they are unusually long and brittle. Care should be taken when removing them from the rooting medium to avoid breaking of roots.

In approximately 10 to 12 weeks most of the seven-week callused and non-callused cuttings will root. I have found that 60 to 75% of

Table 1. Effect of source of cutting material and IBA treatment on callusing and rooting of *Phaedranthus buccinatorius*.

IBA Concentration and Dip Time	Callusing Time in Days		Rooting in Weeks		Rooted in 7 Weeks		Callused in 7 Weeks		No Callus in 7 Weeks		Loss		Average Number of Roots		Average Root Length in Inches	
	IN[1]	OUT[2]	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
1,000 ppm 5 sec.	12	17	6	5	1	14	49	35	25	24	0	2	1	2	2	2.5
5,000 ppm 5 sec.	12	20	5	5	1	11	51	36	20	26	3	2	1	2	1	2
5,000 ppm 10 sec.	12	22	5	5	11	1	36	51	18	19	10	4	1.5	1	2.5	1
10,000 ppm 5 sec.	17	17	6	4	5	12	48	25	22	19	0	24	1	2	2	2.5
10,000 ppm 10 sec.	17	17	5	5	7	6	58	37	10	16	0	16	1	2	3	2
10,000 ppm 30 sec.	12	22	5	6	1	1	61	6	3	3	0	0	2	1	3	2

75 Cuttings used in each treatment

[1]In — Indoor-grown cuttings

[2]Out — Outdoor-grown cuttings

our *Phaedranthus buccinatorius* cuttings root, and feel that this is a good percentage.

These results are summarized in Table 1.

DAVID ADAMS: We have with us now, Dr. Robert Warner from the University of Hawaii. Dr. Warner lived in California for a number of years before he went to Hawaii, but he is now a resident in the Hawaiian Islands for I believe, eleven years. He's been working in quite a wide range of crops, macadamia, bananas, citrus rootstocks, and various nutritional problems. He is also in charge of the instructional arboretum which he tells me will be on the tour for the Western Region Meeting next year. He has some slides showing many of the things we can expect to see next year on the Hawaiian trip Today he will talk to us about propagation of certain tropical plants. Dr. Warner:

PROPAGATION OF TROPICAL CROP PLANTS[1]

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PLANTATION FIELD CROPS

SUGARCANE, *Saccharum officinarum* L., is a member of the grass family and, except when breeding for new varieties, is propagated vegetatively. Cane sections about 22" long with 4 nodes are cut by hand or mechanically from mature plants, soaked in a fungicide and placed horizontally in furrows and covered lightly with soil Shoots and roots are produced at the nodes. In Hawaii the plant crop (the first after planting) matures in about 22 to 24 months. The cane is cured by withholding water and nitrogen during the last 3 to 6 months.

When ready for harvest, the field is burned to reduce the amount of dead leaves and trash. The stalks are bulldozed into windrows, loaded onto trucks and transported to the mill for grinding. The irrigation furrows are reestablished and the ratoon crops grow from

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the underground parts which remain after harvest. There are usually three ratoon crops harvested before the field is replanted, a total of 8 years Temperatures above 70° F are required for root development and 80° F. is considered optimum. High light energy and frequent irrigation are required (5).

PINEAPPLE, *Ananas comosus*, (L.) Merr. is propagated from various parts of the plant. The crown, attached to the top of the fruit, is removed in the field before the fruit goes to the cannery; the slips grow out of the peduncle below the fruit; hapas are shoots which grow out from the junction of the peduncle and the stem Suckers emerge from axillary buds on the main stem of the plant. These planting materials are broken off the plants and allowed to cure in the field for one or two weeks during which the base of the stem calluses They are then less susceptible to fungus diseases when planted

The time required for each plant part to produce its first fruit (the plant crop) is different enough so that only one kind of plant part is planted in a particular field. Crowns take 22 to 24 months, slips 18 to 20 months, hapas 19, and suckers about 17 months to mature the plant crop. Hapas are of minor importance.

Before planting, the fields are subsoiled, disced and black plastic is laid mechanically over the beds immediately after fertilizer and DD are injected into the soil After several days the plants are inserted through the plastic in double rows 2 feet apart and staggered 12-15 inches apart in the rows. This gives about 17,000 plants per acre Recently yields have been increased by higher densities experimentally up to 30,000 plants per acre The common density now in Hawaii is 19,000 to 21,000 plants per acre. Even higher densities are used for fresh pineapple production which requires smaller fruits

The smooth Cayenne type and its sub-varieties are used almost exclusively in Hawaii. Yields decrease and the fruit size is reduced in the ratoon crops The fields are usually replanted after harvest of one plant crop and one ratoon crop which makes about a four year cycle (7, 8)

PLANTATION ORCHARD CROPS

MACADAMIA For many years propagation was entirely by seed The seedling trees were quite variable in size, time of fruit maturity, nut size, shell thickness and yield of kernels (3) The need for selection of superior trees was realized but all attempts at grafting had failed until Moltzau in 1927 grafted potted seedlings successfully for the first time Then in 1937 Jones and Beaumont discovered the importance of carbohydrate accumulation in both the scion and stock (16). Ringing the scion increased the carbohydrate storage in the wood significantly. This increased the number of takes among grafts of macadamia.

Fahmy (10) made macadamia grafts in Florida several times during the year and reported that the highest percent takes were during the early summer season He found no difference between the girdled and ungirdled twigs. He found accurate matching of the cambium layers of stock and scion was critical and difficult since *macadamia wood is very hard During the other times of the year he* advised the use of girdled twigs. Fahmy concurred with Hawaiian results (14) that the side wedge graft gave the best results

The development of grafting methods for macadamia opened the way for the development of an industry based on superior clone selections (17, 25)

There are only two species of macadamia considered to have edible nuts. They are the Smooth-shell, *Macadamia intergrifolia* Maiden and Betche and the Rough-shell, *Macadamia tetraphylla* L. Johnson In Hawaii, the Rough-shell species has now become the accepted and preferred rootstock for clonal selections of the Smooth-shell macadamia (12, 26) The seeds of the Rough-shell germinate and grow more rapidly, induce earlier bearingand heavier crops but do not reduce the size nor the quality of the Smooth-shell nuts (26).

Pope (1969) recommended that boxes of washed sand 12" deep be used for macadamia seed germination. The seeds should be planted 2" apart and 2" deep in the direct sun to make strong plants of great stem diameter. They should be transplanted into well-drained soil in containers (20), or 6 to 8 inches apart in nursery rows (14). The taproot should be clipped back to 6 or 7 inches to prevent it from being bent in the container. Graft when stems are slightly woody and ⅜" diameter or more, i.e. 6-8 weeks after transplanting (21)

The best procedure was to prepare scion wood by girdling 6 to 8 weeks before it is needed. Carbohydrate storage in scion and stock is vital to grafting success. Stored starch can be tested by an iodine starch test in the wood rays. The growth of stock should be retarded by withholding nitrogen and reducing the water during the last 4 to 6 weeks to permit accumulation of food reserves in the tree (3, 21).

Pope and Storey (1933) also recommended adding nitrate fertilizer to the seedling stocks 10 days before grafting and the tree of scion source about 3 weeks before cutting the scions (21).

Scion wood ½ inch or more in diameter is cut into pieces 4 to 5 inches long and having 2-3 nodes. The leaves are cut off. Flushing branches should not be used. The side wedge and the side-paste (veneer) graft were recommended (3) but the side wedge is most widely used now (14, 22, 23).

Another method of grafting is the approach graft or inarch. The inarch is used to develop braces for better wind resistance (12). For grafting old trees, a chisel slit can be made in the bark and the scion is driven in. The scion is held in place with small wire nails.

For top working macadamia, the tree is cut back 4 to 5′ above ground and suckers, which grow out in 6 months to a year, can be grafted (3, 23) or scaffold limbs can be bark-grafted directly (14).

Tonks (29) in Southern Rhodesia, because of limited scion wood, grafted very young leafy scions down to 1½ mm in diameter in 90% shade in containers and covered them with plastic bags with split bamboo supports He made liberal use of Dithane M-45 on the scions, the bamboo, and inside the bags to control fungus growth. In 8 weeks he was able to cut off corners of the bags, opened bags in 10 days more and removed them 5 or 6 days later. Grafted plants were produced in as little as 14 weeks He now produces grafted trees at the rate of 10,000 per year

Budding macadamia, generally considered very difficult, was successfully accomplished at the Turrialba Center of the IICA, Camacho reported (6).

For rooting cuttings under intermittent mist, partially matured leafy cuttings 4 to 9" long are recommended They can be rooted in 6 to 10 weeks. Rooting is speeded up by a 5-second dip in 5,000 to 10,000 ppm solution of IBA and bottom heat at about 75° F (2) Rooted cuttings have produced shallower roots than macadamia seedlings and are not used commercially.

The BANANA, *Musa sp.*, is another crop which is generally vegetatively propagated Edible types almost never have seeds Most edible bananas are triploid and produce fruit parthenocarpically The primitive wild ancestors of these types and some ornamental bananas produce seeds

The seeds show best germination when planted soon after they mature. Seeds of *Musa velutna* Wendl and Drude, an ornamental from Assam, all grew when planted immediately. Seeds of *M. balbisiana* Colla, one of the seedy ancestors of our cooking banana cultivars is reported to germinate better when subject to alternate warm and cold temperatures of 32° and 10° C (90° and 50° F) (28) We had good germination from well-ripened seeds when the whole banana with its seeds inside were planted in furrows in the field Perhaps it prevented the seeds from drying out *Musa arnoldiana* DeWild is a plant within Musaceae which does not produce suckers, so must be propagated by seeds

The banana plant grows from a corm. As the plant grows, suckers develop from the corm and new shoots are produced which replace the old ones The old plant dies after it produces flowers and fruit As the new shoots are formed, a mat of the corms all more or less connected results Commercially, the number of plants developing from a mat is controlled by pruning — cutting off the excess shoots

The suckers that develop on the sides of older plants are used for propagation The small ones just showing are called *peepers*. The intermediate sized shoots 1 to 3 feet tall are called *sword suckers* because they have narrow, lance-shaped leaves. These make the best propagative material because they have more food reserves and grow vigorously. Bullheads are old stumps from plants which have fruited. The stump is cut into sectors each with one more "eyes" (buds) which can develop into new plants.

Only clean healthy mats free of virus or fungus disease symptoms should be used for propagation. Bunchy top virus (not reported in Hawaii) and Panama wilt are the most serious; the later is a wilt disease that is caused by a pathogenic fungus, *Fusarium oxysporum* f *cubense*. Varieties resistent to Panama disease are used where this soil fungus is present. They include 'Dwarf Cavendish' ('Chinese'). 'Williams hybrid', 'Hamakua', 'Taiwan', 'Brazilian', 'Walha', Phillipine 'Lacatan' and 'Golden Beauty' (24).

The burrowing nematode, *Radopholus similis*, is common throughout the tropics and causes root and corm lesions which reduce plant vigor and eventually kills the plant. The corm treatment for cleaning up plant material involves trimming off all roots and discolored corm tissue and cut the pseudostem back to 6 or 8 inches and submerge for 15-20 minutes in hot water at 50-55° C (122-130° F). A fungicide such as Panogen may be added to the hot water to suppress decay organisms, or a cold 1:5 solution of Clorox for 5-10 minutes after the heat treatment may be used. Then plant in uninfested soil. New roots grow out at the base of the leaf sheaths. Bananas grow best in well drained soil with frequent watering and fertilized with a high potassium fertilizer mix.

COFFEE: There are three important species of coffee but probably 90% of the world's coffee production comes from *Coffea arabica* L. In the relatively cool mountains, 3500 to 6500 feet in the tropics, it produces the best quality coffee as compared to *Coffea canephora,* Pierre, ex Froehn. the Robusta coffee and *Coffea liberica,* Hiern. which are grown at low elevations. In Kona, a District of Hawaii, at an elevation of 700 to 2200 feet, the *C. arabica* coffee is rated among the best (7, 11, 19).

Most coffee propagation is from seeds sown in well prepared beds under shade which germinate in 6 or 7 weeks. When the plants are 6 to 8 inches high, they are ready for transplanting. Coffee is sensitive to root disturbance and must be transplanted with special care unless it is grown in containers.

Clonal varieties are propagated by cleft-grafting on seedlings in the nursery beds or on seedlings in containers. Rootstocks should be of pencil thickness before they are cut back for grafting. Scion wood must be from upright branches; if horizontal branches are used, the plants will be prostrate. Cuttings may be used as rootstocks.

When rooting hormones have been used, satisfactory results have been obtained with softwood leafy cuttings (19). For best results, high relative humidity (90%), temperature of 21-23° C (70-75° F), and about 50% shade is needed until the plants are well established.

PAPAYA, *Carica papaya* L.· The commercial papaya in Hawaii is completely of the Solo variety and the predominant type in home gardens. The papaya is propagated entirely from seed although it can be grafted or grown with difficulty from cuttings.

Seeds are taken from healthy ripe hermaphroditic fruits After the seeds are washed and dried, they can be stored in a cool dry place or in a sealed jar at low temperature. Under these conditions, they remain viable for 2 to 3 years. The seeds should be germinated in vermiculite or sterilized soil to prevent damping off. They germinate in about 2 weeks and are transplanted to small pots when they have 2 leaves. Papaya may be planted directly in the field by placing 10 or 15 seeds in prepared holes and later thinning them to 2 or 3 About 2/3 of the seedlings will be hermaphroditic and 1/3 will be female plants. The sex of the plants cannot be distinguished until they produce their first flowers, about 4-5 months after planting. Since the market preference is for the pear-shaped hermaphroditic fruits rather than the round female fruits, the female plants are removed. The female flowers have no anthers and the white petals are almost completely free and are attached below the ovary. The flowers of the hermaphroditic trees have pollen bearing anthers and the petals are fused together for one-half to three-fourths of their length, forming a corolla tube attached at the base of the ovary.

The male trees, not from the 'Solo', produce a long pendulous inflorescence with small staminate flowers and rarely set fruit.

Trees are planted in the field from 6 to 9 feet within the rows and from 9 to 11 feet between rows (7, 32).

PASSIONFRUIT. *Passiflora edulis* var. *flavicarpa* Deg., the yellow passionfruit is grown commercially in Hawaii for its juice. It grows and produces well at low elevations whereas the purple passionfruit *Passiflora edulis* Sims will produce best at 1500 to 2000 feet elevations The purple passionfruit is more suited for the fresh market

Passionfruit is propagated by seeds, cuttings and layers. Cuttings should be taken from actively growing vines between the winter and the summer crops in Hawaii. Cuttings should have at least one node It is necessary to have one leaf or a portion of it attached to the top node and the cutting set in the medium 2/3 of the way Cuttings with leaves root best, especially if treated with 1,000 ppm of NAA or IBA Cuttings usually start rooting in one month (7, 18)

Seeds may be planted immediately without cleaning and they germinate in 2 to 3 weeks. The ripe fruit for seed may be stored 1 to 2 months at 55° F If cleaned and dried, seeds may be stored 3 months or much longer if held at low temperatures and will give 85% germination (1)

Layers should be made on the partially hardened stems. They root in 4 to 8 weeks (1).

A high degree of self-incompatibility exists in passionfruit. For good production two or more clones growing near each other are needed for cross pollination. The flower structure is such that pollination is accomplished best by large insects. In Hawaii the carpenter bee is the principal pollinator, although the honeybee and hoverfly may also be effective (1).

Yellow passionfruit is planted at 10 foot intervals in rows 12 to 20 feet apart on trellises 10 or 12 feet high. More leaf surface is exposed to the light and increased yields result (7).

GUAVA: *Psidium guajava* L., the common yellow fruited guava, is the only one of this genus which is grown commercially in Hawaii 'Beaumont' is the only named cultivar at the moment, although several new processing types are expected to be released soon

'Beaumont' is propagated by patch budding, bark and side-wedge grafting and by rooting cuttings under mist (13, 18). Use of air layering and root cuttings has also been reported. Guava is easily grown from seeds. In fact, birds have distributed seeds over the moist mountain areas and pastures of Hawaii and have created a major weed problem. The acid, pink-fleshed fruits from these wild trees are harvested and processed along with the cultivated fruits in the production of frozen juice concentrate (7,9).

MINOR AND HOME GARDEN FRUITS

The MANGO, *Mangifera indica* L. is propagated vegetatively, except for the polyembryonic type which usually comes true from seed The Hawaiian or common mango, 'No. 9'' Chinese mango), 'Paris', and the 'Shibata' varieties are polyembryonic and widely distributed in Hawaii. Most of the selections in Hawaii and Florida such as the 'Haden', 'Joe Welsh', Momi K' and 'Gouveia' are monoembryonic and must be propagated vegetatively.

The side veneer graft is commonly used in Hawaii although the approach side wedge, side tongue, whip grafts and chip bud are also used. Budding is difficult, and special scion preparation is usually needed, such as removal of leaves and the terminal bud. Mango seeds grow readily but some of the seeds are destroyed by the mango weevil *(Sternochetus mangiferae)* which matures and exits after the mango is ripe and the seed has been discarded (30).

LYCHEE, *Litchi chinensis* Sonn., is usually propagated by air layering About 2 to 3 months are required to produce sufficient rooting before cutting and potting the layer. Layers should be grown in the pots for 6 to 8 months before planting out.

Budding and grafting have been demonstrated in Hawaii but are too difficult for general use The scion wood should be girdled 4 weeks before needed. Approach grafting is also used. Plants should be shaded and given wind protection when set in the field (7, 30). Seeds vary in size but appear to germinate readily when fresh

ANNONAS· These are easily propagated by seed Some varieties have been named and clones are propagated by graftage The trees have soft wood and are subject to dieback especially after a heavy crop. The soursop, *Annona muricata*, L. grows well from seeds and produces numerous large fruits. The custard apple, *A. reticulata* L. and the sweetsop, *A. squamosa* L., are propagated from seed. The cherimoya, *A.cherimola* Mill., is in high demand for its delicious fruit It is grafted on cherimoya seedlings. Cherimoya grows slowly, rarely fruits at low elevations in Hawaii but does well at Kona (1,500') and Kula (3,000'). There are several named varieties. The mountain soursop, *A. montana*, Macfadyan is seed-grown and produces many seedy fruits, which are edible but rarely grown. The Pond apple *A. glabra*, has been suggested as a rootstock for other annonas (7,19).

BREADFRUIT: The two species, *Artocarpus communis* Forst. and the jackfruit, *Artocarpus heterophyllus* Lam. are interesting members of the Mulberry family. The former produces no seeds and is propagted entirely from root cuttings. The latter, which seldom suckers, has edible seeds which grow readily. Both species produce large attractive trees. They have milky sap and large succulent leaves and twigs, not well adapted to production of rooted cuttings (7, 19).

CACAO: *Theobroma cacao* L. may be grown from seeds or leafy cuttings. Seeds can be stored for a short time at 60 to 70° F but at 45 to 50° F chilling injury may prevent germination. Seedlings can be budded in containers. Patch bud is best, but shield or Forkert buds have been successful. Cuttings seldom root without leaves attached. The cacao shoot does not store much carbohydrate. Rooting hormones, if used, must be applied before the cuttings are made. A mixture of IBA and NAA in equal amounts accelerates rooting. A well-aerated rooting medium is necessary with 100% relative humidity and light at 25 to 50% of full sunlight. Special care in hardening is necessary (7, 19).

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DAVID ADAMS· Well, that is just a taste of what you might see at the Western Region Meeting next year There are quite a few things to see and, of course, it's all new to us.

Our next speaker is Mr. Eichelser. He is from the Melrose Nursery near Olympia, Washington. He primarily grows rhododendrons and kalmia; he also has a few slides here showing some very beautiful kalmia. Mr. Eichelser:

PROPAGATION OF KALMIA LATIFOLIA

JOHN E. EICHELSER
Melrose Nursery
Olympia, Washington 98502

The *Kalmia latifolia* I am talking about today is the Dexter strain and the red form of this strain, which is known as 'Ostbo Red'. Perhaps not all are familiar with this red clone or with the Dexter strain so I would like to show a few slides at this time to

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I became interested in kalmia about 18 years ago when I first saw this red strain which is now known as 'Ostbo Red'. In the past it has been variously known as 'Dexter No. 5', 'Ostbo No. 5', 'Red Bud Kalmia', and 'Westcoast Kalmia'. The first time I saw it was while visiting the nursery of the late Endre Ostbo in Seattle, Washington. I acquired a plant of 'Ostbo Red' at this time and was told by Mr. Ostbo that it was useless to try to root it as it had been tried and could not be done. The only way to propagate it was from grafts, I was told.

The first few years we put in cuttings with little or no success. We tried all of the different available hormone mixes, plus mixing our own indolebutyric acid. We tried taking cuttings in each month of the year from June through January. We tried many different media including pumice, peat and pumice, sand, peat and sand, peat and perlite and both fresh sawdust and rotted sawdust. We found we could root some from soft wood material, especially from plants held in the greenhouse. We found we could root some summer cuttings, we could root fall cuttings, but over the years our best take was always from cuttings taken in January. Our take has always been extremely variable and for reasons that we could not determine. We have now settled on a more or less standard way of propagating kalmia. This is the method which consistently has given us the best take and is the method I shall talk about at this time.

We take our cuttings as close to January 15th as possible. The cuttings all come from young plants, two to three years old. These seem to root better than from older stock plants. We are careful to take them on a day when the plants are not frozen.

By this time of year the plants have all had some frost and probably several nights of real hard freezing. We like cuttings between 2½ and 3 inches long. Longer wood is shortened down to this length. We use a double wound after submerging the cuttings in a Benlate solution and allowing them to drain for a short time. Immediately after making the wound the cuttings are dipped in a solution of 5,000 parts per million of Jiffy Grow. The cuttings are then placed in plastic bags and allowed to remain for a few hours or sometimes over night before being stuck in the bench. Our benches are six inches deep, heated by electric cables. We use a polyethylene house, not heated. The rooting medium is approximately ½ peat moss and ½ perlite. We use an automatic mist system. We hold the temperature at 73° to 75° F. We find these kalmia extremely slow to root. The cuttings are left in the bench till late May or early June. At this time the greenhouse has to be cleaned out and made ready for a new crop. We transplant at this time and find that about 25 to 30% have rooted. We, of course, remove any dead material, bad leaves, etc. The rest of the cuttings that have callused and look clean are restuck, but this time into flats containing peat and perlite, 1:1 These flats are moved out into a shaded house and again intermittent mist is put over them, but no bottom heat. The mist is allowed to run over them throughout the summer until fall, then it is turned off. The cuttings are left in the flats throughout the winter.

We find, by spring, many of these restuck cuttings are rooted. Our total take after this method, both from the original transplants and the restuck cuttings, was 53% last year. This was on 4,500 cuttings. This is the method we use to propagate 'Ostbo Red' kalmia. The Dexter strain is much easier to produce since they are raised from seed sown in January. This strain will range in color from medium pink to dark pink with an occasional red. We are in the process of selecting two or three of the choicest pinks to propagate as clones. Over the years we have looked for a red which would be as good as 'Ostbo Red' but which would hopefully propagate a little easier. We have yet to find such a plant.

In summary, I would like to say that we really have no deep, dark secrets to disclose in regard to rooting kalmia cuttings. It amounts mainly to patience over a period longer than is required for most plant material to root, and close attention to details.

DAVID ADAMS· Thank you very much, Mr. Eichelser Our last speaker of the day is Mr. J D. Vertrees, Maplewood Nursery, Roseburg, Oregon. He has been growing Asiatic maple species for quite a long time. He's another one of these people that had a hobby that outgrew him and he found himself working at his hobby instead of at his regular job. He, like myself, was an Agricultural Extension Agent for many, many years. Now he will talk to us about the production of the Asiatic maples. Mr. Vertrees.

OBSERVATIONS ON PROPAGATION OF ASIATIC MAPLES

J. D. VERTREES
Maplewood Nursery
Roseburg, Oregon 97470

In studying Asiatic maples for the past nine years, we have been able to collect much information from commercial nurseries, Arboreta, propagators, and collectors from all over the U.S. as well as Europe and Japan. We offer here some procedures and variations we have observed, or carried out ourselves. We emphasize that for a new crop. We transplant at this time and find that about 25 to 30% have rooted. We, of course, remove any dead material, bad leaves, etc. The rest of the cuttings that have callused and look clean are restuck, but this time into flats containing peat and perlite, 1:1 These flats are moved out into a shaded house and again intermittent mist is put over them, but no bottom heat. The mist is allowed to run over them throughout the summer until fall, then it is turned off. The cuttings are left in the flats throughout the winter.

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What was a hobby-study a few years back is now a full time effort of working with the smaller maples, particularly *Acer palmatum* and *A. japonicum,* and their numerous variations.

Remarks on propagation of this group must be proceeded with a few words on nomenclature. The abundance of synonyms in *A. palmatum* is massive. Evidentally this species is prone to sporting, or producing atypical seedlings. We know of over two hundred named clones or cultivars of this species. We have over one hundred sixty named varieties and cultivars in our nursery, as well as ten named types of *A. japonicum,* plus variants of other closely related species.

I am sure, however, that these are not all distinct. We, and other maple specialists are trying to collect and. grow as many named individuals side by side to compare, and eliminate when possible, the duplicity in name. Several men in the U.S. as well as England and Holland are doing this. Propagation commercially under the wrong name is leading to mass confusion.

One plant is sold under four names here in the U.S.: 'Sangokaku', 'Senkaki' (also 'Sengaki'), 'Corallinum', and coral bark maple[1].

Another example is 'Crispa', 'Chishio', 'Crispum', all of which are really 'Okushimo', but also known as 'Involutum' and 'KuruiJishi'[2].

I find 'Chisio'[3] ('Chiseo') applied to three different maples in the trade. 'Crispum' is applied to two. 'Shishigarshira' is sold as 'Chiseo', 'Cristata', and 'Crispum'.[4]

We could give many more examples, but only mean to point out that the proper nomenclature is essential. Unfortunately the red selection from *A. p.* 'Ornatum' (*A. p.* 'Dissectum Atropurpureum') called 'Ever-Red' is loosing its identity and purity in the trade. We find almost any *A. p.* 'Ornatum' being sold as'Ever-Red', in some cases.

Anyone producing seedlings becomes fascinated with the occasional unusual variant he finds. Most are not superior to named clones already on the market. There are two good exceptions here in

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Ref: Monograph of the Aceraceae, A.E. Murray, 1970

1Corallinum' takes precedence

2'Crispum' is the valid name

3'Chishio' is in the Sanguineum group

4'Shishgashira' the prior name

the Northwest: A selection from *A. palm. atropurpureum* owned by Will Curtis, seems more vigorous and retains better red tone in the summer months than does 'Burgandy Lace'. Another is a particularly nice clone of *A. japonicum,* of the cut-leaf form, and a more prostrate habit than the type. It was originated by Art Wright of Canby, and has been named 'Green Cascade'.

Seedlings are easily produced for understock, and for green or red palmatum lining out stock. Seed shipped from overseas, and other dried seed, germinates rather poorly the first year, even with pre-treatment. Left in the seedbeds, a good percentage will germinate the second year. Dried seed may be soaked in 100° F water, gradually cooling, for 24 hrs. It can then be planted directly into seed beds in the spring, or held if necessary, in stratification.

Freshly collected seed may be planted directly in seed beds outdoors to over-winter, given protection from insect and rodent damage. It is sometimes desirable to stratify in peat-sand, moistened, in plastic bags at 34° F for 90 to 120 days, or until proper planting time in the spring. In the Northwest, planting can be rather early since light spring frosts do not seem to damage the young seedlings.

Soil fumigation for insect, disease, and weed control is important. We have excellent results with a methyl bromide-chloropicrin mixture. A seedbed high in organic matter, but with good drainage, gives excellent results. Since our soil ranges in pH from 5.6 to 6.6, we find the addition of dolomite lime beneficial. We feed nitrogen heavily while maintaining a high potash-phosphate level.

Our one-year seedlings are transferred to pots in the fall, for growing on the second year as understock. Some growers line out the yearlings and grow the two year understock in beds, potting them up the fall prior to grafting. Both methods work well.

Grafting periods seem to be a matter of personal choice. Many nurseries graft *A. palmatum* in February, others in March. Still others graft in July, August, November, December, or January. Each has his own schedule.

Some do summer budding in June, while others prefer a stick-bud method in July or August. The grafting and budding methods need the mist systems, or plastic enclosed benches to maintain high humidity and prevent dessication before the union heals.

Understock used commercially varies from ⅛ inch to ⅝ inch. We have seen propagators use even larger. Most use the side graft method, but some use the cleft graft on well established large size understock. Some grafters like to place the graft about ground level, some at 4 to 6 inches up. Of course, many of the dissectum group are worked on high standards.

We bring our understock in the greenhouse in October, keep it cold, and a little on the dry side, until we heat the houses the first part of January. As the understock buds break dormancy, grafting is started. Some nurseries like them leafed out fully, but we like about one-half inch new growth. Scions are collected in plastic bags and refrigerated in January during full dormancy. So many papers have been presented on the grafting of *A. palmatum* that more detail is unnecessary.

Disease control and sanitation is essential. Verticillium wilt is one of the biggest threats in production of maples. It is widespread in native stands of *Acer* throughout the west, and must be guarded against in landscaping and nurseries. In landscaping death is often attributed to other causes, when the disease is often introduced into the plants by pruning or root damage. It can be easily introduced into the propagating nursery.

Sanitation of cutting tools while collecting scions or cuttings is imperative. Taking a scion from an infected limb can spread the fungus to other trees, and to scions collected at the same period. While shaping the scions during grafting, or making the cut in the understock, one can spread the disease down the grafting bench on later grafts. It is important to repeatedly sterilize the grafting tools during the grafting period.

Infected potting soils are another large cause of loss to the grower, after the grafts are transplanted. Sterile potting mixes such as bark-sand, or sterilized lining-out beds have great advantages.

Protection against tissue damaging insects such as root weevils must be carried out. They not only do mechanical damage to the plants, but afford a means of opening up entry into the plant for diseases.

Striking cuttings of these maples has been described for many years. Back issues of the Proceedings contain good procedures. Some nurserymen have reported dissatisfaction to me with plants on their own roots, feeling that the plants have less vigor after five years or so, than those grown on vigorous seedling rootstock. Some large nurseries, however, are now expanding their cutting-grown plants, and are producing very fine material.

A soft or semi-soft wood is preferred (during June, in Oregon). Higher strength hormone dips seem to work best. We have had good results with both the powder hormone and the liquid quick-dips. Bottom heat of 72 to 80° F is the preferred range of most growers. Mist systems, or totally enclosed plastic covered benches are essential to prevent dessication before new leaf formation. Gradual hardening off is important, keeping the humidity high. Excessive heat becomes a problem with plastic enclosed benches. The rooting medium varies with growers, from sand-peat, peat-perlite, to straight perlite.

Striking the roots is not the difficult part. If the cutting goes into full dormancy in the fall, following leaf and shoot growth, it is often difficult to get them to break dormancy in the spring. Some successful growers keep the rooted cuttings growing vigorously through the first winter period and on to the time of lining out in the spring. Severe losses have been reported on cuttings that go dormant.

Maples such as *A. ginnala, A. buergerianum, A. davidii, A. capillipes, A. campestre, A. sieboldianum, A. carpinifolium, A. crataegifolium, A. micranthum, A. maximowczii,* and *A. mono* are easily propagated from seed. When we get into the desirable clonal variations of the species, grafting becomes necessary. Cuttings have been successful on a few. They are best grafted on their own species rootstock, of course.

The beautiful species *A. griseum* presents a problem. Cuttings are extremely difficult. Although it sets heavy seed crops, much of the seed is not viable. I have collected and sampled bushels of seed only to find that most of it is hollow. Some individual *A. griseum* trees set good seed but tend to be rather rare. Grafting of *A. griseum,* as well as *A. mandschuricum, A. pentaphyllum, A. orientali* and a few others is difficult from the standpoint of suitable understock. Usually we try and stay within the species. We hope to be able to report on the successful grafting and propagation of some of the more rare maples at another time.

TED VAN VEEN: We have time for just a few questions for any of our speakers.

VOICE: Mr. Vertrees, did you soak the maple seeds at 120° F?

J. D. VERTREES: 100° F; just good warm water, then just let them cool.

WES HUMPHREY: Mr. Vertrees indicated the use of methyl bromide for control of verticillium wilt. But I wondered if he meant, rather, chloropicrin for this use rather than methyl bromide. At least, as I understand, methyl bromide does not have much effect on the verticillium organism.

J. D. VERTREES: That's right. I could show you some literature that says it does and some literature that says it doesn't. To answer your question specifically, I'm using a mixture of chloropicrin and methyl bromide.

WILLIAM CURTIS: We have some more questions from the Question Box. The first, how do you root *Prunus tomentosa* cuttings? We had this question last night but no one had the answer. Later one party stopped me and said, "I dig up the plants and put them in the greenhouse and when the side shoots come out, I take off the shoots and then put them in straight sand with bottom heat and they root very readily." He hadn't any more finished telling me that when Rudy Wagner told me the same thing. He said, "I don't know why I didn't answer the question, but," he said, "that's the way I handle it."

WILLIAM CURTIS: Where can I buy granite grit?

VOICE: At the feed store. Turkey grit number two. At any reliable feed store that's still in business.

WILLIAM CURTIS: How do you control algae under a mist system without discouraging rooting?

DAVID ADAMS: I think probably the easiest way to do that would be to make sure that the whole bench area is well sterilized before you start; and between each crop, if you've got steam, cook it good. Granted you're going to get algae back before the crop is out of there but if you don't clean it up you're in trouble.

ANDY LEISER: We never were able to control it as long as we used our tap water, which is high nitrate, high boron, high calcium carbonate, etc. It's rather expensive but we've gone to deionized water for our mist system in the greenhouse. Now we're pretty well free of algae.

WILLIAM CURTIS: The rooting of hardwood cuttings of *Prunus cistena*. Is anybody growing *Prunus cistena?*

DAVID ADAMS: According to Frank Schmidt, I think he roots all his right in the field.

WILLIAM CURTIS: Thank you, Dave. Union Carbide Company has a granular size insecticide called *Chemic* or *Ambush*. Has anyone had any experience with this? Registration is possible in California. Does anyone use *Chemic?*

ROBERT TICKNOR: It was quite a few years ago, when it was a numbered compound, we used it on birch for birch leaf miner. It did a fine job on that but the problem was the trees didn't go dormant in the fall. The leaves didn't drop off and the grower couldn't dig them at the normal time.

WILLIAM CURTIS: So *Chemic* held back the dormancy?

ROBERT TICKNOR: Right. The trees stayed green longer.

RICHARD SMITH: I'm speaking for the Andersons who already left. At lunch time there was talk about this. They commented that it seemed to have been very poisonous. The people who worked with it had mint julep and the mint had grown where they had put this *Ambush* on the ground. Later Mrs. Anderson was taken to the hospital that evening very ill from supposedly the effects of the mint roots absorbing this *Ambush* from the ground.

WES HUMPHREY: Bill, could I add a comment along that line? It is a systemic insecticide, a miticide, that has an extremely low LD50. In other words, it's poisonous as the devil. Its LD50 is less than one milligram per kilogram of body weight; in other words, it's a very poisonous material. That's the reason it's only available as a 10% granular material. It may find some use in the ornamental field but, as indicated, it is to be handled with a lot of good common sense as any hot insecticide needs to be handled. Highly effective on some sucking insects but no panacea.

WILLIAM CURTIS: What pines are compatible as understock for grafting? Are all two-needle pines compatible with other two-needle pines? Who grafts two-needle pines? Who grafts a lot of pines? Well, for many years, it's been said in the trade that you had to graft two-needle pines on a two-needle pine, and a five-needle pine on a five-needle pine and so on like that. But there's an old gentleman on the coast down in Washington who said that's all poppycock. He grafts everything on our coast pine and he has no problem whatsoever. In the meantime, Goddard's, they believed this man, because they saw what he was doing and they're doing the same thing and they have no trouble. A couple of years ago, I took some pines over to Bill Omar. I used to do a lot of grafting myself, but then I got so busy, I didn't have the time to stay with it. And Bill realized after he had some eastern white pine grafted on some coast pine what he had done. But I couldn't see any difference, they survived. So I don't know whether it makes any difference or not.

ANDY LEISER: I've got some dwarf Japanese white pine that have been on Scotch pine for about 15 years and so far I don't see any incompatibility. One thing — it is not two-needle versus otherwise, because there is a one-needle white pine, a two-needle white pine, a three-needle white pine, a four-needle and a five-needle white pine, and there are two-needle to eight-needle yellow pines — but the old saw was to graft yellow or black pines on yellow or black and white pines only on white pines.

WILLIAM CURTIS: Is budding practical to multiply scarce rhododendron varieties?

VOICE: It's been done — taken in June with very good success. It's a quick way to get more of them.

WILLIAM CURTIS: The next question — why do they not undercut the walnut understock after the first season? Harry Lagerstedt mentioned yesterday that the stock got so big in two years there was difficulty in grafting it.

HUDSON HARTMANN: In California we don't have that as a serious problem. The seedlings grow fast enough the first year so we can handle them by patch budding in the fall. Or if the seeds are planted very close together — 6 inches apart in the row — this prevents the seedlings from getting excessively large. Another solution would be to undercut the first year to hold them back.

WILLIAM CURTIS: Another question — why not use Tree-Heal and no tape in grafting walnuts: This question was brought up yesterday by the comment that the pressure of the wrapping tape inhibited callus formation.

HUDSON HARTMANN: The common practice in California when whip grafting walnuts is to wrap the unions tightly with cloth adhesive tape and put a lot of pressure on it. They heal very well; this is the way they are handled commercially. After growth starts, then the tape is slit so as to release the pressure, otherwise there is harmful constriction and girdling.

WILLIAM CURTIS: Well I know in grafting flowering cherries, we taped them with cloth tape and, as the callus grew, and maybe grew over a little bit, there was a tendency to kind of mold it and have a nice, smooth union. We would wait until it got full and tight, and then we would split the tape if it didn't split itself.

FIRST TECHNICAL SESSION

PROPAGATION OF COTONEASTERS

BASIL S. FOX
*University College of Wales,
Aberystwyth, Wales*

Cotoneasters being rosaceous plants closely related to *Sorbus* and *Crataegus*, it is fortunate that they pose far fewer problems for the propagator than either of the other two genera. We have no great difficulty in propagating them and are, therefore, concerned with the most effective method to use. It may seem too elementary to start by impressing the importance of securing material from correctly named plants. Cotoneasters are notorious for bad labelling, and it applies most especially to cultivars in the Watereri group; also hybrids are frequently seen bearing the label, *C. frididus*.

Undesirable Methods of Propagation. I can think of no excuse whatever for the practice of grafting or budding these plants when raising them for general planting, and the use of *Sorbus* or *Crataegus* stocks is indefensible It is very likely also that, in the past, seedlings of the early cultivars have been distributed under the cultivar names — adding to the confusion, but people may more innocently collect seed from freely hybridising species that are not grown in isolation. The same applies to plants raised from imported seed-bearing collector's numbers; these should be vegetatively propagated

Cotoneasters from Seed. Our only native British cotoneaster is *C. integerrimus* and this is struggling for survival, whilst *C. microphyllus* is the only introduced species which has become naturalised. This apparent lack of ability to establish themselves in the wild seems odd when self sown seedlings abound in our gardens.

Seed of all species requires after-ripening because of dormant embryos. It is necessary for the seed to be in a moist medium, and be subjected to low temperatures for a period of time. In addition to this, some species have an exceptionally thick seed coat that must be softened so that the seed can imbibe the moisture essential for after-ripening

In considering the suitability of a species for propagation by seed, first see how it compares with vegetative methods. It is important that resulting seedlings be true to type and, therefore, the best seed source would be a group of plants of the species required that are themselves true, and are growing in isolation from other species

A number of cotoneasters are apomicts, these will be safe to collect from, even when they are close to other species. Although a headache to the hybridiser and taxonomist, apomixis is a great help to the propagator

Treatment of the Seed. The fruits should be collected from the selected plants as soon as they are ripe. This early collection is of great importance. The procedure, in its simplest form, is to crush the fruits into a mush, then mix them with an equal quantity of silver sand. First add water to this mixture to make sure that it is really moist then carefully drain off any surplus so that air is not excluded It is then stored in thick polythene bags which must be made mouse proof and placed at the foot of a north-facing wall or hedge This is more or less aiding the natural process and is similar in effect to the old fashioned method of stratifying seed in pots in a bank of clay. Given normal winter conditions this will be sufficient to stimulate the thin-coated seed species into growth. There is an element of doubt with this method and it is helpful to place the bags in a refrigerator at 0° to 5° C towards the end of the winter up to sowing time in April or May.

With species having thicker coated seeds and where more certain results are required, the seed coats can be softened prior to the breaking of dormancy by warm moist conditions, or better by treating with concentrated H_2SO_4 for 1.5 hours (1,2).

This last treatment, of course, requires the cleaning of the seed, which might be considered desirable in any case This done by pulping the fruits, sieving and washing, then finally putting them in a bucket of water where the seed sinks to the bottom.

Dr M. A. Hall, University College of Wales, Aberystwyth, has been working on the use of ethylene in the germination of seeds. A small test on some *C. dammeri* seed that had not responded to normal after-ripening showed about 8% germination, whereas nothing happened in the control.

Seed Sowing. Instead of treating the seeds as just described, they may also be sown directly into cold frames shortly after collecting. By this method it may well be 18 months before germination takes place, during which time the seed is open to attacks by mice.

Where seeds have been treated so that dormancy has been overcome, they may be sown in frames in April, or smaller quantities may be sown in pans. The density of sowing for clean seed can be calculated, but where the fruits were pulped and mixed with sand a complete covering of the surface with sand and seed gives a fair distribution, however, inaccuracies must be allowed for. Cotoneaster seedlings do not seem to suffer from being crowded.

When germination takes place, care must be taken to watch for damping off, though this applies mostly to seedlings raised in containers in a propagating house. If coarse grit is used as a final covering, damping off is not so prevalent; however, it is advisable to give an application of Captan as a precautionary measure. Seedlings may be pricked off right away, but if left until the following spring, they become woody and easier to handle. A short list of species that I consider most conveniently raised from seed includes:

C. acutifolius	*C. frigidus*	*C. obscurus*
C. bullatus	*C. harrovianus*	*C. salicifolius*
C. dielsianus	*C. horizontalis*	*C. simonsii*
C. distichus	*C. lacteus*	*C. splendens*
C. franchetii	*C. multiflorus*	*C. tomentosus*

Vegetative Propagation. This is the only means of reproducing cultivars, it also enables one to maintain the best forms of the species. Cultivars are likely to suffer setbacks in the form of viruses, but whilst they remain vigorous and healthy they are worth perpetuating this way indefinitely.

Cuttings. All cotoneasters can be raised from cuttings, and it is a stroke of good fate that most of the really garden-worthy ones are easy to root

The treatment of cuttings depends to a considerable extent on both the number of plants required, and the purpose for which they are grown. With this in mind, I would like to describe how we propagate cotoneasters at Aberystwyth where a collection of a range of species, varieties and cultivars is kept. Apart from this the more ornamental forms are used extensively for general planting on the University campus and quite large numbers are used as ground cover on the many steep banks of its sloping site

First the production of ground cover plants. The ones we find most useful are: *C.* 'Skogholm', *C. microphyllus, C. conspicuus, C. dammeri* var. *radicans, C. prostratus and C. horizontalis.* To a lesser extent, *C. microphyllus* 'Cochleatus', *C. adpressus, C. praecox* and many others *C. horizontalis* is best raised from seed but the others we find can be managed best by cuttings under mist The cuttings can be taken in June, July, and August though possibly July is the best month. Tip cuttings are used, being made 10 to 15 cm long and trimmed up approximately 4 cm They are quick-dipped in IBA in 50% alcohol at either 2,000 ppm or 4,000 ppm, according to the type of growth. *C. microphyllus* roots the most readily and hardly merits hormone treatment.

The cuttings are inserted 35 to a seed tray in a rooting medium of 1 loam, 1 peat, 1 grit The trays are placed under mist with a bottom heat of 21° C and when rooted are transferred to a cold frame where they are kept cool and shaded for a time. The cuttings are not weaned in the true sense, though in doubtful cases, the trays are placed on the floor of the mist unit and kept under observation for a few days before being transferred to a cold frame. One of the most critical periods is when the freshly made cuttings are placed under mist, when they must be shaded with special care for the first few days.

The plants are then overwintered in a cold frame or, in some cases, on open standing ground, and are planted into nursery rows the following April; normally they are fit to plant as ground cover the following spring. The plants are lifted and balled in rootainers; this is most important with us as heavy rain on newly-planted steep slopes can otherwise wash the soil out of the roots. Instead of lining in the nursery in April plants could be transferred to containers. We find with cuttings that it is most important not to starve plants during the growing season as this can have a long lasting effect; rooted cuttings must never get a check during the growing season *C. conspicuus* is perhaps the most awkward, taking much longer to root than the others; also the tips occasionally die back causing delay in the plants growing away. An alternative treatment for this subject is to transfer them when rooted into peat pots. This means an early start with the cuttings, for plants that suffer root disturbance late in the season may suffer in the cold during the winter; we consider it advisable to complete all the potting of cuttings by mid-September if they are to overwinter satisfactorily without heat. It has been shown that the time of taking cuttings not only affects the rooting response but is also concerned with the ability of the rooted cuttings to overwinter (3).

For general planting. Here we require smaller numbers of plants and put the cuttings in "4 in Long Toms" for ease of handling, particularly where species of different rooting potential are propagated together. The size of cuttings for smaller-leaved kinds is 10 to 15 cm and the larger-leaved ones, such as those in the Watereri group, up to 20 cm. Where cuttings can be taken with heels quickly and efficiently I believe this to be a distinct advantage. An experienced eye can quickly find branches bearing shoots of the right length and the arrangement of shoots in cotoneasters makes it an easy job Again, a quick-dip of either 2,000 ppm or 4,000 ppm of IBA in 50% alcohol is used and the cuttings are put on an average of 10 to a pot depending, of course, on the size of the cuttings into a medium of equal parts sphagnum peat and coarse grit. With slow rooting cuttings the pots can be surfaced with grit as well

When the cuttings are reasonably rooted but before they suffer from lack of nutrients which is, in practice, when the first roots reach the bottom of the pot, they are potted individually in 3-in pots, or into polythene containers of similar size. These plants are overwintered in cold frames, and then, in April, lined in the nursery or in some cases planted in their permanent positions. Where the potting of rooted cuttings continues into September, care must be taken that the plants get sufficient warmth to establish themselves before being placed in cold frames.

I consider that with young, rooted plants great care must be taken that they get no check in growth whatever during any period they would normally be growing. If such care is taken, then tremendously vigorous plants can be produced, though these could be an embarrassment in the nursery trade. On the other hand, the effect of starving a plant can last for years and such plants are overtaken by much younger vigorous ones The same applies to containerised plants packed close together and becoming drawn

Forms that are not so easy to root. Remarks on the rooting of cuttings have so far referred to propagation under mist but there are some forms that do not respond too well to this treatment. Some of these, such as *C.multiflorus,* are not easy under any conditions but others, such as the hairy-leaved *C. integerrimus,* do better in a cold frame Where clonal material is not required, both of these may be raised from seed. The best cold frame for these awkward cuttings is a north facing one, the cuttings being taken with a heel The presence of a tip is not important with cold frame cuttings and can even lead to wilting There must, however, be a substantial leaf area and active buds in the axils of the upper leaves The best time for inserting these is mid-September, great care in watering and shading is necessary for the first month and again in March and April.

I am not aware that wounding of cuttings has any advantage, and know of instances where such cuttings have failed. Regarding the use of rooting compounds other than IBA, both NAA and IAA have beneficial effects with cotoneasters, as have the proprietary brands of rooting powders. Both talc and charcoal-based powders have given good results, but I prefer quick-dip methods using 50% alcohol for speed and ease of application.

Neglected species. In trying to arouse interest in neglected species, the plant propagator is the obvious starting point; I should like to take this opportunity to mention some that I feel could be used much more widely than they are:

C. multiflorus for its graceful form, free flowering, and early fruiting. *C. hebephyllus* var. *fulvida* for its free flowering and very large dark red fruits. *C. splendens,* and the cultivar 'Sabrina', for their low spreading arching branches and profusion of large shiny orange-red fruits *C. turbinatus* for its unusual upright form, being evergreen and its freedom of flowering *C. obscurus* for its fruits of an unusual dark red and its fine autumn foliage effect Lastly, a mention for *C. divaricatus,* a fairly popular plant but not grown enough, for its pink flowers, bright red fruits later turning to dark red as the foliage colours superbly in the autumn.

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C. E SALTER: Are there certain clones of cotoneaster — especially *C. horizontalis* — that do not produce berries?

B.S FOX· I have never found this. It is a good thing to grow several kinds of cotoneaster when you are using them for ground cover to ensure good fruit set. It must be remembered that when raising them from seed they may not flower for a while because they are going through a phase of juvenility, but the advantage of raising from seed is that you get denser, more compact plants. Some of the hybrids I have raised do not get their full fruiting potential for about 5 years.

KELVIN LAWRENCE· There is a plant distributed as *Cotoneaster congestus* 'Nanus.' Is this a truly named compact form?

B S FOX: I believe so. This is the one originally distributed by Will Ingwersen at *C. cooperi; C. congestus* is a difficult species as all the plants in cultivation are triploids and is therefore difficult from seed In spite of the smallness of its leaf it is quite a vigorous plant and in time will cover a wide area

J B GAGGINI. In Scandinavia *Cotoneaster praecox* and its cultivars are grown and fruit well. What is your opinion of this species?

B S FOX: Some taxonomists regard this as a species, others a variety of *C.adpressus*, (*C. a.* var. *praecox*). Unfortunately, we find it very susceptible to scale insects. It is a very free fruiting variety and there are some excellent forms of it in Spetchley Gardens near Worcester

A.R. CARTER: What do you use against scale insects and have you found any disease in the wilting of the tips?

B.S. FOX: White oil spray is quite effective on outside plantings. The wilting is, I think, purely physiological.

D. KNUCKLEY: Do you get a lot of fasciation on *Cotoneaster microphyllus?*

B.S. FOX: Not a lot but it is always present. One factor which is of interest is that we find fasciation occurring in certain definite areas where a number of plants show the effect; for example, *Forsythia, Olearia nummularifolia* and *Cotoneaster microphyllus* are all affected in one small area of the garden.

D. KNUCKLEY: We find this fasciation a feature of *C. microphyllus* where it has naturalised on the tin mine country in Cornwall.

J KELLY: Is there any advantage of laying cuttings of *C. congestus* flat on the propagating bed?

B.S. FOX: We have not had any difficulty in rooting cotoneasters, but in propagation generally one finds some plants that give better response when the cuttings are inserted at an angle of 45° .

SOME PLANT PROPAGATION TECHNIQUES CURRENTLY BEING USED IN JAPAN

D. W. ROBINSON

Kinsealy Research Centre

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Because Japan extends over many degrees of latitude (the four major islands stretch for 31° to 46° N) and experiences a great range of climate, tree and shrub production methods vary in different regions. As in western Europe, plant nurseries occur in many parts of the country but three very concentrated areas of production are: Angyo, Saitama Prefecture, 15 km north of Tokyo, Yamamoto near Kawanishi City, Hyogo Prefecture and Kurume, Fukuoka Prefecture in Kyushu. All three areas are composed of a large number of small nurseries providing trees and shrubs, firstly for the local markets (Tokyo and Osaka respectively in the case of the first two areas) but more recently for all of Japan. Farm size is very small. In 1965, 69% of holdings had less than 1 ha of cultivated land. Most of the nurseries visited were less than 1 ha in size and were intensively cultivated.

In some important respects Japanese nurseries differ from those in the West. A smaller number of plant species are propagated but many plants are sold as mature specimens. This difference is due to the contrasting concepts of the function of a garden in the two areas. The object of a garden in Japan is to represent quiet natural beauty in a small area around the home to counteract the noise and tension of urban life. The main aim appears to be to create in a few square yards the impression of being high up in the mountains. For this purpose, rocks, shrubs and trees are arranged with great skill to leave no trace of artificiality.

Because of the emphasis on established natural beauty, the Japanese favour native plants: they do not usually plant small shrubs and trees and watch them grow but prefer to plant mature

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Because of the emphasis on established natural beauty, the Japanese favour native plants: they do not usually plant small shrubs and trees and watch them grow but prefer to plant mature specimens. In the small shady areas between high density housing, tall mature plants have the additional advantage of being able to make better use of available light.

In many nursery areas in Japan the dominant feature is the large number of mature trees and shrubs that are recuperating and being trained after having been lifted from mountain or coastal areas. Although most Japanese prefer native species many appear to prize variations in colour or form of these native plants. However, there are many indications that Japanese tastes are changing. There is an increasing interest in trees and shrubs from overseas and also in foreign cultivars.

Among the important shrubs and trees in Japanese gardens at present are: *Pinus thunbergiana, P. densiflora, Podocarpus macrophylla, P. m.* var. *maki (P. chinensis), Rhododendron obtusum, R. indicum, Camellia sasanqua, C. japonica, Pieris japonica, Fatsia japonica, Acer palmatum, A. palmatum* var. *dissectum, Ilex integra* and *Nandina domestica.*

The Japanese use the same basic methods of plant propagation as in Britain — seed, cuttings, layering and grafting, but these methods are often modified to suit the different conditions prevailing, viz. philosophy of gardening, climate and availability of materials and labour.

Cuttings. Many different methods are used for raising plants by cuttings in a wide range of rooting composts. Natural conditions for rooting cuttings are generally good and many nurserymen claim that they have no need to use bottom heat or auxins. Cuttings of many species, e.g. *Rhododendron obtusum,* are inserted outside under plastic or muslin shading shortly before or at the start of the rainy season, which extends from about early June to mid-July Rainfall is much higher in Japan than in Britain and the relative humidity is also greater because of the higher temperatures during the growing season and the maritime nature of the country. Mist propagation units were seen in many nurseries, all operated by means of a time-switch and not by an artificial leaf. Few nurserymen considered that this refinement was justified.

Peat is scarce in Japan, the deposits in the north island of Hokkaido being of poor quality. Peat is imported largely from Siberia but also from Canada and some high quality peat is brought in from Finland and Sweden. Because much of the soil is volcanic and rather porous, the cuttings are rooted directly in the local soil in some areas. In other districts Kanuma soil, a highly porous volcanic soil is used, either alone or mixed with the local soil.

The use of a plastic sheet through which cuttings are inserted in pre-formed holes appears to be becoming popular. This method is used for cuttings of many plants, including *Thujopsis dolabrata, Acer negundo, Camellia* spp and *Malus prunifolia* (Fig. 1). The

Fig. 1. Hardwood cuttings of *Malus prunifolia* inserted through 0.05 mm polythene sheet at Aomori Apple Experiment Station.

plastic is usually clear and about 0.05 mm in thickness but sometimes black plastic sheeting is used to reduce the weed problem. The compost is usually a coarse sand or volcanic soil and the plastic helps to maintain satisfactory moisture conditions. For example, large cuttings of *Thujopsis dolabrata* 'Hondai', 15 to 18 in long, inserted in outside beds in April at the Aomori Prefectural Forestry Experiment Station had rooted by early June.

Grafting. Grafting methods in general are similar to those in the West but some of the techniques used are different. Fairly extensive use is made of plastic covering over beds or individual plants, presumably to help prevent drying of the graft union and to promote rapid callusing by raising temperatures. During the last five years much use has been made of small bags approximately 3 in x 1 in (0.03 to 0.05 mm polythene) in the grafting of apple, citrus, chestnuts and other plants. After the dormant scion has been inserted in the rootstock in early spring, the bag is placed over the scion and fixed to the stock by means of a small elastic band (Fig. 2). When the graft is growing strongly, the plastic is perforated to allow the young shoot to emerge.

The use of plastic bags for covering grafts is also extensively used for top working fruit trees to other cultivars. At the Aomori Prefectural Apple Research Station, the use of plastic bags has resulted in a significantly increased "take" (Fig. 3).

Fig. 2. Citrus scions grafted on *Poncirus trifoliata* rootstocks and covered with 3 in x 1 in plastic bags near Kurume City, Kyushu.

Fig. 3. Top working of apple 'Mutsu' on 'Red Jonathan'. Scions covered with plastic bags to improve "take".

In addition to the use of polythene bags over dormant grafts, their use with actively growing scions is also becoming popular (Fig. 4). This method, known as "Green Stem Grafting" is used during the growing season but particularly in August for the propagation of apples, pears, peaches and *Cornus* spp. It is also used in glasshouses during the winter. The scion up to 3 in long is made with a razor blade from an actively growing shoot with its basal end in the form of a wedge (Fig. 4). The stock must be a young actively growing shoot so that the grafting position is relatively high on the plant. The graft is tied with thread and covered with plastic and shading. The bag keeps the soft graft turgid. Grafts of *Malus* spp made in August unite within one week and produce about 18 in of growth during the following three months. This method is popular in the Angyo region for two reasons. It is reputed to be an easy technique and a saleable plant is produced earlier, in just over one year instead of two years from a dormant scion.

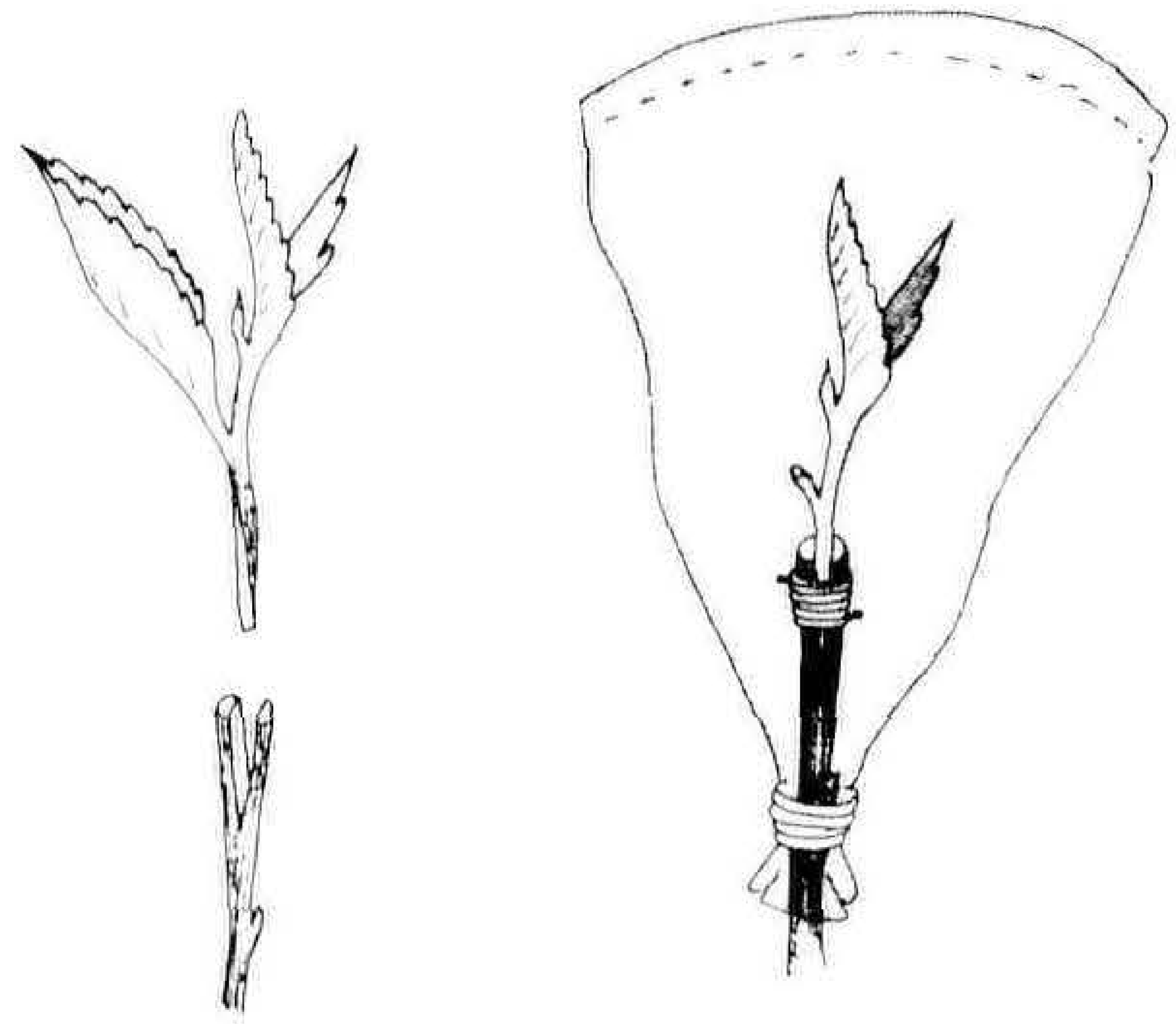

Fig. 4. Green stem grafting. Plastic bag used to keep scion turgid after grafting.

Budding. Traditional shield budding for *Malus* spp is used widely in Japan (Fig. 5a). In the Angyo district, rapidly rising labour costs and the decline in labour availability near Tokyo have popularised a simpler form of budding. Instead of making a T shaped cut on the rootstock a downward incision is made in the rind as far as the cambium. Two-thirds of the flap of rind is then cut off transversely and the bud is held temporarily by the rind at the lower end of the cut surface (Fig. 5b). A plastic tie is used to cover the bud and petiole entirely and is removed when the bud is well united. If budding is done in September, the plastic is normally cut in February. This method of budding is reputed to be less successful than conventional shield budding in the Angyo area (about 80% and 90% "take" respectively) but enables a skilled budder to insert about 3,000 buds per day instead of the usual 2,000.

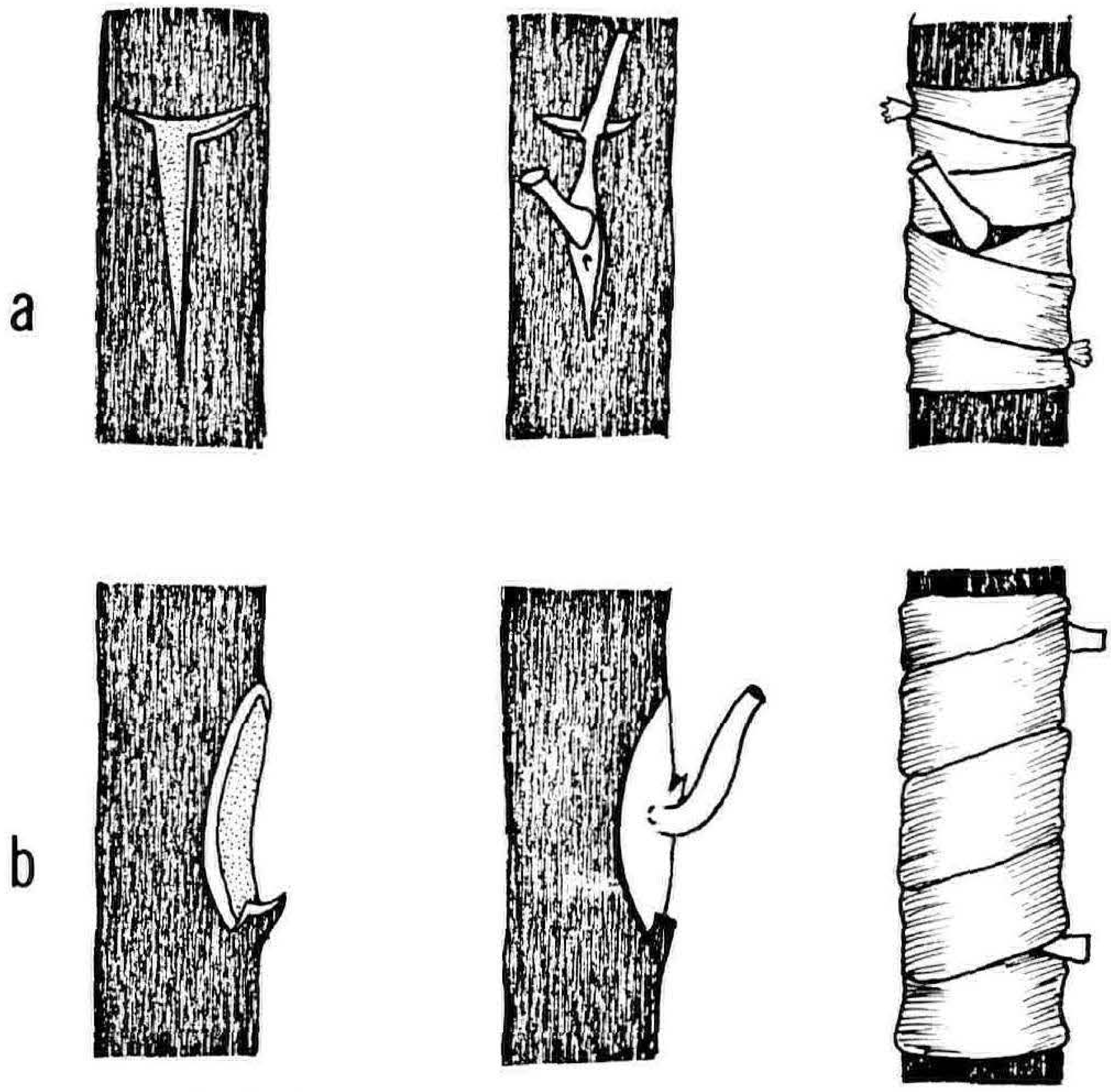

Fig. 5. Budding methods in Japan
(a) Kyoto and Osaka districts
(b) A more rapid method of budding, popular in the Angyo district (Nr. Tokyo)

Propagation of Bonsai trees. Although many Bonsai trees are raised from seed, this requires much time and many methods are used to enable "old" trees to be produced ready for sale in a short time. Many of the most highly prized Bonsai trees are natural dwarfs, collected from high elevations or from the seashore where the poor soil and strong winds produce stunted plants with naturally distorted trunks. It is not uncommon for nurserymen to plant azaleas in plots high up the mountains for their sons or grandsons to lift 50 years later to turn them into Bonsai azaleas for sale two or three years later. Many well-tended azaleas in gardens are purchased at high prices by nurserymen. These are then skillfully, but severely, root and top pruned with well over nine-tenths of the plants discarded to leave a potential Bonsai with thick distorted trunk and one or two main branches only. A plant treated in this way will be inserted in a small container and tended for two or three years in the nursery before being sold.

Air layering and division are also commonly used to produce in a short time, "old" trees with restricted roots that will fit conveniently into a small pot or container. Nurserymen are continually on the lookout for branches of trees that have a particularly suitable "wind pruned" shape or that have unusually small leaves. Suitable branches of plants such as maples, junipers, willows, camellias and *Cryptomeria japonica* are air layered by tightly twisting copper wire around the branch in the spring and covering the stem where roots are required with moist sphagnum moss and plastic which is usually tied at both ends. Frequently, pines which form roots slowly, or very old branches (over 10 years old) are air layered. In these cases, where a satisfactory root system may not be produced for over three years, fresh moss is applied each year in early spring.

Many pines raised in Japanese nurseries are for Bonsai trees. Grafting is not normally a popular method of propagation for high quality Bonsai because of the unsightly scar between stock and scion. A five needle pine *Pinus parviflora (P. pentaphylla)* is, however, often grafted onto *Pinus thungbergiana* because the latter quickly produces an attractive trunk. The method used is shown in (Fig. 6). A wedge graft is prepared (Fig. 6 a), the stock (Fig. 6 b) is cut horizontally but instead of then cutting downwards, the stock is split down the middle with finger and thumb. This results in a better "take" presumably on account of the production of less resin. No wax is used but after insertion (Fig. 6 c) the needles are gathered tightly together and tied (Fig. 6 d).

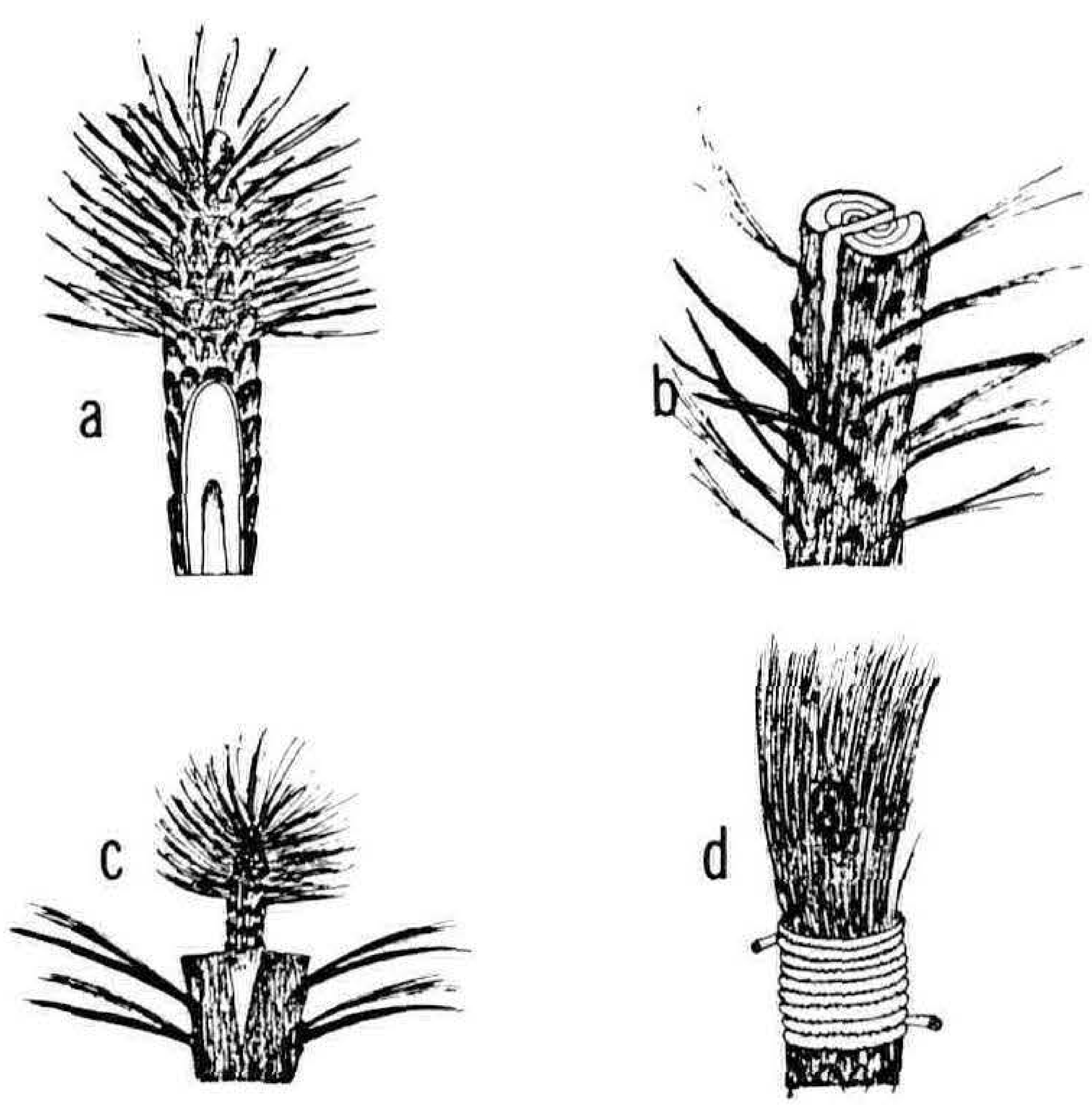

Fig. 6. Top grafting of bonsai pine
(a) Prepared scion of *Pinus parviflora*
(b) *Pinus thungbergiana* rootstock cut horizontally and split vertically by finger and thumb
(c) Scion inserted in stock
(d) Needles of stock gathered up and tied around scion

Side grafting (Fig. 7) is frequently used particularly for uniting a young scion with an old stock, a method used for the rapid production of a plant with an old trunk to simulate age. The wood of the stock is often so hard that a chisel is required to make a suitable slanting cut (Fig. 7 a). Where the trunk of a Bonsai tree is required to grow at a wide angle to its base to suggest age and wind pruning, a wedge type graft is made (Fig. 7 b). Where the scion is required to grow in the same direction as the stock, the graft is prepared by means of a long oblique cut (Fig. 7 c).

Normally at grafting time the scion should be dormant while the sap is rising in the stock. In addition to removing and heeling in shoots for scion material in the autumn prior to early spring grafting of pines, earlier growth in the stock than in the scion is often achieved by covering the stocks with a plastic tunnel during the winter for grafting in February.

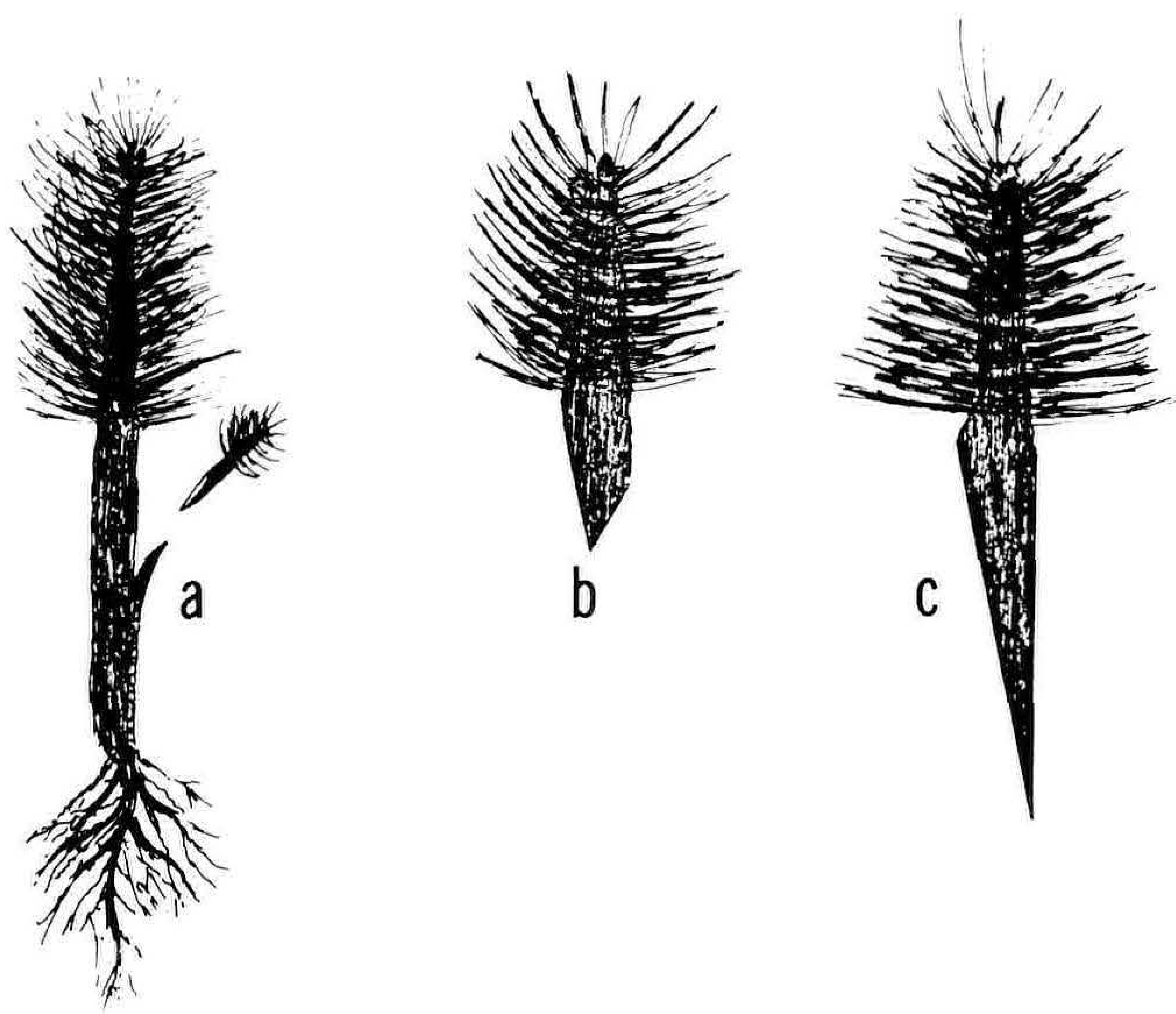

Fig. 7. (a) Side grafting
(b) Scion prepared for inducing spreading growth
(c) Scion prepared for inducing upright growth

Preparation of specimen trees. Mention has already been made of the trade in naturally wind pruned trees lifted from the wild. Some nurserymen also prepare specimen or artificially trained plants from large fairly symmetrical trees. These trees are prepared for transplanting to the nursery one year in advance by cutting a trench around the tree and by severing the tap root as low down as possible (Fig. 8 a). The trench may be refilled for the year with friable soil or compost to encourage the development of a fibrous root system. When moved to the nursery, the trees are planted shallowly so that the top of the main roots is exposed to increase the semblance of age. The tree is often planted at an angle (Fig. 8 b) and if necessary the leader shortened; unwanted branches are removed and the remainder trained into position as necessary with stakes and wire (Fig. 8 c). Strongly growing upright trees can be trained into garden specimens in about four years. To keep the tree small in relation to trunk diameter, most young shoots are nipped out in May or June according to geographical location. Needles on the lower parts of twigs and branches are often removed to give a flat appearance and, where necessary, branches are trimmed back if they are shading those below. If the tree is required to spread in a particular direction, the young shoot is not pinched out but is wired down as necessary.

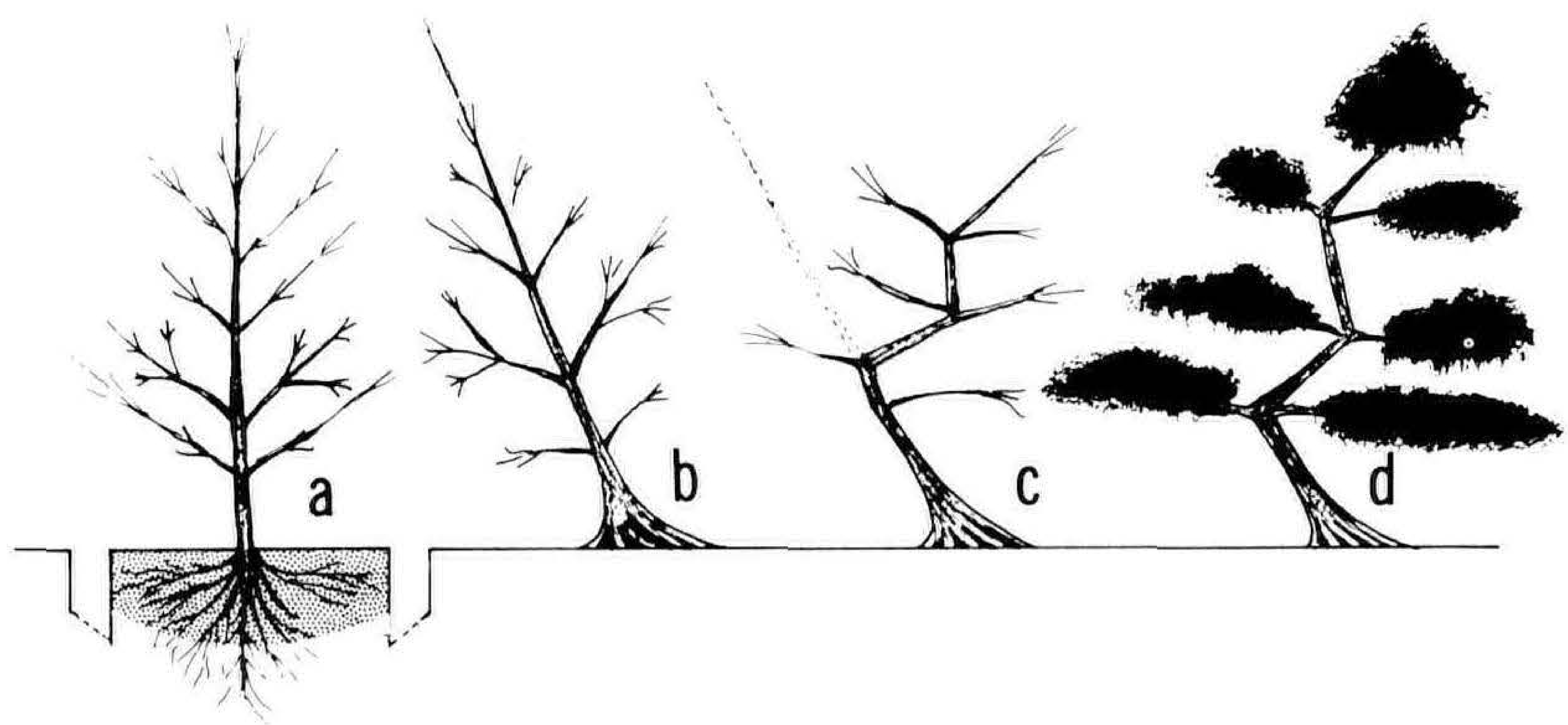

Fig. 8. Steps in the propagation of a specimen pine tree
(a) Tap root cut one year before moving to nursery
(b) Planted in nursery in sloping position; upper surface of roots exposed
(c) Leader removed and new branch structure formed
(d) Finished tree 3 or 4 years later

Very high prices are obtained in Japan for specimen trees. For example, a six foot high trained tree of *Pinus thunbergiana* on a Kurume nursery was priced at £750.00. On the same nursery a 150 year old tree about 12 feet high was valued at £3120.00.

Wherever I went in Japan I was made to feel welcome. Scientists and nurserymen alike were very willing to impart information and keen to learn about Western methods. Language difficulties impeded progress on occasions. English is as difficult for the Japanese to learn as it is for British and North Americans to learn their language Although many Japanese can read and write English they find it difficult to relate the written word to the sound of the language.

Japanese nurserymen are very skillful propagators and much of the scientific research that I saw was of a high standard, but few Japanese horticulturists know the botanical names of the plants they are dealing with. In general, only Japanese names are used and a visitor is well advised to carry with him a Japanese/English flora, such as T. Makino's "A Concise Pictorial Flora of Japan".

Because of the different climatic and economic conditions, many of the propagation practices I saw or heard about could not be transferred directly to Western Europe. Nevertheless, there is much to be learned from Japanese horticulture, particularly as gardens in the West are tending to become smaller at a time when individual householders are prepared to spend more money on their gardens. It seems likely, for example, that the demand for specimen or character trees will increase and that much more could be done to beautify shady corners and narrow passageways between houses with plants, mosses and rocks. It is also clear that some Japanese propagation techniques, e.g. the use of plastic coverings for grafting with actively growing scion material, are worthy of testing and adaptation for use in this country.

NURSERY EXPERIMENT INTERIM REPORT

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In 1970, experiments carried out by members showed that wounding improved rooting in conifer and other cuttings (see IPPS Combined Proceedings, *Vol. 21 p. 267)*. At least two factors appeared to be involved, one being that the effect of auxin applied to the wounded stem was enhanced.

At the 1971 Annual Conference it was decided to examine whether the mechanism of the wounding response could be attributed to the enhanced absorption of IBA and/ or water. Seventeen members did an experiment in which cuttings of X *Cupressocyparis leylandii* clone 2, (supplied where necessary from the Glasshouse Crops Research Institute, by D. Whalley) were wounded and then treated with a readily absorbed solution of IBA in 50% alcohol, or a less readily absorbed powder formulation, both at 4,000 ppm. Cuttings treated by each method were inserted in relatively dry or wet rooting beds, the latter obtained by supplementary watering in addition to the normal mist. The purpose of this approach was to investigate whether wounded cuttings rooted better than normal cuttings where auxin and water were relatively less readily available.

The value of wounding was confirmed and similar responses to wounding and auxin treatment were frequently obtained in the dry and wet locations on each nursery. Results were too variable, however, to provide information on the mechanism of the wounding process, despite all practical steps being taken to standardise the conditions of each experiment.

The probable explanation of this is that in a wide range of nursery situations it is difficult to prescribe and maintain the necessary level of available auxin or water so that each is limiting for normal cuttings and a response to wounding obtained.

Wounding was beneficial, but in association with different auxin treatments and water regimes in different nurseries. This raises the question of whether these effects are likely to be consistent from year to year. Only if this were the case would the Society's Experimental Programme in its present form be of value to the participating members, and an opportunity exist for establishing the normal response in different nurseries and to investigate differences between nurseries which might contribute to their individual success or failure.

To this end it was agreed at the 1972 Annual Conference that members who have taken part in experiments to-date should be asked to repeat them during 1973 to afford a comparison between two years' results as a measure of consistency. The 1972 experiment with *X Cupressocyparis leylandii* will form an essential part of this comparison and detailed results of this experiment are, therefore, not given in this interim report.

THE LONG ASHTON BUDWOOD DE-LEAFING MACHINE

C.G. THOMAS
University of Bristol
Long Ashton Research Station

At the Long Ashton Research Station large quantities of budwood of virus-tested apples, pears, plums, cherries and ornamental *Malus* are distributed to the nursery industry each year. The preparation of this material takes considerable time and the leaves must be removed immediately to reduce water loss by transpiration. The need arose for a De-Leafing Machine which would reduce this time to a minimum.

Machines have been constructed before using razor-blades and a few are in use in Europe, particularly in Holland. It proved impossible to purchase a machine and it was decided that one should be designed and built to our own specifications by the Long Ashton Instrument Workshop (Fig. 1).

The machine is powered by a 12v motor which can be run off the electrical system of a Land Rover vehicle in the field or with the aid of a small transformer by mains electricity. A belt drive from the motor rotates a cylindrical stainless steel cutting blade mounted on a nylon core at a speed of approximately 3000 r.p.m. (Fig. 2). The nylon core acts as a guide to ensure the leaf is removed leaving a portion of petiole (for use as a 'handle' during budding) and the bud left undamaged. The notched blade is used to reduce the need of the frequent sharpening and replacement that many of the European machines require (Fig. 3).

The nylon core can be changed to deal with the variations in budwood thickness which occur; e.g. the ornamental *Malus* species require a much smaller diameter core than more vigorous apple two years' results as a measure of consistency. The 1972 experiment with *X Cupressocyparis leylandii* will form an essential part of this comparison and detailed results of this experiment are, therefore, not given in this interim report.

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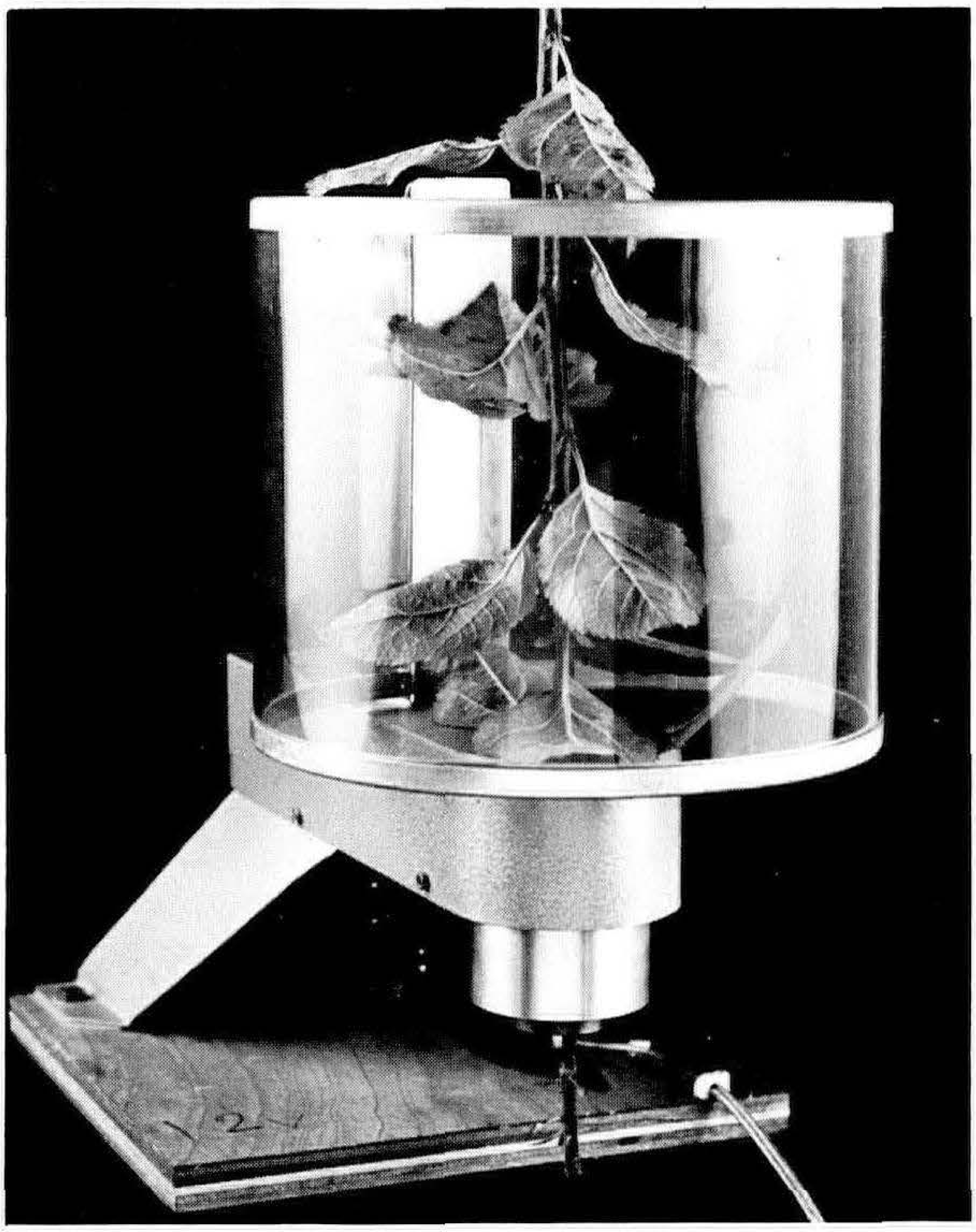

Fig..1. The Long Ashton budwood de-leafing machine. NOTE (1) Well guarded cutting blade; (2) Budstick inverted to present leaf petioles at correct angle.

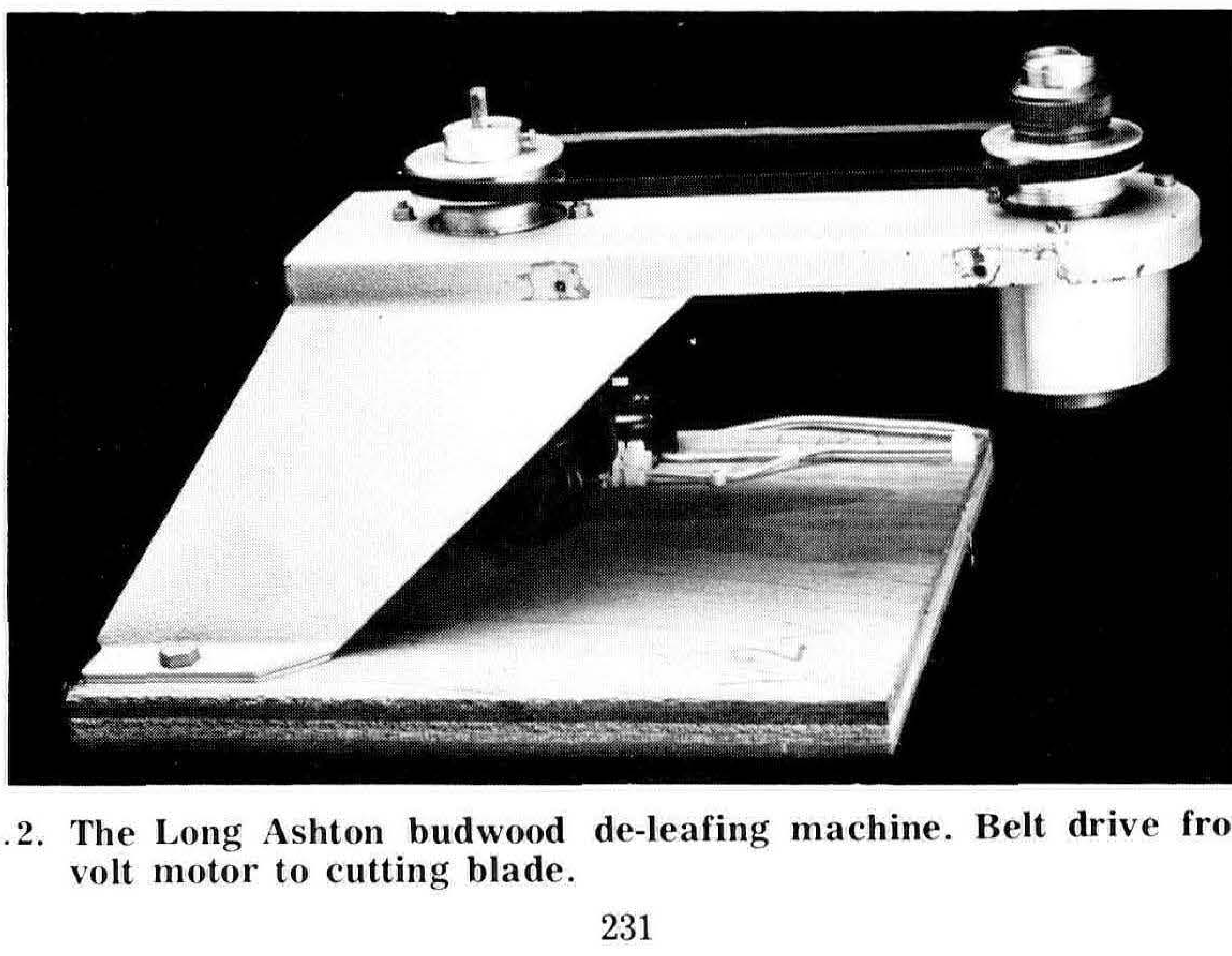

Fig..2. The Long Ashton budwood de-leafing machine. Belt drive from 12 volt motor to cutting blade.

Fig..3. The Long Ashton budwood de-leafing machine. Cutting blade. NOTE (1). Notched cutting blade; (2) Nylon core for correct placement of shoot.

cultivars such as 'Bramley's Seedling.' Slight modifications to the nylon core are necessary to deal with bud wood of roses and similar material which is rarely as straight as that of top fruit.

The machine was used extensively during the 1972 budding period and enabled two people to deal with the preparation of the budwood instead of the team of four or five used in previous seasons.

SECOND SESSION

STERILIZATION OF OUTDOOR SEEDBEDS

D.C. HARRIS[1]

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In many spheres of horticulture the use of chemical soil sterilants is well established. They are widely used for glasshouse crop production and, to a lesser extent, for vegetable crops in the open ground against a wide range of soil-borne pests and diseases. Comparatively recently they have been used on a field scale for the control of certain soil-borne virus vecting nematodes (eelworms) affecting strawberries and the "Specific Replant Disorder" of cherries and apples. This broad spectrum of activity has stimulated the interest of many nursery stock producers and, in the wake of increasing costs, seedling plant raisers are looking towards sterilants for an answer to problems associated with pest, disease and weed control, soil "sickness", and general growth improvement.

During recent years the materials which can be broadly termed soil sterilants have increased in number and some of the more representative types are described below.

CLASSIFICATION AND USE OF MATERIALS

Halogenated hydrocarbons:

(a) DBCP — Dibromochloropropane (Nemagon)
Mainly active against nematodes.

(b) DD — Dichloropropane / dichloropropene mixture
Mainly active against nematodes.

(c) Dichloropropenes mixed with other hydrocarbons (Telone)
Mainly active against nematodes. One of the constituents of DD. An *'Approved' product under the *Agricultural*

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* *Editorial Note: The term 'Approved' throughout this article refers to a* product approved under the Agricultural Approval scheme, which is a voluntary scheme in Great Britain under which proprietary brands of crop protection chemicals can be officially approved. The purpose of the scheme is to enable users to select and advisers to recommend efficient and appropriate crop protection chemicals and to discourage the use of unsatisfactory products. Approval cannot be given to a product containing a new chemical until it has first been considered and cleared under a different voluntary scheme, the Pesticides Safety Precautions Scheme.

[1]**Present address: A.D.A.S., Coley Park, Reading, Berks.**

Chemicals Approval Scheme, but not specifically for nursery stock.

(d) Methyl bromide
Active against nematodes, fungi, insects, other pests and weeds. High mammalian toxicity. May be applied only by authorised contractors in Great Britain.

Carbamates

(a) Aldicarb (Temik)
Active against nematodes but may have inhibitory effect on certain fungi. High mammalian toxicity. Systemic. Not currently 'Cleared' for general use under the Pesticides Safety Precautions Scheme.

(b) Dazomet (Basamid)
Active against nematodes, fungi, insect, other pests and weeds. Releases methyl isothiocyanate (MIT) as the active constituent. 'Approved' as a general soil sterilant.

(c) Metham sodium (Vapam, Sistan, etc.)
Active against nematodes, fungi, insects, other pests and weeds. Releases MIT as the active constituent. 'Approved' as a general soil sterilant.

(d) Nabam (Dithane A40, etc.)
Active against fungi. One of the dithiocarbamate fungicides. When mixed with zinc sulphate can also be applied as a foliar spray. 'Approved' as a soil applied fungicide but not specifically for nursery stock.

Organophosphates

(a) Thionazin (Nemafos)
Active against nematodes, insect and other pests. High mammalian toxicity. 'Approved' but not specifically for nursery stock.

Miscellaneous

(a) Allyl alcohol
Active against weeds, but partly fungicidal and nematicidal. High mammalian toxicity. Not marketed as a pesticide/sterilant and therefore not 'Cleared' or 'Approved'.

(b) Chloropicrin (Tear Gas)
Mainly active against fungi, but moderately effective for nematode, insect and weed control.

(c) Chloropicrin/DD/MIT (Di-Trapex CP)
Active against nematodes, fungi, insects, other pests and weeds. Combination product of 3 important materials. 'Approved' as a general soil sterilant.

(d) Cresylic Acid (Novo)
Active against miscellaneous pests and weeds but also mildly fungicidal.

(e) Formaldehyde (Steriform, Formasan)
Mainly active against fungi, but moderate pesticidal and herbicidal properties. 'Approved' as a general soil sterilant.

This brief summary is representative but not comprehensive. Several of the materials are not officially 'Approved' for nursery stock use in this country. A few do not even have 'Clearance' for use and are therefore not generally available or currently recommended. They all, however, fall within the broad category of soil sterilants and are potentially worthy of consideration.

Over the years soil sterilants have been used almost exclusively to combat existing or suspected pests or diseases but little attention has been paid to their effect on crops and weed growth in the absence of a noticeable problem. With this in mind, the effect on plant growth of chloropicrin and dazomet used on apparently "clean" land has recently been experimentally evaluated. These 2 sterilants were selected from the list of available materials because of their particular activity and relative ease of handling.

Chloropicrin is injected into the soil at 9 to 15 in centres and at normal application rates of 10 to 33 gal/acre; costs are comparatively low. At soil temperatures of 55-60° F planting can usually take place 4 to 8 weeks after treatment. It is mainly fungicidal with activity against the diseases verticillium and phytophthora. It also has moderate herbicidal action At East Malling Research Station soil injection at a rate of 10 to 25 gal/acre overcame the "Specific Replant Disorder" of cherries and apples. On sites where cherries followed cherries and chloropicrin was used to treat the soil before planting the new crop, growth increases approaching 300% were obtained in comparison with untreated areas The response where apples followed apples was significant but not so dramatic. Under field conditions in other parts of the country growth increases of 70% in the first year and 50% in the second year were obtained from young apple trees after chloropicrin treatment of old apple orchard sites

Dazomet is marketed as a granular prill for rotovation into the soil. It is a combined wide spectrum pesticide, fungicide and herbicide and when applied at the normally recommended rates of 320 to 340 lb/cp/acre cost is approximately £160 per acre for materials only. Lower rates may be acceptable under certain conditions. Soil temperature should be not less than 45° F at time of application and should remain above 40° F during the ensuing 4 weeks. Cropping normally begins 8 weeks after treatment but this period is variable depending on time of year when application is made. The weed control properties of dazomet can be extremely valuable and accumulating evidence suggests that it stimulates crop growth Conflicting views exist concerning the best method of sealing the volatile fumigant in the soil after rotovation. Polythene sheeting over the treated area is normally recommended but further opinion suggests that a capped soil surface which can be created by heavy flooding on certain soils is equally satisfactory.

A description of some preliminary work may help to illustrate the growth amendment and other effects obtainable from using soil sterilants on outdoor seedbeds.

Experiment. Replicated plots were prepared on land which had been summer fallowed. The site was apparently free of pest, disease and weed problems. Treatments applied during autumn were as follows:

(a) Chloropicrin at 25 gal / acre (plots immediately covered for a minimum period of one week with plastic sheeting to restrict loss of sterilant vapour).
(b) Dazomet at 320 lb / acre (plots covered as above).
(c) Dazomet at 320 lb / acre (plots heavily watered to seal the soil surface and restrict loss of sterilant vapour).
(d) Nil (untreated).

During the spring following treatments, stratified seed of *Acer platanoides* and *Rosa corymbifera* 'Laxa' *(R. dumetorum)* were sown in equal amounts on all plots. Crop and weed seedling emergence and growth was recorded. Results are shown in Tables 1 and 2:

Table 1. Crop emergence and yield (emergence in untreated plots designated 100. All other data are relative to this base).

	Untreated		Chloropicrin		Dazomet (plastic seal)		Dazomet (water seal)	
Crop	Emergence	Saleable size plants	Emergence	Saleable size plants	Emergence	Saleable size plants	Emergence	Saleable size plants
A platanoides	100	68	126	106	120	93	149	137
R c 'Laxa'	100	91	133	118	170	150	167	145

Table 2. Weed growth 5 and 10 weeks after sowing. [1]

	Untreated		Chloropicrin		Dazomet (plastic seal)		Dazomet (water seal)	
Date	Weeds psy	% soil cover	Weeds psy	% soil cover	Weeds psy	% soil cover	Weeds psy	% soil cover
27 May	170	—	79	—	7	—	5	—
30 June	134	33	93	18	14	4	11	4

[1]Plots were hand weeded immediately after the first weed count.

In order to try to explain growth amendment effects, all plots were examined before sterilants were applied and during the subsequent growing season for free living eelworms (particularly *Xiphinema, Longidorus* and *Pratylenchus* spp), nutrient levels, and nitrifying and de-nitrifying bacteria. Although treatments greatly reduced the number of free living eelworms there was no obvious correlation between number or type of eelworm and crop growth. It was interesting to note, however, that eelworm recovery was slowest on the dazomet/ plastic sealed plots. In this particular trial treatment had no obvious effect on nutrient status or the numbers of nitrifying and de-nitrifying bacteria. A supplementary trial one year later, on a different site, using the 2 dazomet treatments on an *Acer platanoides* seedbed produced similar results as shown in Tables 3 and 4.

Analysis of treated and untreated soil for free living eelworms again showed nothing significant, but in this second trial nutrient analysis indicated that the differential response may be connected with higher levels of ammonium in the treated soils. These combined results show that: (a) all 3 sterilant treatments increased crop seedling emergence and also the number of plants which attained saleable size, and (b) both Dazomet treatments made a very significant contribution towards weed control.

Table 3. Crop emergence (emergence in untreated plot designated 100. Other data are relative to this base).

Crop	Untreated	Dazomet (plastic seal)	Dazomet (water seal)
A. platanoides	100	181	180

Table 4. Weed growth 5 and 10 weeks after sowing.[1]

	Untreated		Dazomet (water seal)		Dazomet (plastic seal)	
Date	Weeds psy	% Soil cover	Weeds psy	% Soil cover	Weeds psy	% Soil cover
19 May	216	10	8	trace	17	1
27 June	75	5	18	1	25	2

[1]Plots were hand weeded immediately after the first weed count.

Conclusion: Many types of soil sterilants are available. In addition to pest, disease, and weed control, at least some of them offer considerable potential for improving seedling emergence and crop growth. The growth amendment effects are worthy of more detailed investigation for the nursery stock producer.

PROPAGATION OF DWARF PICEAS AT KINSEALY

JAMES C. KELLY
Kinsealy Research Centre
Malahide Road, Dublin 5, Ireland

The suitability of dwarf spruces for the modern small garden, their unavailability in the general nursery trade and the ban on their importation into Britain and Ireland prompted preliminary work into their propagation and culture. Observational trials in 1969 indicated satisfactory rooting with the use of 0.8% IBA powder. There were also indications that mid-summer cuttings of current season's growth responded better than one year old shoots taken as cuttings in March. In 1970 further observational trials were carried out, in which 30 cuttings of 14 dwarf *Picea* cultivars were taken at two week intervals from July 21 to September 1. The rooting medium used was two parts peat moss to one part granitic sand. All cuttings were treated with a proprietary 0.8% IBA rooting powder and placed under mist, with a base temperature of 21-23° C.

Each batch of cuttings was lifted after three months. Table 1 shows the rooting percentages of the cultivars rooted on the dates indicated. Generally rooting in all types decreased after August 19, except in *Picea abies* 'Nidiformis'. All *Picea abies* cultivars except *P. a.* 'Repens' showed a marked increase in rooting up to mid-August. There was a sharp drop in rooting after August 5 with *P. a.* 'Juniperinus' and *P. glauca* 'Conica'. (*P. albertiana* 'Conica').

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Table 1. Rooting percentages of cuttings of 14 cultivars of *Picea* taken at four different dates in 1970 at Kinsealy.

Cultivar		Date of Insertion			
		July 21	Aug. 5	Aug 19	Sept. 1
Picea abies	'Microsperma'	80	72	80	33
,, ,,	'Pseudo Maxwellii'	0	2	10	8
,, ,,	'Decumbens'	27	68	30	30
,, ,,	'Nidiformis'	70	80	86	86
,, ,,	'Barryi'	7	30	55	20
,, ,,	'Dumosa'	5	10	30	5
,, ,,	'Prostrata' ('Procumbens')	10	66	80	38
,, ,,	'Capitata'	27	33	45	20
,, ,,	'Pumila Glauca'	0	5	20	35
,, ,,	'Tabulaeformis'	12	8	50	43
,, ,,	'Repens'	50	33	27	3
,, ,,	'Juniperinus'	40	33	30	5
,, *glauca*	'Conica'	20	45	10	27
,, *orientalis*	'Nana'	5	27	20	3

The rooted cuttings were planted in April in a pure peat medium with a range of nutrients added — Kinsealy Range Mix (1). The plants had been overwintered in pots to ensure good establishment. In 1971, their first growing season, they produced one flush of growth, but did not increase much in overall size. In an attempt to produce two flushes of growth per year some plants were potted in January, 1972, and placed in a growing room for two months with the temperature maintained at 20° C. Watering was automatic by capillarity, and the plants received 17 hours of light per day. Under these conditions an early flush of growth took place. It was expected that the plants would continue to grow during the following summer. This did not occur and the only difference between these plants and the plants left in the frame outdoors is the slightly less mature shoots of the latter due to coming into growth later than the growing room treated material. Both sets of plants will be observed for any subsequent differences in the coming season.

Although development of these cuttings is slow, a saleable dwarf spruce (12 to 24 cm diameter, 8 to 12 branches) can be produced in three seasons. Many of the cultivars in this trial have similar growth habit and general characteristics, and would be equally effective in a garden setting. *P. a.* 'Nidiformis', *P. a.* 'Pumila Glauca' and *P. a.* 'Repens' are examples, but the latter two showed much reduced rooting in this observational trial; the consistently high rooting percentages of *P. a.* 'Nidiformis' over the entire period of the trial suggests it would be a suitable nurseryman's cultivar. The attainment of a saleable size quickly is also an important consideration; plants of cultivars, Barryi, Capitata, and Dumosa, after two growing seasons, are 20 cm, 24 cm and 18 cm across respectively.

ACKNOWLEDGEMENT

The co-operation of the National Botanic Gardens, Glasnevin, Dublin in providing plant material for these trials is gratefully acknowledged.

LITERATURE CITED

1. Woods, M. J., Lynch, M. R., and Kenny, T. 1968. Developing a peat compost suitable for propagating a wide range of species. *Third International Peat Conference,* Quebec, Canada.

VEGETATIVE PROPAGATION OF JAPANESE MAPLES AT KINSEALY

J. G. D. LAMB
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In earlier trials on the propagation of *Acer palmatum* cultivars the methods similar to those described by Wells (1) and Anstey (2) gave satisfactory rooting percentages. Young, actively growing, shoots from outdoor trees wounded and treated with Seradix 3, rooted well in a mist unit but it soon became apparent that overwintering losses were high. Subsequent trials, therefore, dealt with cultivar difference in rooting ability and treatments to ensure better winter survival.

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Over the three seasons, 1970-1972, the cultivar, Atropurpureum, has been one of the easiest to root. In April, 1970, cuttings were taken from mother bushes forced under glass. After potting the rooted cuttings, subsequent development was observed under three treatments:

1) Pots plunged in a sheltered and shaded bed out of doors.
2) Kept under glass, minimum temperature 15° C, ventilating at 27° C (sun heat)
3) Same as for (2), but given a 17 hour day by means of 75 watt tungsten filament bulbs from August 19 to October 14

Overwintering losses were heavy in the plants kept out of doors. Those kept under glass made up to 30 cm extension growth before leaf fall, with further extension up to 80 cm in the illuminated plants. No losses occurred in these plants.

Similar results were obtained under glass in 1971, from cuttings taken in March. By leaf fall the plants averaged 49 cm (not illuminated) and 63 cm (illuminated July to October).

In 1972 mother plants were placed on January 29 in:

1) Glasshouse heated as in 1971
2) A plastic house with no artificial heat

Cuttings in the glasshouse were taken from February 7 to February 28. Those in the plastic house (sun heat only) were not ready until April 4. Rooting was good in all cases (80 to 90% in 22 to 36 days).

The rooted cuttings were grown-on in pots in the heated house. By mid-July the February cuttings had developed into plants 30 to 50 cm in height, while those from the plastic house were 20 to 30 cm high.

These results indicate that while forcing in heat to get early cuttings will give bigger plants before the end of the year, mother plants of cv. Atropurpureum forced in a plastic house will give cuttings sufficiently early to ensure good shoot growth the same season, an essential for good overwintering potential. Though further work is needed to check the point, observation suggests that mother plants forced in an unheated plastic house give a more uniform flush of cuttings. Three such plants gave 100 cuttings on April 4, as compared with 90 cuttings over the period February 7 to February 28 from three similar plants grown under glass. The mother plants were purchased specimens, grafted, and apparently four years old.

Under conditions in U.S.A., Wells (1) recommends that cuttings be taken from actively growing plants. We have had 100% rooting of cuttings of 'Atropurpureum' taken at the first stop stage. In our experience the earliness of taking the cuttings is more important than waiting for a stop in growth.

In other trials the cultivars, Atrosanguineum (outdoor cuttings in May) and *dissectum* Inabashidare (forced under glass in April and May), rooted 90 to 92% in 25 to 45 days. By July the April cuttings of the latter had made 10 to 14 cm new growth but the May cuttings had scarcely started to make extension growth. Notable has been the ease of rooting of 'Senkaki'. Even comparatively poor material taken in June rooted well, made good growth, and overwintered without loss.

Cultivars of *A. palmatum* that have been comparatively difficult to root at Kinsealy include var. *heptalobum* 'Osakazuki' and var. *dissectum* 'Paucum'. Though the final percentages of the former have been from 43% to 90%, rooting has been prolonged (heated house cuttings) necessitating two lifting dates (30 and 70 days). Rooting from mother plants in the plastic house has so far been low (26%, 50 days). *A. p.* var. *dissectum* 'Paucum' in initial trials (April, plastic house) has given 28 to 55% rooting after 40 to 50 days, but by July the cuttings had not made new growth freely.

A. japonicum 'Aureum' has given good rooting (83 to 100% in 22 to 43 days) from mother plants forced in March and April. Growing-on has been difficult owing to leaf scorch, attributed to greater susceptibility to salt concentration in the compost. Insertions of *A. japonicum* 'Vitifolium' rooted readily (87 to 93% in 29 to 40 days) and have made good extension growth.

In our trials with Japanese maples we noted that they respond readily and quickly to forcing. Both mother plants and young stock have grown well in plastic structures. The deeper colour of cv. Atropurpureum has been notable under plastic as compared with similar plants under glass. Overwintering in the plastic house has been satisfactory. Though *Botrytis* infection of the shoots appeared, a spray with Captan gave good control. Loamless composts have proved good for container grown specimens but vine weevils appear to be especially attracted to these plants and have caused losses unless controlled.

By the methods described it has proved feasible to produce container grown *A. palmatum* in bush form of saleable size in 12-15 months. We have also had good success in the production in one year of standard (60-75 cm) specimens of 'Atropurpureum' from early (March) cuttings. A single stem is run up, side shoots being pinched and finally removed during the winter.

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SOME PROPAGATION TECHNIQUES OF RHODODENDRONS AT A NURSERY IN THE UNITED STATES [1]

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Propagation time. About 50,000 to 60,000 rhododendron cuttings are taken each year from August through November with October usually as the ideal month. (Of course this can vary with different years).

The cuttings are taken in bulk early in the morning when they are fairly turgid. These are then brought in and dipped in a solution of Benlate (3 oz/50 gallons water). This washes and cleans the cuttings. They are then drained, labelled, and stored under polythene sheeting to keep them fresh and turgid.

These cuttings are taken from healthy, well grown stock plants, which are grown in a wooded area; they are of current year's growth, with thin growth being preferred to thick

Preparing the cuttings.

(a) Cuttings are approximately 4 in. long.

(b) The lower leaves are removed leaving 4 or more leaves at the top of the cutting.

(c) A heavy wound is given on both sides of the cutting, approximately 1½ in in length.

(d) The terminal bud is removed.

(e) Large leaves are trimmed by half.

(f) The cuttings are dipped in a powder hormone. (Mr. Wells has his own mixes and adds Benlate to all of them. He has found that using Benlate increases rooting and cuts down on cutting decay in the mist.) Easy rooting varieties respond to IBA at 0.8%; more difficult ones may need 2% IBA.

Sticking the cuttings. Cuttings are stuck in a mist bench which has a medium of peat, perlite, 1:1, to a depth of 6 inches. The mist is worked on a time basis, coming on 12 seconds every 5 minutes and is controlled through a weaner unit. This is very important because you are able to alter the length of time between mistings and thus control the amount of water applied to the cutting. This may not be so critical with rhododendrons but with deciduous azaleas it is very

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(Ed. Note)

[1]This account was given by a young man who, after completing his technical training at the Pershore College of Horticulture, spent 15 months working at James S. Wells' Nursery, Red Bank, New Jersey, U.S.A. engaged in the wholesale production of rhododendrons and azaleas

critical because too much water will leach the nutrients out of the leaves This can, and usually does slow down rooting — in fact, rooting has been known to stop.

The temperature of the medium is kept at 70° F; the air temperature is controlled by shading and ventilation. The cuttings are stuck in a bench 1 in. x 2 in., or 2 in. x 2 in., depending on the size of the cutting. The cuttings are given this spacing to give good air circulation and help to control decay in the mist. They are watered in with Benlate and Truban solution — 3 oz. of each per 50 gallons of water; this also helps to control cutting decay and *Phytophthora* development, both of which are serious problems in the U S A. because of the high summer temperatures.

Growing. The propagation house is covered with lath shades to protect the cuttings from the bright sun rays. The cuttings usually root in 8 to 12 weeks then are lifted and prepared either for containers or for open land production. Some are canned in 1 gallon cans (potted into 5 in pots), using a medium of 80% peat, 20% grit (⅛ in) These plants are then stood on gravel in a polythene house and watered in with Benlate. The houses have heaters and when the temperature drops below 45° F they automatically cut in and heat the house.

These plants are only watered when they need it. We found that the plants rooted better and were more sturdy if the medium was kept barely moist Once growth commences in the spring, the plants will be fed every time they are watered, using NPK (20-20-20). The fertilising is worked out by experts taking analysis of the medium, then the correct fertiliser requirements are injected into the watering system.

The plants are pruned during the following 6 months so they make bushy, sturdy plants. They will then be sold in the following autumn as one-year rhododendrons in gallon cans (one-year rhododendrons in 5 in pots), which seems to be getting very popular with the American retailer.

The rest of the rooted cuttings (at least 40,000) are lifted and flatted (put in boxes) into 3 parts peat and 1 part perlite, 28 per flat, 7 rows of 4 cuttings. The flats are then stood on gravel in a polythene house and watered in with Benlate and Truban. They get the same treatment as the cuttings in cans until May; then they are lifted and separated out of the flats and planted outside into beds 6 ft. wide and 150 ft. long, each bed containing approximately 1,200 plants.

The beds will have already been fumigated with Vapam a few weeks before, then rotavated and marked out, so that the cuttings can be planted by hand. The cuttings are watered in by irrigation and shaded right after planting.

The red rhododendrons cuttings are flatted and put into a different polythene house because they are stood on gravel under artificial lights to force them into growth. These are given this special treatment because the Reds are slower to commence growth and will make smaller plants unless boosted in this way. They sell 50% reds and 50% all other varieties. The reds are treated the same as the others except for the artificial lights.

Red varieties: 'America'
'Nova Zembla'
'Besse Howells'

Other varieties:

'Catalode'	'Maximum Roseum'
'Catawbiense Boursault'	'Purpureum Elegans'
'Catawbiense Grandiflorum'	'Roseum Elegans'
'Chionoides'	'Roseum Pink'
'English Roseum'	'Roseum Superbum'

The spacing of the cuttings in the bed varies from 6 in. x 6 in. to 6 in. x 8 in. The spacing, of course, depends on the vigour of each variety; vigorous varieties such as 'Maximum Roseum' need bigger spacing. They will stay in these beds until they are sold as 2-year plants — size range 10 to 12 in. and up to 12 to 15 in. This means the plant is 10 to 12 in across and 10 to 12 in. high.

All plants that are sold are lifted, labelled, burlapped, and put on pallets ready to be loaded into a truck (lorry) and shipped to their destination. The plants that are not sold, if any, are either transplanted and sold the following year as a bigger size, or canned (potted) in peck baskets, and sold as canned (potted) stock the following year.

This is the main way of propagating rhododendrons in the nursery, but Mr Wells has also been experimenting with rooting them straight into pint cans (3 inch pots) under an open air mist system with a medium of peat — perlite, 1:1, and he has been very successful with this. He thinks that by this method he will get larger and sturdier plants because the plant does not get such a check when being lifted out of the mist bench.

The cuttings were taken about a month earlier than the first batch, i.e. early July, and given the same treatment, except for being canned (potted) instead of being stuck in the mist bed.

THIRD SESSION

LIGHT AND THE PLANT PROPAGATOR

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The task of the propagator is to produce a good quality plant in the shortest possible time, either from seed or from cuttings, and to do this as economically as possible. In this he is very much dependent on the facilities at his disposal for manipulating the environment of his material.

Over the years techniques have been developed to enable him to optimise a number of environmental factors either by a process of trial and error or as a result of research — for example the control of bed temperature, the use of mist propagation techniques, etc. However, one very important factor has received relatively little attention, and that is the light on which the seedling or cutting is so dependent. For a large part of the year light may be regarded as the most important factor, in that it is the one which is limiting growth or development in one way or another.

Growers are now beginning to realise the magnitude of this limitation and an increasing number have sought to effect some form of improvement in the performance of their plants by the use of artificial light. Whilst this has been especially true of those raising plants from seed, nevertheless a number of growers concerned with rooting cuttings have also started to investigate the possibilities of this additional tool. They are hampered to a considerable degree by the lack of experimental data on which to base their efforts and they are therefore forced to adopt an empirical approach. This is likely to be most rewarding when the fundamental principles involved are more fully understood and the characteristics and capabilities of the equipment available are better appreciated. The object of this paper is to consider the latter in relation to these principles, and to summarise the present position, in order to see how artificial light may best serve the propagator both now and in the future. A more detailed discussion of these principles and their practical application has been published elsewhere (2).

RESPONSES TO LIGHT. It is important to distinguish between a number of plant responses to light for these to be efficiently controlled. In the first place, light is the energy source for photosynthesis and when light is in short supply this process slows down. Logically, therefore, in such a situation, an improvement can be effected by supplying additional light from an artificial light source. There are, however, other interdependent factors — such as air temperature, CO_2 level, water supply, etc. — which must be non-limiting if the full advantage is to be obtained from this extra light

In photosynthesis light energy is absorbed, largely by the leaves, and the rate at which the photochemical process proceeds is determined mainly by the irradiance of the incident light, other factors being non-limiting. The amount of growth made by a plant in a given period of time is therefore dependent both on irradiance and on the length of time it has been exposed to this irradiance, i.e. on the total light energy received during this period. Under natural light conditions the irradiance varies from moment to moment and so therefore does the rate of photosynthesis and growth; this has led to the concept of the "light integral", the product of irradiance and time, and given by the area under the irradiance/time curve.

The rate of growth can therefore be increased either by increasing the irradiance, extending the daily period of exposure to light or by both. In order to improve the rate of growth appreciably the amount of artificial light given daily must be at least of a similar order of magnitude to that received naturally, and this is relatively high by illuminating engineering standards, even during the light-deficient months of winter.

Daylength. There is a second major plant response, or rather a series of responses, to light in which light performs more of a managerial function in controlling the way in which the products of photosynthesis are used These responses are sensitive to the length of the daily dark period and are known as photoperiodic or daylength responses A further characteristic is that they are activated by comparatively low levels of irradiance.

The most widely known response of this type is that of the flowering process leading to the categorisation of plants into "long-day plants", which will only flower when the daylength is greater than a critical value, "short-day plants" which will flower only when the daylength is shorter than a critical value, and "day-neutral" plants which show no sensitivity to daylength. This simple grouping proved to be quite inadequate, as it was found that in some cases the requirements for flower initiation differed from those for flower development — leading to short/long-day plants and vice versa — and also in other cases the daylength requirement proved to be temperature sensitive.

It was later found that many other processes were day-length sensitive, including two of particular importance to the propagator, namely, the onset of leaf fall and dormancy in perennial plants and also the initiation and growth of roots on cuttings. In spite of their significance in the nursery stock industry, surprisingly little research has been undertaken on these responses.

There are a number of stages in the growth of plants in which light responses are of importance to the propagator. These are (a) when the cutting is still attached to the stock plant, (b) when it is in the rooting bench, and (c) after it has been potted on.

Experience has shown that there are times of the year when cuttings will root most readily and this is largely due to the physiological condition of the cutting as determined by the prevailing environmental factors. Unfortunately, far too little is known about the role these factors play in the production of the growth substances which control root initiation and development in the cutting. Evidence has, however, been published which suggests that some species of *Salix* and *Cornus* show a rooting response in the cutting that is dependent upon the day length in which the stock plant has been growing (6, 13). This information is not sufficient to be of great help to the propagator at the present time, but it does emphasise the need for research on this aspect of propagation.

More work has been reported from the U.S on the direct effects of daylength on the rooting of cuttings (13). *Abelia grandiflora, Cornus florida* and *Magnolia soulangeana* cuttings appeared to root best in an 18 h day, but continuous light was best for *Salix blanda* and *Weigela florida* Again there appears to be sufficient evidence that daylength does play a role but not enough to enable the propagator to make practical use of this technique.

Some growers have, however, considered it sufficiently worthwhile to undertake trials themselves. A grower in the Midlands, for example, reported a 65-70% "take" with *X Cupressocyparis leylandii* by the end of December whilst the corresponding plants in natural short days had shown no signs of rooting (9). Success was also reported with *Chamaecyparis lawsoniana, Thuja occidentalis* 'Rheingold', *T. orientalis* 'Decussata' and *Juniperus horizontalis* 'Glauca'

In other trials, high-intensity light has been used to lengthen the day, with the result that it is not possible to separate any possible responses to daylength from effects due to higher rates of photosynthesis In such trials at Kinsealy, supplementary high-intensity light during the day failed to produce the improvement in rooting found with *Chamaecyparis lawsoniana* 'Fraseri' and *C. pisifera* 'Aurea' which resulted from a similar treatment given during the night (5). This suggests that it was a response to daylength rather than high light intensity and if this is so, it could be obtained with a much cheaper and simpler lighting installation.

True long-day lighting techniques have been used by some growers to delay the onset of dormancy and extend the rooting period of deciduous azaleas, but it is in the later stages of rooting and after potting on that this has been found of particular advantage.

If the rooted cutting is allowed to go dormant before it has established an adequate rooting system, overwintering problems can be serious, and the use of long-day lighting to delay dormancy has proved beneficial in deciduous azaleas, *Betula papyrifera* and some

Acer spp Work in the U.S. has demonstrated the continuation of extension growth in many ornamental trees and shrubs (7,12) but at temperatures far higher than the British grower would contemplate Work by David Whalley and K. M. Cockshull at the GCRI (14) and Margaret Scott at Efford EHS (10) has shown a similar — if less spectacular — response in some species of *Acer, Cornus, Weigela, Berberis* and some conifers.

Trials at Boskoop have suggested that this technique may even have possibilities in the summer, when all-night lighting has resulted in continued extension growth with a number of species of woody shrubs and trees (4).

More detailed discussions on the photoperiodic responses of woody plants have been published by Nitsch (8) and Wareing (11).

EQUIPMENT FOR ARTIFICIAL LIGHTING When the use of artificial light is proposed in order to provide further control over the environment, it is important first of all to decide whether it is required to provide a long-day treatment or to boost a slow growth rate due to reduced photosynthesis in poor winter light. This may be especially important as slow winter growth may be due to short-day dormancy rather than low natural light integrals. Long-day treatment is relatively cheap and easy to provide, but supplementary lighting for increasing photosynthesis is much more expensive.

Long-day treatment. A long-day response may be promoted either by extending the length of the natural day by switching lamps on at dusk, or by providing a few hours of "night-break" light in the middle of the night. In either case, relatively low irradiance levels from incandescent lamps (sometimes called tungsten-filament, or general lighting service lamps) are effective. Threshold levels have not been determined but a minimum of 50 lux is normally aimed at in the case of the flowering control of year-round chrysanthemums and a level of 60 lx has been used successfully in trials at the GCRI Until more is known about the responses of ornamental nursery stock it is suggested that a rather higher figure, say, a minimum of 200 lux, should be used, which can subsequently be reduced if a positive response is obtained. The arrangement of lamps needed to provide this will depend on the width of bench or standing ground to be covered, but 150 W lamps, six feet apart and 4 ft to 4 ft 6 in above the plants, should be effective over a width of about 5 feet, using a simple aluminium foil reflector.

Cables are available with moulded lampholders at appropriate intervals; these are quite suitable for this purpose and are widely used in year-round chrysanthemum and carnation production. They may be switched on at dusk to extend the daylength to 16 h, 18 h or even 24 h as required, or for about 4 h to 5 h in the middle of the night to provide a "night break". There is not yet sufficient information available to enable any particular regime to be recommended for the propagator, but satisfactory results have been obtained at GCRI and Hadlow with dusk-to-dawn lighting and at Efford EHS using an extended night break from 23.00 h to 07.00 h. The effects of various daylengths — including a night break — were compared by Nitsch (7) on a range of woody shrubs and trees.

Supplementary Light. High-intensity supplementary light is now being used increasingly by growers of tomato, lettuce and bedding plants and a range of suitable lamps is now available. Irradiance levels in the range 5,000 to 15,000 lux are currently being used, depending on the subject, but any propagator considering a trial installation of this type would be well-advised to aim for the lower level in the first instance. It is a much more expensive technique than long-day lighting and for maximum economy should be restricted to areas containing large numbers of closely spaced plants. This points to the rooting bench as the most obvious location but there is still relatively little known about the role of photosynthesis in the rooting process.

It may well be that the requirements vary between the early stages when a callus is being formed and roots are being initiated and the later stages of root growth.

Light sources. The lamp which has been most widely used in supplementary-lighting installations in recent years has been the high-pressure mercury-flourescent lamp with its own built-in reflector. This is known as the type MBFR/U lamp and is available in a range of sizes from 125 W to 1,000 W. The 400 W size has been the most popular for bench work but in a number of installations, where large areas are appropriate and paths are narrow, the 1 kW lamps have been used. A variation on the standard type is also available in the 400 W size only and is known as the HLRG lamp; it is said to be free of ultra-violet radiation which can prove detrimental to some sensitive species. In these lamps the light is produced in a quartz arc tube containing mercury vapour and the outer bulb carries a fluorescent powder which adds red light to the basic blue/green of the original arc, giving a whitish coloured light.

The same principle is used in the fluorescent tubular lamp, or "fluorescent tube" as it is often called, but these are low-pressure lamps of limited output so that a large number are required to provide high illuminance levels. Furthermore the arc is contained within the outer tube rather than a separate arc tube. Sizes range from lamps 6 in. long x ⅝ in. diameter and rated at 4 W up to 125 W lamps 8 ft. long. Some have built-in reflectors.

They are available in a wide range of light colours from blue through to red and including several different shades of "white". The colours known as "warm white" or "white" are those most frequently used for plants. Special "plant growth" lamps have been produced from time to time, usually containing a mixture of blue and red light with very little green, but so far there appears to be little scientific evidence to indicate that they offer an overall economic advantage.

The 125 W 8 ft lamp is currently the one most widely used horticulturally. It can be suspended with its long axis parallel to the sides of the bench with an unequal spacing to give maximum uniformity of illuminance, but it is more economical when mounted across the width of an 8 ft. bench. A reflector board is necessary above the lamps to ensure that the maximum amount of light is reflected down on to the plants, but due to its large size, it effectively cuts out most of the natural daylight which one is trying to supplement! Such a reflector is less essential with lamps with their own built-in reflector, and these should be seriously considered if the fluorescent tubular lamp is to be used. For this reason, together with considerations of size, this type of lamp has considerable disadvantages compared with the higher-powered lamps. On the propagating bench a further disadvantage is its low mounting height (ca. 18 in above the bench) which is too low for mist propagation nozzles. Its adavatages, however, lie in the small amount of radiant heat the lamps produce, which minimises the rise in leaf temperature, and in the better uniformity of light distribution.

Recent Developments. More recently, interest has centred round three further lamp types: two relatively new lamps and the third a street lighting lamp, the efficiency of which has improved dramatically over the years so that it has become the most efficient currently available.

The first of the new introductions is the mercury halide lamp, which is basically a high-pressure mercury lamp with rare earth halides added to the mercury in the arc tube. This results in further radiation in the yellow and red region of the spectrum to give a whitish light without having recourse to a fluorescing powder on the outer bulb. Such lamps are compact and the 400 W size can be operated in a plant irradiator fitting, originally developed for the earlier mercury-vapour lamp. Its cost is, however, higher than that of the MBFR/U lamp.

Another recent introduction is the high-pressure sodium lamp which emits a golden yellow light. This is also available in various sizes and in two shapes of which the 400 W type SON/T is of most interest to the grower. Its high efficiency means that it can be mounted further from the bench and covering a wider area than the corresponding MBFR/U lamp. This is, however, only of value on wider benches. It, too, can be used in the mercury plant irradiator fitting, but again the cost is relatively high.

Finally, the low-pressure sodium street lighting lamp, type SOX, is now creating a considerable amount of interest due to its high efficiency. Of the sizes available, the 180 W appears to offer the greatest advantage. In spite of its limited spectral output — virtually all the radiation is in a double spectral line at 589 nm — many plants appear to grow satisfactorily when this is used to supplement daylight. This is, no doubt, due to the spectral qualities of daylight making up for any deficiencies in the monochromatic sodium light. Horticulturally, it is still in the experimental stage but it does appear to offer definite economic advantages over other lamps. A reflector has been designed for it and this is now commercially available.

Control gear. Unfortunately, all the lamp types mentioned, with the exception of the incandescent lamp, require certain items of control gear for their efficient operation. These usually comprise a choke, a power-factor correcting capacitor, and sometimes some additional starting equipment. This can form an appreciable part of the cost of an installation but is unavoidable. Some provision must be made for this control gear to be mounted in a convenient position not too far from the lamps and protected from moisture.

The choice of lamp. With so many alternative light sources at one's disposal, the final choice must be made based on a number of relevant factors. Foremost amongst these must inevitably be the question of economics which, in turn, depends largely on the shape and extent of the area to be covered and the arrangement of lamps which gives the most efficient installation.

Physical limitations on the mounting height — headroom, clearance of mist nozzles, etc. — also have a bearing on this. It is, therefore, not possible to generalise and growers are recommended to take advice for their own particular circumstances. Some data are included in the appendix to provide a guide to the comparative costs. They are taken from a report by Cooke (3) and reproduced by permission of the Electricity Council. They apply only to benches 3 ft to 3 ft 6 in wide; further calculations are required for wider benches.

Lighting period. In Britain light is limiting for 3 to 4 months during the winter. Data from the Lee Valley EHS have shown that the long-term average daily light integral (of photosynthetically-active radiation on the bench inside a glasshouse with an average transmission of 60%) falls below 0 75 $MJ.m^{-2}$ for three months, with daily values falling to about 0.31 $MJ.m^{-2}$ For a large area of the country to the north of this station the position is even worse.

Current recommendations for lighting chrysanthemums call for a daily minimum of 1 25 $MJ.m^{-2}$, of which 0.94 $MJ.m^{-2}$ are required to be provided artificially. As the daylength is limited to 12 h during the short-day period of these plants, this requires an installation capable of providing a level of 7,200 lx of light from MBFR/U lamps for 12 h/ day. This would be a reasonable starting point for empirical trials on nursery stock but the 12 h per day restriction would no longer apply. Extending it to 16 h per day would require only 5,400 lx to provide the same daily light integral. The corresponding figures to give the same daily total of photosynthetically-active radiation with the other lamps mentioned would be: fluorescent tubes, 6,000 lx; mercury halide, 5,400 lx, SON/T, 7,000 lx and SOX, 7,800 lx.

It might even be possible to provide the artificial light continuously for 24 h per day with further economies in installation cost.

Growing rooms. A further technique of using artificial light in commercial horticulture is the use of growing rooms. These are rooms from which daylight is excluded and the plants grown entirely in artificial light. This gives good control over climatic factors in the winter and eliminates the variable features of the natural light climate. Such rooms are currently being used for raising bedding plant seedlings and young tomato and lettuce plants, but at least one is being used commercially for the rooting of pelargonium cuttings.

The lamps used in such rooms are almost exclusively warm-white or white fluorescent tubes, arranged to give a total of 8,000 lx or 15,000 lx. Full details of such rooms are given in an Electricity Council booklet (1)

CONCLUSIONS

Artificial light provides an additional means of effecting some control over the growth of a wide range of plant species of interest to the propagator. At present, however, very little information is available to guide him in the use of this new tool and there is scope for much research to establish the responses of a large number of important species to provide him with this information. A number of lamp types are available which can be used to provide long-day conditions, or to speed up the processes of photosynthesis and growth, but the choice depends ultimately on the conditions prevailing on any particular nursery.

Until the required information is available, growers will naturally be tempted to conduct their own investigations. This can prove difficult and inconclusive unless they are properly carried out, and any grower interested in doing so would be well advised to consult the Ministry's nursery stock specialists before embarking on such a course.

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APPENDIX

In Table 1, which is based on one prepared by Cooke (3) and included by permission of the Electricity Council, the characteristics and costs of a range of lamp types which may be suitable for supplementary lighting purposes are compared. The initial capital costs include the cost of the control gear (ballast, capacitor and ignitor where necessary) the lampholder or reflector and the lamp, allowing 13% discount off the manufacturer's recommended prices but not including the cost of installation. Gear cost is spread over 10 years but no allowance is made for interest charges and the cost of a SOX relflector is taken to be £10. A bench width of 3 ft to 3 ft 6 in has been assumed and the lamp spacings quoted are expected to give similar average irradiance levels and comparable plant performance. Electricity costs are based on 1 p per kwh.

Table 1..Characteristics and costs of a range of lamp types suitable for supplementary lighting.

Lamp type	Lamp power (watts)	Assumed life (h)	Lamp spacing (feet)	Initial capital cost £ / ft	Running Costs pence per 1000h per ft		
					Lamp	Electricity	Total
MB	400	7,000	5	3.13	10	84	94
MBFR	400	7,000	5	2.10	15	84	99
HLRG +	400	7,000	5	2.40	19	84	103
MBI	400	5,000	6	5.19	32	71	103
MCFRE	4 x 125	7,000	8	2.66	5	69	74
SON / T *	400	5,000	8	4.85	40	55	95
HPS †	400	5,000	8	3.87	40	55	95
SOX	180	6,000	5	4.60	25	40	65

\+ with simple lampholder
* with separate ignitor
† with ignitor built into the lamp

PRODUCTION OF "SIX-WEEK ROSES" IN ROCKWOOL

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Abstract. Miniature roses and most floribunda roses may be produced in six weeks, from cutting until flowering. Three one-internode cuttings are planted directly in a block of rockwool and are put under intermittent mist with bottom heat. The cuttings are treated with growth substance, 500 ppm IBA, and are fertilized right from planting After 10 to 12 days the cuttings have formed roots, and the mist is gradually removed. After three weeks the cuttings are spaced on benches or beds with sub-irrigation. No pruning is made and, after three weeks in glasshouse, the plants are ready to be sold.

INTRODUCTION

In Denmark the method of propagation of roses by cuttings is well known to most nurserymen. For several reasons, though, this method has not gained a good foothold. Some of the reasons are. the method does not fit in with the running of the nurseries. The nurseries do not have the glasshouse facilities needed. The nurserymen tried to make a traditional rose by propagation by cutting, a rose equalling a budded rose with its demands for quality, but there was a lack of experimental results to tell the nurserymen about methods of production, selection of cultivars and, not in the least, the growth and development of these roses in the consumers' gardens

Roses propagated by cuttings are excellent for container growing, which makes it possible to sell the roses when flowering. To many rose producers it means a new form of selling, which again entails gross production, especially of six-week roses. We have chosen to name roses that can be produced in six weeks — "six-week roses" These roses should not be compared with budded roses It is a new product, which the consumer may place in the house for some time and then plant in the garden or where he wishes. If the buyer plants this rose in his garden, he may notice that after some time it will appear like a budded rose of the same variety, only that it does not give rootstock suckers.

MATERIALS AND METHODS

All sorts of miniature and most floribunda roses are types well suited for "six-week roses." Tall floribunda varieties and hybrid tea are less suited, being too tall and vigorous Furthermore, these types require seven to eight weeks, some even more, from cutting to flowering. Moreover, yellow varieties, with *R. foetida* inheritance, are unsuccessful on their own roots, as their rooting ability is poor and their growth is usually poor also.

"Six-week roses" may be produced throughout the year, except for the coldest and darkest period. This product will be in demand all year, but the month of May will, of course, show the biggest sale. In order to have "six-week roses" ready for sale in the beginning of May, the production must start at the end of March.

In order to have cutting material at this time of year, the mother-plants have to be started in the glasshouse at the beginning of February. The mother-plants should not be given too high a temperature from the beginning. The temperature in the glasshouse is not critical. At a low temperature it will, of course, take longer time before the cuttings can be taken. From a big mother-plant we can get a hundred or more cuttings per plant of miniature roses.

We can use sales plants as mother-plants by starting them in the glasshouse at the beginning of February, as previously mentioned. After five to six weeks we can take cuttings from the plants A rose which has been cut down will need five weeks to beginning of flowering, dependent on the temperature. Thus we can get excellent sales plants about the first of May from the plants which have been cut down From a sales plant, originating from three cuttings in one container, we get 15 to 20 cuttings, i.e. about 500 cuttings per square meter of the miniature roses.

The Cuttings. We use softwood, one-node, cuttings Various types of cuttings for propagation of roses are, among other things, described by Margaret E. Marston (5).

The length of the cuttings varies with the internode length, as we are cutting 0 5 cm over the leaf-bud. To ensure a safe and uniform rooting we use a rooting substance, IBA at a concentration of 500 ppm The base of the cuttings is dipped 1 cm in the substance after the quick-dip method (4).

Combined Rooting and Growing Substrates and Containers. At the Experiment Station at Hornum we have been working on rooting and growing substrates for container growing of plants. We have endeavoured to find a good inert substrate, and we have succeeded in making the insulation material, rockwool, into a container substrate, meeting most of the requirements we have for a growth substrate (1, 3).

For a short term culture as roses, the rockwool block has no obvious advantages to a good peat moss, except for its cheapness and its labour saving, as we save the filling of the containers. The rockwool block used for six-week roses is 7.5 x 7.5 x 6.5 cm covered with plastic foil on the four sides, uncovered top and bottom. The block is thus growth substrate and container in one, and ready to be planted. It is easy to plant the cuttings in the block, which gives a good support to the cuttings. The block costs nearly the same as an equal-sized plastic container.

The rockwool blocks are placed on the propagation bench under intermittent mist with bottom heat, with a layer of 1 to 2 cm sand for drainage. The blocks are watered with 0.1 per cent Hornum mineral nutrition mixture (2). Three cuttings are placed in each block, and in the course of 10 to 12 days the cuttings will have rooted. Until rooting, the plants are watered daily with 0.05 per cent nutrient solution. After rooting the concentration should be increased to 0.1 per cent, and the mist is gradually removed.

After three weeks the plants are spaced. To get a quality product, the plants should not be placed too close, 15 to 20 cm, according to the size of the cultivar. Nutrient solution (0.1 per cent) should be added each time water is needed. When using mother material of good quality, we have no special problems with fungal diseases, but precaution should be taken to avoid a build-up of mites.

Six weeks after planting the cutting, the roses begin to flower, and the plants are ready for sale. The last days before despatch we must try to harden the roses, as they are often exposed to severe conditions during distribution. Normally, the plants will be sufficiently hardened for planting in the open, if the weather conditions are not too unfavourable for the plants.

DISCUSSION

Our investigations regarding production of "six-week roses" in rockwool have not yet been finished. Above is given an example of how to make a nursery product in six weeks. The method described may be adapted to the production facilities of various nurseries; for instance the propagation process itself may take place under plastic cover (instead of intermittent mist), various growth substrates and containers may be used.

A short termed culture will, in most cases, be the most profitable The basis for a short-term culture of roses is: good cutting material, optimal growing conditions, no replanting, no pruning.

The results obtained so far have given more than 95 percent rooting and bursting, with a very uniform product as a result. The methods are so promising, that everything points in the direction of an increasing production of this new product in future.

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[1]**Editorial Note:** References 1, 2 and 3 above refer to 4-page advisory leaflets without English summaries. Reference 4 — "Experiments with the propagation of polyantha and hybrid tea roses by softwood cuttings" has a 1¼ page English summary; the address of the Research Station is Statens Planteavlskontor, Rolighedsvej 26, 1958 Copenhagen V, Denmark.

PROPAGATION OF SOME SHRUB ROSES BY GRAFTING AND BY CUTTINGS

D. M DONOVAN

F. Toynbee Ltd., Croftway Nurseries, Barnham, Sussex

Rosa bracteata 'Mermaid' is usually grafted in winter as it fails to summer bud with a physically sound union in the field, while *R. banksiae* 'Lutea' is too tender for field exposure *R. moyesii* 'Geranium' and *R holodonta* 'Maidwell' have low bud takes in the field

Grafting. Seedling *Rosa canina* of broad caliper and with long hypocotyls suitably straight, are selected from imported rootstocks on arrival, and potted into 3½ inch pots with the full length of the hypocotyl exposed The pots are plunged in a sand bed for the rootstocks to establish for a year, when management is confined to some watering and weeding The thickening of the hypocotyl during the growing period is minimal

In early January the rootstocks are removed from the bed and the roots and tops are trimmed, and then they are placed in a grafting pit, using some bottom heat to dry them off for working in late January.

Scion wood of 'Mermaid' and 'Lutea' is collected mid-December from stock plants in a cold house, the others from outdoor plants It is essential, especially with 'Mermaid', to select out fully mature material, and to discard thin or unripened material. Suitable scion wood dethorns fairly readily and with any defoliating is reduced to suitable lengths for bundling and storing upside down in a sand heap until required

About the last week of January grafting may commence when the buds of the rootstocks begin to burst. The scion wood is washed clean of sand and allowed to dry, and reduced to 3 or 4 bud portions for bench working. Rootstocks from the pit are beheaded below the branches and worked with whip and tongue or side graft. The completed grafts are tied and waxed and returned to the pit for flooding. With a bottom heat of 75 °F, and high humidity maintained by a polythene drape and further watering, the grafts break bud in 2 or 3 weeks and, after a similar interval, the bottom heat can be reduced and gradual airing introduced. On completion of hardening off, about mid-April when the shoots are 2 or 3 inches long, the grafts are potted on and initially grown under glass.

The success rate by grafting can be very high; the essence being the selection of scion wood (particularly for 'Mermaid'), and many modifications of the above account are available. The state of the moisture content of the pot at grafting is not critical, nor the bottom heat figure. Probably bare-root working is practicable if understocks are available at the appropriate time; the scion wood need not be visibly dormant for successful working.

Cuttings. 'Mermaid and 'Lutea' root readily from cuttings during late summer (July to September) using, in 'Mermaid', non-grafting material, i.e. thin floral shoots, when ripe. A dip in Seradix is beneficial for conventional cuttings or leaf-bud (in 'Mermaid') and rooting occurs in 3 or 4 weeks under mist.

However, cuttings of 'Mermaid' lack the robust quality of grafts although of similar rates of growth and flowering a few days earlier, and more freely, but this method is not recommended. 'Lutea' propagated from cuttings produces plants comparable to those grafted by time of sale.

Grown under fairly low temperatures some weeks after grafting, i.e. during March, 'Mermaid' may shed its leaves from the young shoots, but without fatalities occurring. This condition is never apparent in cuttings under similar conditions of temperature, and rarely so where growing on temperatures are high (65° F) in grafts

Pests are usually limited to aphids during propagation, and sometimes voles in hard weather. 'Geranium' and 'Maidwell' are singularly free of diseases, while 'Mermaid' is occasionally susceptible to mildew.

CONIFER PRODUCTION FROM CUTTINGS

B H ELLIOTT
Ned Yates Walkround Nurseries
and Garden Centre
Bagnor Regis, Sussex

The short talk I wish to give this afternoon is based on work I did whilst Practical Instructor in Nursery Practice at Hadlow College of Agriculture and Horticulture. It relates to a 2 year production system of containerised conifers. This project was made possible through the help of Bruce MacDonald, and of the students I was instructing at the time.

1. **Propagation.** Propagation was carried out during the winter months under conventional mist. The cuttings were 4 in long, preferably with a ripened base of ½ in All cuttings were treated with Seradix No. 3 Seed trays were used to give greater flexibility of handling and in which 60 cuttings were inserted. The compost used was 3 parts sphagnum peat to 1 part sharp sand and then the cuttings were placed under the mist with a basal temperature of 75° F.

Two main batches of cuttings were rooted. The first during October-November consisted of *Chamaecyparis* and *Thuja* cultivars — the great majority of cultivars being easy to root. Those which had not rooted by the time the second batch of cuttings were placed under the mist, were discarded. This second batch in January-February consisted of *Juniperus* and *Taxus* cultivars. These latter plants benefit from a winter "frosting". This helped them to root more readily.

The mist was manually controlled at night when it was completely switched off. On very dull days it was manually controlled also. The high ratio of peat in the compost may have meant that manual operation of the mist was necessary. It was essential that the subsequent cuttings had a good root system. Subsequently they require little attention after rooting.

When the rooted cuttings were 'weaned off', they were removed from the mist beds and placed in dutch light cold frames. During very cold weather they would be given additional protection in the form of hessian matting. All watering, whilst the conifers remained in the trays, was done by hand.

2. **Potting Off.** The potting-off was carried out during March and April, but was usually governed by the completion of the heather potting The rooted conifers were potted in 8 cm peat pots using a compost 3 parts peat to 1 part sharp sand, together with Vitax Q4 fertilizer and ground chalk.

The potted conifers were plunged almost to the top of the pot in spent hops within a dutch light frame. This use of spent hops was very important as it created rapid root development. The spent hops were kept for 6 months prior to plunging to remove the pungent odour which they always possess on delivery from the brewery The time spent on plunging was greatly rewarded by growth during the summer months. The plunged conifers were next covered with lights and shaded until established. Later the conifers were ventilated and finally the lights were removed in the latter part of May, by which time the conifers were touching the glass.

The plants were given a top dressing of Eclipse fish manure at this time. I used fish manure because I had been told that it imparted good colour to conifers. The conifers did have very good colouring, but this might not have been attributable to the fertilizer. During this time a dilute liquid feed was given through the irrigation system.

The conifers remained in this frame during the rest of the summer, during which time they grew rapidly to produce an excellent liner upon removal from the hops. This was not a difficult task as might be thought from the abundance of roots. Generally the conifers when removed, depending on the genus and cultivar, were 9 in to 18 in tall.

Potting-on. This was carried out during October and November. Polythene sleeves 6 in diameter were used, and also a similar compost which contained Vitax Q4 HN at ¾ lb/c.yd. Potting was very easy and, as no root restriction occurred in the peat pot, establishment was very quick. The potted conifer was placed under protection for the winter using polythene 'walk-in' structures with overhead watering through which liquid feeding commenced in the spring. With the autumn potting the conifers were established by the winter and grew away rapidly in the spring still protected. The polythene cover was removed in June to ensure they were adequately hardened off for late summer/autumn despatch.

General. Giving simple protection for two winters, rapid unchecked growth could be attained. Being uncovered during the summer and giving no heat whilst rooting, one can see that this is a cheap production system. The spent hops were most beneficial and a great contributor to rapid growth during the first season. The examples of conifers which I have brought with me are over two feet high in july and are still rapidly growing. Three foot high container-grown conifers could easily be expected by autumn in two growing seasons instead of three. Finally it is important to note that this is a relatively cheap production cycle.

DISCUSSION GROUP REPORTS

Group A.

Propagation under Polythene Tunnels

CHAIRMAN — J.L.W. DEEN

This subject was not an easy one to discuss because of the lack of information and experience of using this technique in Great Britain. The only written information on the subject is in the CAB Digest No. 2, *Mist Propagation of Cuttings,* by Patricia Rowe-Dutton, 1959, and in the short paper by the Chairman of this group in Vol. 21 Combined Proceedings of the IPPS (p. 248). The section in Miss Rowe-Dutton's book on 'Plastic Tents' (p.23-25) contains descriptions of systems of polythene tunnels for plant propagation. In particular the Phytotektor unit introduced by Templeton in Tennessee in 1953 has similarities to the systems being introduced in several nurseries in Great Britain.

The various systems in use in Great Britain were reviewed starting with that developed at GCRI and described in the 1971 Proceedings. Simple wire hoops are used to support white translucent polythene over a prepared bed three feet wide, the polythene being secured by polypropylene baler twine. The propagating bed is prepared by chemically sterilising the soil with Dazomet and rotovating into the top 3-4 in. to give a rooting medium of approximately 1:1, peat-soil. Cuttings are inserted into this prepared bed and kept covered for a period about 4 weeks. During this period whilst rooting is taking place the bed is watered by trickle irrigation or, where this is not available, by hand application of water. The cuttings are weaned by progressively raising the sides of the tunnel until the polythene can be removed completely. The plants are then left *in situ* to grow on for a further season. The approximate cost of materials (hoops, polythene, twine, peat and Dazomet) for a tunnel of this type 100 ft. long is £ 10.70. This tunnel will cover approximately 2,500 cuttings at a spacing of 4 in. x 4 in., giving a cost of materials per cutting of 0.43p.

A similar system of propagation used last year at Blakedown Nurseries was described, the differences here being that the cuttings were inserted directly into pots under the tunnel and the sides of the tunnel were sealed by covering the edges of the polythene with soil. In the system used at GCRI it was not found necessary to seal the tunnel in this way to maintain an adequately high humidity Some difficulties were experienced at Blakedown due to drying out of the pots resulting in losses. It was also suggested that handling costs might be higher than in more traditional systems of propagation.

Probably the most well developed system is that used at the nursery of Hillier and Sons, located at Winchester which was described by Postill. The tunnel construction used is a little more detailed than that previously described. Sterilised beds 4 ft. wide are prepared by machine and wooden boards are laid down along the edges. The wire hoops which support the polythene are fastened to the boards and the polythene stretched over the hoops and stapled to the boards The cuttings are inserted in a layer of sand on the beds and watered at intervals by mist applied from nozzles positioned down the centre of the tunnels. Weaning is achieved by cutting holes in the polythene after about 6 weeks. Eventually the polythene hoops are removed completely and the rooted cuttings grown on for a further season before lining out in the field.

A similar system has been used at Hadlow College. In this case soil sterilisation was avoided by eliminating perennial weeds from the area to be used, allowing weed seeds to germinate and burning them off with Paraquat and then covering with a layer of sand to suppress further weed seed germination. The polythene was supported with wire netting and the polythene dug into the soil at the edges of the tunnel to completely seal it. Again irrigation was applied by mist nozzles centrally positioned in the tunnel. At the close spacing of the cuttings used here it was necessary to lift and line them out at an earlier date than in the previously described system so that the plants were not grown on for a further season *in situ*.

Members of the Conference also had the opportunity to see a system in use at Hills Limited, Stone, Staffordshire, where existing frames had been adapted to form polythene tunnels by erecting metal hoops over the frames, over which was stretched clear polythene. Shading was provided by diluted white emulsion paint. The cuttings were rooted directly into small peat pots in trays. The rooted cuttings were transferred to the field in the trays for field planting.

There is an obvious contrast in the conditions achieved under tunnels and those in a normal mist propagation bench. Temperatures, in particular, may be very much higher under tunnels and the leaves are not cooled as in the mist system by the evaporation of water. The cuttings are also not able to maintain a high photosynthetic rate because of the heavy shading necessary to prevent excessively high air temperatures. The reserves of the cuttings must in consequence be severely depleted, but it was felt that for the range of subjects which can be successfully rooted under tunnels this was not a limiting factor. It would probably however, be a limiting factor for those subjects which were normally difficult to root.

It was suggested that one possible advantage of polythene tunnels would be the potential use of much larger cuttings than would be normal. Results from GCRI had shown that cuttings 9-12 in. long of *Cornus alba* 'Argenteo-marginata' and *Cornus alba* 'Spaethii' could be rooted and grown-on successfully, as could large cuttings of ground-cover *Cotoneasters*. Considerable success had also been achieved with large cuttings (3-4 in. long) of a range of heathers.

Mr. Salter considered that it was important to remember labour costs when considering systems of this type as the low capital cost might mask high handling costs inherent in the systems. He felt that a more flexible system using mist under "walk-in" polythene tunnels would be more satisfactory particularly as a series of crops could be rooted in the same area in a single season thus off-setting the initially higher capital costs. A cautionary note was added here on the use of the dense white polythene, available in Great Britain for "walk-in" tunnels. Whilst this type of polythene seemed to provide a good growing enviroment in conditions of high light intensity, some nurserymen had found that the reduction of light was too great in poor light conditions in spring.

In conclusion it was felt that the types of structure described provided the nurseryman with a number of alternatives which might fit into his system of production. It was important, before adopting one of these systems, to consider the end product the nurseryman wished to achieve and to use the system appropriate to this. It might be worthwhile to divide the subjects being produced by cuttings in a nursery into those which were difficult to root, where traditional methods would give the best results, and those subjects which were easy to root, where a simpler method provided by the use of polythene tunniels might be successfully adopted.

DISCUSSION GROUP REPORTS

Group B.

Field Budding

CHAIRMAN — STEPHEN HAINES

The Group was mostly composed of members with considerable experience in the practice of budding. We were, therefore, able to be fairly specific in our discussion, having a useful blend of commercial, research and advisory experience to draw upon, and it is proof of the interest in this subject that such a knowledgeable group wished to exchange views and information.

On 20th July several members had attended the Open Day at East Malling Research Station, when field budding problems had been discussed. Talking to various growers and to the East Malling staff during the visit, it was apparent that many had suffered low bud takes due either to frost damage or to other reasons which were not too obvious. Although at East Malling the frost damage was on apple buds, many growers were more concerned with bad bud-take on *Prunus* species, particularly on the ornamental cultivars.

The Chairman, having encouraged everyone to take part in the discussion, launched the debate in typically "John Blunt" fashion by might mask high handling costs inherent in the systems. He felt that a more flexible system using mist under "walk-in" polythene tunnels would be more satisfactory particularly as a series of crops could be rooted in the same area in a single season thus off-setting the initially higher capital costs. A cautionary note was added here on the use of the dense white polythene, available in Great Britain for "walk-in" tunnels. Whilst this type of polythene seemed to provide a good growing enviroment in conditions of high light intensity, some nurserymen had found that the reduction of light was too great in poor light conditions in spring.

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The Chairman, having encouraged everyone to take part in the discussion, launched the debate in typically "John Blunt" fashion by asserting that, "we are less capable of achieving high bud takes than were our predecessors. What are the reasons?".

C. G. Thomas from Long Ashton Research Station suggested that virus infection could be a contributing factor and wondered how many growers were using virus-tested material for propagation. He said that bud take at Long Ashton had been improved with *Pyrus malus* and apple varieties since the inception of virus-tested rootstocks and bud-wood. They also used the inverted T method of budding and subsequent growth had improved. Commercial growers felt that in budding cherries there was little obvious benefit between using clonal stock 'P. F. 12/1 and *P. avium* seedling stocks; there seems to be little factual evidence one way or another.

The Chairman then listed the following figures for ornamental cherries which represent the percentage of live buds on the same nursery but in different years.

Prunus cultivar	Percentage live buds	
	A.	B.
P 'Accolade'	57	90
P. avium 'Flore pleno'	57	86
P. serrulata 'Kanzan'	37	90
P 'Pink Perfection'	77	98
P. serrulata 'Hillierii Spire'	66	86
P. serrulata 'Tai Haku'	42	90
P. serrulata 'Ukon'	45	77

List A is for trees budded on stocks planted in ground which had previously been heavily manured; the stocks grew vigorously, and simazine (1½ lbs/acre active ingredient) was applied in spring before budding and in autumn afterwards. Trees in List B received neither manure nor simazine and stocks grew less strongly. All buds had the wood removed. List A represents the typical bud take over the past five years.

Some time was spent exchanging opinions on vigour of root-stocks at time of budding, the ideal stock to plant, timing of budding, selection and condition of budwood and herbicide treatments, and reference was made to the I.P.P.S. budding experiments. Was the breaking-over of the stock before or after budding beneficial, particularly with *Acer platanoides* cvs. or *Betula* spp? John Gaggini told us of the success he had seen with birch budding in America but no member could claim any consistent success.

Peter Wiseman stressed that production of ideal budding wood could be achieved from well managed hedges or mother trees, rather than from using wood from production areas. One member observed that wood sent by post usually succeeded despite sometimes being far from peak condition, and most of us had to agree. In fact H. R. J. Byford had received wood in various ways, some wrapped in cotton wool and others with their leaves still attached, yet even these had produced a fair crop. We wondered whether, perhaps, we should let buds and stocks go past their fastest growing period before budding. M. E. Roberts mentioned success with *Acer negundo* cvs. budded in September and others had had similar experiences.

Many references had been made to the various forms of budding and H. R. J. Byford of East Malling and C. G. Thomas of Long Ashton were surprised at how many nurserymen still removed the wood from the back of the bud; for many years they have left the wood in the bud — the bud being thinly cut. Now with *Malus sylvestris* and apples they favour chip-budding which, as some of us had seen at East Malling, gives more growth in the maiden year. Dr. Altman had some experiences with chip-budding citrus, using six-month old rootstocks and very soft budding wood, which had given good results. In Dr. Robinson's talk, it was mentioned that in Japan the plastic ties binding the chip buds were removed the following spring; but at Long Ashton we were told, five weeks after budding is considered the best time for removal. Apparently there is little experience so far in chip-budding cherries and we wondered how *Acer* would react to this method. D. Leaman said that he left the wood in his *Acer* buds and felt it was worth trying chip-budding.

Following our discussion, many of us will be trying these different methods of budding and of rootstock culture before and after budding The commercial members felt their problems had been given a real airing and the non-commercial members seemed moved to look into the obvious difficulties confronting the trade. We look forward to meeting again to compare our results a year hence.

DISCUSSION GROUP REPORTS

Group C.

Bench Grafting

CHAIRMAN — DOUGLAS WEGUELIN

The Chairman opened the discussion by giving a list of subjects for which bench grafting was particularly important, either because they were difficult to root by other means or because, when raised from seed, they might produce very poor forms. The list included —

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Acer, particularly *A. palmatum* 'Dissectum' forms
Berbris x lologensis
Betula spp.
Cedrus atlantica 'Glauca'
Cytisus battandieri
Fagus spp.
Hamamelis
Juniperus
Malus spp. (a useful way to build up stock).
Picea pungens 'Koster'
Pinua spp.
Prunus spp.
Rhododendron spp.
Robinia pseudoacacia 'Frisia'
Rosa spp. especially *Rosa* 'Mermaid'.
Wisteria.

The first subject discussed was *Wisteria*. Stocks raised from seed sown in spring should be ready for grafting in the following spring The top of the stock should be cut well below any eye and a wedge graft should be used. The plant should then be potted and put on gentle bottom heat They callus quickly and grow away very fast When stocks are short, pieces of roots can be used with very good results

The second subject was *Pinus*. The question was raised as to whether it was necessary to use a five-needled stock for grafting a five-needled variety, likewise a three for a three? Could *Pinus sylvestris* be used for most pines? M G Adcock claimed that the stock was not all that important though the growth of the tree could be regulated by the type of stock used. He grafted *P pinaster (P maritima)* on *P. strobus* but a good rule was to graft the smooth-barked varieties on *P. strobus* and the rough-barked ones on *P. sylvestris*. The Japanese use very dwarf stocks for their Bonsai work.

Magnolia. It was agreed that *M. kobus* was the best stock, but it was an advantage to use a stock different from the scion as suckers were so difficult to see. A lot of work could be done on chip budding, which was widely used in Japan.

Betula. Why is it sometimes difficult to get the scion to start growth? It was suggested that the cause might be that the scion wood was too soft; harder wood was preferable. The plants should be kept in the grafting house until the first flush of growth was over, then they should be planted out and they would grow away again. It was very important to have the stocks well dried off before grafting. Bare-rooted stocks can be grafted quite successfully if potted ones are not available.

To the question "How do Hilliers manage an 80% take with birch grafts!" — their answer was, "We have just celebrated our Centenary!"

Cedrus atlantica 'Glauca'. If 1-year seedlings of *C. deodara* are potted up they will be ready for grafting the following autumn or spring. Autumn grafting is preferable and is best done in a cold frame where the temperature does not rise above 65° F. When grafting in the spring, use only very little bottom heat or the roots will be killed. Adcock stated that at Hilliers they often grafted cedars in the frame which the stocks had been bedded in — leaving the grafted plants in the same frame.

Fagus. Difficulties arise whenever grafting is done too late and after the sap has begun to rise. The conclusions drawn were that whenever possible grafting should not be done when the sap is rising, the stocks should be very dry, and if grafting was unavoidably late, it was suggested that a cut should be made below the graft to drain the sap thus preventing flooding the scion. This technique might also be applied to *Betula*.

Cytisus battandieri. This should be grafted on 1-year *Laburnum* seedlings, using a whip and tongue graft which will unite rapidly if given bottom heat. The scion wood should be taken from proven good flowering stock plants; some seedlings flower very badly.

Hamamelis. Problems arise in obtaining adequate stocks of *H. japonica* and *H. virginiana*. An allied plant, *Distylium racemosum*, is easy to graft on and can be grown from cuttings; it has the advantage that suckers are easily recognised, but little is known about its hardiness. It was advised that it should be planted deeply with the union below ground level. More research is needed on this stock.

Picea pungens 'Koster'. A discussion arose on how the Japanese technique of splitting the stock, described by Dr. Robinson in his paper at the current conference, might be used for this subject It was thought to be worth trying. White plastic bags to protect and maintain the right environment for soft scions was also worth consideration The discussion ended with a simple demonstration of tying a graft with a rubber band, which avoided making an actual knot and saved a lot of time; simplicity to perform but, regretfully, too complicated for your reporter to describe in words!

The final conclusion of everyone was that these small discussion groups were an excellent innovation and a 'must' for future conferences.

DISCUSSION GROUP REPORTS

Group D.

Azalea Production

CHAIRMAN — ARTHUR R. CARTER

The Chairman was hopeful that the subject could be discussed under three headings: (a) stock plants, (b) propagation methods, (c) overwintering. The contributions from members were so plentiful that the discussion was not completed. However, this summary contains, in addition to the points brought out in discussion, the chairman's notes which covered all three sections. The whole session was a joint effort and no individual contributions are identified.

STOCK PLANTS

A more uniform crop will result if sufficient cutting material is available to produce a reasonable size batch at any one time.

The "age" of the material is important. Stock plants should be "young". Taking cuttings retains juvenility. Three year old stock plants pretty well stripped every year for five years produced about 250 cuttings per plant over the propagation season. It was suggested that if 30 cuttings were available from a small plant, 5 shoots should be left intact. Flower buds were produced and then a flush of useful growth developed.

Stocks plants under protective cover produce earlier cuttings.

On the continent, stock plants in beds have the flower buds removed in February and are covered with plastic or glass at the end of March. An article by David Leach suggests bringing stock plants into a glasshouse before any autumn foliage change occurs. Give minimum night temperature of 60° F. Use 75 watt internal reflector bulbs at 3 ft. centres, 30 inches above tips of plants. Either use continuous lighting from dusk till dawn or give 5 to 15 seconds every minute. By late November, first crop of cuttings is ready. Six weeks later a second batch is available. Early cuttings can be given lights and the tops can then be taken out for rooting.

Other work suggests that increasing the day length appears to increase shoot length, but has no effect on shoot number, or can even reduce it.

Work at Kinsealy suggests cuttings from plants under glass at 75° to 80° F are ready for collection about mid-April. This is two weeks earlier than those under plastic and four weeks earlier than those outside.

Martin Hall successfully uses polythene tunnels for advancing cutting material. The mother plants are not covered during autumn and winter.

Number of Cuttings. This varies according to cultivar. Kinsealy quote 'Gold Dust' as giving up to 300 cuttings from two 4 year old bushes. Mr. Thorburn, prior to the meeting, gave the chairman figures showing 25,000 cuttings from 380 six-year old plants of Exbury azaleas. Cultivars, Ballerina, Cecile and Exbury White were said to be shy producers and Balzac, relatively shy.

PROPAGATION METHODS

Type of Cutting. Usually soft-wood 6 to 9 cms long. Generally the earlier the cuttings are taken, the better the chances of successfully overwintering them.

Work at the University of Minnesota showed that semi-soft, fully expanded cuttings taken in the late stage of growth rooted better than succulent cuttings still elongating. Also, cuttings with a hardwood base, but with a still-expanding terminal growth in early spring, rooted as well or better than softwood cuttings.

In Volume 17, No 1, *The Plant Propagator,* February 1971, was an account of work carried out by two exchange students at Jim Wells Nursery. Here cuttings were 7.5 cm long and either buttersoft, without a terminal bud having been formed, or very hard with a terminal bud The hard cuttings had better roots and a higher percentage rooted.

During discussion it was stated that cuttings rooted after mid-July formed flower buds. One member described a suitable time for taking cuttings as when four fully unfolded leaves were present and no terminal bud had formed. It was stated that rooting directly into pots eased the overwintering problem. Another view expressed was that single cuttings in peat pots were not as good as rooting in peat in boxes.

Cultivar response. Work at Kinsealy gave the following results:

At a period of nine weeks from insertion on 5th June:

'Berryrose', 'Golden Girl' and 'Ballerina' gave . 50% or fewer rooted.

'Strawberry Ice', 'Klondyke' and 'Cecile' . 62 — 66% rooted

'Gibralter', 'Kathleen' and 'Gold Dust' . 87 — 100% rooted.

However, timing is also important for some cultivars, as cuttings inserted earlier gave poorer results: for 'Strawberry Ice' (24%) and 'Cecile' (33%), but 'Klondyke' (75%) and 'Kathleen' (87%) responded well.

Martin Robinson, just over a year ago, listed the following as likely to root without much difficulty:

Knaphill and Exbury 'Berryrose', 'White Swan', 'Persil', 'Gallipoli', 'Marion Merriman', 'Toucan', 'Gibraltar', 'Klondyke' and 'Harvest Moon'.

R. x Kosterianum (R. japonicum x R. molle) — (often known as *Mollis/sinensis* hybrids) 'Kosters' Brilliant Red', 'Baron Edmond de Rothschild', 'Koningin Emma' ('Queen Emma'), 'Lemonara', 'Dr. M. Oosthoek', 'Mrs. Peter Koster', 'Adriaan Koster', 'Directeur Moerlands' and 'T. J Seidel'.

Wounding. Whenever you take a cutting you are bound to wound the tissue but, for the purpose of this discussion, wounding implies the removal of some additional tissue. Dutch recommendations include wounding for *Rhododendron luteum (A. pontica)* hybrids but not for *R. (A.) indicum, R.* x *Kosterianum* or *R. (A.) obtusum* hybrids.

In the trial at Jim Wells' nursery mentioned under "Type of Cutting," wounding had no significant effect on the rooting of 'White Swan' and 'Firefly'.

Kinsealy work also indicates that there is no significant advantage derived from wounding. Roots are formed along the stem.

Treatment with root promoting substances. Fashions vary. Some propagators used a powder dip on most subjects. Some members dipped all azalea cultivars in IBA, 0 3 powder (Seradix 2). Increased rooting in cultivars, Balzac, Ballerina, Golden Girl and Strawberry Ice was obtained by using IBA 0.8% powder (Seradix 3).

Work at Boskoop suggests no growth substance is necessary. In a trial in U S A using cv. Red Wing, untreated cuttings yielded the highest rooting score Commercial rooting compounds containing a mixture of NAA, NAAA and IBA gave poorest results. A herbicide 2,4,5-T, was also used. At 40 ppm it gave the earliest rooting, but in other work it gave poor results and seriously reduced the take. Cultivar, Coral Bells, rooted less easily and responded to IBA

Fungicidal dip. Various materials have been used. Captan at 5 to 15% has been quoted and benomyl also has its champions. In Holland, nurseries visited by Miss Helliar and Miss Scott all used benomyl as a dip, prior to insertion, though one grower found some varieties were liable to scorch and were now sprayed when rooting started This seemed rather late.

At Brooksby Hall, dipping in captan solution was better than dipping in water. Benomyl was better in trials in U.S.A. as a 5% dip than as a drench (add 9 parts of 60% w.p. benomyl to 100 parts rooting powder). Members were generally agreed that some fungicidal dip was useful and the preference was for benomyl (Benlate).

Rooting medium. It should be well drained. Adding fine sand can fill in spaces between peat particles and reduce drainage. It should be acidic, a range of pH 4.5 to 5.0 is often quoted. Calcium is important and ground limestone should be added to very acid peat In Holland, 2 to 3 kg per cubic metre is added to peat with a pH of 3-7 Frequent applications of hard water can alter pH. Use of thin plastic film plus shade should be considered as an alternative to mist where water is very hard. Kinsealy found peat best overall rooting medium, although peat, sand, 2:1, gave quicker rooting. A mixture of 40% polystyrene granules, 40% loamalite, 10% fused mica and 10% peat was reported to be giving a higher rooting percentage and a compact root system

Lighting during rooting. This is unlikely to be much use during long summer days, but earlier or later in the year it would be worth trying

OVERWINTERING

Problems arise with late struck cuttings, particularly with deciduous azaleas Various methods of reducing losses have been suggested

(a) avoid distrubing the rooted cuttings until spring,
(b) Storage in cold store until spring,
(c) extending day-length by lighting 60 watt bulbs, 4 ft apart, 30 in. above cuttings to give 16 to 18 hours total day-length is useful. It must be started early (end July) before onset of dormancy or leaf fall. Continue treatment until leaves colour or fade, then stop. It can produce somewhat leggy cuttings and it would be interesting to see the effect of a pinch, provided it was early enough for extension growth to be produced.

GRAFTING CAMELLIA SINENSIS

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Abstract. Grafting *Camellia sinensis*, the tea plant, has only recently become a commercial practice. This paper describes two methods, based on the cleft and stub grafts, which have proved successful.

INTRODUCTION

Malawi, where the techniques were developed, lies in the Southern tropics. The tea growing areas, at the foot of two mountains, (which cause the necessary high rainfall for tea culture) are about 3,000 ft above the sea level, thus temperatures are not excessively hot.

The four seasons can be described as:

December to March	—	hot and wet
March to June	—	cool and damp
July to September	—	cool and dry
October to November	—	hot and dry

Although Malawi only produces about 1% of the world's tea, the industry is a major one for the small country. Tea is a fairly conventional crop but tends to be surrounded by a shroud of oriental mystique There are three factors which make it differ from other crops·

a) it is an evergreen
b) it is a woody perennial used for its leaves
c) plant populations of 3500 per acre are usual (up to 10,500 have been considered) which means a large scale nursery with low production costs

The plant is usually trained to a small bush about 30 inches high with a flat surface of 16 sq ft This is a convenient height for the pluckers when harvesting.

If it is allowed to grow unpruned and planted at a wide spacing, it will develop into 30 ft high bushes, with a well developed frame Such plants are grown for seed production and form the usual rootstocks for cleft grafting

CLEFT GRAFTING METHODS

The best season for cleft grafting is June to August when there is no sap flow in the stock plants. Should the grafts made in this season fail, ther is an opportunity for re-grafting in September / October.

Ideally the rootstock is 6 or 7 years old with several branches about 3 inches in diameter. Bushes up to 40 years old with 8 inch diameter stems, and young plants 2 years old with ½ inch diameter stems, have been successfully cleft grafted, but good results are not easily attained.

The first operation is to cut back the growth to 5 feet, then erect a shade over and around the plant. Just before grafting, five branches are removed. Any moss and lichens growing on the selected branches are removed. The stock branches are then cleft with a heavy knife. The direction of the clefts should follow the circumference of an imaginary circle, joining the five branches. Scionwood, which can be 6 months to 3 years old, with green to gray bark, is cut into about 9 inch lengths with at least 3 leaves. If the clone is large-leaved, the leaves are often halved. The lowest leaf is removed and the scion is shaped so that the cut starts about 1 inch above the lowest bud, with the bud on the outside of the scion. A wooden wedge, or the end of the heavy knife, is used to hold the cleft open while the scions are put into place. Besides aligning the cambium layers, care is taken to place the lowest scion bud just below the top of the stock branch. So far the system is similar to any cleft graft top — working procedure. The whole graft is now wrapped with moist sphagnum moss or foam plastic, held in place by a polythene tape. Then the scions and top of the stock are covered with a polythene bag which is tied just below the moss.

The graft is left like this for about 8 weeks until callus is obvious on both stock and scion. The use of the shade should now be evident. The sunlight is so strong that excessively high temperatures would rapidly build up in the sealed polythene bags, so that shade must be arranged to allow as much light as possible to penetrate *without* excessive temperature build-up. The shades need constant attention. The grafts may need the moss re-moistening and an aphid or caterpillar spray during the 8 weeks.

After callus has been seen, the bag is untied but left *in situ* as a weaning stage. A week or so later the bag and polythene tapes are removed, and after another week or so the shade is thinned. If shade reduction is delayed all the new scion growth is floppy, like "rubbery-wood" disease; however, normal growth takes place if the plant is pruned and the shade removed.

Comment. The union is very strong. In a few cases the wind may have broken the shoots above the union. It is for this reason that the lowest bud should be below the top of the stock. I have seen several trees with severe bark scorch when the shade has been removed before the polythene tape; there have been cases of the stock dying shortly after the union has taken place. There is no indication that the unsealed cleft has ever been the cause of trouble, in fact attempts to seal the cleft with hot or cold waxes or bitumastic products have seriously reduced the number of successful grafts.

Uses of the Cleft Graft. So far there are two practical applications:

a) Improving existing seed gardens.

b) The rapid build up of clonal material.

Seedgardens. Although seed is rapidly being replaced by vegetative propagation there is still a place for improved seedlings. In Malawi, plant improvement has been geared to quality rather than to quantity. At present five clones selected for quality and compatibility are grafted into a seed garden. Ultimately it is hoped to reduce this to two clones. Tea is always cross pollinated so with only 2 clones in a seedgarden it will be practical to collect the seeds so that the male *and* female parents are known.

Even from 5 clones the progeny produces excellent quality and much greater uniformity than the old seed types. If a seedling is to be used as seed bearer, about 8 years elapse between germinating the seed and harvesting a seed crop. Grafting an existing seed garden produces a seed crop in 3 years.

Clonal material. Growth from the grafts is very rapid, resulting in a large quantity of cuttings in a very short period. Eight months after the stock is grafted about 100 cuttings per bush are available If, at this time, the plant is pruned about 15 inches above the graft, a further 500 cuttings per bush are available during the next ten months. Had the scarce clonal material been used as cuttings, rather than scions, the plants would still be in the nursery and it would be another two years before they provided any cuttings at all The grafted bushes are not easy to manage for cutting production and it is my opinion that after a few years, planters will use clonal plants in the fields as a source for further cuttings.

STUB GRAFT METHOD

The other type of graft I have adapted successfully for commercial use in tea is the stub. A year old plant, in a polythene pot, is selected as the stock plant. An oblique cut is made, about 3 inches above soil level, so as to cut just less than halfway through the stem. The scion, which is usually a 6-inch piece of green-barked wood with 2 nodes, has its base shaped into a wedge with one long cut and one short cut. The scion leaves are usually halved to reduce the weight of the scion. The cut in the stock is opened by bending the stock branch and the scion is put in place. When the stock branch is released the scion is firmly gripped. No sealing or tying is needed.

The top of the stock branch is cut back to be slightly higher than the top of the scion. A polythene bag is carefully put over the whole plant, taking care not to knock the scion out of place. The bag is tied just below the level of the soil in the pot. The grafts are then placed in an area of shade I am developing another variation where grafted plants are put in sealed polythene tunnels rather than each have its own bag So far the results have not been so good as the bags

As soon as callus is obvious on both stock and scion, hardening-off can begin The first stage is to untie the string but leave the bag in place Later the bag is completely removed and the stock shoot cut away just above the union. Later the shade is gradually thinned. It seems that this graft can be successful at any time of the year. The controlling factor is the field planting of the grafted plants, which is restricted to December-January, and this works back to grafting in about March, or holding the plants a long while in the nursery

Comment. Once again the graft is left unsealed. A seal of "Flintkote" (an aqueous suspension of bitumen) has been found detrimental As yet there is very little known about the influence of the rootstock on the growth of a tea bush. However, extending the knowledge of apples, it seems possible that the rootstock will influence vigour and, in turn, yield. However, as rate of growth is usually inversely proportional to the quality of prepared tea, the rootstock might also influence quality. Trials are already in hand to investigate rootstock influences

Uses of the Stub Graft. The ease with which cuttings root is a clonal characteristic in tea. It is probable that if a clone of exceptional quality needed for a breeding programme was a poor rooter, then it could be stub grafted. Even on a large scale the production of composite plants is practical, although suckers may be a problem

SUMMARY

These two methods of grafting have become a practical proposition by using polythene bags to surround the leafy scions. Both methods are relatively simple and can be undertaken by unsophisticated labour It seems possible that the methods could be adapted for other species which are difficult to graft.

A CHEAP AND SUCCESSFUL METHOD OF GRAFTING ROBINIA PSEUDOACACIA 'FRISIA'

D KNUCKEY

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The title might suggest that the economic gain of this method is in the grafting of *Robinia pseudoacacia* 'Frisia'; however, from the start may I say that the cost reduction lies in the treatment of the grafts

We usually begin our bench grafting at the end of January onto stocks of *Robinia pseudoacacia* of pencil thickness and upwards. These are drawn from outside where they have been heeled in for the winter, and are then headed back to approximately 6 inches. The scion wood taken from the previous years growth is also chopped into 6 to 9 inch lengths

The graft itself is a shallow, simple side veneer about 2 to 3 in long, bound with grafting cotton, and sealed with paraffin wax The grafts when completed are bundled in 25 or 50 with damp moss between and around their roots. These bundles are then placed in polythene bags with their tops left open.

Although different nurseries seem to use different methods for after-treatment of bench grafts, some store their grafts in damp peat and keep them cool. We find that if the grafts are put into a temperature of 65° -70° F we get very quick callusing within 8 to 10 days.

We use no heated glass in the winter, apart from bench heating in our mist house, so to overcome this problem I first tried a few bags of grafts in our domestic drying cupboard, where there was a constant temperature of 65°—70° F There was an obvious necessity for cleanliness hence the use of clean damp moss and polythene bags. Naturally as I piled more in my wife became more annoyed so another method had to be found! This came quite unexpectedly one day when visiting a friend's Battery Poultry House; here again there was a fairly constant temperature of 65° -70° F. There was plenty of room at the end of the shed so our problem was solved, and the bundles of grafts stacked on their sides.

As stated previously the grafts were left in this warm 'chamber' for 8 to 10 days until well callused and the buds on the scions just beginning to break. They were then removed, the moss in the bags checked for moisture, and stood upright in a cold greenhouse where they were left until early April. Then they were planted directly into field rows and have since grown on successfully.

Having tried this method for two seasons, we found one slight improvement; we attained better and quicker callusing when the stocks were given the "heat treatment" and just brought to the 'bud-break' stage prior to grafting; then dried before actually grafting.

We have also used this method successfully with bench grafting *Prunus, Crataeagus,* top fruit, *Malus, Magnolia* and *Hamamellis.*

THE ROLE OF AUXIN IN ROOT INITIATION IN CUTTINGS[1]

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(Dedicated to Prof. Kurt Mendel, Rehovot, Israel, on his 70th anniversary)

Abstract. Root formation in bean cuttings was investigated in terms of its pattern in various tissues, the presence of leaves, and accumulation and transport of sugars with regard to auxin treatments It was found that root-forming ability of various types of cuttings was different, and that the presence of leaves was of prime importance in the expression of the auxin effect IAA enhanced sugar accumulation at the base of the cutting concurrently with root formation, and increased the transport of ^{14}C-labelled assimilates from the leaves in a basipetal direction. A general scheme for root formation is discussed and it is suggested that one of the roles of IAA in promoting rooting of bean cuttings is to increase sugar availability at the site of root formation

INTRODUCTION

Since 1934, when the identity of the "root forming hormone" and endogenous auxin was first established by Went and Thimann, IAA and other synthetic auxins have been extensively used in promoting rooting of cuttings The universality of auxin action is evident from Audus's analysis of 1240 sets of experiments with various stem cuttings (1): in most cases applied auxin improved rooting, 8.5% of the total did not respond to auxin, and only 5.5% were inhibited. On the other hand, it is generally found that plants which normally root with ease will usually respond readily to auxins, whereas poor rooters are much less responsive This, together with the fact that there is a definite relationship between the presence of leaves and buds on a cutting and its capacity to root (10, 15), suggests that the

[1]Thanks are due to Professor P. F Wareing for his interest and hospitality at the Department of Botany, U C W., Aberystwyth, Wales, where this work was carried out

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auxin effect is connected with substances produced in leaves and buds

Apart from hormones and various co-factors that had been shown to affect root formation (3, 4, 6), the nutritional condition of the cutting is known to the horticulturist to be of prime importance It was found that the number of roots on tomato cuttings was affected by the ratio of carbohydrates to nitrogen (9), and that starch was associated with the rooting ability (17). Several sugars were shown to have a positive effect on root initiation (16), and it was suggested that in certain cases the main function of the leaves in the process of rooting is to supply the cuttings with sugars and nitrogenous substances (15). It is of interest, in this respect, to note that the advantage of mist propagation of some plants is a result of the fact that the physiological activity of the leaves and the build-up of dry matter continue at a normal rate (8).

Although being extensively used, the role of auxin in promoting root formation is not well understood It might directly affect the differentiation of the primordia, or increase the quantities of carbohydrates (and other nutrients) that are essential for root formation This latter possibility was investigated in the present study

MATERIALS AND METHODS

Plant material and rooting experiments. Seedling of dwarf bean, *Phaseolus vulgaris* L cv. Canadian Wonder, were raised in John Innes No. 1 compost in a glasshouse. Eight to ten day old seedlings were used in all experiments. At this stage the seedlings had a fully-elongated hypocotyl, an epicotyl with the pair of primary leaves and an apical bud. Cuttings were prepared by removing the cotyledons and excising the hypocotyl 5 cm below the cotyledonary node. Except where mentioned otherwise, the blades of the two primary leaves were trimmed to a uniform area using a circular cutter of 3.7 cm in diameter (Fig. 1). Cuttings were introduced into glass vials containing distilled water or indole-3-acetic acid (IAA) at a specified concentration, the hypocotyl being completely immersed in the solution. The cuttings were transferred to a growth cabinet maintained in the dark at $24 \pm 1°$ C. After a period of 24 hr treatment with the hormone, the cuttings were rinsed and transferred to vials containing tap water and 5 ppm H_3BO_3 and kept in a growth cabinet maintained at $22 \pm 1°$ C and a 16 hr photoperiod.

Data on number of roots produced on each hypocotyl were recorded either 7 days after excision, when roots were completely visible, or 4 to 5 days after excision following staining of the primordia with aceto-carmine. In some cases other types of cuttings, prepared from older seedlings, were used, and these included: epicotyl cuttings (epicotyl excised 1 cm above cotyledons and primary leaves treated as above), internode cuttings (1st in-

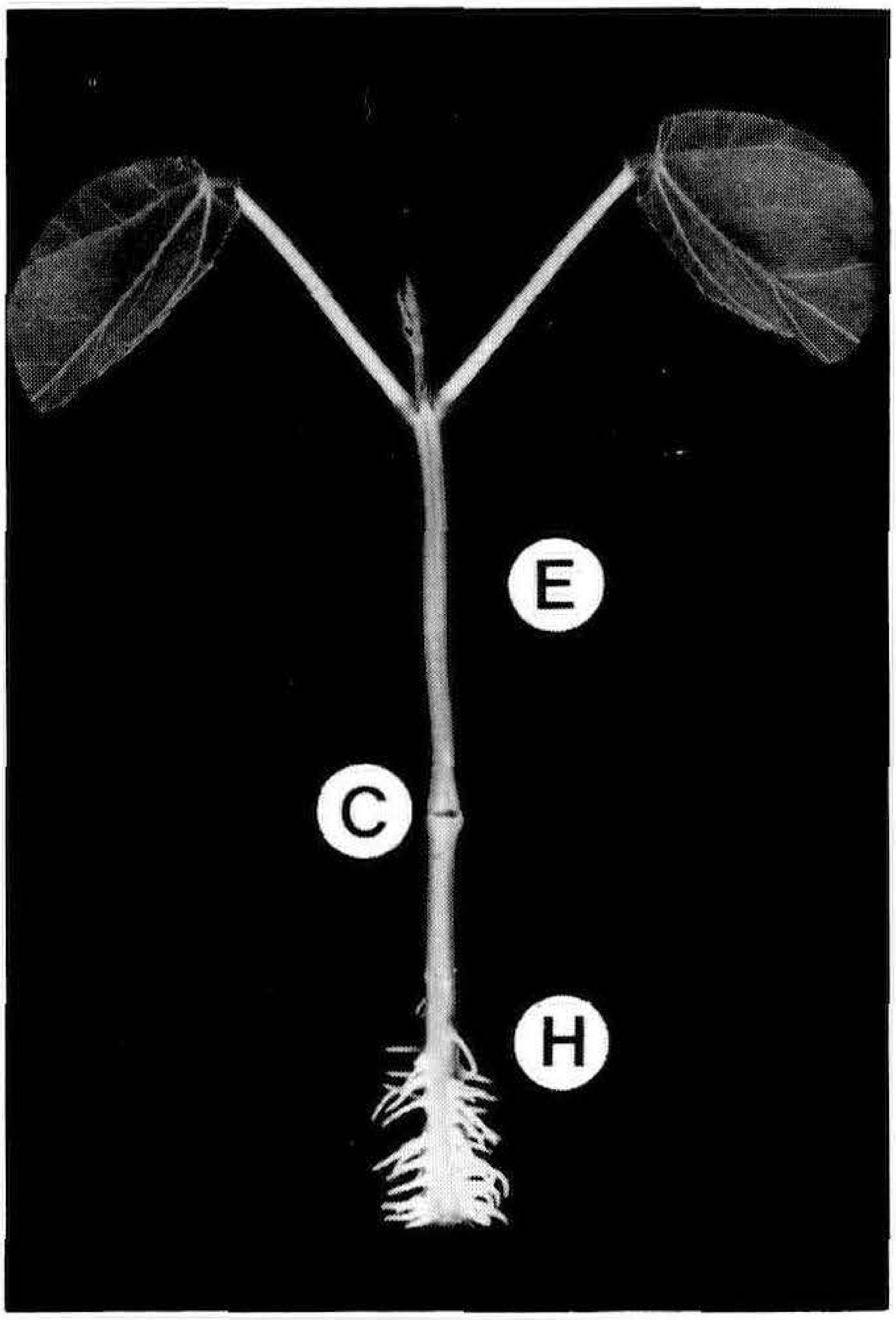

Fig. 1. Standard bean cutting used in the experiments, after 7 days in culture.
H= hypocotyl; E= epicotyl; C= cotyledonary node.

ternode excised 1 cm above the primary leaves node, the two side leaflets of the 1st trifoliate leaf were trimmed as mentioned and central leaflet discarded) and petiole cuttings (petiole of the primary leaf cut 1 cm above the node and leaf area reduced).

Uptake of IAA. Uptake and transport of IAA was followed in standard cuttings during the 24 hr period after excision, using the isotopically-labelled hormone (3-indolyl acetic acid 2-C14 ammonium salt). The label was counted in successive sections of the cuttings, after being extracted in hot 80% ethanol. Experiments were performed in an illuminated growth cabinet (as mentioned above).

Sugar accumulation. This was followed during a 4 day period after excision, in standard and in starved (seedling raised for the last 2 days before excision in the dark) cuttings. Hypocotyl sections were extracted in hot 80% ethanol and soluble sugars determined with the anthrone reagent. Experiments were performed in an illuminated growth cabinet.

Transport of ^{14}C-labelled assimilates. One of the primary leaves was exposed to a pulse of $^{14}CO_2$ by sealing assimilation vials containing ^{14}C-Na_2CO_3 onto the lower surface of the blade. The radioactive CO_2 was released by addition of HCl, and the leaf was allowed to assimilate for 1 hr after which the vial was removed. The cuttings were left for an additional period of 23 hrs for transport, and successive sections were then extracted as described above. ^{14}C-labelled assimilates were counted in the extract. All experiments were performed in the light.

RESULTS

Patterns of root formation. Since this study is concerned with the influence of IAA treatment on carbohydrate reserves, our first aim was to establish the relationship between leaves (as the source of assimilates), root formation and auxin.

The relative effect of the presence of leaves and buds is seen in Fig. 2. Leaves were the major factor in root formation, while the presence of the apical bud seemed to play a smaller role as judged from the control cuttings. Furthermore, the presence of leaves was essential for the expression of the auxin effect, since with leaves IAA increased root formation above the control (of intact cuttings). This is also illustrated by the data of Table 1 where the effect of leaves and IAA is shown for various types of cuttings. Partial or complete defoliation caused inhibition of root formation in hypocotyl and epicotyl cuttings.

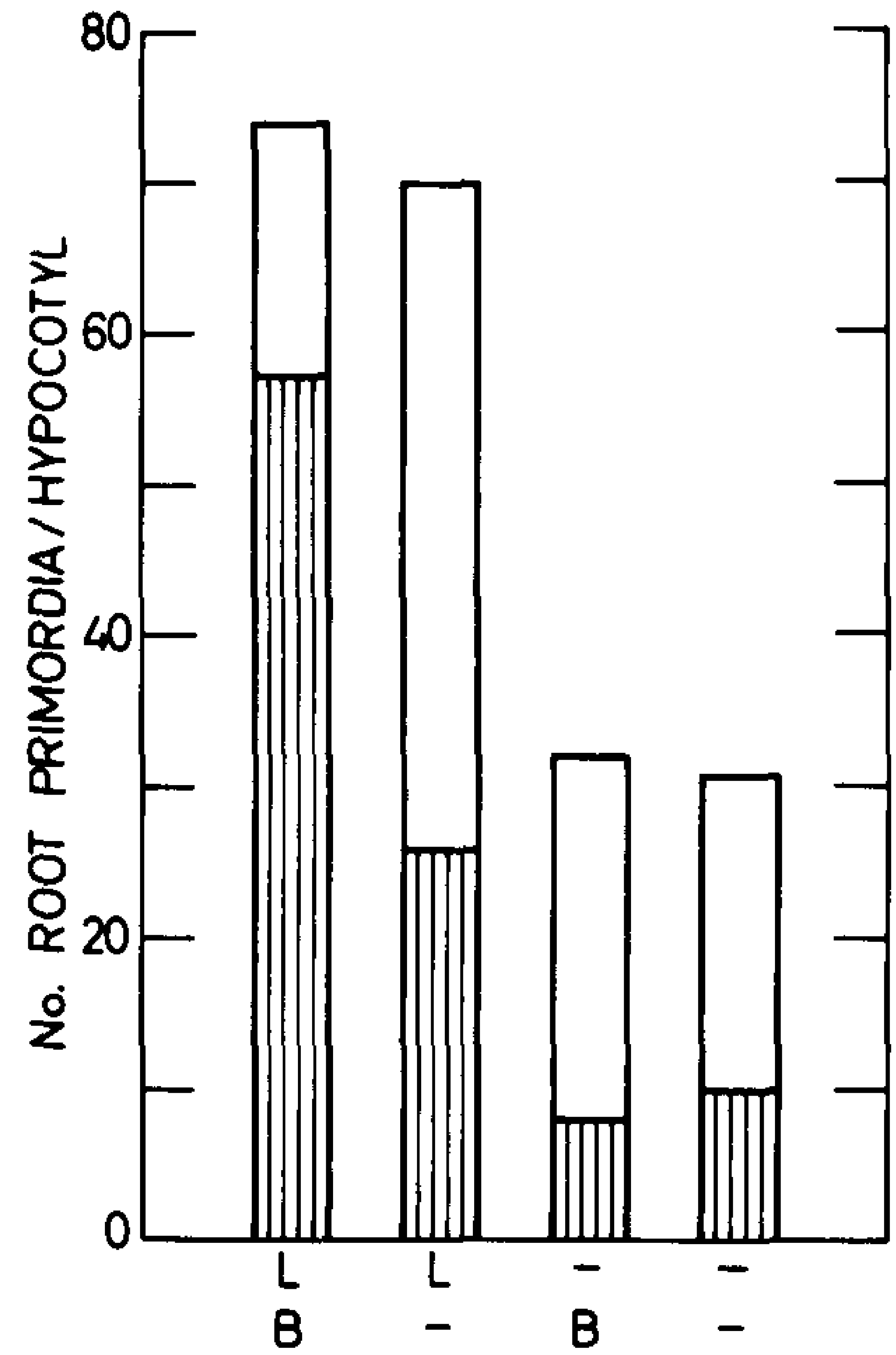

Fig. 2. The relative effect of the presence of leaves and apical bud on root formation in standard cuttings, in the control and with 5 x 10^{-5} M IAA. L = leaves (not reduced); B = apical bud; striated columns = control; white columns = addition with IAA

Table 1. The effect of leaves and IAA (2 x 10^{-5}M) on the number of root primordia in various cuttings from 10 day-old seedlings (counted after 7 days in culture).

	No. of whole leaves	No. of root primordia per 5 cm cutting		
		Control	IAA	IAA, % of control
hypocotyl	2	66	88	133
	1	51	76	151
	0	19	33	177
epicotyl	2	28	93	336
	1	21	79	383
	0	13	21	170
petiole		6	73	1327

Due to intrinsic differences in the "rooting ability" between "leafy" hypocotyl, epicotyl and petiole cuttings, the combined effect of IAA and leaves was also different. Thus, percentagewise, the enhancement by auxin in hypocotyl cuttings was greater when leaves were absent, while in epicotyl cuttings the presence of leaves seemed to be more important. This difference is illustrated also in Fig. 3 with regard to the position of the root primordia. In hypocotyls, roots were formed in 4 distinct rows in association with the vascular tissue and auxin only increased the number of primordia. In epicotyls and petioles, where the arrangement of the vascular tissue differs, roots appeared to form at random (and auxin increased the number of primordia).

In another experiment older seedlings were used to include cuttings of the 1st internode. Fig. 4 shows the "root forming ability" of cuttings from different positions on the seedlings, proceeding from "root-like" tissue as the hypocotyl, to successive distant "shoot-like" tissues. Roots were formed abundantly in the hypocotyl even in the absence of auxin treatment, while auxin was found to be essential for the establishment of epicotyl and internode cuttings. Petioles treated with IAA had many primordia, although at this stage these had not fully developed into roots, while none were formed in the control.

Uptake and transport of IAA. Before going any further as to the mechanism of auxin effect, it was of interest to establish how the IAA was distributed in the cuttings under the experimental con-

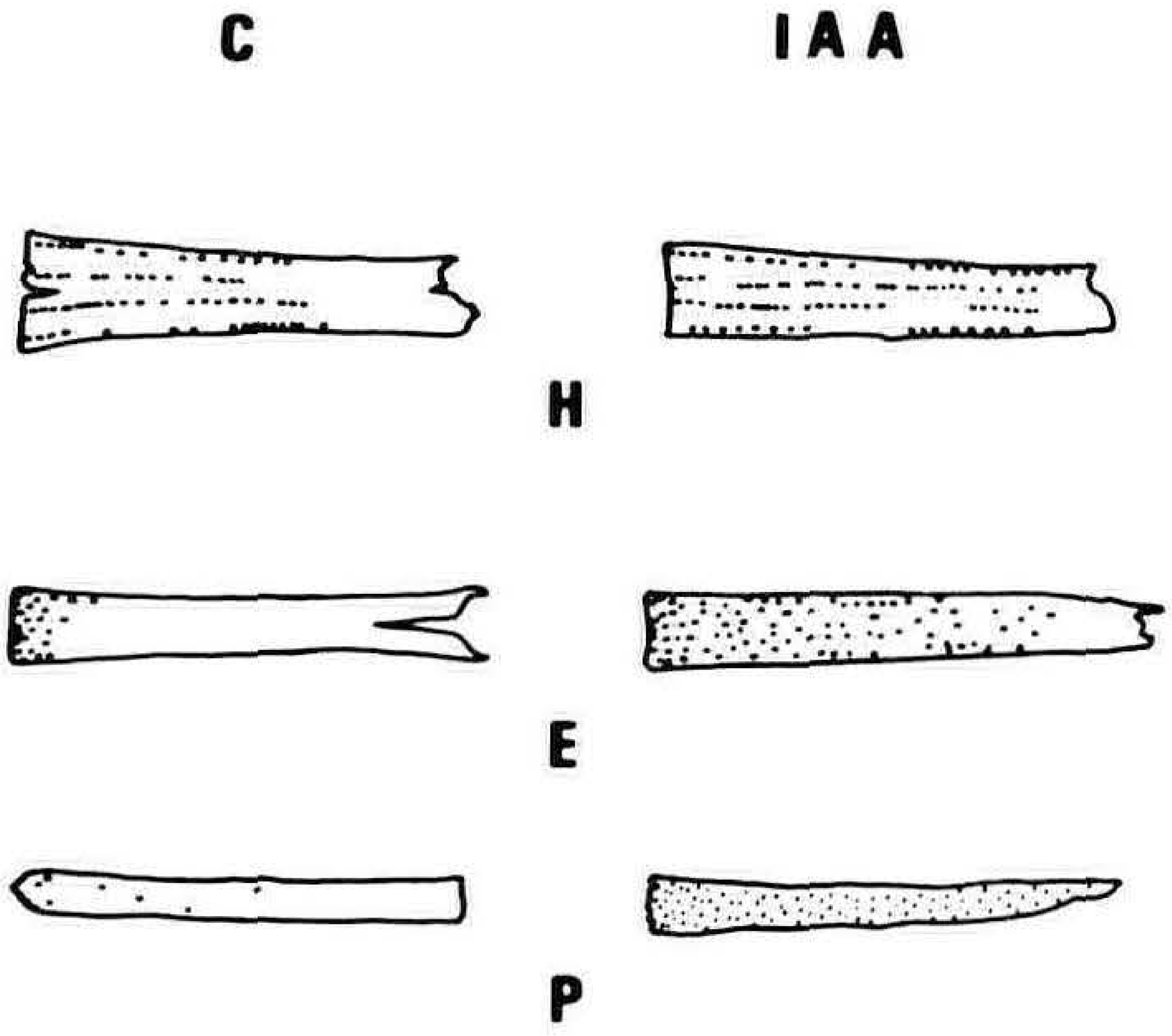

Fig. 3. The position of root primordia in 3 different types of cuttings (with leaves); in the control (C) and with 2 x 10^{-5}M IAA. Redrawn from stained specimens.
H = hypocotyl; E = epicotyl; P = petiole.

ditions. This is of primary importance in any discussion of possible sites of IAA action.

Data of an experiment where cuttings were placed in solution of radioactive IAA are given in Table 2. The majority of the label was retained in the hypocotyl, to which it was applied, and only 10 to 13% was transported to other parts of the cuttings. However, this transported fraction reached the upper parts in the first 2 hr. Thus, at this early stage auxin was present in the transport system (epicotyl and petioles) as well as in the blades, where photosynthesis and carbohydrate interconversions are carried out.

Accumulation of sugars. After establishing that root formation was markedly inhibited in the absence of leaves, while being promoted with IAA, the possibility that these two phenomena are interrelated through the accumulation of carbohydrate at the base of the cutting was investigated.

In Fig. 5 results of an experiment in which sugar accumulation was followed during 4 days after excision of the cuttings, are shown. Sugars accumulated slowly in the base of control cuttings, the rise in accumulation was evident only after 24 hr. The IAA-treated cuttings evinced an initially smaller accumulation of sugars, but 12 hr after preparation of the cuttings the levels of sugars were found to be similar to those of control. Twenty four hours after the start of the experiment sugar content was considerably increased in the presence of auxin, the levels being almost twice those of control cuttings.

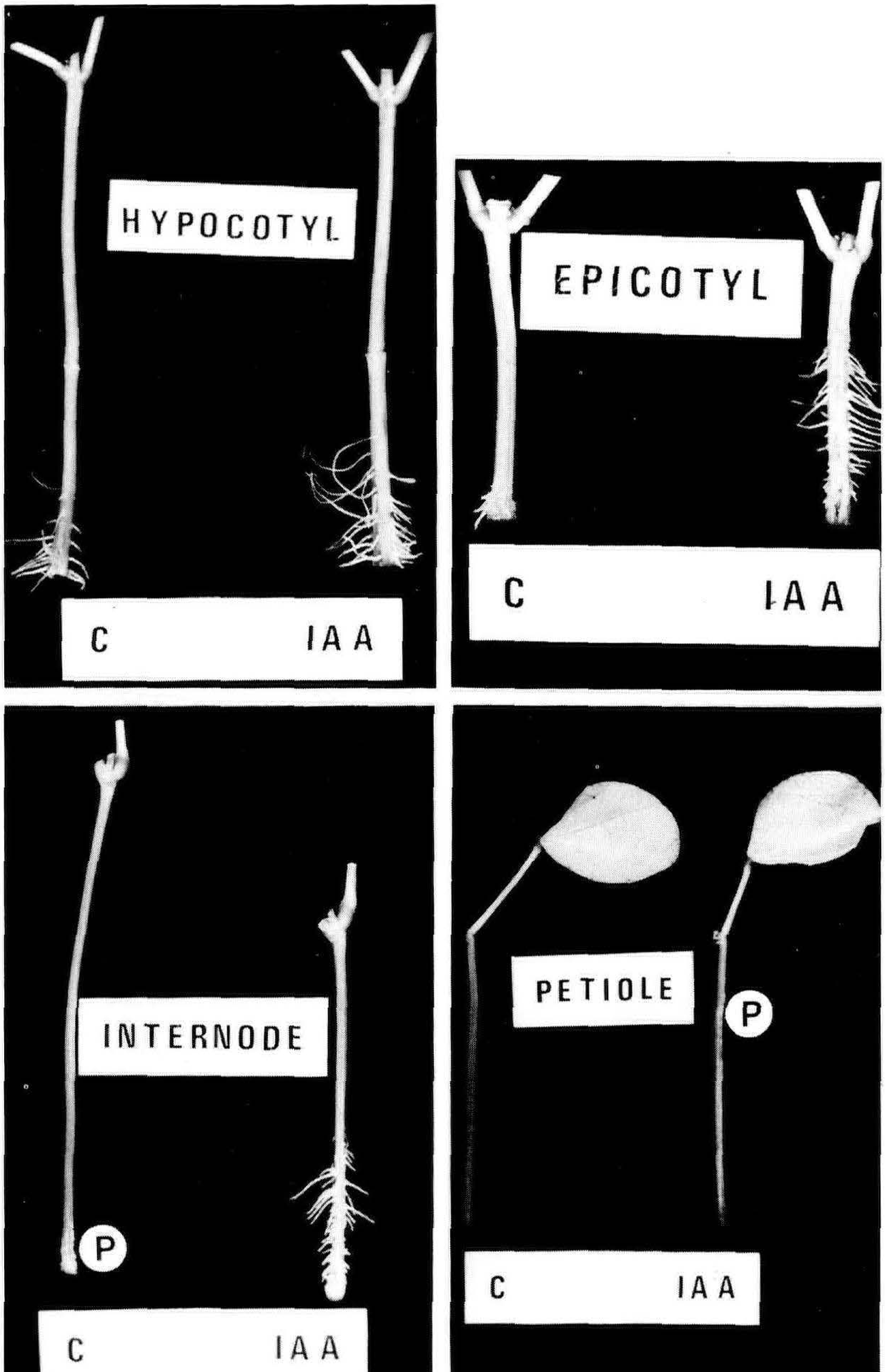

Fig. 4. Root formation in 4 different types of cuttings prepared from 21 day-old seedlings, in the control (C) and with 5 x 10^{-5}M IAA. All cuttings possessed leaves at the time of rooting.
P = root primordia.

Table 2. Uptake (by the hypocotyl) and transport (to other parts) of ^{14}C-labelled IAA in standard bean cuttings. The radiocarbon was counted in sections taken at various periods after the excision of the cuttings: A = 5 cm hypocotyl; B = 5 cm epicotyl; C = rest of epicotyl and apical bud; D = petioles of the 2 primary leaves; E = blades of primary leaves.

Hr after excision	DPMx10^{-3} / 100 mg dry weight					
	A	B	C	D	E	
2	232	28	11	6	6	
4	430	44	15	10	8	
8	825	84	31	21	14	
24	1385	133	60	42	51	
	DPM, % of total					
	A	B	C	D	E	B-E (% transported)
2	87.2	6.3	1.4	1.7	3.4	12.8
4	89.7	5.3	1.1	1.6	2.3	10.3
8	90.0	5.1	1.0	1.4	2.5	10.0
24	89.3	4.3	1.0	1.6	3.8	10.7

A comparison of sugar accumulation under the effect of IAA in green standard cuttings and in cuttings prepared from starved seedlings (Table 3) further substantiates the relationship between root formation and sugar accumulation. Sugars accumulated in the hypocotyl during the 24 hr period, and this accumulation was considerably greater in the presence of IAA in both types of cuttings. The level of sugars in IAA-treated starved cuttings was found to be higher than that of the control green cuttings. Percentagewise, the effect of IAA in starved cuttings was greater than in green ones, as a result of an initial lower sugar content in starved seedlings. In the same experiment, green cuttings had 56 roots (per hypocotyl) in the control and 76 roots in the IAA treatment, compared with starved cuttings that had 30 roots in the control and 66 roots with IAA. Thus, there was a close relationship between the enhancement of sugar accumulation and the formation of roots in the presence of auxin.

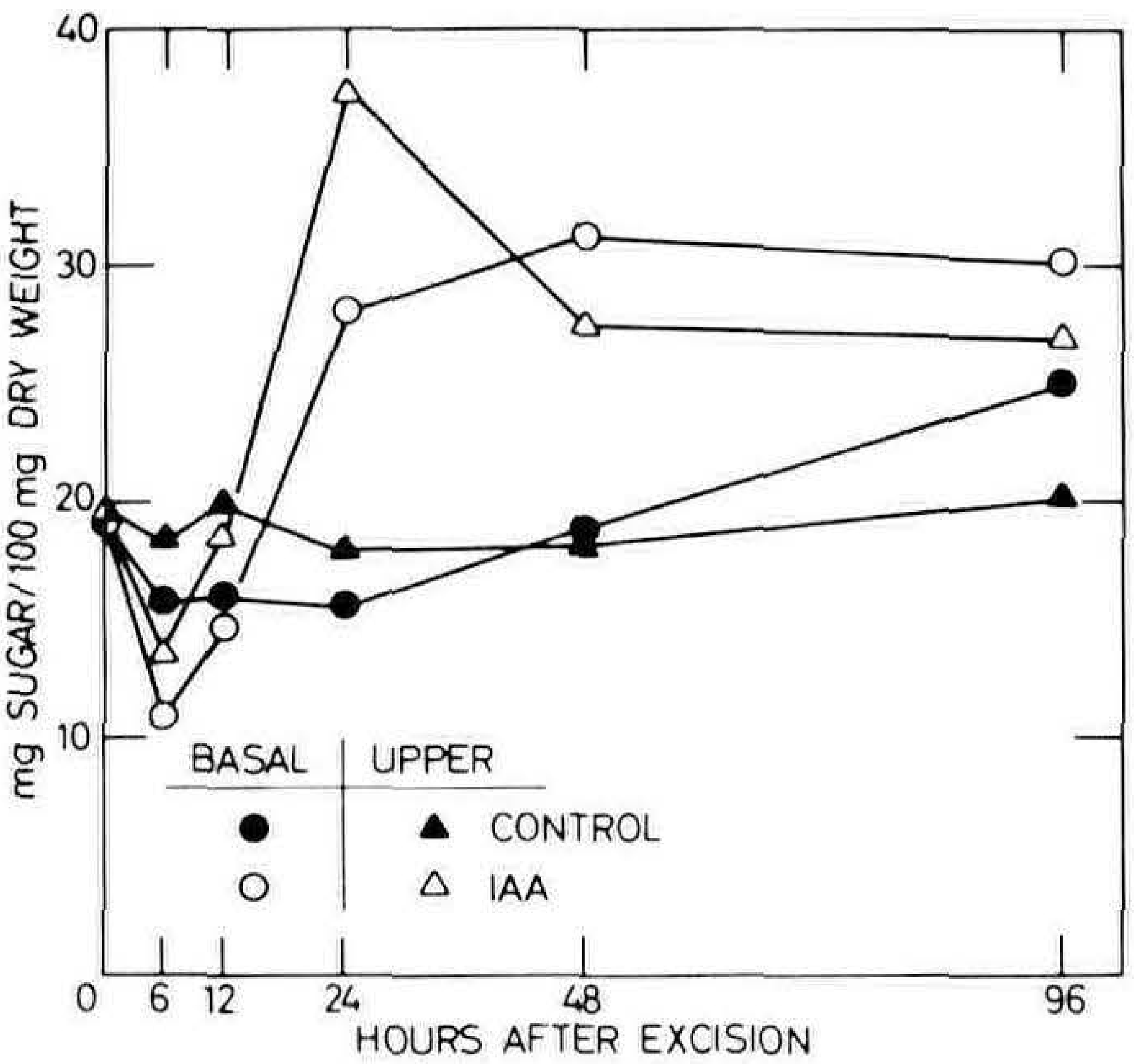

Fig. 5. Sugar accumulation in basal and upper segments of the hypocotyl during 4 days after excision of cuttings. Cuttings were treated during the first 24 hr either with water (C) or with 5 x 10^{-5}M IAA.

Transport of ^{14}C-labelled assimilates. One of the mechanisms by which IAA can enhance sugar accumulation at the base of the cutting is by directly affecting its transport from the source where they are produced (assimilated in the leaves). This possibility was tested after feeding the leaves with radioactive carbon dioxide.

Data of one such experiment are presented in Table 4 from which it is evident that IAA markedly increased the transport of labelled assimilates to the base of the cutting (more than 4 times of control). This increased basipetal transport was due to the fact that assimilates were more readily mobilized from the upper parts (Table 5): 49.9% of the total counts assimilated were transported from the leaf in the control, as compared with 60.6% in the presence of IAA. The same holds true with regard to the percentage transported from upper parts of the cutting to the lower sections. This pattern of distribution of ^{14}C-labelled assimilates under the effect of auxin is even more clearly evident from Fig. 6.

DISCUSSION

Experimental data. The importance of leaves in promoting root initiation in bean hypocotyls and epicotyls (Fig. 2, Table 1) is in accordance with data of other studies on root formation (15). While in some studies buds also were found to be essential for rooting (3, 10), excision of the apical bud of bean cuttings seems to be less detrimental. As buds are regarded as the site of auxin production, it is assumed that in the present study endogenous auxin content was not a limiting factor for the formation of primordia. However, an exogenous supply of auxin enhanced root formation if leaves were

Table 3. Sugar content (80% ethanol-soluble) at the start of the experiment and after 24 hr in culture, in green and in starved cuttings.

	Green			Starved		
	0-time	24 hours		0-time	24 hours	
		control	IAA		control	IAA
	mg glucose equiv. / 100 mg dry weight					
basal hypocotyl (0-25 mm)	16.0	19.5	30.1	9.7	12.2	20.9
upper " (25-50 mm)	18.0	19.9	37.1	10.2	18.4	29.7
average	17.0	19.7	33.6	10.0	15.3	25.3
	% of sugar content at 0-time					
basal hypocotyl	100	122	188	100	125	215
upper "	100	111	206	100	180	391
average	100	116	198	100	153	253

present, thus showing that it was associated with substances derived from the leaves. There are reasons for believing that carbohydrates transported from the leaves are the main factor, rather than unknown "co-factors" of a hormonal nature.

The marked difference between tissues and organs of the same plant in their rooting ability (Fig. 3 and 4, Table 1) is a good illustration of the well known variability between species or even between varieties of the same species (3, 6). The fact that roots are formed abundantly in the hypocotyl might be related both to its intrinsic similarity to the root system and to the ease with which substances essential for rooting are supplied from the root system. Indeed, it is known that certain plants root better if cuttings are prepared from twigs closer to the root system (5).

Most of the radioactivity from labelled IAA remained at the base of the cutting (Table 2), and this is in accordance with other data of basal application of auxin (13). However, since a certain

Table 4. The effect of 5 x 10^{-5} M IAA on the transport of ^{14}C-labelled assimilates in standard cuttings.

	DPM x 10-3 / section		
	control	IAA	IAA, % of control
hypocotyl 0-50 mm	121	512	424
epicotyl 51-100 mm	169	438	260
whole cutting	909	1900	209

Table 5. Percentage distribution of ^{14}C-labelled assimilates in various regions of standard cuttings.

	% of total DPM in cutting	
	control	IAA
hypocotyl 0-25 mm	3.7	10.2
26-50 mm	3.8	11.6
Total for hypocotyl	7.5	21.8
epicotyl 51-75 mm	5.4	8.8
76-100 mm	4.6	4.6
Total for epicotyl	10.0	13.4
rest of cutting, except for treated leaf.	32.4	25.4
treated leaf	50.1	39.4

amount was transported to upper parts it is possible that the influence of auxin on root initiation is due to its combined effects at the site of root formation and on physiological processes in the hypocotyl and leaves.

Accumulation of sugars and soluble nitrogen compounds was found in cuttings (15) and in girdled stems (12) of *Hibiscus*, and this

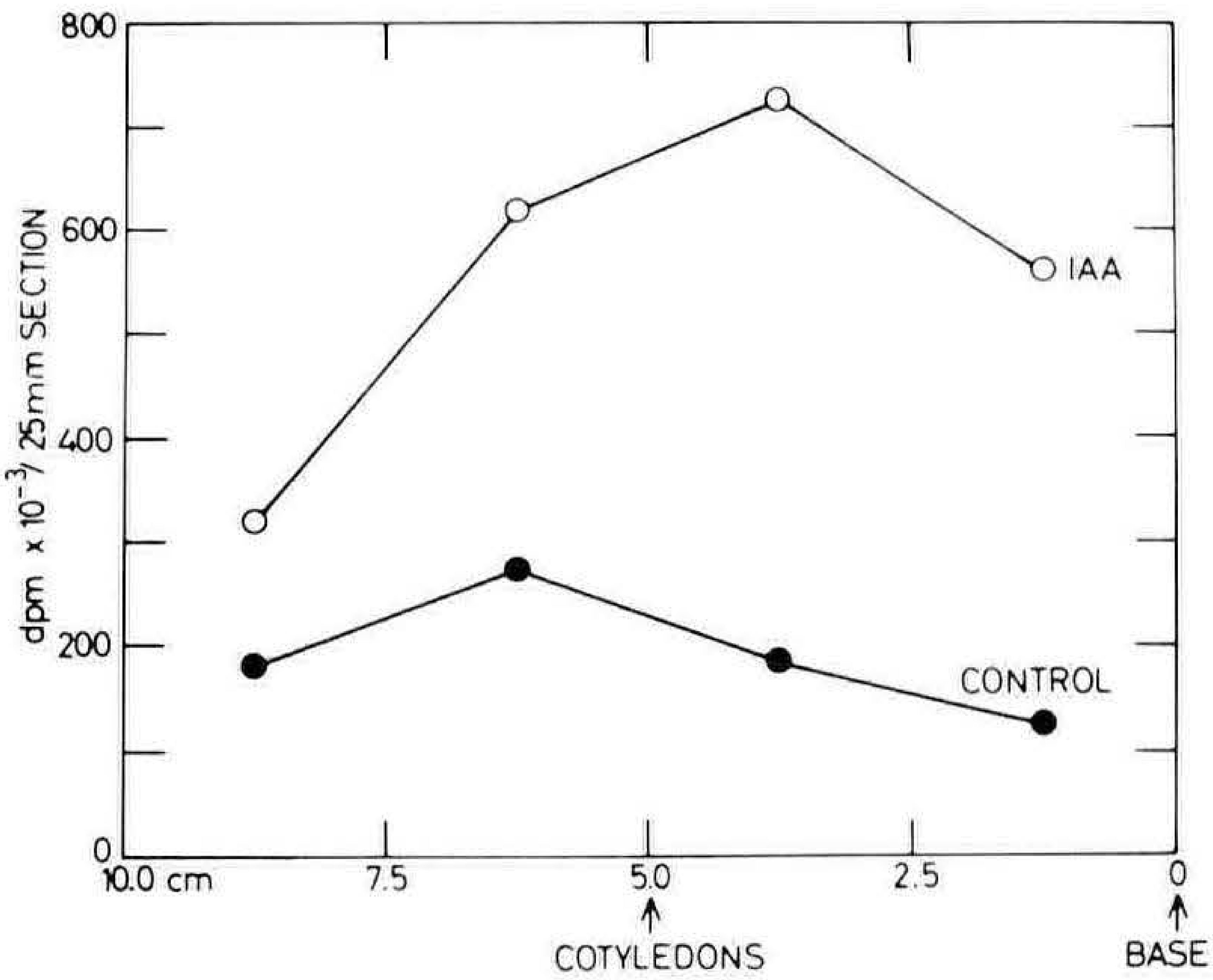

Fig. 6. Distribution of ^{14}C-labelled assimilates that were transported from the leaf during a 24 hr period, in the control and in the presence of 5 x 10^{-5}M IAA. Radioactivity was measured in 2.5 cm sections from the upper part down to the base of the cutting.

was dependent on the presence of leaves and on environmental conditions. Treatment of bean cuttings with auxin resulted in a considerable accumulation of sugars at the base (Fig. 5, Table 3). Thus, IAA directly affected the availability of the sugars as well as root formation. The close relationship between the enhancement of sugar accumulation and root formation in starved cuttings (Table 3 and text) suggests that a certain minimal sugar content should be present in order to enable the development of a certain number of root primordia, and that this can be affected by IAA.

The auxin-induced sugar accumulation can be brought about by 4 different ways, or in combinations thereof:

1. By increasing the production of photosynthates in the leaves.
2. By increasing the rate of breakdown of carbohydrate reserves in leaves and in other tissues, *i.e.* affecting enzyme activity.
3. Increasing the rate of transport from the leaves to the zone of auxin application.
4. By increasing the demand for carbohydrates at the area of root formation, *i.e.* directly affecting primordia formation.

There is evidence in the literature to support any of these possibilities, although they were not investigated with regard to root formation in cuttings. Data of transport experiments (Tables 4 and 5, Fig. 6) show that the auxin-induced sugar accumulation is mediated, at least in part, by a direct effect on the transport. Hormone-directed transport of assimilates and minerals is now an

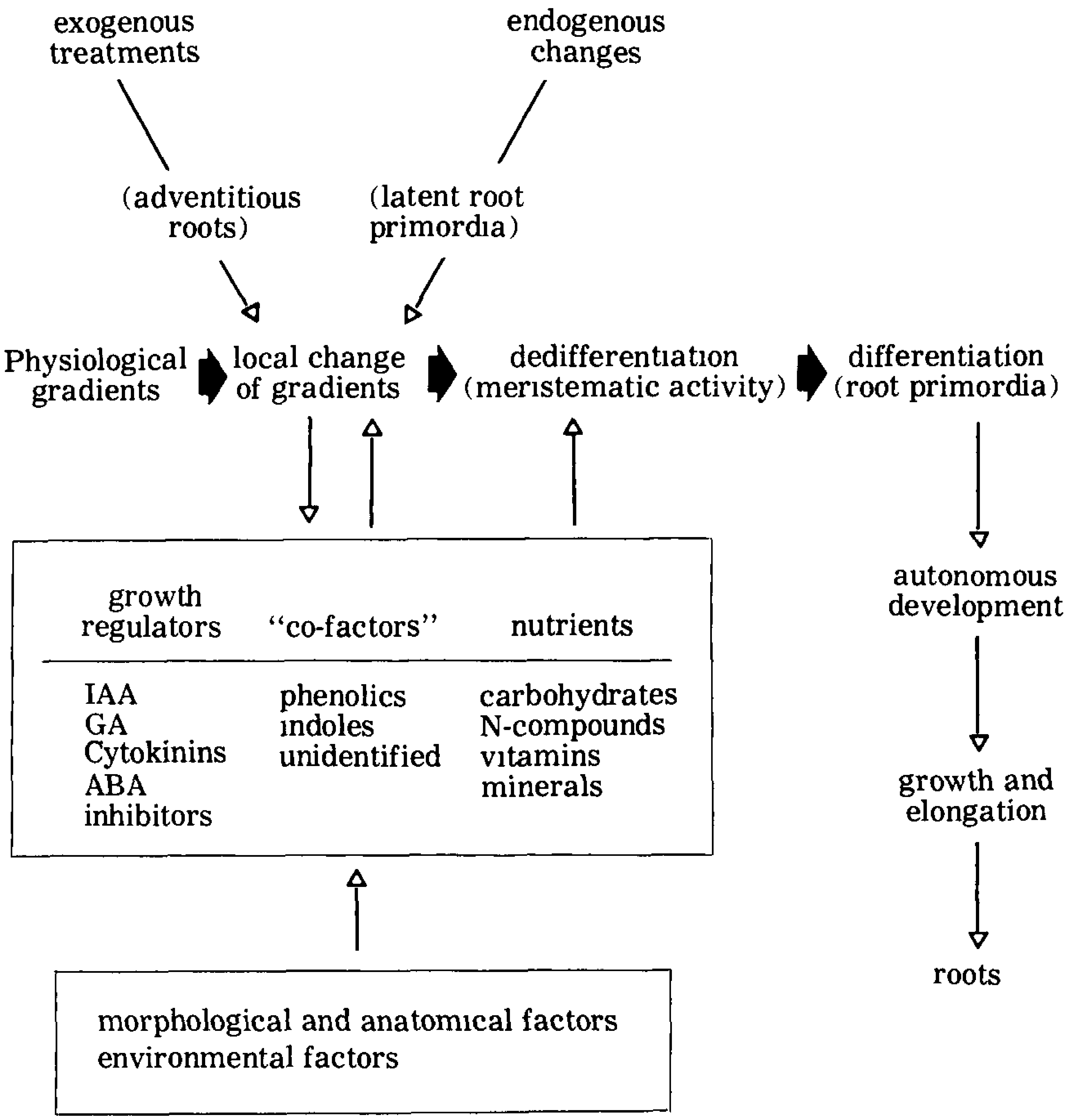

Fig. 7. General hypothetical scheme of root initiation in cuttings.

established fact (2, 11) although the underlying mechanism is still an open question. It has been suggested that hormone-induced transport involves a direct effect of the hormone on the transport system as such, and/or an affect on the developing "sink" (by increasing its metabolism). Data not presented here suggest that in bean cuttings both these mechanisms are involved, *i.e.* direct effect on the transport system and root formation.

CONCLUSIONS

1. Leaf area markedly affects root formation in the cuttings.
2. The expression of auxin-induced root formation is dependent on the area of leaves.

3 IAA increases sugar content at the site of root formation, with an equivalent increase in the number of root primordia.
4. IAA increases the transport of ^{14}C-labelled assimilates from the leaf to the base of the cutting.

It is suggested that one of the roles of IAA in promoting rooting of bean cuttings is by increasing sugar availability at the site of root formation.

GENERAL

Based on extensive experimental data as to the physiology of root formation (1, 4, 5, 7), a general, hypothetical, scheme of root initiation in cuttings can be presented (Fig. 7).

Intrinsic physiological gradients exist in any plant, organ and tissue as an integral part of their programmed development. The first step in the initiation of roots is a local change of gradients in the cutting. These can be brought about by either of two ways: (1) exogenous, horticultural, treatments (cutting, layering, girdling, etc.) that lead to the formation of adventitious roots, and (2) endogenous changes, resulting in the formation of latent ("preformed") root primordia. In the first case there is a change of one type of tissue to another and a continuous development, while the latter is complicated by a state of arrested growth of the primordia. Due to local change in the gradients, tissues in this area undergo a dedifferentiation process leading to meristematic activity. Root primordia are then formed, which at a certain stage attain an autonomous development, and finally roots emerge from the cutting. Levels and activities of growth regulators, co-factors and nutrients are apt to be influenced by the change in gradients, but at the same time can markedly affect these gradients and, thus, the differentiation process and the formation of roots. Superimposed on this, are morphological, anatomical and environmental factors.

Any hormonal treatment might affect root formation in two general ways: (1) directly, on the processes of dedifferentiation and differentiation, and (2) indirectly, by affecting certain steps of the overall metabolism. It is, thus, obvious that in a complex scheme like this all the factors are interrelated, and any one of them can be rate-limiting. Since the limiting factors are different in various plants and tissues (being part of its programmed development), the expression any given treatment in any given tissue will be dependent on the interplay between these factors.

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VISIT TO BLOOMS NURSERIES LIMITED, BRESSINGHAM, DISS, NORFOLK ON THURSDAY, 8TH JUNE 1972

A. B. MACDONALD
Hadlow College of Agriculture and Horticulture
Hadlow, Tonbridge, Kent

Over eighty members and their guests attended the one-day meeting at Blooms Nurseries of Bressingham, near Diss in Norfolk. Blooms is one of the five nurseries within the well-known Anglia Group. The nursery produces 1½ million alpines, 1 million herbaceous plants, 200,000 dwarf conifers, 200,000 ground cover plants and 150,000 heathers; besides these, other lines include a varied range of taller growing conifers and ornamental grasses.

A warm welcome was first given to members by Adrian Bloom, and everyone received the new well-designed Anglia Group catalogue which was just 'hot-off' the press. The next stage was a tour of the nursery, and three groups were efficiently guided by Adrian Bloom, Maurice Prichard, manager of their herbaceous department, and Lawrence Flatman, manager of alpine and container departments.

The alpine section was very impressive and we were able to see many operations in progress, including some of the propagation techniques used. Plants, such as *Lithospermum* and *Penstemon,* were grown in polythene-clad structures, equipped with fan ventilation, at a temperature of 65° F; a softer and earlier cutting is obtained, which was found to root better under mist than cuttings taken from outdoor stock plants and, in addition, suitable material is available for a long period during the year. The rooted cuttings were potted off into a loam based compost, containing Vitax Q4 at 4-6 oz per bushel.

A talking point was the eye catching new alpine-plant display pack for garden centres, developed by Blooms. This non-returnable tray is made of white expanded polystyrene, in which there were five batches of seven varieties of alpines, each individually labelled. It was obvious to all that this should stimulate the public's interest in alpine plants and increase sales in garden centres.

The area designated to ground-cover plant production had just recently been completed. The design of the beds was interesting as they were arranged in pairs, divided by a path, in order that a polythene-clad structure could be erected if necessary in winter, should the plants require protection. The beds themselves are lined with polythene with a gravel base. A varied range of ground cover plants were grown, including large batches of the ever popular *Epimedium*, *Vinca* and *Pachysandra.* A point worth noting was that

Hypericum calycinum does best if lined out, rather than being containerised.

The demand for dwarf conifers has been rapidly increasing. The nursery roots their conifer cuttings during 2 main periods of the year. Firstly, from late June to October, when junipers and *Picea glauca* 'Conica' (*P. albertiana* 'Conica) are rooted in cold frames and, secondly, in January to March, where mist is used to root *Thuja* and *Chamaecyparis*. The rooted cuttings are potted off into peat pots or polythene sleeves and the plants are subsequently overwintered under 'milky' polythene structures; in the following year they are sold as two year plants in the autumn. Experience has shown that ventilation of these structures has proved difficult, resulting in some damping off of the soft growth. Clear polythene covered with a latex paint was to be tried as an alternative to milky white polythene film.

Heathers are another speciality of the nursery. The propagation programme commences in June with the ericas, using soft top cuttings. Later in the year heel cuttings are often used. Basically it is a one-year production system, and at the end of the selling season any plants which are left over are grown on to produce a two-year plant. We were told that there seems to be a considerable demand for a larger container grown plant.

Nutrition was considered by Blooms to be one of the most important factors to produce a high quality plant. The basic programme, where the liquid feed is injected through a Baggaley injection unit, commences in April using Vitax S, applied through overhead irrigation. Where possible this is carried out in the evening to minimise scorching. In June, Vitax 301 is used, and the programme is concluded with a high potash feed to harden off the season's growth.

Prior to lunch we were privileged to view the very attractive five-acre Dell Garden designed by Alan Bloom, also the private garden of Adrian Bloom, which was particularly eyecatching with its effective layout of conifers and heathers.

One of the features of the Nursery is the adjacent 'Steam Museum' which houses such famous railway locomotives as the 'Royal Scot' and 'Oliver Cromwell', and a variety of smaller engines which delight the enthusiast and brings crowds to the holding twice a week when they are open to the public. A narrow gauge railway circulates the nursery and, after lunch, Alan Bloom with his engine under full steam, gave his passengers a tour of the outside land to view the herbaceous production. Prior to bedding out the young plants, the beds were chemically sterilized with Dazomet (Basamid) at the rate of 1 lb/ 20 sq. yds. (cost £ 2/ 100 sq. yds.) In order to save the somewhat time consuming operation of 'sheeting' the treated ground, a liquid plastic substance called Vinamul 8114 (cost

£2/ 100 sq. yds.) is sprayed over the ground. We were told that it was essential that there were no undulations in the top surface of the soil prior to applying Vinamul 8114 — sold by Vinyl Products Ltd., Mill Lane, Carshalton, Surrey. The total cost for this sterilisation treatment was £4/ 100 sq. yds.

During the course of the afternoon we were able to view an interesting display of machinery used in the production of herbaceous plants. Maurice Prichard explained the particular merits of the machinery, such as the modified 5-row Accord planting machine, which could be used for both live and dormant material, and the Vicon Rotaspa which is preferred to a rotavator on light sandy soils as it prevents panning.

Planting distances are orientated to the bed system of production, which makes subsequent operations earier. Herbicide applications was essential for efficient production, and lenacil (Venzar) at 2 lbs/ acre is effectively used.

During the day a variety of production systems were seen which were geared to produce high quality plants. We all departed with a wealth of information and were extremely grateful for the warm reception given to us by Adrian and Alan Bloom, together with their colleagues.

RECENT DEVELOPMENTS IN PROPAGATION BLOCKS

D.J. COOK

Silva-Development Limited,
Darrington, Pontefract, Yorks.

The most important factors which have stimulated the development of propagation blocks manufactured from synthetic materials are:—

1. It is possible to develop propagation blocks with properties which are reproducible.
2. It is possible to develop blocks with known air-water ratios,

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which wet readily, and which hold their water content.

3. It is possible to develop blocks which have been conditioned to stimulate root development, and which contain plant nutrients.
4. Once rooting has started in the blocks, it is possible either to transfer them into larger blocks, or to potting-on composts with minumum root disturbance.

A number of manufactured propagation blocks have been marketed. They can be categorised into four main groups:—

1. Those based on polyurethane foam:—

(a) Nutri-Foam was manufactured by the Dow Chemical Co. of America. It contained plant nutrients in the form of ion exchange complexes. It has now been withdrawn from the market because of difficulties experienced in use.

(b) Baystrat is a development of Nutri-Foam and is manufactured by Bayers of Germany.

(c) Rack-Substrate was developed by Rack of Germany, and is marketed by Hartmann International GmbH. It is manufactured from scrap polyurethane foam shreds, and contains admixed shredded peat.

2. Those based on foamed urea-formaldehyde. These blocks suffer from the disadvantage that when manufactured they are hydrophobic (i.e. cannot be wetted), and require treatment with surfacants before use. When so treated the foams tend to collapse, and the blocks waterlog readily. Although the principle of production is attractive because they can be produced by the grower himself, using a foaming machine, nevertheless they are not likely to be as effective as those made from other raw materials.
3. Those based on padded and modified cellulosic fibres, for example BR-8 manufactured by the American Can Co., U S.A. We understand that these blocks are no longer manufactured.
4. Those based on mineral fibres, 'rockwool'; for example, Grodan, developed by Mosegard of Denmark, and evaluated by Bovre of the Hornum Research Station of Denmark.

Certain of these products tend to disintegrate when saturated, that is, they have poor wet strength; others showed evidence of waterlogging when exposed to a watering regime and therefore suffer from minimal air contents when wetted. Others, particularly those based on polyurethane, showed marked drainage leading to a moisture gradient from the surface to the base when the wetted blocks were allowed to stand for relatively short periods of time.

The basic problem with this type of block is that the foam membrane has not been conditioned to accept water, and therefore sheds the surface water rapidly.

Van Elk of Boskoop (1) has compared the rooting performance of many species of plant cuttings in peat-sand mixtures, BR-8 and Baystrat. He concluded that Baystrat was not as effective as BR-8, and root development within the blocks was poor. He also compared BR-8, Grodan and Baystrat under double glass and under mist Although under double glass, Grodan was nearly as effective as BR-8, and certainly considerably more effective than Baystrat; both Grodan and Baystrat were inferior to BR-8 under mist, using cuttings of five species of plants.

Bøvre (2) has reported on his own results comparing propagation tests using sphagnum-sand mixtures in various types of pots and four types of propagation blocks. He confirmed the findings of Van Elk that Grodan appeared to be superior to Baystrat when used with his particular species of cuttings. The main problem associated with the use of Baystrat appears to be the non-acceptance of water by the polyurethane membrane. (Table 1).

As a generalisation, the modified cellulosic fibre blocks appear to be more effective than those made from mineral fibre. These, in turn, appear to be better than the foamed polyurethane blocks. Unfortunately the quality of roots developed in the modified cellulosic blocks are not always as good as those formed in the more conventional peat-based, soil-less composts. Even when rooting is good, as Orum and Wilde (3) have observed "The most serious problem in the use of these blocks is the matter of timing. Cuttings rooted in the blocks must be potted or containerised before roots from adjacent blocks become interlocked or the blocks become ruptured by root pressure".

We have been investigating new types of materials for use in the manufacture of propagation blocks which will overcome the problems associated with the types of blocks now manufactured, and which will meet the four important factors noted in the first section of this report. One of the most promising approaches appears to be in the use of phenol-formaldehyde foam systems. We became interested in the use of such foams during the investigations into a much larger project which included the development of a new type of floral grade foam. We discovered that not only could we modify the ratio of large to small pores in the foam, thus enabling us to vary the water-air relationship, but we could vary the water acceptance of the foam membrane at will. In a further project we have been having a close look at the sequence of biochemical events leading to root initiation including the use of growth regulators to stimulate root development We have been investigating not only the possibility of using the lessons learnt in this work to the development of new synthetic rooting hormones, but also to the development of the new type propagation blocks.

We have had some evidence from Bovre's work that certain types of phenol-formaldehyde foams did not appear to present toxicological problems in the rooting of cuttings. This was confirmed in the modified phenol-formaldehyde foam blocks, free of nutrients and growth promoting substances, which have been evaluated at the Pershore College of Horticulture.[1] We were surprised at the rooting performances in these blocks. Having established that there do not appear to be problems of phytotoxicity, various nutritional and growth factors have been introduced into the blocks, and most promising results have been achieved. We will be reporting further on this work when all the results have been assembled.

LITERATURE CITED

1. Information supplied to us by B.C.M. Van Elk during our visit to the Research Station for Arboriculture, Boskoop, Holland in 1971.
2. Bøvre, O. 1972. *Statens Forsøgsvirksomhed i Plantekulture 74,* (9th March).
3 Orum, P., and Wilde, J., 1971. *The Plant Propagator,* 17 (3):5.

QUESTION BOX

JOHN GAGGINI: Could Mr. Purcell elaborate on *Hamamelis mollis* budding? What percentage take did he get?

G.B. PURCELL: The stocks were *H. virginiana* which came from the U.S.A. Budded in August with traditional 'T' cut with the wood removed from the bud. The time of budding varies with the availability of the budwood which can be as late as October; you will still get a good take so long as the sap is still rising in the stock. The percentage in 1970 with 250 stocks was about 90%. The varieties were 'Jelena' *Hamamelis x intermedia* 'Jelena'), *H. mollis* 'Pallida', 'Gold Crest' and a variety we call 'New Red'. In 1971 we budded about 150 stocks with about the same take, and this year we hope to do about 200. I would like to obtain 20 or so *Distylium racemosum* stocks in the next month or so to try budding them and to compare the results.

G.B. PURCELL: Is it not true that there is a big demand for standard Japanese maples in variety, but that the trade has not shown the ability to produce a good quality product?

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[1]These were exhibited at the Conference.

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Table 1. Propagation tests using composts and propagation blocks exposed to mist.

Propagation medium	Percent rooting at suction forces of (cms.):—					
	Rosa 'Queen Elizabeth'.			*Pernettya mucronata*		
	5	2	0	5	2	0
Sphagnum-sand 2:1, in:—						
Fertilpots.	75	88	80	58	62	58
Jiffy-strips	80	70	83	37	43	43
Plastic pots	100	100	93	77	73	77
Granulated mineral wool. 'Grodan'	77	97	83	57	70	47
Jiffy —7	87	77	77	56	40	47
Grodan blocks.	100	95	95	49	79	66
Baystrat.	23	26	62	28	20	15
Phenol-formaldehyde foam.				61	78	69

Reference: Odd Bøvre - 'Statens Forsogsvirksomhed i Plantekulture' Vol 74, 9th March 1972

DAVID CLARK: We have a few standard *Acer palmatum* 'Dissectum' for which there is a limited demand, but they are very expensive. If it were possible to produce them more cheaply I am sure there would be a larger demand, but frankly I prefer to see them as a branched plant, which is its more natural habit.

MISS ANSTEY: Can anyone tell me please how to make *Magnolia soulangeana* and *Magnolia stellata* cuttings grow on? We take them in July, they root easily but fail to grow on in most cases.

A MEMBER: It is important that the cuttings should come from vigorous stock plants. The stock plants should be fed, cut back and mulched annually to produce long vigorous shoots. We use 2% IBA for rooting. It is a help to have supplementary lighting to ensure good results.

C.D. DEMPSTER: It is important to pot the plants up immediately root initials form. Many plants may be lost if the roots are too fully developed. Rooting into a Jiffy pot, even as late as August, can assist overwintering.

A MEMBER: Can I ask Douglas Harris if he has any information on the germination of seeds on a sterilized seed bed? He has mentioned the difference in growth after sterilization, but does sterilization have any effect on the percentage germination?

D. HARRIS: It increases the germination — or rather the emergence; the actual germination may be the same in both cases but, without sterilization, we have been losing some of the plants in the soil after germination, but before emergence.

P.J. WISEMAN: The traditional tree which the public buys in this country is a standard or half-standard. We heard from Dr. Robinson that in Japan there is much demand for very bizarre shapes. Is there a tendency in this country to consider a multi-stemmed tree or even a tree furnished to the base?

D. CLARK: Landscape architects are asking for this type of tree now. Nurserymen are slow to change, but some are beginning to meet this demand. Dr. Robinson used the term "character trees" which is a term I like very much, and I think there is a demand for them.

D.C. LEAMAN: These "character trees" will have to be planted where the public will leave them alone. Multi-stemmed trees are much more vulnerable to vandalism.

A. POSTILL: Is there a way to stop weed seeds from germinating under polythene tunnels filled with cuttings? Are "pre-emergent" sprays feasible?

A. CARTER: Yes, certainly. First, it is important to get rid of the weed seeds in the ground before inserting the cuttings and secondly (as some seeds may be brought in on the leaves of the cuttings) it is worth considering black polythene on the floor and inserting cuttings through this so that you have a mulch. Against this, of course, you have the disadvantage that the soil temperature in the spring will be lower under the polythene. I cannot recall any trials of herbicides specifically designed to test pre-emergence materials against hardwood cuttings.

G. THORBURN: I have evidence that if the top pairs of leaves of *Acer palmatum* cuttings are removed from the nearly rooted cuttings the plants will grow away, whereas those not so treated remain dormant. Can anyone comment on this?

A. CARTER: I believe this has been shown to be true with *Vitis* cuttings, but is not the case with *Hydrangea petiolaris*.

C. A. BOND: Does the constant use of herbicides around nursery stock plants have any effect on the rooting of cutting material?

A. CARTER: I think that somewhere in the West Midlands, where a hedge had been treated, cuttings gave bad results.

C. SALTER: We had trouble with *Daphne x burkwoodii* where Casoron was used. Before using it we averaged 75-80% take; afterwards — and I am talking about two years after — the take was about 25%. Since we have used new stock the percentage is back to its original.There are reports also, I believe, of trouble with *Picea*, which might be attributable to the stock plants having been treated with Casoron in the seed bed.

THE PROPAGATION OF CERTAIN DECIDUOUS PLANTS BY HARDWOOD CUTTINGS

D. N. WHALLEY

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Abstract: The heated bin technique for propagating fruit tree rootstocks may be applied to ornamental and forest subjects.

When used for this purpose, modifications are required to the conditions used for fruit rootstocks. These include the use of lower temperature, lower growth regulator concentrations, and more frequent irrigation in the bins

INTRODUCTION

The propagation of fruit tree rootstocks from hardwood stem cuttings in heated bins is well established and current developments of this technique have been outlined by Howard (1). In reviewing this method of propagation, Martyr (5) suggested that it could be of value for the production of high value ornamental crops. In some of the work reported a high rooting percentage was achieved, but subsequent establishment was poor, the highest value being obtained with *Aronia melanocarpa*,where a 10% survival was observed. This low survival rate after planting would appear to be the main problem associated with the use of this technique on crops other than fruit rootstocks.

In reviewing methods of propagating *Corylus* and *Viburnum* McMillan Browse (6) also noted the possible potential of this technique for certain cultivars. This supports initial work by Howard (2) on the use of heated cutting bins for propagation of *Corylus avellana*, where the propagation requirements were considered similar to those necessary for fruit tree rootstock production

Discussing aspects of propagation used in forestry, Jobling (4) cited work with *Platanus x acerifolia*, which may be propagated from hardwood stem cuttings inserted in the field in autumn. With this method a rooting percentage greater than 70 is rarely achieved and values are often lower. He states that there is preliminary evidence that propagation in heated bins may lead to more rapid rooting, with greater success in terms of percentage rooting, but that subsequent handling of the cuttings may be more difficult.

In studies on bud dormancy in hardwood cuttings, Smith (7) and Smith and Wareing (8), observed that chilling shortened bud dormancy and increased both the number of wound roots produced on M2 apple rootstocks and *Populus x robusta* cuttings and promoted the emergence of pre-formed roots from poplar cuttings. Evidence has also been cited, (Howard (3)), that pre-rooting cold treatments may be beneficial in rooting apple rootstock clones.

At present there is little comprehensive work on the use of this technique for propagation of ornamental and forest subjects. Basal temperature, growth substance concentration and irrigation requirements of ornamental subjects may differ from those necessary for fruit tree rootstock production. Preliminary work at this Institute indicates that such factors appear to play a critical role with some of the more sensitive ornamentals.

This paper presents the results of experiments designed to provide information on the requirements of plants other than fruit rootstocks.

MATERIALS AND METHODS

The results of three experiment, using 21 different subjects, are presented. For the first two experiments, cuttings were obtained on 17 January 1972, from stock plants grown at Notcutts Nurseries, Woodbridge, Suffolk. These were cold stored in 250 gauge polythene bags in a direct cooled store at 0° C (32° F) prior to insertion in the heated bins. Cuttings for the third experiment were obtained from stock plants grown at this Institute.

Bin Construction. The heated bins were installed under cover in a pre-fabricated concrete barn. Construction was of bitumen-covered "Thermalite" blocks, with a base of light, aerated concrete blocks, also bitumen painted. Basal drainage was provided by a 23 cm depth of coarse aggregate. Within each bin, heating wires to give a loading of 15 watts/sq. ft. were tied to "weldmesh" grids with a Maclaren rod thermostat (type GAG) set 2.54 cm (1 in.) above the wires. A 23 cm deep rooting medium of equal parts peat and grit was used with a temperature at cutting base level of 15.6° C±3° . Monitoring of temperature was by a Grant D, nine channel recorder, with thermistor probe sensors (type C).

Cutting Preparation. All cuttings were made to a length of at least 30.5 cm (1 ft.). The exact length depended upon the internodal length below the distal bud and varied slightly both within a treatment and between subjects.

The basal levels of cuttings were trimmed immediately upon removal from cold storage. Cuttings were then dipped to a depth of 1.2 cm in. 4 — (3-indolyl) butyric acid (IBA) in 50% ethyl alcohol, at concentrations of either 1250 or 2500 ppm. Control cuttings were untreated in experiments 1 and 2, but dipped in 50% ethyl alcohol alone in experiment 3. The bases of cuttings were allowed to dry before being placed in the bins.

Experiment 1

Cuttings of *Acer platanoides* 'Crimson King', *Acer platanoides* 'Drummondii', *Betula pendula* 'Youngii', *Sorbus intermedia, Laburnum x vossii, Crataegus oxycantha* 'Rosea' and *Crataegus oxycantha* 'Paul's Scarlet', (Coccinea Plena) were trimmed and dipped as described and inserted into one heated bin on 20, 21 and 22 January 1972. A randomized block design was used with 90 cuttings of each subject, giving 30 cuttings of each treatment, arranged 10 cuttings per bundle in 3 blocks.

Cuttings were lifted and data recorded on 14 March 1972. Half of the experiment was field planted into a brickearth soil with the following analysis: -pH 5.72, conductivity 0.79 mmho (water:soil ratio 2.5:1 v/v), 48 ppm N, 61 ppm P, 461 ppm K, 2085 ppm Ca, and 128 ppm Mg into trenches 23 cm deep and 15 cm wide, filled with equal parts peat and grit to a depth of 10 cm, at a spacing of 1 metre between rows and 11 cm between plants, on 17 March 1972. The remaining cuttings were cold stored at 0° C until 11 April 1972 and then field planted in the same manner.

Experiment 2

Cuttings of *Acer platanoides, Syringa vulgaris* 'Esther Staley', *Acer saccharinum, Platanus x acerifolia, Crataegus monogyna* 'Stricta', *C. prunifolia, Hibiscus syriacus* 'Woodbridge' were trimmed and dipped as previously described and then inserted into the second heated bin from 24 to 27 January 1972. A randomised block design similar to that used in Experiment 1 was employed, thirty cuttings of each subject per treatment being used.

The cuttings were lifted and recorded on 15 and 16 March 1972. These were then field planted in the manner described for Experiment 1.

Experiment 3

Cuttings of *Cornus alba* 'Spaethii', *Cornus alba* 'Variegata' (Argento-marginata, Rehd.), *Viburnum x bodnantense, Corylus avellana* 'Aurea', *Corylus maxima* 'Purpurea', *Ulmus hollandica* 'Commelin' and *Betula pubescens* were taken on 8 and 9 February 1972. These were then trimmed and dipped as previously described. A comparable randomized block design, with the same numbers of cuttings, was again used. These cuttings were lifted and recorded on 6 and 7 April 1972. One third of the cuttings (i.e. one block) was field planted. The remaining two blocks were made into 'Nisula' rolls in a compost of 100% peat with the following fertilisers added, 2340 g Osmocote, 1780 g ground limestone, 1780 g dolomitic limestone and 297 g Frit 253A per cubic meter. The treatment for block 1 differed from block 2 in that twice the volume of peat was used for the latter. These cuttings were retained in an unheated bin cleared of compost for three weeks and then transferred to a cool glasshouse where a minimum air temperature of 12.8° C was maintained.

Results of Experiment 1

The results for Experiment 1, (Figure 1) showed that very few roots were produced with any subject by any of the treatments. The

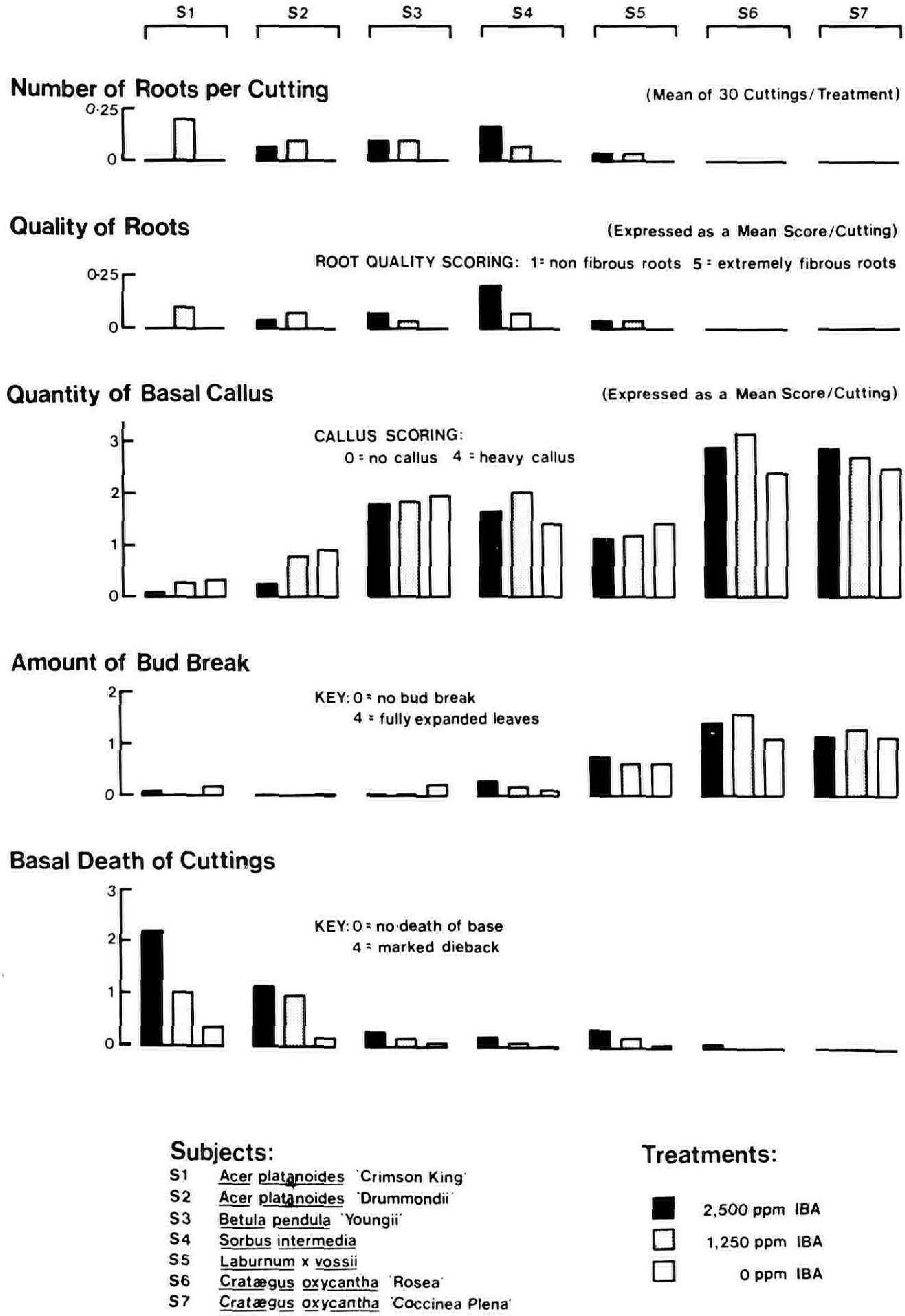

Fig. 1. Criteria recorded on lifting cuttings from the heated bin for plants used in Experiment 1.

score for root quality was therefore similarly low. However, a fairly large amount of basal callus was seen with *Betula pendula* 'Youngii', *Sorbus intermedia* and *Laburnum x vossii* and a larger amount for *Crataegus oxycantha* 'Rosea' and *C. monogyna* 'Stricta'. Very little bud break was observed except for the two *Crataegus* cultivars where a small amount was seen, corresponding to a slight greening of the bud. Little death of the base of cuttings was observed with the exception of the two *Acers* where a marked response to IBA concentration was seen, the highest concentration causing considerable browning and death of the basal few cm of stem. This was particularly noticeable with *A. platanoides* 'Crimson King', but was also marked in *Acer platanoides*, 'Drummondii'. In all cases except *C. oxycantha* 'Paul's Scarlet', a gradient in sensitivity with response to concentration was observed.

When the values for percentage rooting and percentage survival in the field 14 and 36 weeks later were compared (Table 1) it can be seen that *Acer platanoides* 'Crimson King', *Betula pendula* 'Youngii' and *Laburnum x vossii* had for all treatments both low percentage rooting and percentage establishment values. For *Acer platanoides* 'Drummondii' the survival of the plants was greater than might have been expected for the corresponding figures for percentage rooting, particularly after 16 weeks. It must be emphasized, however, that this value was a score of living buds and not of extension growth or full establishment, the score after 36 weeks representing the pattern seen at the end of the season. With this cultivar it might appear that, initially, growth regulator concentration suppresses bud survival in the field and this could be related to the dieback of the stem, previously mentioned. For *Sorbus intermedia*, a response to growth regulator concentration was seen with respect to rooting percentage. However, high numbers of living buds were observed in the field but little active extension growth was evident. For the two *Crataegus* cultivars, high values for percentage survival of buds and young extension growth were noted, the greatest response being seen for the control. This was not a response to the presence of an established root system, as the cuttings had only been at the callused state when planted. The presence of developing root primordia was noted at the time of planting and cuttings lifted after 36 weeks were still healthy, possessing actively differentiating callus but few roots and showing little extension growth.

Experiment 2

When the subjects used in this experiment are considered (Figure 2), large numbers of roots and a corresponding high quality were obtained for certain treatments with *Platanus x acerifolia, Hibiscus syriacus* 'Woodbridge' also rooted moderately well.

Table 1. Percentage rooting and establishment of hardwood cuttings

Subject	Percentage rooting on lifting from bins.			Percentage survival in the field 3½ months later.			Percentage survival in the field 8½ months later.		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Acer platanoides 'Crimson King'	0	3	0	0	0	3	0	0	3
Acer platanoides 'Drummondii'	3	7	0	33	57	77	3	7	17
Betula pendula 'Youngii'	7	3	0	0	30	10	0	0	0
Sorbus intermedia	20	7	0	53	67	80	7	13	7
Laburnum x vossii	3	3	0	10	17	3	10	10	*3
Crataegus oxycantha 'Rosea'	0	0	0	80	63	97	70	47	77
Craetaegus oxycantha 'Paul's Scarlet'	0	0	0	83	83	87	57	73	83
Acer platanoides	14	20	0	10	23	13	10	23	*0
Syringa vulgaris 'Esther Staley'	0	0	3	10	10	3	10	0	0
Acer saccharinum	3	14	0	10	0	0	7	0	*0
Platanus x acerifolia	84	100	100	47	67	90	47	67	*80
Crataegus monogyna 'Stricta'	0	0	0	10	20	67	3	7	30
Hibiscus syricus 'Woodbridge'	87	97	0	97	100	93	97	97	*93
Crataegus prunifolia	0	0	0	0	3	7	0	0	3
Cornus alba 'Spaethii'	94	100	100	0	0	60	0	0	40
Cornus alba 'Variegata'	97	100	90	20	0	60	10	0	50
Viburnum x bodnantense	43	23	23	0	0	0	0	0	0
Corylus avellana 'Aurea'	0	0	0	0	10	40	0	0	0
Corylus maxima 'Purpurea'	7	0	3	40	10	20	20	10	10
Ulmus hollandica 'Commelin'	97	90	3	30	30	30	30	30	*10
Betula pubescens	0	0	0	0	0	30	0	0	0

T1 — 2500 ppm IBA   T3 — 0 ppm IBA
T2 — 1250 ppm IBA   * Cultivars showing good extension growth.

In both of these cases, the order of root production with respect to treatment was 1250 ppm>2500ppm>0 ppm IBA. The trend for all subjects is shown in Figure 2. Detail of the root type produced by *Platanus* treated with 1250 ppm IBA is shown in Figure 3.

Little root production was noted for *Acer platanoides, Acer saccharinum* or *Syringa*, the only treatment where any response was seen being the control. For the two *Crataegus* cultivars, no roots were produced with any treatment. When values for callusing were compared following the trend observed in Experiment 1, high scores were noted for *Crataegus* and both *Platanus* and *Hibiscus.* Again a general trend was for 1250 ppm IBA to be the most suitable treatment for the production of an optimum response. The highest values for bud break were observed with *Syringa* and the two *Crataegus* cultivars. However, scores for this criterion were generally very low

The only subject where high values for death of the base of the stem were observed was *Acer platanoides*, where a gradation of response with increasing growth substance concentration was noted, as reported for Experiment 1.

Experiment 3

Three subjects showed high values for the number of roots produced; these were: *Cornus alba* 'Spaethii', *Cornus alba* 'Variegata', and *Ulmus hollandica* 'Commelin'. The latter responded particularly well to a high IBA concentration.

Bud break values were generally slightly higher than for the previous two experiments, probably due to the later planting. The two *Cornus* cultivars, and *Betula pubescens,* exhibited bud values corresponding to the "green bud" stage, the greatest activity being seen with cuttings treated with 1250 ppm IBA. The highest values were obtained with *Viburnum.* A stage of bud development just preceding bud break being noted for treatments 1250 and 0 ppm IBA. The greatest amount of basal death was seen for the two *Cornus* cultivars, where a concentration gradient was observed, higher concentration promoting more dieback. Some stem dieback was also noted for *Viburnum, Ulmus* and *Betula.* Data for all subjects is presented in Figure 4.

General trends from all three experiments. When these data are compared with those for percentage rooting and percentage survival measured twice in the field (Table 1) certain trends may be seen.

All *Crataegus* cultivars failed to root but produced heavy callus and two of them could be said to have produced satisfactory results in terms of bud survival, viz *C. oxycantha* 'Rosea' and *C. oxycantha* 'Paul's Scarlet'. However, with all cultivars of this genus, it can be

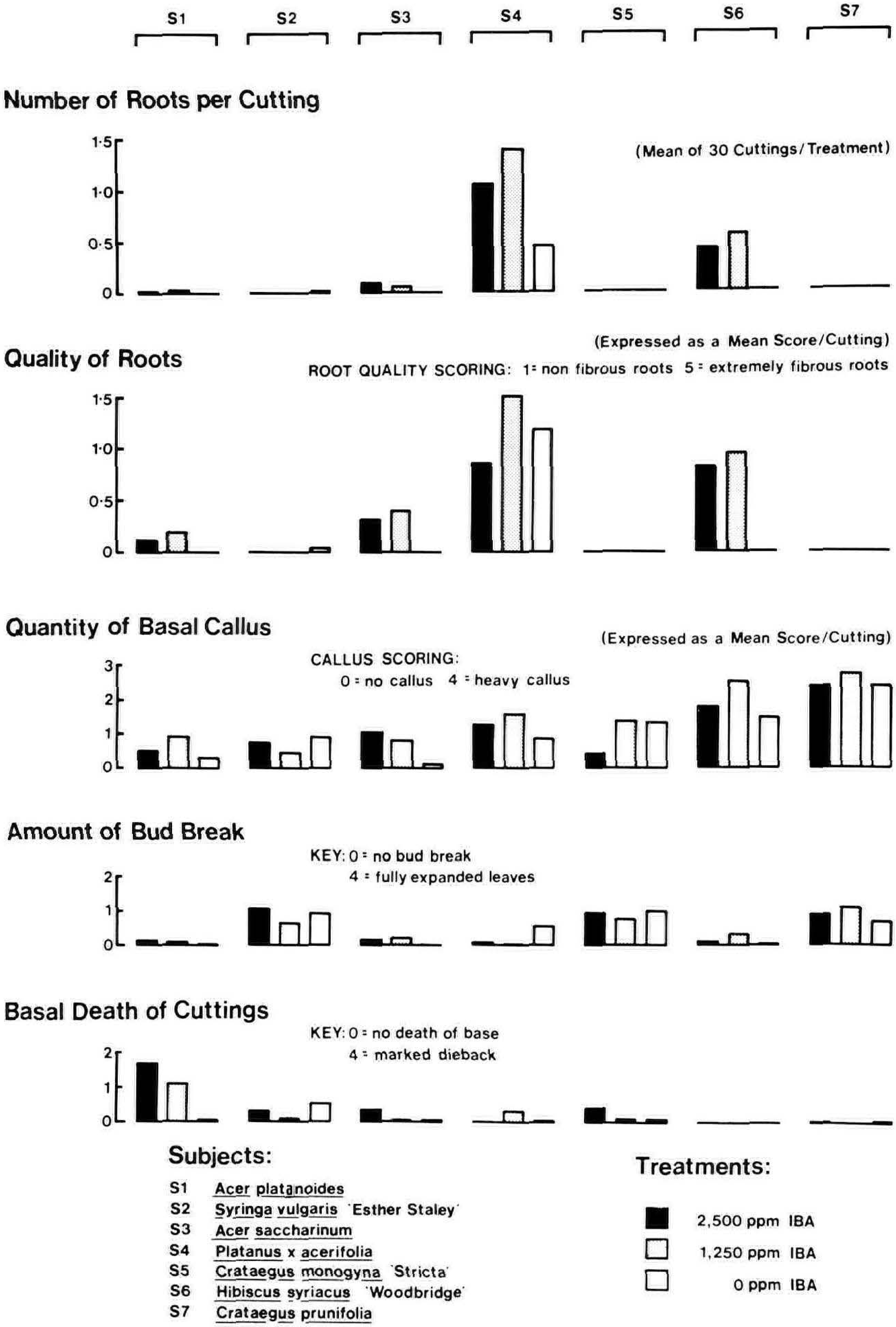

Fig. 2. Criteria recorded on lifting cuttings from the heated bin for plants used in Experiment 2.

Fig. 3. Detail of the thick, fleshy, nonbranched roots produced by *Platanus x acerifolia* cuttings previously dipped in 1250 ppm IBA.

noted that the highest values for percentage survival were seen in the untreated plots (Figure 5). It could be suggested that any subsequent rooting is a response to heat treatment of the stem bases rather than to growth substance concentration.

For *Platanus* (Figure 6) 100% rooting was obtained for both 0 and 1250 ppm IBA with a fall at the higher concentration. This effect was accentuated when values for percentage survival are considered.

For *Ulmus*, (Figure 7), percentage rooting increased with growth regulator concentration, but percentage survival was similar for all treatments. This indicates that rooting is not always correlated with survival and points to the importance of post rooting treatment. For *Acer platanoides* both percentage rooting and percentage survival were greatest at 1250 ppm IBA and declined at either a lower or a higher concentration.

Hibiscus (Figure 8) showed a marked response to growth regulator concentration, again reaching a maximum percentage rooting at 1250 ppm and declining slightly at the higher concentration. Percentage survival values showed a similar trend, but here a high value was observed where no rooting had taken place in a similar manner to *Crataegus*.

When field observations of bud number, numbers of actively growing buds, dessicated buds and fully expanded leaves were assessed, it was seen that in many cases the values observed for these criteria followed those recorded for root number and establishment. This was particularly evident where data for *Hibiscus, Acer platanoides* and *Platanus x acerifolia* were compared. Cuttings cold stored after lifting from the bin but before planting in the field, appeared to suffer less bud damage in the form of dessication and consequently to show a greater percentage of

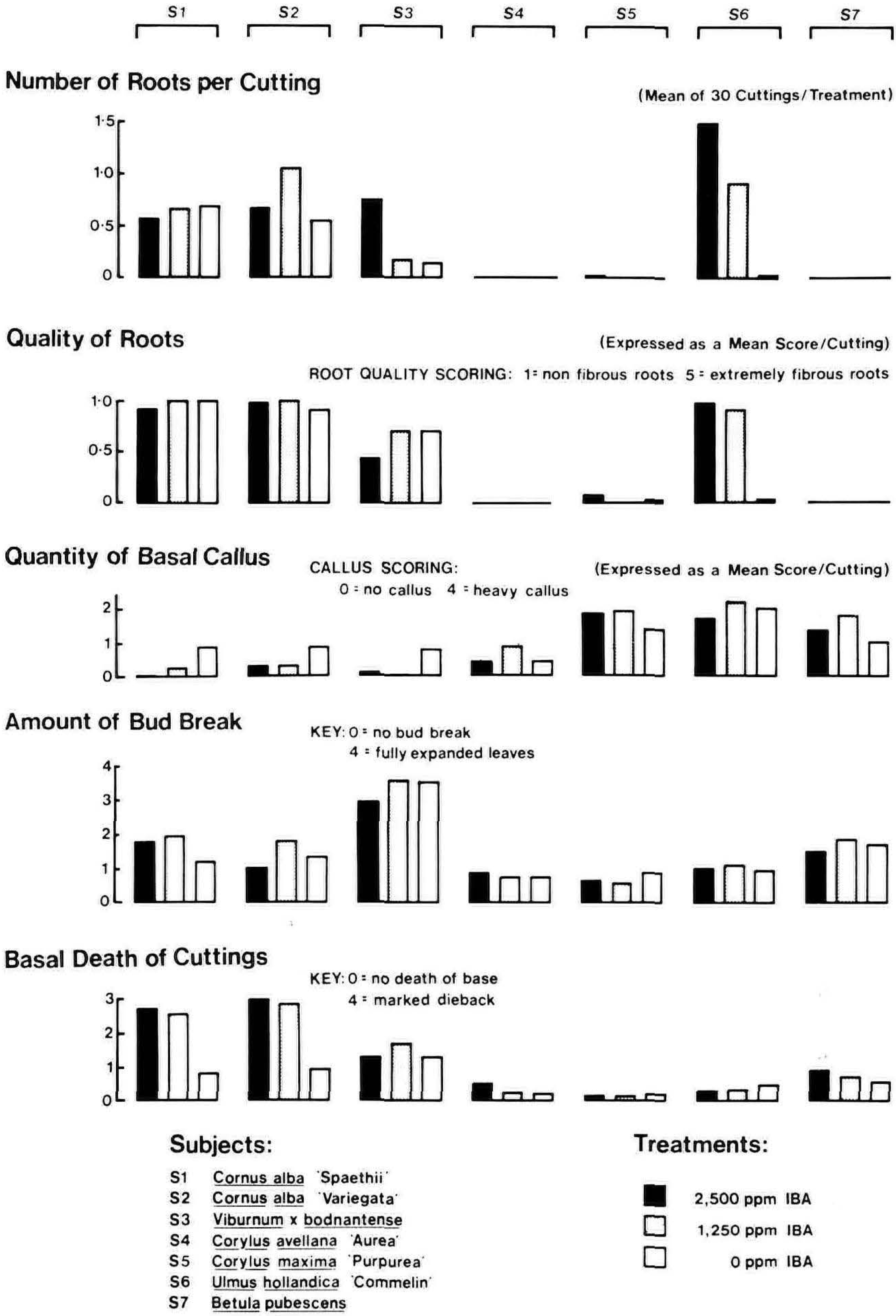

Fig. 4. Criteria recorded on lifting cuttings from the heated bin for plants used in Experiment 3.

actively growing cuttings As the season progressed this effect became less marked.

No detailed observations were made on root numbers with respect to cold chilling.

DISCUSSION

This method of propagation would appear to present certain differences than when used for fruit rootstock production. Fruit rootstocks are in many respects more tolerant of adverse conditions than many of the subjects for which data has been presented. This difference was clearly seen, in the previous season when M26 apple rootstocks were included in a preliminary trial to test the working of the cutting bins. The apple rootstocks rooted well but many of the more responsive ornamental subjects did not.

The response to rooting of the subjects used in these experiments would appear to fall into three classes.

1 Subjects which callused heavily but did not root in the bin, e.g. *Craetagus.*
2. Subjects which rooted well in the bin but showed a sensitivity to a high IBA concentration, e.g. *Hibiscus* and *Platanus.*
3. Subjects which respond in a similar manner to fruit rootstocks, with a high percentage rooting at the IBA concentrations to which the latter respond, e.g. Commelin elm.

When planted in the field, the percentage survival (as assessed by the presence of living buds) appeared to decrease with the increasing growth regulator concentration in both rooted and unrooted cuttings, examples being *Platanus* and *Crataegus monogyna* 'Stricta'

It would appear that with many of these subjects it is not always necessary to have fully developed root systems at the time of planting for subsequent establishment. Transplanting just when root development has begun appears to be more conducive to rooting.

Cold storage of cuttings after lifting from the bin, particularly in the event of adverse weather conditions, may be beneficial, enabling a crop to be held until soil conditions are more conducive to effective planting. It is possible that a problem associated with this modification of the technique could be an induced dormancy caused by this cold treatment. Another method of attempting to overcome adverse conditions which may be present at the time of planting, could be to place cuttings in "Nisula" rolls. This technique was found to induce quick rooting with certain subjects, in particular *Corylus avellana* 'Aurea', when callused cuttings were placed in rolls of this type. Subsequent survival of these plants was, however, poor and it may well be that the greater benefit of this technique could be found by rooting cuttings directly into the rolls, as the establishment phase of these cuttings would appear critical.

Cuttings taken in these experiments were planted in as near commercial field scale conditions as possible. However, this does not prevent more critical post rooting treatment on an intensive scale, where the problem of establishment, so clearly illustrated by the data for the Commelin elm, and reported by other workers, is a major factor limiting the technique at the present time. Stem dessication in early spring was thought to be an important causal factor in the death of many cuttings, particularly with *Laburnum x vossii*, Commelin elm, *Crataegus prunifolia* and *Acer platanoides* 'Crimson King'. The use of anti-dessicants may well be of benefit in such cases. It is of interest to note that certain subjects, namely, *Acer platanoides* 'Drummondii' and *Sorbus intermedia,* although retaining living buds, made less extension growth than other cultivars, the buds appearing to remain in a semi-dormant state.

It is noteworthy that where high survival values were observed, as for instance, in *Hibiscus*, the rooted cuttings produced leaf growth with a vigour directly related to the rooting score for a particular treatment.

Certain subjects appear not to respond to this technique as it has been applied in this instance. For example, *Betula, Virburnum* and *Syringa* showed very little response and *Cornus* may well be better propagated by other methods currently in use, unless a much higher survival rate is to be achieved following field planting. Rooting individual cuttings in small containers may be a possible means of overcoming this difficulty.

The values quoted in the text figures, refer to recordings taken during early summer and in late autumn and it must be emphasized that in many cases the high scores recorded for percentage survival, where the presence of living and actively growing buds was used as an index of this criterion, did not persist throughout the season. The data presented in Table 1 shows this clearly. Certain subjects look extremely promising initially but do not establish sufficiently well to grow away. This observation agrees with those of previous workers. *Crataegus* is a genus of particular interest although little extension growth was seen, the cuttings were still alive and active at the end of the season. The growth with these cultivars, which produced good extension growth, e g. *Platanus,* Commelin elm and *Hibiscus* was extremely vigorous, all plants of both the plane and the elm being of more than adequate size for transplanting into nursery rows, as were the majority of *Hibiscus.* This indicates the potential of this technique.

It would thus appear, that modifying the conditions required for fruit tree rootstock propagation, by lowering the temperature, the growth regulator concentration, increasing the irrigation requirement and field planting at an earlier stage, may lead to the rooting of certain more sensitive subjects. In general, it is probably true to say that a lower growth regulator concentration appears to be necessary, although this varies with the subject. However, it must be emphasized, that there is still a great deal of critical work yet to be done in this field.

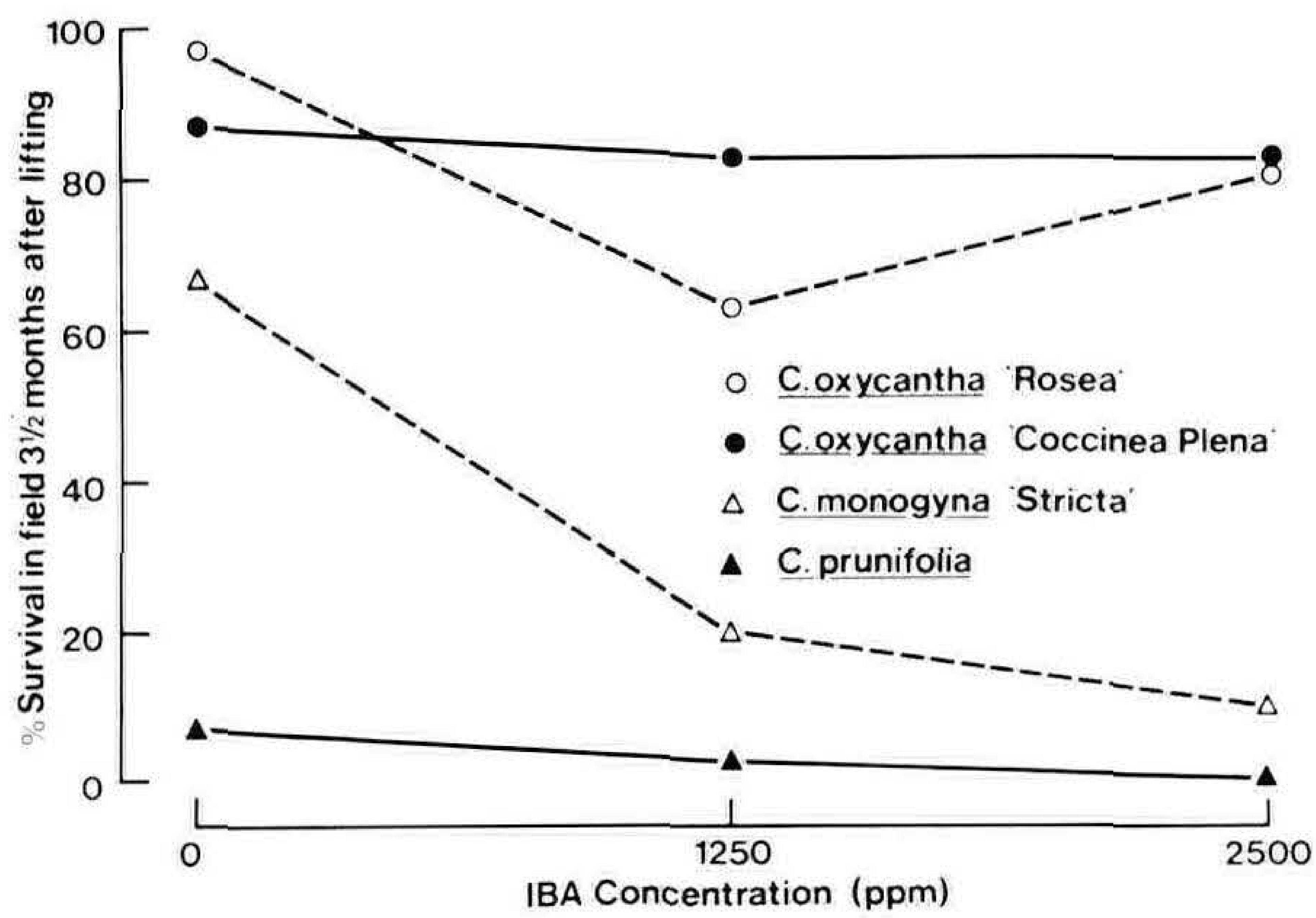

Fig. 5. Percentage survival of cuttings of four *Crataegus* cultivars.

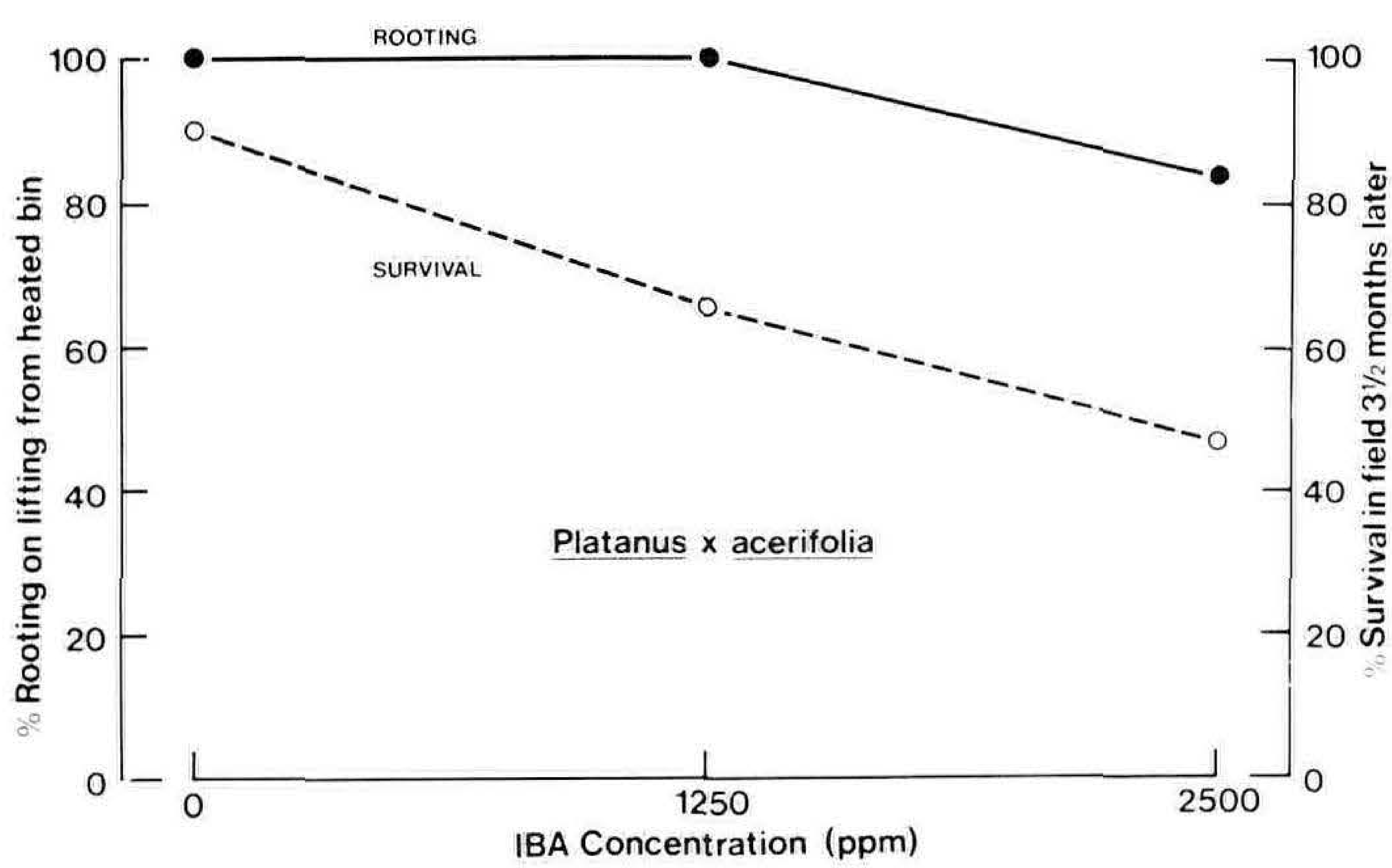

Fig. 6. Percentage rooting and survival of *Platanus x acerifolia* cuttings.

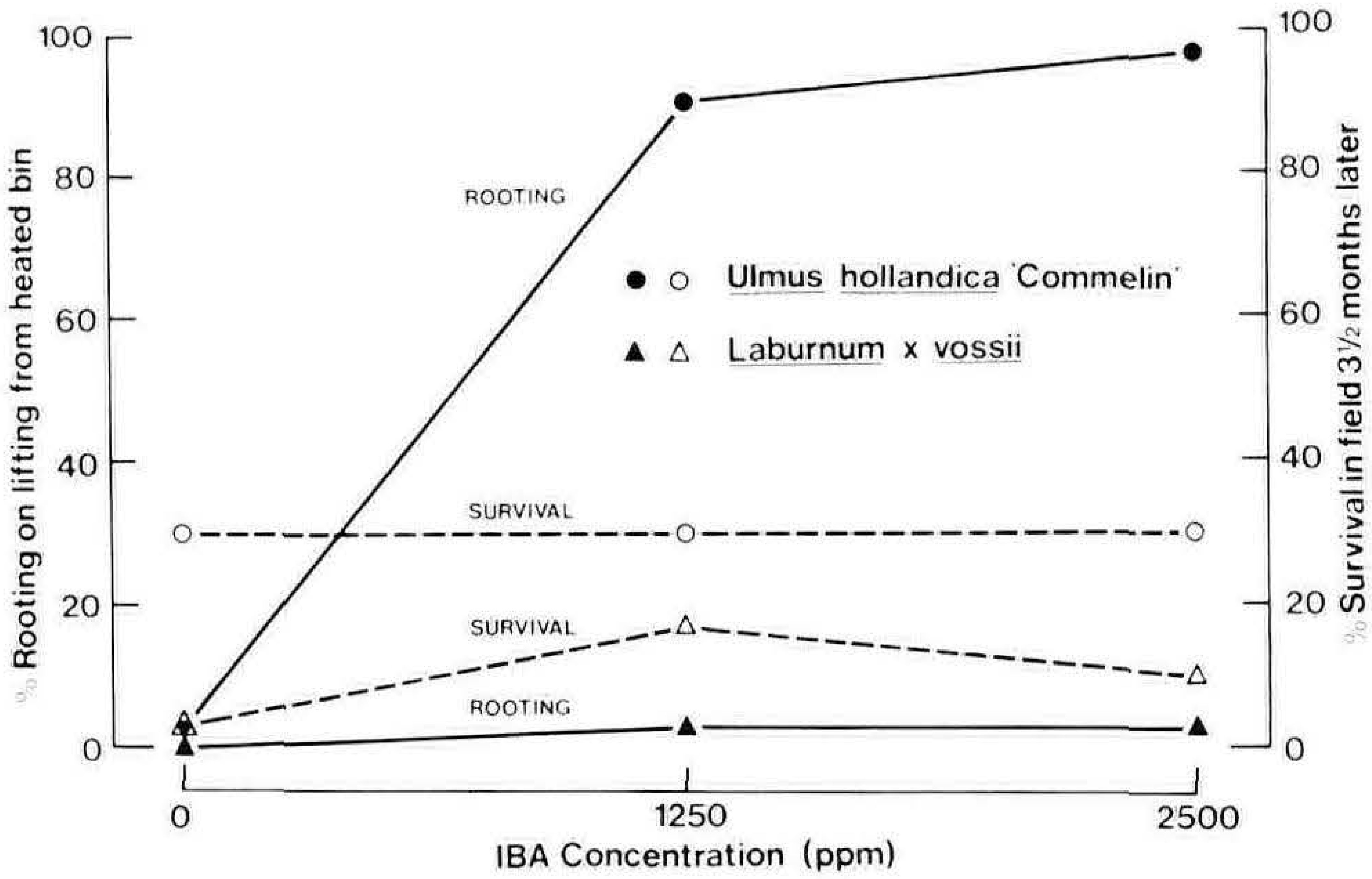

Fig. 7. Percentage rooting and survival of *Ulmus hollandica* 'Commelin' and *Laburnum x vossii* cuttings.

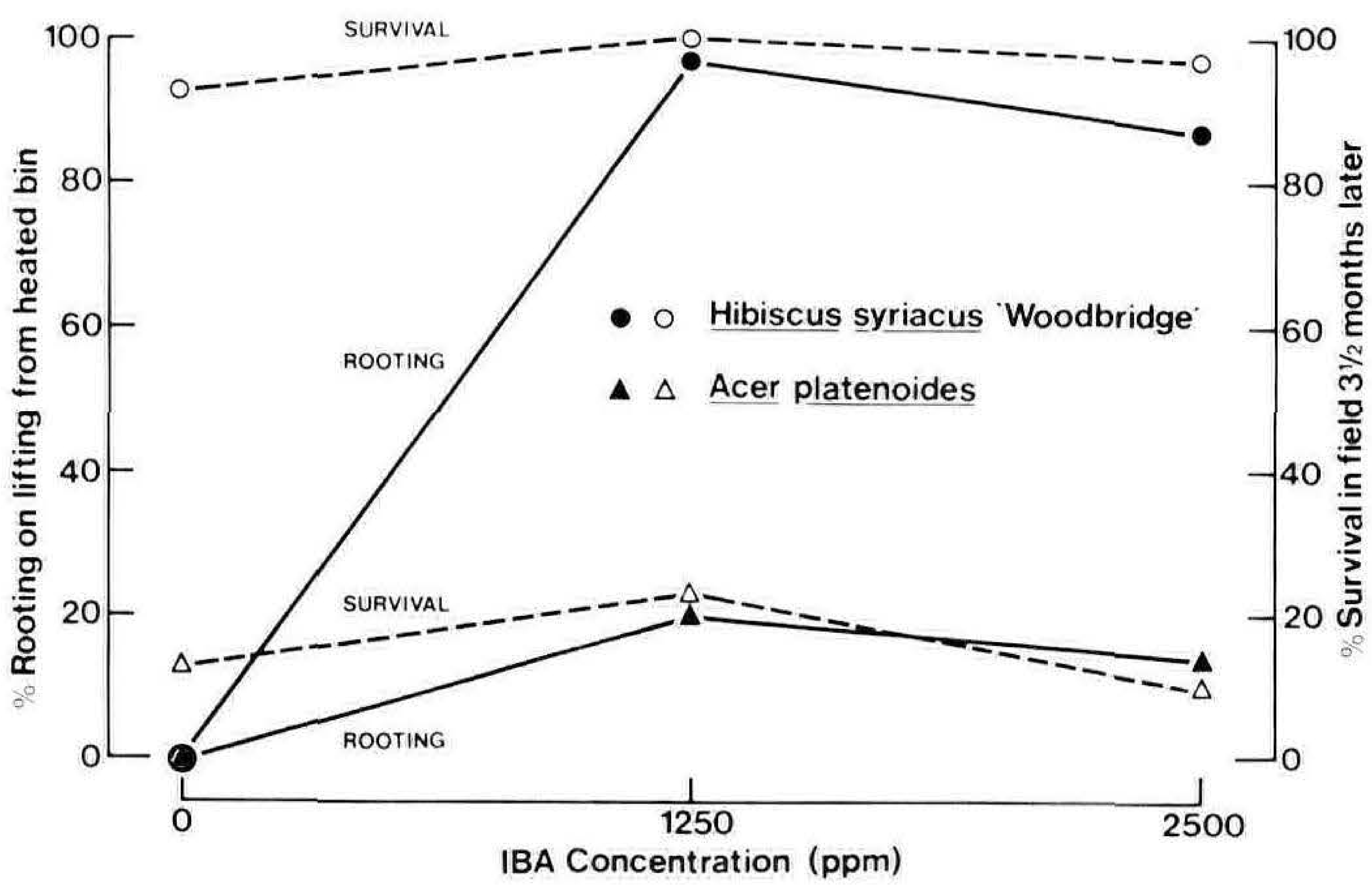

Fig. 8. Percentage rooting and survival of *Hibiscus syriacus* 'Woodbridge' and *Acer platanoides* cuttings.

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DISCUSSION GROUP REPORT— GROUP C
ORNAMENTAL TREES FROM SEED

CHAIRMAN — P.D.A. McMILLAN BROWSE

When raising ornamental trees from seed on a commercial scale, the object must be to produce the seedlings as economically as possible. In general terms this entails the production of the maximum number of acceptable seedlings from a minimum area of seedbed and the occupation of this seedbed for as short a period of time as may be considered reasonable.

However the important aspects of the situation revolve around the definition of what is acceptable. In real terms this is represented by the particular quality expected, i.e. the size and grade of the seedlings. Nevertheless, before embarking on a project to grow seedling trees it is important to define, in reasonably exact terms, what is required as an end product in any particular instance. To achieve this aim the following factors are relevant when raising seedling trees. It is necessary to know from where seed can be obtained, how it should be stored, how it should be dealt with to ensure satisfactory germination and how the seedling population should be managed.

Seeds of ornamental trees can be obtained either by collection from particular local sources and personal contacts, or from the usual commercial seed houses throughout the world.

The former source is usually more desirable as it is possible that as a parent tree it is correctly identified, is hardy in that particular geographic area, is of acceptable characteristics and, more important, can be collected at that moment of maturity which is desired. However, not all species will be available from plants in a mature seed-bearing condition within the localised catchment area which any one nursery can service efficiently. Thus, unless the propagator is able to obtain seed from reliable personal contacts, it is necessary to obtain seed from the conventional commercial seed houses. These have the advantage that as wholesale agents they are able to offer a wide range of species from widely scattered areas. However, the quantities involved and the time scale in collection, organisation and dispatch, the methods of collection and storage all may well materially influence the viability of a sample; similarly it is not always possible to rely on supply or on accurate identification until it is too late to be able to compensate for it in any particular year. Nevertheless, these firms are a useful adjunct to the nursery trade and a very necessary aid to the propagator who requires to produce a wide range of ornamental trees from seed.

Much could have been said about the provenance and the selection of sources of seed, but in the context of ornamental plants it has, as yet, little significance because choice of source is not widely available; but wherever possible seed should be selected from well shaped, typical trees which are vigorous and healthy. As it has been pointed out previously, one of the problems in collecting, processing and storing under commercial conditions is the level of viability of the finished sample and it is obvious that any unnecessary loss of viability during these processes makes the surviving viable proportion more expensive.

The viability of a seed sample is an expression of the proportion of seed which is alive at the time of assessment and hence it is a measure of the potential number of new plants which could be produced if the seeds were able to be germinated at that moment.

The term "longevity" is also employed in the context of viability and this refers to the period over which an acceptable level of viability will be sustained and this, in part, will be influenced by storage conditions although primarily it is an inherent factor.

However, what is of importance to the propagator is how the proportion of viable seeds can be recognised as it is only this part of the sample which is of value to him.

The maintenance of viability at its highest economic level is an important factor in the production of trees from seed and thus it is relevant to indicate those conditions which are suitable for the storage of particular seed types in order that the maximum degree of viability is maintained but at the same time being aware that there is a natural ageing process which represents the longevity of the sample.

In general terms, reduction in temperature and seed moisture content are the salient features of storage — below 38° F for the former and below 14% for the latter although the maintenance of a high relative humidity is necessary for seeds storing fats etc., in order to avoid deterioration viz. *Aesculus*, *Acer*, *Fagus*, etc

The complexities of seed dormancy were discussed with especial reference to the avoidance of dormancy by collecting the seeds when the embryo had matured but while they were still 'green' and had not developed inhibiting factors. A number of fallacies were also exposed, viz — the collection of *Fraxinus excelsior* seed in the 'green' in order to avoid dormancy.

nurserymen, take pleasure in having the Society meet here.

Connecticut has a long history of nurseries. The first, evidently, was owned by George Fenwick of Saybrook, as early as 1641. At that time he was producing apple, cherry and peach trees. Henry Wolcott, Jr. was also selling fruit trees as early as 1648.

One of the early booms in the Connecticut nursery industry came in the late 1700's and early 1800's when thousands of mulberry trees were produced to feed silk worms for the silk industry, which lasted in this area for about 50 years. Unfortunately, the silk boom collapsed in 1839 leaving thousands of mulberry trees and a lot of lonesome worms.

Today the Connecticut nursery industry devotes over 6,000 acres of land to the production of trees and shrubs. Horticulture-floriculture comprises the fourth largest segment of Connecticut agriculture, exceeded only by dairy, poultry and tobacco, and we are fast moving up on tobacco. In fact, some of our finest Connecticut nurseries are run by ex-tobacco men who are now in the nursery business.

Although a wide variety of plant material is grown here, Taxus does extremely well in our climate and makes up a large portion of our production for shipment to mid-western markets.

So with that brief background, let me just say that the 200 members of the Connecticut Nurserymen's Association welcome you to Hartford and hope you have a very enjoyable and rewarding stay in Connecticut.

HAROLD TUKEY: Our first speaker for the formal session of our program is a farm advisor in one of the bustling nursery producing areas of our country — and that is Los Angeles County. He is going to tell us about an interesting new development in southern California — a marketing system which has been devised for growers in the southwest Los Angeles County area. I am pleased to introduce Mr. Richard Maire.

MARKETING WHAT IS PROPAGATED: SOME EXPERIENCES FROM THE GOLDEN WEST

RICHARD G. MAIRE

Cooperative Extension, University of California
Los Angeles and San Bernardino Counties

The question is often asked of me, "What does a farm advisor do in urban Los Angeles County?" To clarify the term "farm advisor;" this corresponds to the county extension agent in most states. As a member of the staff of the Cooperative Extension in Los Angeles County, it is my major responsibility to assist the wholesale nursery growers in any way possible. What does this mean? Los

Angeles County is the largest wholesale nursery-producing county in the world with over 600 wholesale nurseries ranging in size from a city lot to 400 acres. Their annual gross value according to the Agricultural Commissioners' crop report is $41 million, and increasing. How are they increasing? By becoming more efficient in their production techniques and by the leasing of land beneath the power lines, the only open land within economic reach for agricultural production. With my connection with plant production, it is only natural that landscape architects, contractors, pest control operators, professional gardeners, retail nurserymen and parks departments call on me for assistance. As a point of interest, there are some 75 cities in Los Angeles County with a population of 100 thousand and up, all with parks departments and all with plenty of problems. As long as they are commercial or professional people, we do our best to service all requests. Due to a lack of staff, we have given only token assistance to homeowners. We get thousands of calls but all are handled by phone or through University of California or USDA pamphlets and bulletins by our public service advisor. We are giving our responsibility in this area serious consideration to determine how we might be more effective in helping the urban population with information.

In California production of nursery products has been on a continuous rise. From 1966 to 1971 it increased from $150 million to $227 million in the state. In Los Angeles County the pattern is much the same. It might be interesting to note how this production in Los Angeles County is divided as to crops: ornamental trees and shrubs, $25½ million; bedding plants, approximately $4 million; ground covers, $2½ million; indoor foliage plants, $2½ million. It is estimated that about 75 to 80 percent of this production is shipped out of Southern California.

As the title of my talk states, I am to cover the marketing of these products. Of course, all normal marketing proceedures are used. Our larger producers have salesmen in all areas of the United States. Many have conglomerates such as nursery and landscape contracting within their company, and are using their own production for their large landscape jobs. Specifically, I want to tell you about the Gardena Valley Nursery Growers Co-op. At present 24 nurseries are members and all are located in southwest Los Angeles County, most of them in the city of Gardena.

With urbanization accelerating, several small nurseries started moving out of the heavily populated southwest area. And in order to let customers know they were still very much there, growers organized to publicize their area and the production available. Customers also needed a central source to find plant material available. The Cooperative Extension Service, with the cooperation of several key growers, contacted every producer of nursery products in the southwest section of the county and invited them to a meeting to consider organizing a cooperative for promotion of Gardena Valley. Fifty-five nurseries were reported at the initial meeting and according to a rough tabulation, reported a total gross figure of approximately $5½ million.At this meeting, with the help of the University of California, the growers decided to form a cooperative.

The first year their main emphasis was on education, and 3 or 4 meetings were held each month first to inform members of the concept of a co-op and second to assist them with production techniques. Plant inventories were very sketchy or did not exist. In order to gather inventory information data processing was employed. The educational meeting attempted to accomplish several things The first was to get growers to work together. Second in importance was an educational program to change growers practices from crude monthly bookkeeping to more sophisticated data processing, and third was to arouse in the growers awareness of the cost of doing business. In order to do this cost studies were conducted by the University.

One of the greatest hurdles that had to be overcome, and even yet presents problems, is the fact that most of the member nurseries are family operations. There exists a wide communications gap among family members. Consequently, cooperation was not always as dependable and constant as would be desirable. Once the growers were organized in a co-op for promoting Gardena Valley products it was decided that cooperative marketing would be a great advantage As individuals they were not large enough to compete in the mass market outlets. As a cooperative of 24 nurseries their production was great enough to effectively bid for mass market sales Flexibility was built into the cooperative, allowing members to continue operating as independent nurseries as well as supplying plant materials to the co-op. This presented serious problems for the co-op sales during the first years since there was no way of being sure of plant availability. This problem is now being overcome by the latest trend in crop production and marketing; that is, contract growing for future sales. With the inception of contract growing, growers are now being forced into programming. Procedures had been to "guesstimate" what they sold previously and what might be required for the next year since no accurate records were kept by many.

Quality control also presented an obstacle to co-op marketing. Each grower produces differently and each has a different opinion as to what is top quality. Visitations are now being made each week by co-op members to observe materials contracted for and to determine if they meet co-op standards of quality.

The Gardena Valley Co-op has had its problems, but on the whole much good has been derived from it as evidenced by its survival. Above all, growers have learned to work together and share ideas; the same objective that we enjoy and benefit from being in the International Plant Propagators' Society. Of course, not to be overlooked is the current year's sales for the Gardena Valley Nursery growers. This extra business has increased from $150,000 the first year to between 3/4 and one million dollars just four years later.

One additional development that could directly affect marketing of nursery products is the formation of the California Environment Landscape Council. This is a group of organizations involved in any aspect of landscape maintenance and supply banded together for improvement of communications and education. It has long been recognized that there is a serious breakdown in communication between the landscape architect who writes the specs, the contractor who puts in the plants and the maintenance gardener who is responsible for keeping the end result attractive and alive. The organizations presently participating include the following:

CALIFORNIA ENVIRONMENT LANDSCAPE COUNCIL

1. California Association of Nurserymen
2. Nursery Growers Association
3. A.I.L.A, American Institute of Landscape Architects
4. A.S.L.A, American Society of Landscape Architects
5. C.L.C.A, California Landscape Contractors Association
6. Landscape Designers
7. Street Tree Seminar
8. Southern California Turfgrass Council
9. Southern California Park & Recreation
10. Southern California Gardeners Federation
11. Southern California Gardeners Council
12. Northern California Gardeners
13. Golf Course Superintendents
14. Nursery and Landscape Suppliers
15. News media — Trade magazines
16. University of California — (as Advisors)

Great strides have been made in marketing Southern California nursery products as evidenced by the high percentage of production shipped out of Southern California and the expanded marketing area. There is still much to be done and improvements to be made; the University and the growers will constantly work to expand, increase, and improve the quality of nursery production in Southern California.

HAROLD TUKEY: Thank you very much for an excellent presentation, Dick. Does anyone have a question they would like to ask at this time?

LES HANCOCK: He mentioned one thing which I would like to comment on; quite frequently the architects put plant materials in their plans which may not even be available in our area of Canada. I think it is very important that there be communication between the architects and the nurserymen with respect to plant materials designated on contracts. I believe it is quite uneconomical to have to bring in plants from as far away as 500 miles when there are often plants available locally that are even better suited to the situations designated on the plans. I wonder if Mr. Maire has any comments concerning this?

R. MAIRE: I believe the Council which we are trying to organize is an answer to this situation. Most of the architects know far in advance of big jobs of plant materials that will be needed. We are attempting to stimulate cooperation so that the architects will let nurserymen know what types of plant materials will be needed and when. Communications with the landscape architect is essential and several years ago we began holding a seminar for them at the the University of California Lake Arrowhead Conference Center. One day of their 4 day conference is devoted to things such as plant materials, soils, water, etc. and though they were at first reluctant to accept this, this is the area of the program that now brings forth the most enthusiasm.

JIM WELLS: I have several questions which will require just short answers.How was this organized? Who is the paid executive at the head of the organization, and who pays him? How do they get revenues to keep the organization running?

R. MAIRE: It was organized by the growers at an organizational meeting; we served mainly as advisors to aid in pulling it together. There is no paid executive at the present time, though I think this is one thing they will have to do in the future to make the operation more efficient. The board conducts all of the business but there is one unpaid individual who acts as secretary-treasurer taking orders. Revenues are derived from a membership fee and a percentage of the sales which the grower has through the co-op. Revenues in excess of those needed for operation are given back to the growers on a prorata basis. One of the keys to the success of the co-op is apparently the option of selling to it or not, as the grower may choose. Also this is not a competitive organization which is taking over sales from the growers but rather one which is going out and finding new markets.

HAROLD TUKEY: We now move across the country to New York. Our next speaker was with New York City in another capacity and did very well at it, but then decided he wanted to do something different so he brought his business expertise to the nursery business. Jim Cross has been a tremendous cooperator and he has some new insights on how to do things. I think you will enjoy the comments that he has to make.

PROPAGATION IS JUST THE BEGINNING

JAMES E. CROSS
Environmentals
Cutchogue, New York

This morning I want to talk a bit about that phase. of programmed production which *immediately* follows propagation. It is the process of producing the so-called "liner" which will then go into the field, or a container of some sort, to be grown on to whatever size your particular market or needs require. My comments will be partial to container growing but the same process would apply if the plants were to be grown on in mother earth.

This initial phase of growing cannot and should not be separated from propagation — it should be a continuation, without interruption of the process begun in the propagation bench. Whatever you wish to call this phase, it should be associated in your mind with **Growing** — for all too often this phase is begun and even continued more as a holding process than as a fully managed growing operation.

We put in all that effort to get new plants started, so why lose the momentum achieved in the propagation house. I assure you that there is a form of momentum involved. For any of you who do not think in these terms, listen carefully to Dr. Krizek's presentation this afternoon, or tomorrow's panel on "Systems" for rhododendrons.

There is one prime characteristic of commercial horticulture which separates it from all other industries. This is the **very long lead time** between the decision as to what plants to propagate and grow and the point of eventual sale or other disposal. Try to think of another industry which even approaches commercial horticulture in this unfortunate respect. Even new passenger airplanes and large custom boilers have lessened their development and production period to less than ours.

This industry characteristic points up very sharply two aspects of plant production where application of more management time can pay off like no other.

1. First, the initial decision as to which plants to grow and in what quantities. With a 2, 4 or 6 year production cycle, it should be obvious that we need well-programmed production more than any other industry.

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1. First, the initial decision as to which plants to grow and in what quantities. With a 2, 4 or 6 year production cycle, it should be obvious that we need well-programmed production more than any other industry.

2. The second aspect which comes to mind is "How to reduce this production time?" This is the subject which I want to stress by looking at one simple method which produces good results for us.

As a starter, I would suggest that if you commercial growers have not reduced your production time by at least a full year over methods of 10 years ago, you have slipped up somewhere. All of the knowledge and materials necessary to do this have long been available. Moreover, you have had this subject will presented at earlier I.P.P.S. meetings. Dick Vanderbilt told us very specifically how with rhododendron in 1967, as did Richard Bosley last year. There have been many other papers which covered this subject in one way or another.

Let me mention a few of the plants where we have managed to reduce production time by at least 1 year.

Probably the ideal plant to make my point is the cotoneaster, because, once started in the propagation bench at the right time for your schedule, it is ready to grow and all one has to do is provide its modest needs.

Cotoneaster dammeri — Normal sized cuttings were taken in November 1971. At the end of its first growing season, the first halt in growth since it was rooted, it is at least a full 18-24" plant in an 8" or so-called 2 gal., container. Our cotoneasters are all sold as 1 year plants or less. About 1/3 of our crop is sold in late summer and fall with no winter carryover. A very wide variety of other plants respond well to the same simple management which produced these cotoneasters.

The brooms, *Cytisus* and *Genista* — Cuttings stuck mid-December 1971. All will be sold this coming spring and early summer as 1 year plants.

Even the very slow growing dwarf conifers respond well to this process. We generally grow these on for a second year but they have a good start for these particular plants and some cultivars can readily be sold for retail use at the first year stage.

Pachistima canbyi — A very nice, acid-soil, ground-cover, limited in availability and usefulness because it is so frequently sold only bareroot in the spring. These plants are finished for our purpose in their first year from a December cutting.

Rhododendron — We already know what is being done with large leaf forms. The techniques work as well with small-leaf dwarf forms, adjusting sizewise to their slower rate of growth.

'Purple Gem' — A well-budded and full 15-18" plant in a 8" container can be produced in 2 years.

'Dora Amateis' — A dwarf white. Full 18" plant, well-budded in 2 years. This past spring season we began to sell these last two varieties when 1 year old. They bloom heavily enough with nice 8" heads, to make good impulse items at retail garden centers. One-third of our crop went out this way with no fall promotion or catalogue listing and no customer had any plants left unsold. So even these might well be converted to a 1 year crop.

'Wilsonae' — With this variety we get only a few flower buds in the second year, but they are sold primarily as foliage plants, so no time has been spent trying to improve budding. These results apply to numerous other cultivars — all small-leaf — which we raise.

Leucothoe axillaris — Nice compact 12-15" plants, ready for sale in retail yards can be produced in less than 1 year.

Ilex glabra — In 2 years a good 15-18" full plant.

Calluna and *Erica* — Any of the many cultivars can be finished and ready for sale at retail in the first year.

In every case the elapsed time in achieving the desired size of these particular plants was one season (or 1 year in the Northeast) — less than that frequently required. This reduction was achieved by little more than continuing the momentum obtained in the propagation house.

Beginning about mid-December, we lift the rooted cuttings, starting with the fastest rooting varieties, cut back all tops hard and roots where elongated and coarse, and transplant them into a fertilized Cornell type mix (vermiculite and peat) in flatted 3" peat pots.

The flats are placed in a heated plastic house of simple construction and management — in this case, 22 x 180 ft.

The flats are kept well off the ground — if too low, not only will the plants not grow well but some will go into winter dormancy, even though there is a 2 foot perimeter insulation. Our heat is oil-fired hot air, distributed by off-center tubing. We originally ran these houses at 65° -75° F, but after listening to Dr. Krizek at our 1968 meeting, we have increased this to more like 75° -85° F with noticeably better results.

The center tube distributes fresh air from the wall fan. In January, and most of February, in our area this is used only manually to bring in dry air in late afternoon for a day or two after irrigation. As the days become longer and brighter this fan takes over at 85° F with a few simple safety procedures to prevent any chance of back draft of fumes from a hot furnace.

A peninsula arrangement of the flats permits ready access to all plants with minimum aisle space. We do keep a fairly wide center aisle for ease and comfort of handling plants and equipment.

Irrigation can be manual, or overhead with manual touch up. I would highly recommend manual irrigation by carefully trained personnel whenever time permits, particularly during the first month or two, as the houses are filling up and the plants are in different stages of growth and, therefore, of water consumption.

This house is filled gradually as plants are rooted and ready to move, with completion about the end of February. The last plants to go in are those in which the cuttings went into propagating space made available by the first entries into this growing house. We have the house set up so that a partition wall limits the protion which needs full heat.

By the time the first transplants have settled in and made additional root growth, the days are beginning to lengthen and we get more sunny days — so the timing works out about right with Mother Nature.

We have used incandescent light as a supplement on quite a few genera of plants but the results, in our case, did not justify continuance of this practice. We did get somewhat more growth, but too rapid elongation produced a taller, but lower quality, plant.

By mid-May, when the danger of frost is past in our area, we begin to move these plants out for potting into their larger containers. The first ones out are those such as rhododendrons and cotoneaster, which are the first to grow out of their peat pots. As they are moved outside in the spring of the year of propagation, you have a good, full, 1 year liner. These plants are ready to continue into the equivalent of their second year of growth, which will be achieved with ease their first summer outside in the normal manner for container growing, as long as this move is well-timed.

In my opinion, good timing at this point is determined by minimizing transplanting setback and getting the plant going into its new home well before the summer heat sets in. We go to the extra effort and expense of using peat pots in order to reduce disturbance in transplanting. It is easy to allow the other severe competitors for our time, such as filling orders and deliveries, to get in the way of transplanting at the prime time. After all, these plants are growing well where they are and need only be maintained. If we allow this year's sales activities to decide this timing, we pay a measurable price on next year's crop.

To go back to the heated plastic house — the management during those winter and early spring months includes nothing whatsoever unusual. Normal, though careful, irrigation and preventive spray programs are followed. Though we eagerly experiment with new chemical growth regulators, we are using no chemical accelerator or inhibitor on a regular program. I would, however, be remiss if I did not stress one type of growth regulator which, if used on a well-timed basis, does a spectacular job. There is still nothing available that I am aware of which produces equivalent results in quantity and quality to the pruning shears.

The frequent pruning done in our growing house is valuable for two reasons in particular.

1. It is done in the off-season when we have fewer interruptions and a much better chance of the best timing.

2. The time to do the pruning, which is the key to quality, is when the plant is starting to build its future base. You waste less growth and get the best response with the least space and effort. Some genera can never be brought back into a really good branching structure once they reach a certain point of elongation or, at best, it takes a long time.

Incidentally, another obvious but important point might be mentioned here. The timing of this pruning is not only right for the plant, but also the nursery manager who is always looking for productive work to justify keeping on desirable personnel in the off season. Moreover, any man who generally works at the far end of the production cycle will benefit greatly, in attitude and interest, from seeing first-hand, and being a part of the full variety of processes which the nursery has to offer.

The objective in these comments is not to argue for faster growth or higher quality for its own sake, but rather to try to show the importance of reductions in production time.

In my opinion, the economics of this particular process for cutting 1 year from production time is very strong. I am certain that costs of this simple process can be reduced — from what we show — by most any astute nursery manager, by finding the always available better ways to do the same thing and from lower costs which come from working with larger quantities. Our costs include some bad mistakes. Our incremental costs for this growing phase are as follows:

Incremental costs of one season's growth in mid-winter in controlled environment

Capital Costs	Est. Life		Cost/yr.	Cost/plant
House frame	20 yrs.		$ 88.	
House cover-fiberglas	10 yrs.		260.	
Heater	8 yrs.		165.	
Oil tanks	25 yrs.		11.	
Ventilating equipment	5 yrs.		45.	
Misc. fittings, etc.	10 yrs.		10.	
Labor — construction	10 yrs.		31.	
		Total	$ 610.	$ .0173
Annual Operating Costs				
Fuel			$ 830.	
Heater maintenance & repair			55.	
Electricity			39.	
Poly liner & tubing			108.	
Labor — preparation			70.	
Shading — mat'l & labor			52.	
Misc. materials			5.	
		Total	$ 1159.	$ .0328
Other				
Flats — amortization & annual treatment			$ .0068	
Peat pots			.0176	
Mix — incl. labor			.0195	$ .0439
		Total incremental costs per plant		$ .094

These are not **total** costs, for I have tried to exclude those cost items which clearly would be incurred in most any approach to carrying on production or even just holding the rooted cuttings.

Nor are they entirely incremental for it might be argued that some of the costs shown overlap those which would be incurred in other methods. I have attempted to stay conservative with these figures. I do not know how you respond to the 9.4 cents cost, as I have not had the opportunity to discuss this with you. By my methods, this figure tells me that our little plastic house is the most efficient thing we do — far and away our best investment of capital.

Keep in mind that it cuts a full year from production time. Our average plant going through this process sells at wholesale for $2.00. If we took the 2 years formerly needed to produce this same plant, I know that our maintenance costs for that second year, including losses and winter protection would be several times this 9.4 cents. However, I do not need to look this far to see the economic benefit. That $2.00 which I received and had use of a year sooner is worth 10 cents at the local bank's lowest savings rate, 12-14 cents in most any good bond these days, probably 16 cents or more if I had to borrow from the bank and 20 cents if we are able to achieve an unspectacular 10% return on the investment of our nursery.

Whenever you can program your production so as to reduce the long production time for woody ornamentals, you are making real progress by most any measure.

HAROLD TUKEY: Jim, that was tremendous and you have done so well we are going to have to ask you back again soon.

G. STROOMBEEK: Do you allow for any dormant period on these broadleaved cuttings?

JIM CROSS: Not as such, though there is some rest as a result of the low light conditions we experience at this time of the year. Also, I do not turn my temperature all the way up when the plants are first put into the houses, it does take a while for the heat to get into the root area and start growth activity — so there is in a sense some rest period but it is not intentional.

PETE VERMEULEN: Would you comment on your fertilization proceedures, timing, etc.?

JIM CROSS: As I mentioned, there is nothing unusual; we use the Cornell Mix and have gone to vermiculite rather than perlite because we can manage it easier — particularly the irrigation. We used two different pH's, the lower one for the ericaceous material and the higher one for euonymus, cotoneaster etc. We add 5 pounds of limestone and 5 pounds of superphosphate plus 2 tablespoons of iron per yard of medium. For the ericaceous material, gypsum is substituted for half of the limestone. Bareroot material that has been in sand or perlite, we pot in the medium with no nitrogen at first and then use a 1 ½ gram Agriform tablet. For those cuttings which have a little rootball we add the nitrogen to the medium. At present we are using 6 pounds of Acid Electra per cubic yard. When they are moved into the larger containers we go to all slow-release fertilizer — Osmocote on the faster growing plants and Agriform tablets on the ericaceous and other slow growing materials.

HAROLD TUKEY: Our next speaker is Dr. Andy Leiser and he is going to tell us about some interesting experiences with plant propagation for highway planting[1].

We have no time for questions and so we will move on to our next speaker, Dr. Hudson Hartmann. Dr. Hartmann has not been on our program before but he is probably well known to all of you. He is the co-author of one of the best books we have on plant propagation and is the International Editor for the Society. Dr. Hartmann is going to discuss some aspects of the present rootstock situation for fruit crops in California.

THE ROOTSTOCK SITUATION FOR TREE FRUITS AND GRAPES IN CALIFORNIA

HUDSON T. HARTMANN

Department of Pomology, University of California
Davis, California 95616

For most of the major fruit crops in California, the plants are propagated by budding or grafting on rootstocks. Very large acreages and high crop values are involved; the proper selection of scion-rootstock combinations is necessary or tremendous financial losses can occur.

The bulk of the deciduous fruit acreage in California is in the Central Valley — the Sacramento and San Joaquin valleys — where considerable emphasis is on the stone fruits — peaches and nectarines (110,000 acres); almonds (254,000 acres); apricots (35,000 acres); prunes (100,000 acres); and plums (27,000 acres). The English walnut is also grown in the Central Valley with smaller amounts in coastal valleys and Southern California, giving a total acreage of 198,000. The vinifera grape is a major and dramatically increasing crop in the San Joaquin valley with lesser amounts in the coastal valleys, making a total of almost 500,000 acres now planted. The San Joaquin valley and, to a lesser extent, Southern California, is the big producer of table oranges with 224,000 acres. The coastal region south of Santa Barbara and, to a lesser extent, Southern California, grows 56,000 acres of lemons. California is the sole producer of olives in the U.S. with 42,000 acres, grown mainly in the San Joaquin and Sacramento valleys. Pears, mainly Bartletts, are grown in the Sacramento valley as well as in the foothills of the Coast Range and Sierra Nevada, with a total acreage of about 46,000.

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The apple is considered a minor crop in California with 25,000 acres, although California ranks 4th in the U.S. in apple production. Other minor fruit crops are the avocado (24,000 acres), figs (17,000 acres), grapefruit (17,000 acres), cherries (14,000 acres), dates (4,000 acres), and pistachio (9,000 acres). The value of the 1969 production of the crops listed above was 787 million dollars. The rootstock situation and propagation methods for the various fruit crops have changed over the years. Rootstocks and propagation methods presently being used are as follows:

Peaches and Nectarines *(Prunus persica)*. Propagation is largely by T-budding in the fall or by June-budding. Since the root knot nematode *(Meloidogyne javanica* and *M. incognita)* is a considerable problem in the light soils of the peach areas, many trees are now being worked on the USDA's Nemaguard (peach — *P. davidiana* hybrid) stock, introduced in 1959, which is resistant to both types of nematodes. This stock may not be winter hardy in the colder areas of the U.S. Clonal mother trees of Nemaguard are used as the seed sources, the seedlings uniformly showing nematode resistance. Trees on Lovell seedlings are also available from nurseries for areas where nematodes are not a problem.

Almonds *(Prunus amygdalus)*. Propagation is by fall or June T-budding on year-old seedlings of peach (Nemaguard or Lovell) or almond. 'Marianna 2624', a vigorous clonal selection from the parent Marianna plum — *Prunus cerasifera x P. munsoniana* (supposedly), propagated by hardwood cuttings, is used for some almond cultivars that are to be grown in heavy, wet soils or where oak root fungus is present. The use of vigorous peach-almond hybrids, propagated by hardwood cuttings, show promise as a future almond rootstock Indolebutyric acid treatments given the hardwood cuttings of these clonal rootstocks before they are set out in the nursery have been of striking benefit.

Apricots *(Prunus armeniaca)*. This is propagated by T-budding, either in the fall, or by June budding. The principal rootstock is apricot or peach (Nemaguard) seedlings or 'Marianna 2624' plum. The California apricot cultivars ('Royal', 'Blenheim', 'Tilton') do well on peach roots but studies in Canada (6) and Michigan (1) show an incompatibility with certain other cultivars on peach roots.

Plums *(Prunus* sp.), including prunes *(Prunus domestica)*. These are propagated by T-budding in the fall. The traditional rootstock, and still widely used, is Myrobalan plum seedlings *(Prunus cerasifera)*. Certain exceptionally vigorous selections ('Myro B', 'Myro C') have been made and are propagated by hardwood cuttings. The clonal stock, 'Marianna 2624', is used to a considerable extent in California, but young trees on this and 'Myro C' stocks are shallow-rooted and will blow over in winds, more so than those on Myrobalan seedlings. Peach seedlings are quite satisfactory as a plum rootstock, especially on light, well-drained soils, but in some areas of California trees of plum on peach roots tend to over-bear and develop a dieback condition.

English walnut (*Juglans regia*). This is propagated in California by patch budding or whip grafting on seedling rootstocks or top-grafting 3 or 4 year old trees in the orchard, planted in place. There is no ideal rootstock available The most commonly used stock over the years is *Juglans hindsii*, the northern California black walnut, but this is highly susceptible to *Phytophthora* crown rot, especially under wet soil conditions, and to root lesion nematode. It is highly resistant to oak fungus (*Armillaria mellea*). A major problem with this stock, however, is its susceptibility to "black-line", a condition occurring after about 20 years, where the tissues around the graft union deteriorate and the top dies, an example, perhaps, of delayed incompatibility. This occurs mostly in cooler coastal regions of the state and the cause is unknown. Seedlings of *Juglans regia* used as a rootstock do not show "black-line", but they are very susceptible to oak root fungus, which limits their usefulness in California. Paradox hybrid (*J. hindsii x J. regia*) makes a strong vigorous rootstock for *J. regia* cultivars and is much in demand. The nurseries charge $1 25 extra for trees on this stock; Paradox seedlings are found occurring naturally in the nursery row where the tree source of the *J. hindsii* seed is growing in close proximity to and is pollinated by *J. regia* trees. Such seedlings are easily located in the rows of *J. hindsii* seedlings by their larger leaf size

Although uniformly vigorous, there is considerable variability among Paradox seedlings in their resistance to nematodes and crown rot. Several superior clonal selections have been made but there is a great need for reliable methods of large scale propagation of these clones by cuttings. Either hardwood cuttings rooted over bottom heat, or leafy cuttings under mist can be rooted, provided IBA treatments are given, but such rooted cuttings will not tolerate any disturbance of the roots. Studies are underway presently to overcome this problem using techniques such as rooting in solid block media.

Grape (*Vitis vinifera*). The steadily increasing consumption of wine in the U.S. has resulted in a dramatic increase in wine grape plantings in California, the extent being limited only by the availability of nursery stock. Figures for 1971 showed a total of about 55,000 acres of non-bearing grapes in California, reflecting new plantings for 1969, 70, and 71 And in 1972 alone, 52,000 new acres were planted. This tremendous demand for nursery stock has quickly led to a modernization of the traditional propagation methods. Cultivars for planting in areas of the state — where nematodes or phylloxera are not a problem — are being propagated in high numbers as one-node stem cuttings treated with IBA and set under mist. With high bottom heat — about 85° F — cuttings root in about 7 days. New growth taken from these rooted cuttings can again be rooted as stem cuttings so a geometrical increase in population can be obtained The original source of the propagating material being used is limited. It is supplied by the University of California's Foundation Plant Materials Service from stock plants that have been indexed and found to be free from known grape virus diseases.

Wine grape cultivars to be planted in the coastal valleys of California, where phylloxera and nematodes are a problem, must be worked onto resistant rootstocks, which complicates the propagation procedures. Again there has been considerable urgency in developing rapid propagation methods for such grafted vines The technique now in use was modified at the USDA Horticultural Field Station, Fresno, California (2). It consists, essentially in grafting in early spring an unrooted, disbudded, hardwood cutting of the resistant rootstock clone to a one-budded scion of the variety to be grown. The grafting is done by one of several devices, e.g. a French grafting machine which makes a saddlegraft, an inverted "V" in the scion and a "V" in the stock, or by a machine having several saw blades, which cuts out notches in the upper end of the stock and the lower end of the scion so that they will interlock upon being pushed together. The graft unions by the former machine are held together preferably by an ordinary desk staple, or in the latter by budding rubbers. The completed grafts are placed for callusing in moist wood shavings at 80° F for 2 to 3 weeks; after this the top of the graft to below the union is dipped in melted paraffin (usually double dipped) held at 140° F to coat the scion and union The grafts are then planted in soil in open 6" x 2" x 2" wax or plastic-coated paper tubes. After a 4-week period under protected greenhouse conditions, when scion shoot growth is 12 to 14 in. long, and when roots are well developed, the grafts — tube and all — are planted in their permanent location in the vineyard.

Rootstocks for *Vinifera* varieties now being recommended in California — all of which are available from the U. C. Foundation Plant Materials Service from virus-tested sources — 'Rupestris St. George' (resistant to phylloxera but not nematodes); 'Aramon x Rupestris Ganzin No. 1' (mildly resistant to phlloxera but not nematodes); 'Solonis x Othello 1613' (resistant to nematodes but not phylloxera); 'Harmony' — a new USDA introduction (resistant primarily to nematodes and moderately to phylloxera); and 'Dogridge' and 'Salt Creek' (resistant to both nematodes and phylloxera, but so vigorous they should only be used in low fertility soils).

Oranges (*Citrus sinensis*), **lemons** (*C. limon*) and **grapefruit** (*C. paradisi*). The commercial propagation methods are the same for all species of citrus— T-budding on seedling rootstocks. Citrus is plagued by several serious virus diseases, as well as possible inferior mutations, so it is very important to use only transmissible disease-free and known true-to-type propagating material. The various members of this genus will intergraft readily and can be grafted to other closely related genera, such as *Poncirus* (trifoliate orange), as rootstocks.

The fact that citrus seeds produce apomictic (nucellar) embryos readily permits the propagation of clonal rootstocks by seeds. With the exception of the psorosis virus, transmissable diseases do not appear in citrus seedlings.

Rootstocks selected for plantings vary according to the type of citrus fruit to be grown and to the area in the state and the soil type to be planted. Those being used in California at the present time are seedlings of:

a) **Sweet orange** (*C. sinensis*). This is a very good stock for all citrus cultivars and does well except on heavy, poorly-drained soils where it often shows a gummosis problem due to *Phytophthora* infection.

b) **Sour orange** (*C. aurantium*) is an excellent rootstock also for all citrus species except that it is subject to the "tristeza" disease, a virus transmitted by an insect vector or by infected budwood. This stock is no longer used in California on this account, but is still widely used in Florida and Texas where "tristeza" has not been a severe problem.

c) **Rough lemon** (*C. limon*). In California this stock is only used on sandy soil in the desert regions, due to its high susceptibility to *Phytophthora*. Trees on this stock are very high yielding but the fruit is of inferior quality.

d) **Trifoliate orange** (*Poncirus trifoliata*). This is a dwarfing stock now widely used in California's central valley citrus region, doing best on a medium-textured soil. Trees on trifoliate orange yield heavily with high quality fruit and develop considerable cold resistance.

e) **'Cleopatra' mandarin** (*C. reticulata*). This stock is widely used in California, as well as in Florida and Texas, due to its resistance to gummosis, "tristeza" and to its salt tolerance. Yields are good and fruit quality is high, but fruit size is somewhat smaller than average. Its chief disadvantage is the slow seedling growth and slowness of trees worked on it to come into bearing.

Citranges (*Poncirus trifoliata x Citrus sinensis*). There are several named cultivars used as seed sources — 'Morton', 'Savage', 'Troyer.' These have been useful as dwarfing stocks for grapefruit and mandarins, and trees of sweet orange on this stock have been good yielders of high quality fruit.

Citrus macrophylla. Due to its boron tolerance this stock has found wide use in California as a rootstock for lemons grown in certain high boron soils. As a sweet orange rootstock, however, the trees would be susceptible to "tristeza".

Pears (*Pyrus communis*). 'Bartlett' pear production in California has had a stormy history of rootstock problems. *Pyrus communis* seedlings over the years have proven to be a satisfactory stock except for their susceptibility to fire blight (*Erwinia amylovora*). In the early part of this century oriental pears, such as *Pyrus pyrifolia* seedlings, were used due to their resistance to blight but pears from trees on this stock were found to develop abnormal conditions, turning black and hard rather than ripening normally (termed "black-end" or "hard-end" fruits). This defect disappeared if the trees were inarched with *P. communis* seedlings, then after the inarches were of sufficient size to hold up the tree, the original *P. pyrifolia* connection was cut. Apparently some material in the original root system was translocated to the fruit where it caused the abnormal condition.

About 1960, the so-called "pear decline" condition swept the West Coast, killing hundreds of thousands of trees, again mostly on oriental roots, *P. pyrifolia* and *P. usseriensis*. An intensive research program over the next 10 years finally determined that the causal agent was a mycoplasma-like body spread by pear psylla (5), but only affecting trees on certain rootstocks, chiefly the oriental pears and quince (7). A phloem breakdown at the graft union caused the death of the tree. The 'Bartlett' clone itself is not susceptible and procedures were developed to propagate 'Bartlett' on its own roots by hardwood cuttings (3). Such trees in rootstock plantings have proven to be quite productive and somewhat dwarfed. At present in California, nurseries are mainly using as pear rootstocks, seedlings of the 'Winter Nelis' pear, where the fruits are collected in 'Bartlett' orchards having 'Winter Nelis' trees scattered through the orchard as pollinizers. This is to avoid indiscriminate collection of 'Bartlett' fruits from orchards where the pollinizing parent could have been an oriental pear, giving a hybrid seedling, which would be susceptible to "pear decline".

Apple (*Malus sylvestris*). Over the years, apple orchards in California have traditionally been on seedling rootstocks. Recently, however, more and more growers are using clonal rootstocks together with close plantings. Preferred stocks are 'Malling 7', 'MM 111', and some 'MM 104', 'Malling 9' has given too dwarf a tree for California growers. The trend toward these clonal apple stocks and away from seedling stocks is likely to continue.

Sweet Cherries (*Prunus avium*). These are propagated by fall T-budding on seedlings of Mazzard (*P. avium*), or Mahaleb (*P. mahaleb*) cherry or on rooted cuttings of a dwarfing clone, 'Stockton Morello' (*P. cerasus*). Registered seed taken from trees indexed as being free of known stone fruit virus diseases is available from the U C Foundation Plant Materials Service. Source wood of virus-tested 'Stockton Morello' is also available.

In California, Mahaleb is widely used as a drought-resistant rootstock, giving trees slightly smaller than those on Mazzard but it is not completely compatible with all varieties. Mazzard roots give a strong, vigorous tree; more resistant to excess soil moisture than Mahaleb, and completely compatible with all sweet cherry varieties. 'Stockton Morello' is best propagated under mist as leafy cuttings. Since the viruses have been eliminated from this clone, the dwarfing influence has not been as pronounced as previously noted.

Olives (*Olea europaea*) In California, olive varieties traditionally have been propagated by cuttings, either hardwood or leafy cuttings under mist, with the exception of one cultivar, 'Sevillano', which is difficult to root. This was propagated by grafting or budding on seedlings of any small-fruited oil cultivar whose seeds germinate readily. With the advent of considerable cotton acreage in the San Joaquin valley, where all plants are infected with verticullium wilt (*Verticillium albo-atrum*), infectious material from the cotton has blown all through olive groves planted throughout the same area until now verticillium damage to the olive trees has become a major cultural problem. The University of California has developed at least two olive rootstocks resistant to verticillium infection so that in the future new plantings will be on these stocks (4).

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HAROLD TUKEY: Thank you, Dr. Hartmann, for a very interesting talk and for the chance of our members here in the Eastern Region to meet and become better acquainted with you and your work.

Now we come to another aspect of the systems approach and that is how to find out what the other fellow is doing. To handle this part of the program, we have Jim Wells.[1]

THURSDAY AFTERNOON SESSION

December 7, 1972

The afternoon session convened at 1·30 p.m. in the Terrace Room with Ralph Shugert presiding.

RALPH SHUGERT: This morning we explored some of the systems approach to plant propagation and this afternoon we will continue in this vein with some new ideas. It has been said that there is nothing new under the sun, but I believe the gentlemen who made that statement did not know plant propagators.

Our first speaker this afternoon is Mak Kawase from my home state of Ohio and he is going to tell us about the role of ethylene metabolism in root formation

[1]Editor's note: Mr. Jim Wells and Doug Weguelin discussed the plant propagators' England tour scheduled for August and September, 1973.

SUBMERSION INCREASES ETHYLENE AND STIMULATES ROOTING IN CUTTINGS[1]

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In 1933, Zimmerman and Hitchcock (5) of the Boyce Thompson Insititute reported that unsaturated hydrocarbon gases, including ethylene, stimulated initiation of roots in 15 species of herbaceous and woody plants. In willow, the gases also stimulated the growth of latent root primordia. Cuttings were exposed to different concentrations of the gases ranging from 10^{-4} to 1% under airtight containers.

According to our results, exposure of willow cuttings to ethylene gas stimulated root formation within an exposure time ranging from 0 to 30 min. Treatment for longer than 30 min. was less effective (Fig. 1).

Ethephon, recently developed by Amchem Co., has been used in many fields of agriculture. After being absorbed by the plants, the compound undergoes decomposition and releases ethylene gas to the plant tissues. Figure 2 indicates the root-forming effect of Ethephon on willow cuttings. The most effective concentration was 880 ppm. The effect of Ethephon on root formation of tomato plant is shown in Figure 3. Roots appeared all the way along the stem of the cutting.

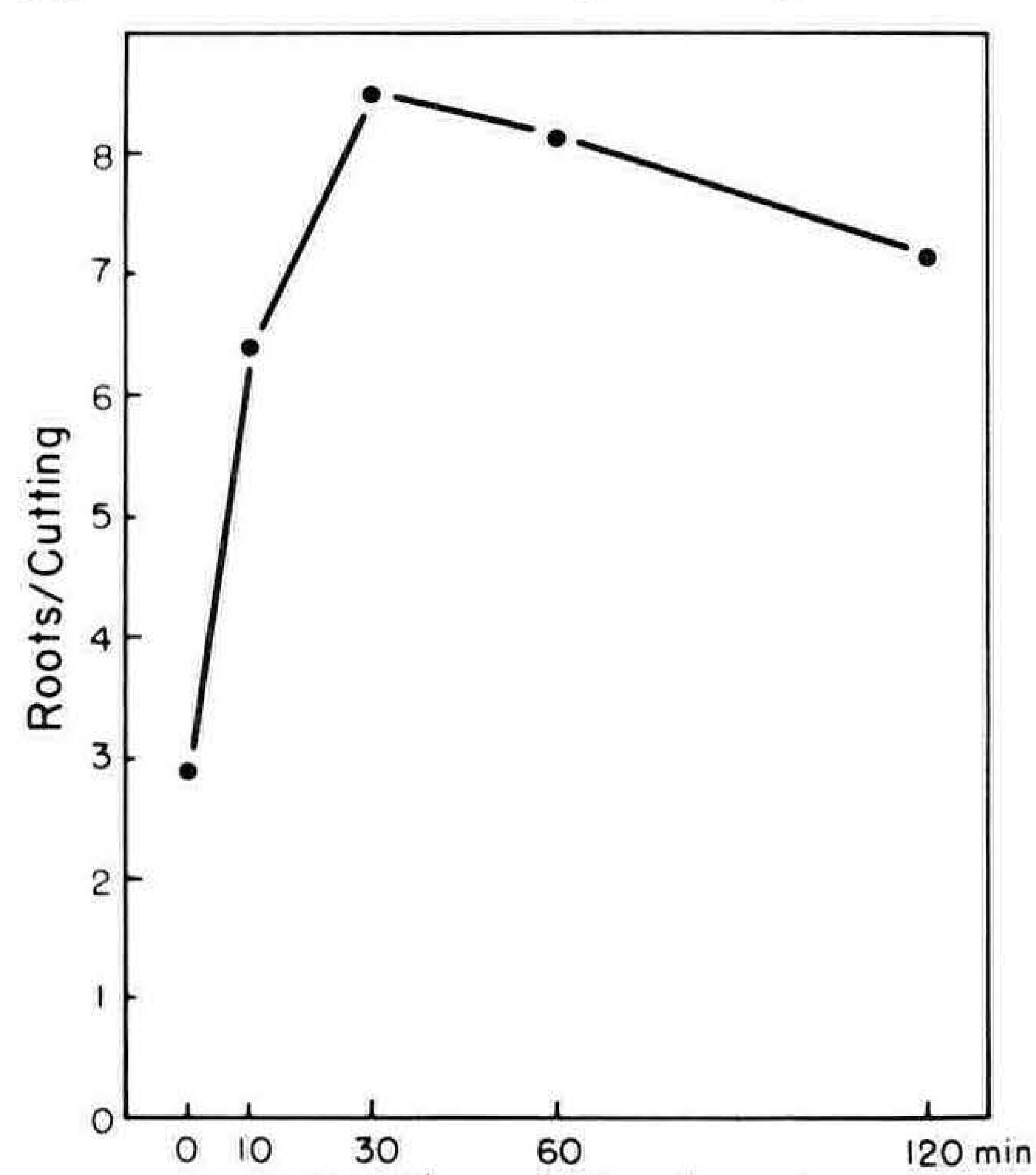


Fig. 1. **Effect of ethylene gas on root formation in *Salix fragilis* softwood cuttings. Cuttings were exposed to ethylene gas for 0, 10, 30, 60, or 120 min and then soaked upright in water 4 cm deep until root formation. (2).**

[1]Approved by the Director of the Ohio Agricultural Research and Development Center as the Journal Article No. 115-72.

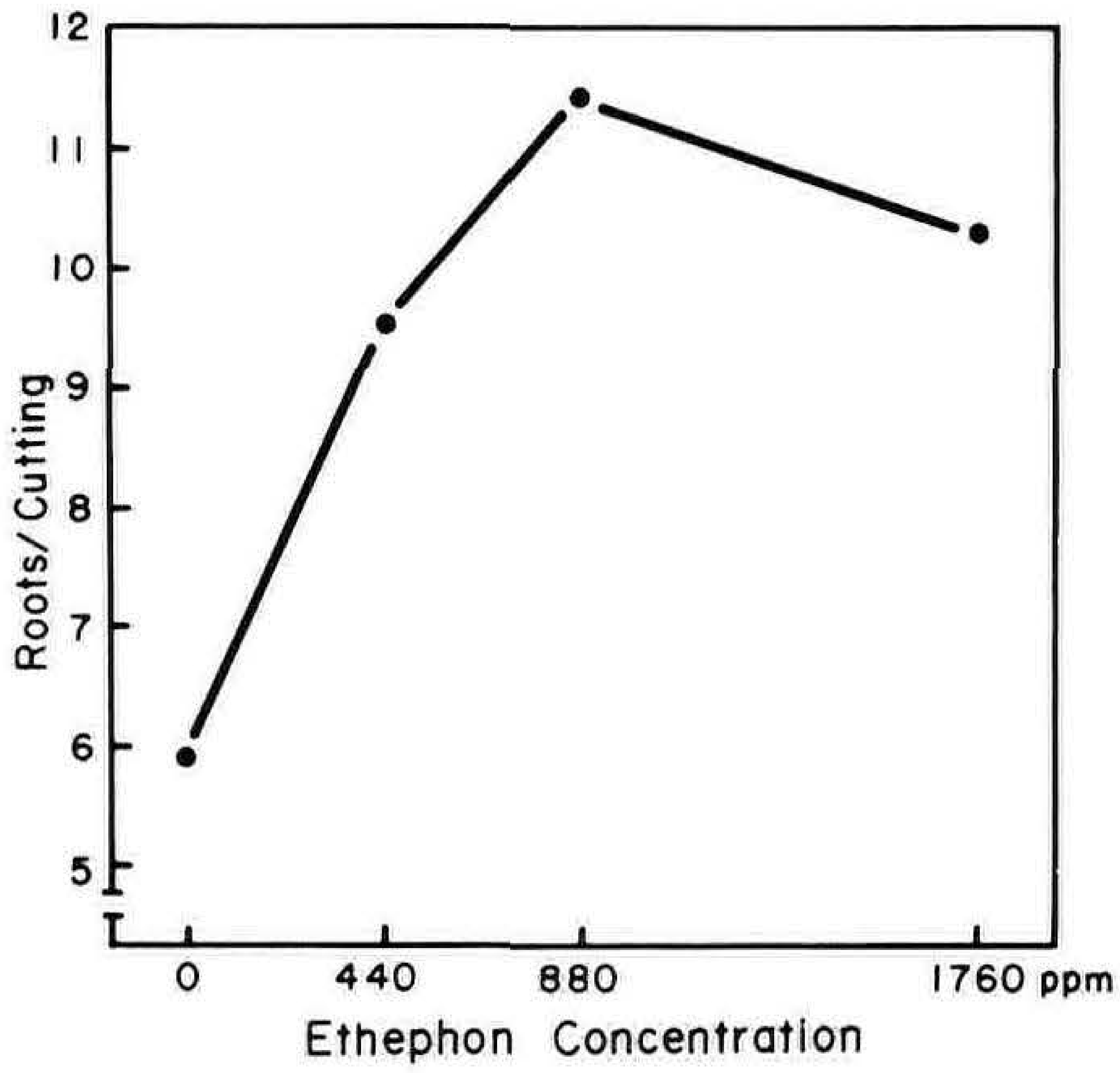


Fig. 2. Effect of Ethephon on root formation in *Salix fragilis* softwood cuttings. The basal 4 cm of cuttings were soaked upright in 0, 440, 880, and 1760 ppm of Ethephon for 24 hr. then soaked in fresh water 4 cm deep until roots formed. (2).

Fig. 3 Effect of Ethephon on rooting of tomato cuttings. Bases of cuttings were placed in 400 ppm solution of Ethephon for 24 hr before sticking in propagation medium.

Ethylene gas has been considered a plant growth regulator and it has, besides stimulation of root formation, many other morphogenic functions such as breaking of bud dormancy, causing leaf epinasty and leaf chlorosis, controlling stem growth, stimulating flower bud initiation, changing flower sexes, wilting of flowers, causing abscission of leaf, flower, and fruit, controlling seed germination, and controlling root growth.

Ethylene is synthesized by the plant itself. For example, it is well known that apple fruits should not be kept in storage with cut flowers. Ethylene gas evolved from the fruits causes carnation to sleep, induces leaf epinasty, and causes roses to shed petals. This is because apple fruits are a rich source of ethylene gas. According to our study (3), the internal gas of apple 'Red Gold' fruits contained over 120 ppm of ethylene. Ethylene is produced by many other parts of plants besides fruits, such as leaves, stems, roots, flowers, tubers, and seeds.

Ethylene production by plants can be examined easily by measuring the ethylene concentration of internal gas extracted from a specific plant part. For instance, when one wants to extract the internal gas of cuttings, cuttings are placed under an inverted funnel filled with gas-free water. The neck of the funnel is sealed with a serum cap. The funnel is placed inside a vacuum desiccator which is half filled with water. The desiccator is then evacuated for 5-30 min by a water aspirator. Under such conditions, internal gas bubbles out mostly from the cut ends of the cuttings and are collected inside the funnel (Fig. 4). A sample can be obtained easily from the collected gas with a syringe through the serum cap. In normal atmospheric pressure, internal gases, including ethylene, diffuse out of the cuttings through lenticels as well as through cut ends. Therefore, ethylene gas production by the cuttings also can be studied by sealing the cuttings in an airtight container. After a certain period of time, a small amount of gas is removed from the container and the ethylene concentration in the gas is measured. The gas chromatograph is a very useful tool for quantitative determination of very low concentrations of ethylene gas. For instance, the instrument can detect ethylene concentration as low as 5 parts per billion yet only 1/5 teaspoonful of gas is required for the test.

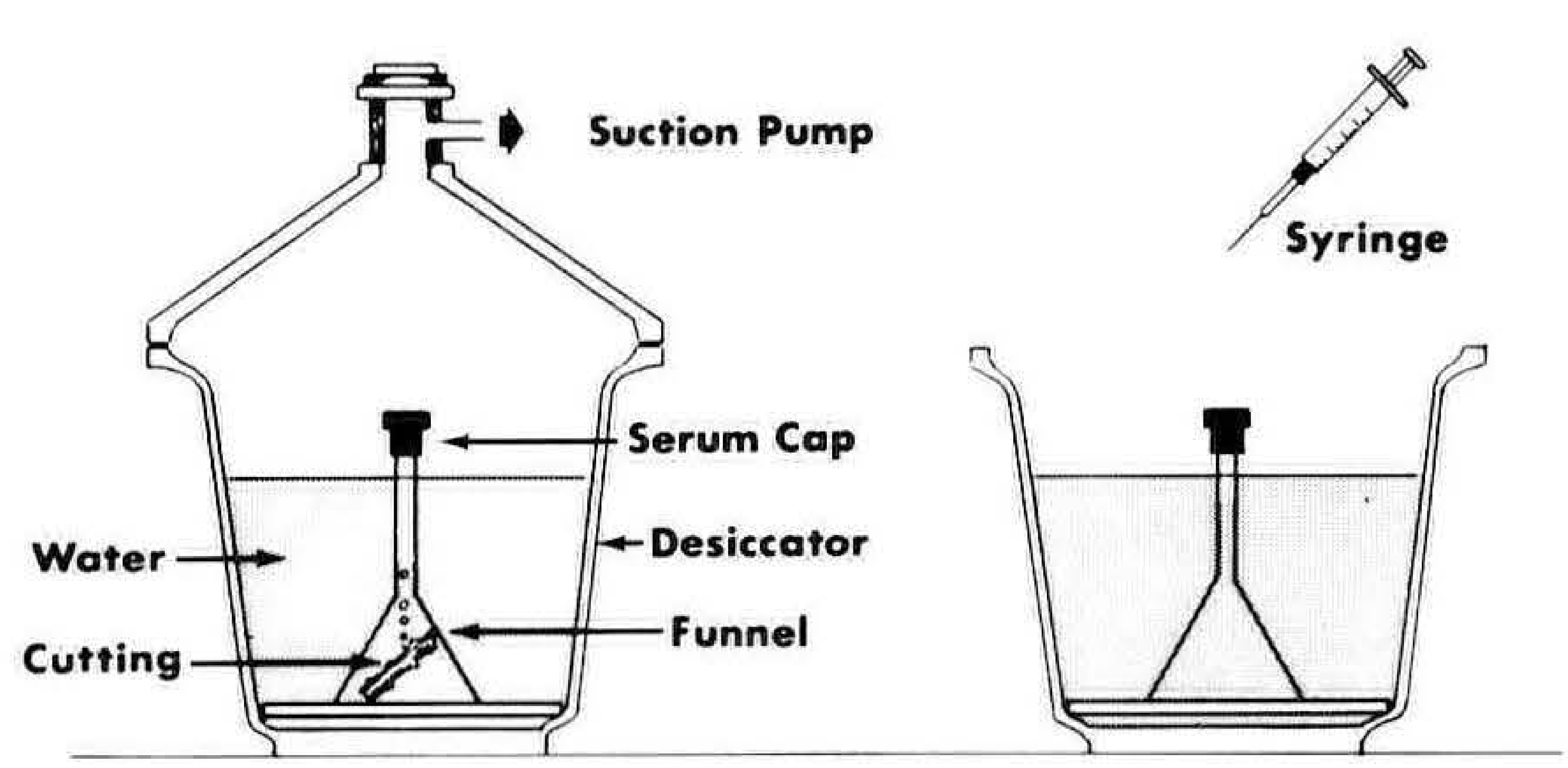


Fig. 4. Extraction method of internal gas from plant materials. Internal gas bubbles out of the plant materials under reduced pressure and is collected in the funnel (left). After removing the desiccator lid, the gas is sampled by syringe through the serum cap for gas analysis (right).

At the 1965 meeting of the International Plant Propagators Society in Cleveland, I presented a paper entitled, "Centrifugation promotes rooting of softwood cuttings" (1). According to that paper, when softwood cuttings of some woody species, including *Salix alba, S. acutifolia, S. pentandra, S. fragilis, Viburnum dentatum,* and

Populus alba, were centrifuged with water, the cuttings rooted better than non-centrifuged controls. The results suggested that centrifugal force apparently accelerated the downward transport of rooting substances in the cuttings, thus causing the accumulation of the substances at the basal ends of the cuttings, which in turn stimulated root formation.

Recently, this author found interesting results which imply that the centrifugal force stimulates rooting of softwood cuttings partially through changing the ethylene concentration in the cuttings (2). During centrifugation with water, water is forced into the cuttings and the water content of the cuttings increases. This increased water in the cuttings apparently provides a barrier for diffusion of ethylene gas out of the cuttings which in turn causes a high concentration of ethylene gas. Thus, the resulting high ethylene concentration stimulates root formation. Even when cuttings were centrifuged with the same force, the deeper the cuttings were steeped in the water in the centrifuge tube, the more water was forced into the cuttings thus resulting in more roots (Fig. 5).

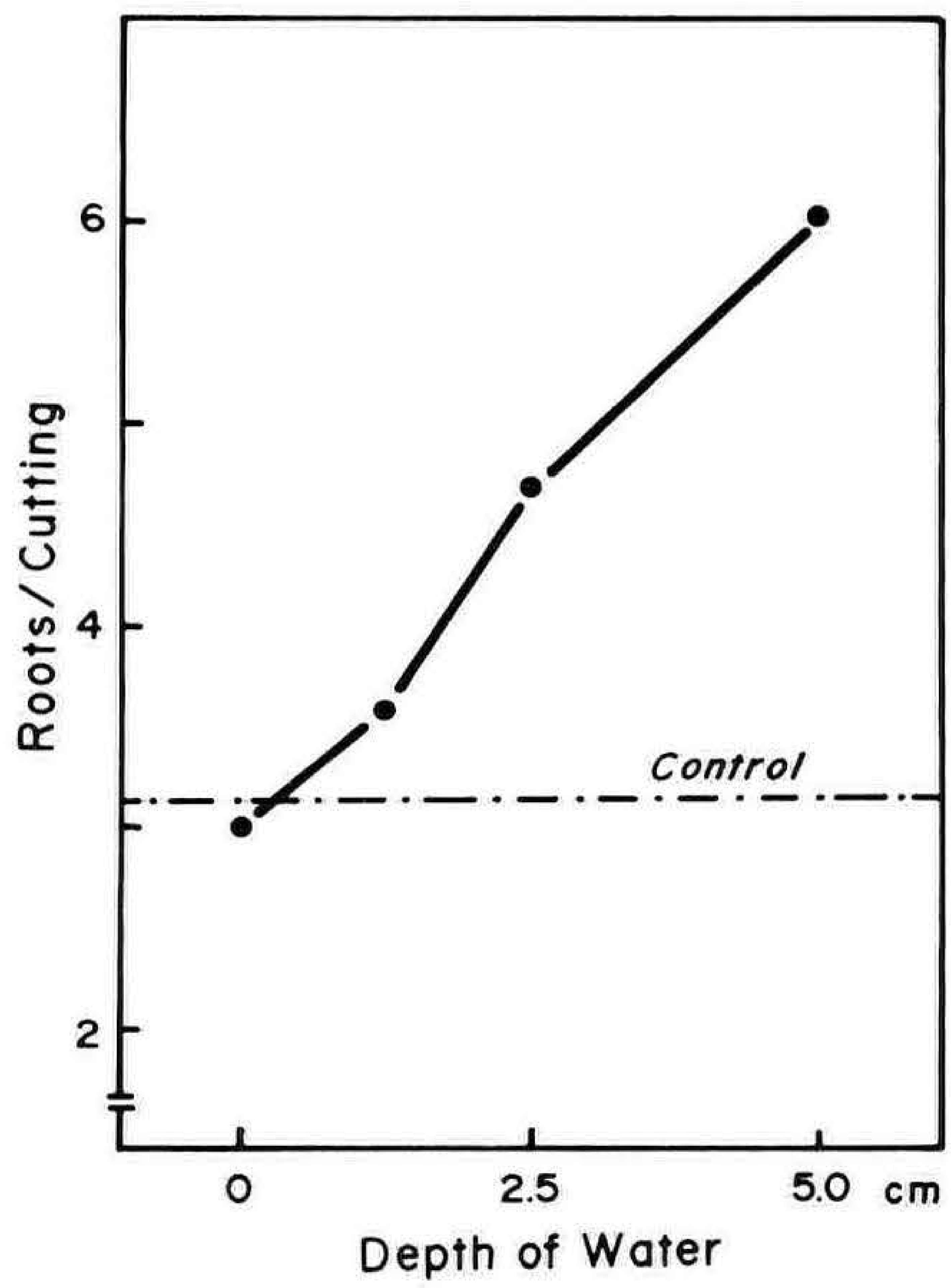


Fig. 5. Effect of water depth during centrifugation on root formation of *Salix fragilis* softwood cuttings. Except for non-centrifuged controls, cuttings 10 cm long were centrifuged for 1 hr at 2000 g with the basal 0, 1.25, 2.5, or 5 cm being soaked in water. After centrifugation, the basal 2.5 cm of all cuttings, including controls, were cut back and the resulting 7.5 cm portions were soaked in water 4 cm deep until root formation. Dotted line indicates number of roots produced by controls (2).

Even without increasing water content of the cuttings by centrifugal force, one can increase the internal ethylene concentration of the cuttings simply by keeping the cuttings in water. For instance, when cuttings of such plants as crabapple, chrysanthemum, and privet were completely submerged, ethylene concentration increased significantly within 20 hr (Table 1). Thus, submersion of cuttings resulted in better rooting, as we might expect (Fig. 6). The deeper the willow cuttings were steeped in water for 24 hr, the more

Table 1. Effect of submersion on ethylene concentrations in crabapple, chrysanthemum, and privet cuttings. Cuttings were completely submerged in water at 24° C for 20 hr and controls were steeped upright in water 2.5 cm deep. (3).

Cuttings and treatment	Ethylene concentration (ppm) Before treatment	After treatment	LSD 5%	LSD 1%
Crabapple				
Control	0.07	0.32	0.13	0.23
Submerged	0.06	1.66		
Chrysanthemum				
Control	0.06	0.37	0.30	0.55
Submerged	0.06	0.67		
Privet				
Control	0.06	0.50	0.40	0.74
Submerged	0.06	1.20		

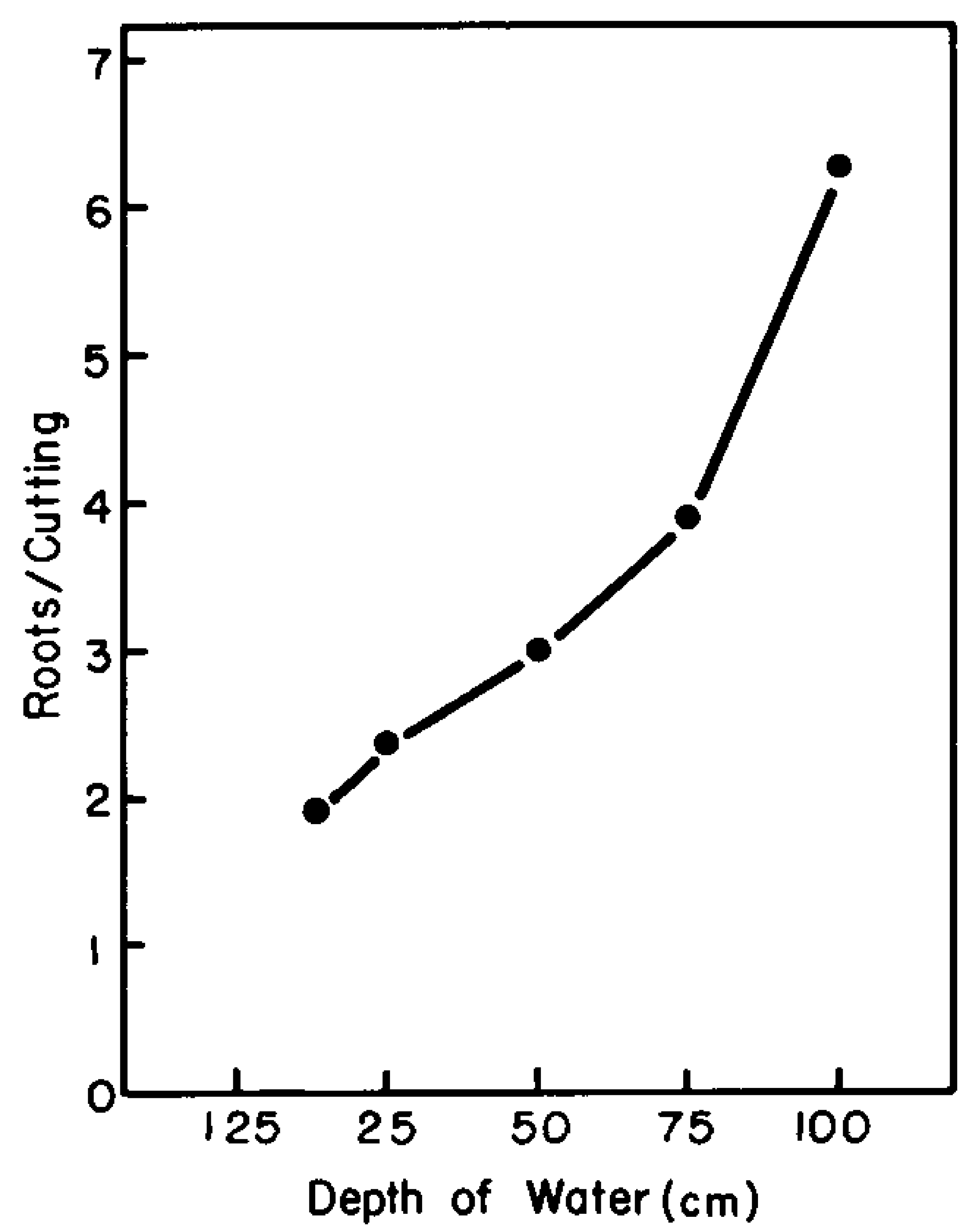
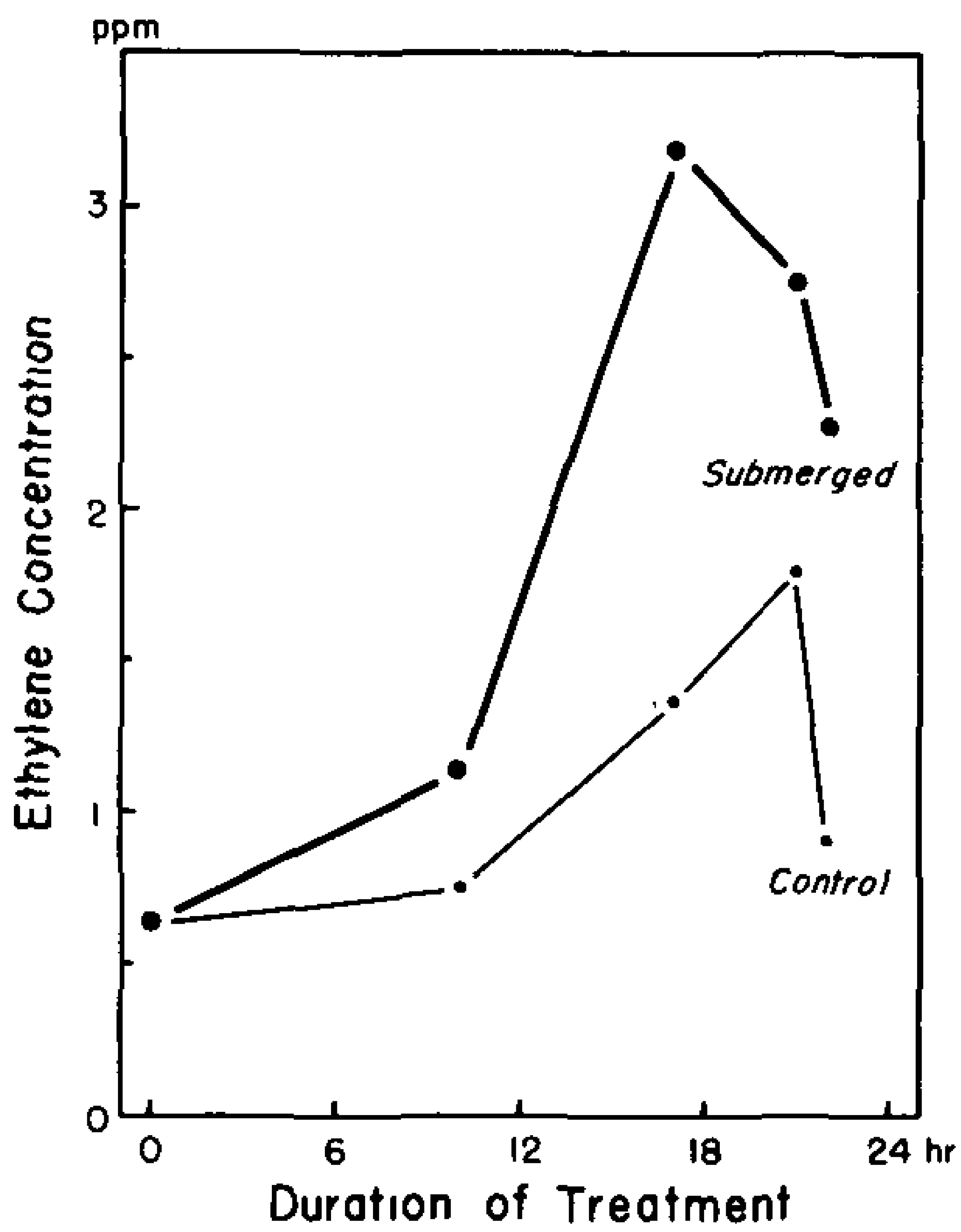
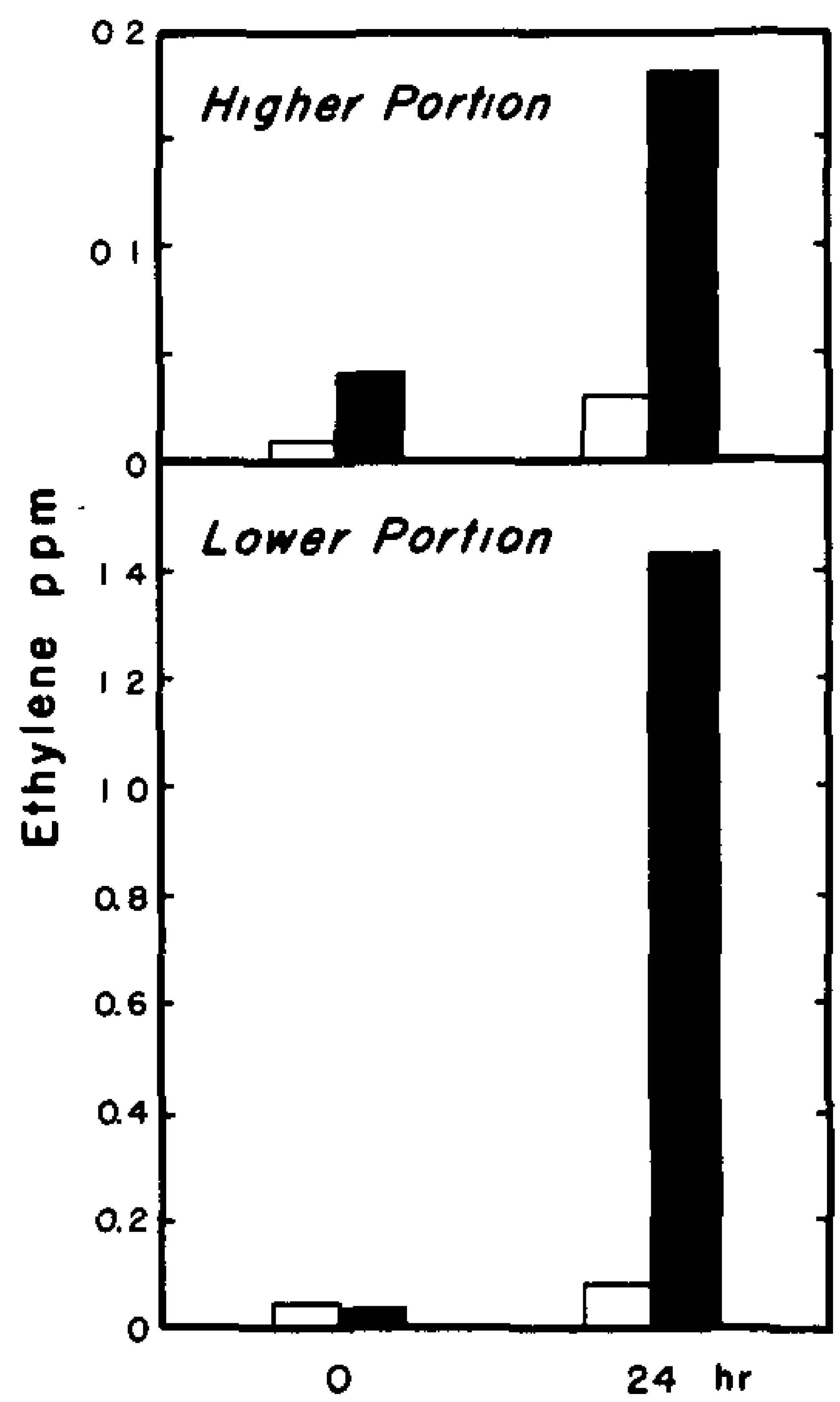


Fig. 6. Effect of soaking-water depth on root formation of *Salix fragilis* softwood cuttings. Cuttings 10 cm long were soaked upright for 24 hr in water 1.25, 2.5, 5.0, 7.5, or 10 cm deep and then transferred into water 4 cm deep until roots formed (4).



7. Effect of water soaking on ethylene concentration in *Salix fragilis* softwood cuttings. Cuttings were completely submerged upright in water, while in controls the base, 2.5 cm of cuttings were soaked upright in water. After treatment of 10, 17, 21, and 22 hr, gas samples were collected from cuttings and their ethylene concentrations were measured (2).



8. Effect of flooding on ethylene concentrations in sunflower plants. Plants were flooded up to midway between cotyledonary and 1st leaf node for 24 hr while controls were not flooded. Ethylene was extracted from lower portions (stems below 1st leaf node and roots) and high portions (stems between 1st and 3rd leaf nodes). White and black bars refer to controls and flood treatments.

roots formed from these cuttings. Soon after cuttings are submerged in water, residual oxygen trapped in the cuttings is exhausted by respiration. Since ethylene synthesis does not proceed without oxygen, ethylene concentration gradually declines after 20 hr in submerged cuttings (Fig. 7).

Quite often, root systems of intact plants are saturated with water Plants grown in containers with heavy soil mixtures often undergo such a condition. Overwatering worsens the situation. Flooding is a common natural occurrence and sometimes plants in the field are flooded after heavy rains. According to our research results, when the base of an intact plant is flooded, ethylene concentration starts to increase in the submerged portion of roots and stems. As seen in Fig. 8, ethylene concentration in the submerged portion of sunflower increased 48 times after 24 hr flooding. There was an apparent gas exchange between submerged and non-submerged portions because ethylene concentration gradually increased in higher parts of the plants which had not been submerged.

Flooding, which costs us millions of dollars annually, even when limited to agricultural commodities, causes different kinds of damage to crops depending on the depth and duration of the flood, age and height of plants, and environmental factors such as temperature, wind velocity, sun's radiation energy , and so on. Generally speaking, flooding damage symptoms are (A) wilted leaves, (B) epinasty, (C) leaf chlorosis, (D) reduced stem elongation, (E) enlarged stem diameter, (F) formation of new adventitious roots. It is very interesting to note that all of these symptoms can also be caused by ethylene gas. It is believed that increased ethylene concentration in flooded plants is largely although not exclusively responsible for the flooding damage symptoms (4).

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RALPH SHUGERT: Thank you, Mak, for an interesting and detailed paper on a fascinating topic.

The next paper on your program has been selected for the graduate student award this year. The author, David Hamilton of Purdue University, could not be with us so his paper will be read by Dr. Phil Carpenter, also of Purdue.

ETHREL FOR BREAKING DORMANCY IN SEEDS OF SOME WOODY PLANTS[1]

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Abstract. Seeds of some woody plants were treated with (2-chloroethyl) phosphonic acid (Ethrel) to determine if ethylene would replace the cold requirement for germination. In the first phase of the experiment, seeds were soaked without a cold treatment in Ethrel solutions and in the second phase seeds were soaked after a cold treatment.

Soaking seeds in Ethrel increased germination of most species, although the effective concentration and length of treatment varied among species. A cold treatment in addition to the soak in Ethrel did not further increase germination.

REVIEW OF LITERATURE

The physiological effects of ethylene on plants are dramatic and commercially important (2,9). One source of ethylene for plant and seed treatment is (2-chloroethyl) phosphonic acid (Ethrel; also occasionally cited as 2-chloroethanephosphonic acid, AmChem 66-240, CEPA, and Ethephon). In 1946 Kabachnik and Rossiikaya (6) reported the chemical synthesis of "2-chloroethanephosphonic" acid and in 1963 Maynard and Swan (8) described the formation of ethylene from this compound. When Ethrel, (2-chloroethyl) phosphonic acid, disintegrates, it releases ethylene and also chloride and phosphate ions (8, 12, 14). When the presence of hydroxyl ions is increased and the pH rises above 4, disintegration of the chemical takes place. The pH of the cytoplasm of plant cells is generally greater than 4, so the plant growth activity of Ethrel has been attributed primarily to its ability to release ethylene to plant tissues (11, 12). Ethrel formulations provide a convenient way to apply ethylene without the need of gas-confining chambers (3).

The effect of Ethrel treatment on woody plant seed germination is not known; however, Ketring and Morgan (7) found that germination of Virginia type peanut seeds from apical and basal stem locations soaked for 16 hr in Ethrel concentrations of 72 to 145 ppm was 100% compared to 13% with untreated apical and 60% with basal seeds. Soaking delinted cotton seed in 10 to 100 ppm Ethrel accelerated and increased germination percentage in greenhouse trials (1). Iyer, Chacko, and Subramiam (5) reported that pretreatment of dormant strawberry seeds with 1000, 2500 and 5000 ppm of Ethrel for 24 hr induced 30, 50, and 90% germination in 4 weeks whereas 20% of untreated controls germinated. In

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[1]Ethrel was supplied by AmChem Products, Inc., Ambler, Pennsylvania

[2]Department of Horticulture

laboratory studies Ethrel has also stimulated germination of dormant witchweed (*Striga lutea* Lour.) seed placed in 1 to 1000 ppm germination solutions. Germination was also stimulated by placing seed in a non-sterilized Eustris loamy sand into which Ethrel had been incorporated at rates of 10 and 1000 mg/ kg of soil (4).

The objective of this study was to determine if treatment with Ethrel would replace the cold requirement of dormant embryos in seeds of woody plants.

MATERIALS AND METHODS

To study the influence of ethylene evolution from (2-chloroethyl) phosphonic acid on germination, seeds of five tree species were treated with Ethrel at various concentrations for different time periods. The following species were used: *Taxodium distichum* L., *Elaeagnus angustifolia* L., *Sheperdia argentea* Nutt., *Cercis canadenis* L., and *Robinia pseudoacacia* L., The seed of *Taxodium, Elaegnus* and *Sheperdia* are often difficult to germinate because they have dormant embryos, while *Cercis* often germinates poorly because the seed has a double dormancy (13). *Robinia* normally germinates readily and was used to see if Ethrel treatment decreased seed germination. Seed of *Cercis* was scarified in H_2SO_4 for 30 min before treatment with Ethrel, and the resinous seed coats of *Taxodium* were removed by hand.

With each species four replications of 5 seeds each were soaked in an Ethrel solution. Ethrel solutions were made with distilled water of pH 5.5. The following concentrations were used: 50, 300, 600, and 900 ppm of Ethrel, and a distilled water control. Different seeds were soaked at each concentration for 0.5, 6, 12, 18 and 24 hrs. After removal from the Ethrel solution, seeds were planted in flats of peat-perlite mix (1:1 v/ v) in the greenhouse. Water was applied as needed to keep the peat-perlite mix moist.

In one phase of the study Ethrel treatments were given to seeds before any cold stratification. In the second phase seeds were stratified for half the maximum number of cold days recommended in the **Woody Plant Seed Manual** (13).

Seedlings were counted periodically for eight weeks, but only the mean percentage germinating is reported here.

Analyses of variance (Steel and Torrie, 10) were then performed on the individual experiments to determine significant variables. Significance of means was determined by Duncan's multiple range test.

RESULTS AND DISCUSSION

Seeds of the various species tested did not respond identically to Ethrel treatment. *Robinia pseudoacacia*,which normally germinates readily without a cold treatment, showed no response to Ethrel

(Table 1). However, seeds of *Elaeagnus angustifolia* not given a cold treatment but soaked in Ethrel germinated significantly better than seeds soaked in distilled water (Table 2). Concentrations of 300 and 600 ppm for 6 to 18 hrs gave maximum germination. Soaking seeds for 24 hrs at these same concentrations did not stimulate germination as much, nor did treatment with 900 ppm Ethrel. However, germination was still greater than that of the seeds soaked in distilled water. Germination was not further stimulated by giving seeds a cold treatment before soaking in Ethrel (Table 2).

Table 1. Effect of Ethrel on germination of seed of *Robinia pseudocacia*. *

Ethrel concentration (ppm)	Percentage of Seeds Germinating** Length of Ethrel Soak (hrs)				
	0.5	6	12	18	24
distilled water	60a	55a	65a	80a	70a
50	60a	65a	65a	65a	65a
300	75a	65a	70a	75a	70a
600	75a	70a	70a	65a	80a
900	65a	70a	55a	65a	70a

*Only seeds of *Robinia* not given a cold treatment were soaked in Ethrel.

**Percentages not followed by the same letter are significantly different at the 5% level.

Table 2. Effect of Ethrel on germination of seed of *Elaeagnus angustifolia*.

Ethrel concentration (ppm)	Percentage of Seeds Germinating * No cold treatment					45 days at 5° C				
	Length of Ethrel Soak (hrs)									
	0.5	6	12	18	24	0.5	6	12	18	24
distilled water	25a	35a	35a	20a	20a	40a	25a	40a	35a	50a
50	35a	40a	30a	55a	45a	25a	25a	25a	30a	45a
300	30a	100b	75b	85c	50b	30a	30a	80b	75b	35a
600	20a	95b	80b	90c	50b	25a	35a	70b	90b	45a
900	25a	60c	55c	45b	25a	30a	25a	40a	45a	35a

*Percentages not followed by the same letter are significantly different at the 5% level.

Germination of seeds of *Taxodium distichum* was significantly increased following an 18 and 24 hr soak at 50 ppm. As the length of soak increased at 600 and 900 ppm, seed damage was apparent. Percentage germination was significantly less than the seeds soaked in distilled water. Germination was not increased by giving the seeds a cold treatment before soaking in Ethrel (Table 3).

Sixty percent germination of seeds of *Sheperdia argentea* not given a cold treatment was obtained with a 50 ppm Ethrel 24 hr soak (Table 4). Germination of seeds under other Ethrel treatments did not differ significantly from seeds soaked in distilled water. No stimulation of germination occurred in seeds given a cold treatment and then soaked in Ethrel (Table 4).

Table 3. Effect of Ethrel on germination of seed of *Taxodium distichum*.

Ethrel concentration (ppm)	Percentage of Seeds Germinating*									
	No cold treatment					30 days at 5° C				
	Length of Ethrel Soak (hrs)									
	0.5	6	12	18	24	0.5	6	12	18	24
distilled water	30a	0a	40a	25a	40a	25a	50a	35a	0a	35a
50	30a	45a	35a	60b	65b	35a	40a	40a	65b	65b
300	20a	35b	40a	40a	35a	40a	40a	35a	40c	45a
600	20a	10a	10b	25a	10c	30a	35a	40a	25c	15c
900	15a	10a	0b	25a	15c	5b	15a	40a	25c	10c

*Percentages not followed by the same letter are significantly different at the 5% level.

Table 4. Effect of Ethrel on germination of seeds of *Sheperdia argentea*.

Ethrel concentration (ppm)	Percentage of Seeds Germinating*									
	No cold treatment					45 days at 5° C				
	Length of Ethrel Soak (hrs)									
	0.5	6	12	18	24	0.5	6	12	18	24
distilled water	20a	0a	20a	10a	0a	10a	20a	15a	0a	0a
50	20a	25b	0b	0a	60b	5a	0b	10a	5a	5a
300	20a	10ab	0b	5a	0a	10a	0b	0a	0a	15a
600	0b	0a	0b	15a	5a	0a	10ab	15a	0a	0a
900	0b	0a	0b	15a	0a	5a	0b	0a	5a	10a

*Percentages not followed by the same letter are significantly different at the 5% level.

Seeds of *Cercis canadenis* soaked in Ethrel but given no cold treatment germinated significantly better when soaked for 6 or 24 hrs at 300 and 600 ppm. The poor germination percentages obtained for 12 and 18 hr soaks at these same concentrations is probably from unrelated factors. Damage to the seeds is apparent at 900 ppm as germination significantly decreased. Giving seeds a cold treatment before soaking in Ethrel did not further increase germination at 300 and 600 ppm (Table 5).

Results from this experiment indicate that (2-chloroethyl) phosphonic acid may be useful to the plant propagator. Elimination of all or even reduction of the cold requirement of seeds would not only decrease the time required to start seedlings, but would also release space used for cold storage of seeds. Treating seeds in this manner would not require expensive equipment.

It is apparent that stimulation of seeds by ethylene does not occur at the same levels in all species. Additional study is needed to determine injury levels of seeds to ethylene. Although (2-chloroethyl) phosphonic acid is known to break down above a pH of 4 releasing ethylene (12), it would also be helpful to know the rate of release and the length of time ethylene is released.

Table 5. Effect of Ethrel on germination of seeds of *Cercis canadenis*.

Ethrel concentration (ppm)	Percentage of Seeds Germinating* — No cold treatment					30 days at 5° C				
	Length of Ethrel Soak (hrs)									
	0.5	6	12	18	24	0.5	6	12	18	24
distilled water	0a	15a	5a	0a	0a	65a	65a	70a	90a	55a
50	40a	55a	0a	35b		45b	55a	75ab	85a	60a
300	50b	100c	0a	10a	85c	75a	90b	70a	25b	65a
600	45b	95c	0a	5a	85c	70a	85b	90b	85a	90b
900	50b	55b	5a	5a	45b	45a	50a	80ab	75a	55a

*Percentages not followed by the same letter are significantly different at the 5% level.

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RALPH SHUGERT: Thank you, Phil, for presenting Dave Hamilton's paper to us.

Our next speaker is Dr. John Ahrens and he is going to talk on a subject which has come up in our meetings on several occasions. His talk is entitled "Rooting Cuttings from Plants Treated with Herbicides".

ROOTING CUTTINGS FROM PLANTS TREATED WITH HERBICIDES

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Abstract. Sixteen herbicides were tested on cultivars of *Rhododendron, Hydrangea* and *Chrysanthemum* over a 3 year period. Cuttings were harvested and rooted from six field and container experiments following herbicide applications. In most cases, dosages of herbicide considered adequate for control of weeds but not injurious to the nursery plants had no significant effects on rooting of cuttings. However, twice normal dosages of herbicides sometimes reduced rooting of cuttings and , in one experiment, two successive annual applications of an herbicide combination reduced the quality of roots formed by cuttings. Plant species and cultivars differed greatly in their response to the herbicides. A reduction in rooting potential of cuttings from treated plants was not always associated with plant injury The greatest effects of herbicides on rooting of cuttings from treated plants occurred in container culture with softwood cuttings. Although in most cases reductions in rooting potential of cuttings were not serious, their occurrence suggests that herbicides continue to be used with care on stock plants. Repeated annual applications of herbicides in the field and herbicide usage in containers should be further evaluated for their effects on rooting potential of cuttings

REVIEW OF LITERATURE

Herbicides are important tools in the culture of field and container-grown nursery plants. Their many advantages over hand and mechanical methods of weed control have led to their general acceptance by the nursery industry. Evaluations of the tolerance of specific horticultural plantings for herbicides have included plant appearance, shoot growth, root growth, and yield of fruit. Little attention has been given to the effects of herbicides on the rooting of cuttings from treated plants. In recent years reports have been received from growers[1] indicating rooting failures in cuttings taken from plants treated with herbicides. Therefore, in 1970 we began to include rooting of cuttings as another criterion for evaluating herbicides in field and container experiments. One study of five rhododendron cultivars grown in containers indicated that the herbicides simazine and trifluralin had no significant effect on rooting of cuttings taken 83 days or more after treatment (7).

McGuire and Pearson (15) applied simazine and diphenamid on container-grown ornamentals and harvested cuttings 30 and 80 days after treatment. Simazine killed some of the plants and reduced the rooting quality of cuttings taken 30 days after treatment from *Ilex glabra, Juniperus chinensis* 'San Jose', and the rhododendron

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[1]1970 Proc. Int. Pl. Prop. Soc. 20:205-206

hybrids, 'Rosebud', 'Mother's Day', and Stewartstonian'. The effects were greater with simazine at 4 lb/A. Diphenamid at 6 or 8 lb/A had no effect on rooting of the cuttings.

The work reported here summarizes the effects upon rooting of cuttings when several herbicides were applied in six field and container experiments over a 3 year period.

MATERIALS AND METHODS

Experiments were conducted in cooperation with commercial nurseries and at the Valley Laboratory of The Connecticut Agricultural Experiment Station. Samples of cuttings were harvested from plants treated with herbicides and rooted in the greenhouse. In some cases the experiments were designed to determine the herbicidal effects on weeds and on the nursery plants, and not specifically to determine herbicidal effects on rooting potential. However, every attempt was made to assure uniformity of handling of all samples of cuttings within a given experiment. Rooting was carried out in greenhouses at two commercial nurseries and in our own greenhouse, using techniques suited to each type of plant material. These techniques and conditions varied greatly from one test to another, but were uniform within experiments.

When the cuttings were lifted, rooting of each was evaluated on a scale of 1 to 6 as follows:

1=dead
2=callused, but no roots
3=poor root development — one or more very small roots
4=fair — roots developed on part of cutting
5=good — roots on all but one side of cutting
6=excellent — roots all around cutting

Percentage rooting was based on the percentage of cuttings ranking fair (class 4) or better. Cuttings judged fair or better were considered fit for transplanting with an excellent chance for survival. For analysis of variance rooting percentages were transformed into angles (20). Rooting scores were calculated by summing the ranks and dividing this by the total number of cuttings within each group. Rooting scores represent the average root quality of a group of cuttings.

The herbicides evaluated in these experiments are given in Table 1. All dosages of herbicides are given in pounds of active ingredient per acre (a.i., lb/A).

RESULTS

The results of the six experiments are given in Tables 2 to 7. Weed control information is included in some cases. In each instance pertinent details are given in these tables.

Dichlobenil was included in three experiments. At 4 or 8 lb/A applied in the fall, dichlobenil injured plants of *Rhododendron* 'Coccinea Speciosa', but reduced rooting of cuttings only at the higher rate (Table 2) Visual injury to plants of *Rhododendron* 'Harvest Moon' was less than injury to 'Coccinea Speciosa', and rooting of cuttings from'Harvest Moon' plants treated with dichlobenil was better than rooting of cuttings from untreated controls Dichlobenil at 4 or 8 lb/A applied in April had no effect on rooting of cuttings of *Rhododendron* 'Grandiflora' (Table 3). Two successive annual applications of dichlobenil at 4 lb/A had no effect on the rooting of softwood cuttings of *Rhododendron* 'Daviesi' or *Rhododendron* 'Tunis' (Table 6).

Simazine, applied alone or in combination with other herbicides was included in all of our experiments on woody plants. A fall application at 3 lb/A injured hybrid azaleas, but rooting of softwood cuttings form injured plants was slightly less than the controls in *Rhododendron* 'Coccinea Speciosa', and higher than the controls in 'Havest Moon' (Table 2) In container-grown hydrangeas, simazine at 2 5 lb/A induced chlorosis in the lower foliage but cuttings from chlorotic plants rooted about as well as cuttings from control plants (Table 4) In other experiments even twice normal rates of simazine did not significantly affect rooting (Tables 3, 6, 7).

In most cases, cuttings from plants treated with combinations of simazine and other herbicides rooted as well or better than cuttings from control plants, but two exceptions were noted. Rooting of softwood cuttings of *Rhododendron* 'Daviesi' was reduced 17% as compared with controls following two annual applications in the fall of simazine at 1.5 lb/A plus DCPA at 9 lb/A (Table 6), and high rates of simazine plus alachlor (2.5 + 8 lb/A) significantly reduced rooting of softwood cuttings from container-grown *Rhododendron* 'PJM',but not 'Purple Gem' (Table 7).

Norea was included in only one experiment with *Rhododendron* 'Coccinea Speciosa' and 'Harvest Moon' at rates of 4 and 8 lb/A in the fall. Although Norea caused chlorosis and necrosis of the foliage of both cultivars, cuttings from these plants rooted as well or better than cuttings from control plants (Table 2).

Diphenamid was included in five of our experiments at normal (4-6 lb/A) or twice normal (8-12 lb/A) rates of application (Tables 2, 3, 5, 6, 7) The high rates of diphenamid reduced rooting of cuttings from *Rhododendron* 'Grandiflora' (Table 3), *Chrysanthemum moriflorum* 'Ruby Mound' (Table 5) and *Rhododendron* 'PJM' (Table 7), but the low rates had no significant effects. In *Rhododendron* 'Coccinea Speciosa' (Table 2) diphenamid caused slight tip burn on foliage but cuttings from injured plants rooted better than the controls. In *Chrysanthemum* 'Chapel Bells' diphenamid reduced top growth, but this injury did not cause marked reductions in rooting of the cuttings (Table 5).

DCPA was included in four of the experiments (Tables 4, 5, 6, 7) Normal dosages of DCPA (9 lb/A) did not affect rooting of any plant treated. The effect of two annual applications of DCPA plus simazine on rooting of *Rhododendron* 'Daviesi' was mentioned in the simazine section. Double rates of DCPA (18 lb/A) distorted the leaves and stunted container-grown plants of *Hydrangea acuminata preciosa*. Rooting of cuttings from these plants was significantly depressed (Table 4). Softwood cuttings from *Rhododendron* 'PJM' that were treated with DCPA at 18 lb/A also rooted less than cuttings from control plants (Table 7). However, DCPA at 18 lb/A had no marked effects on rooting of cuttings from *Rhododendron* 'Purple Gem' (Table 7), two chrysanthemum cultivars (Table 5) or *Rhododendron* 'Boule de Neige' (Table 4).

Trifluralin was included in all of the rooting tests (Tables 2-7). Only in two instances was there any indication of effects on rooting, and those were at high rates of application. In container-grown chrysanthemums (Table 5) cuttings from plants injured by trifluralin at 4 lb/A developed poorer roots than the controls Cuttings from field-grown *Rhododendron* 'Daviesi' treated with two annual applications of trifluralin at 4 lb/A in the fall also developed roots of poorer quality than control plants, but cuttings from *Rhododendron* 'Tunis' were unaffected (Table 6) Two annual applications of simazine plus trifluralin seemed to reduce rooting of cuttings *R*. Tunis', but this reduction was not statistically significant.

Bensulide was included in three experiments (Table 2, 4, 6) At 8 or 16 lb/A, bensulide did not reduce the rooting of cuttings.

Chlorpropham applied at 8 or 16 lb/A in two container-grown rhododendron hybrids, had no adverse effects on rooting of cuttings (Table 7). Similarly, both EPTC and **chloramben**, which injured chrysanthemums, did not markedly affect rooting of cuttings from the injured plants (Table 5).

Nitralin was included in three of the experiments (Tables 2, 3, 4), alone and in combination with simazine. Nitralin at 4 lb/A injured azaleas but did not affect rooting (Table 2). Similarly, cuttings from other plants treated with nitralin rooted as well or better than controls (Tables 3, 4).

A few experimental herbicides that are not now registered for use on woody plants in the United States were also tested. These included R-7465, cycloprofulan, pronamide, alachlor, and oxadiazon.

Cycloprofulan did not affect rooting of chrysanthemums (Table 5) and **pronamide** did not affect rooting of azaleas, following one or two annual applications (Table 6).

R-7465, however, significantly reduced rooting of *Rhododendron* 'Daviesi' following two annual applications at 3 lb/A without affecting rooting of *R.* 'Tunis' on the same field at 6 lb/A (Table 6). R-7465 also reduced rooting of cuttings from plants of *Rhododendron* 'PJM' in containers without affecting rooting of *Rhododendron* 'Purple Gem' (Table 7).

Alachlor alone or in combination with simazine had no effect on rooting of cuttings in field-grown *Rhododendron* 'Grandiflora' (Table 3), or container-grown *Rhododendron* 'Boule de Neige', or *Hydrangea acuminata preciosa* (Table 4). A high rate of alachlor plus simazine reduced rooting of softwood cuttings from container-grown *Rhododendron* 'PJM', but not 'Purple Gem' (Table 7).

Oxadiazon at 2 or 4 lb/A did not affect rooting of cuttings from container-grown *Rhododendron* 'PJM' or 'Purple Gem' (Table 7).

DISCUSSION

Herbicides could affect the rooting of cuttings from treated plants, either directly or indirectly. Direct effects could be produced by uptake of the herbicide and translocation to the shoot where the herbicide, or one of its metabolites could alter plant metabolism. Direct effects might also result from root inhibition which could alter shoot growth and metabolism. Indirect effects of herbicides could result from the control of weeds which compete with other plants for nutrients and water. Herbicide-treated woody plants frequently grow more vigorously than untreated plants that are periodically weeded. These indirect effects might improve rooting potential or reduce it, depending on when the cuttings are taken. The optimal time for taking cuttings from plants might be altered by the herbicide application which directly or indirectly affected plant metabolism and growth.

Since plants differ in their tolerance to herbicides, and soil and climatic conditions affect this tolerance, it will be difficult, if not impossible, to predict for all species and cultivars whether inhibition of rooting will occur from herbicide usage. We can only learn from experiments and experience on individual plants and systems of culture which herbicides are likely to cause problems. In this respect, the effects of herbicides on rooting of cuttings are similar to the effects of the herbicides on growth and appearance of the stock plants themselves. Thus, rooting potential becomes another criterion by which to evaluate herbicides in assessing their safety to horticultural plants.

In the experiments reported here, several herbicides had no adverse effects on rooting and in some instances herbicides appear to have caused improved rooting. No herbicide consistently reduced rooting. Most of the adverse effects of herbicides on rooting were obtained at twice normal dosages or in leachable container mixes that allowed greater than normal exposure of the plant root system to the herbicide.

The herbicides that adversely affected rooting of cuttings from one or more treated species included dichlobenil, simazine, diphenamid, DCPA, trifluralin and R-7465.

Dichlobenil, which acts primarily as an inhibitor of root growth, is the only preemergence herbicide currently available to nurserymen that has been effective against established perennial weeds. It has been tested for use in containers but it is primarily applied in field-grown stock during the dormant season (1, 2, 4, 6, 9, 10). It is absorbed by plant roots and is translocated to foliage (14) where it either is metabolized or evaporates. Despite some reports of success (1, 8, 10), dichlobenil appears to be too hazardous for general use in container stock because we have found that it is readily leached to root zones in the soil mix most commonly used, containing equal volumes of sand and sphagnum peat (6). Exceptions might be the use of dichlobenil on containers with less permeable soil mixes or during the winter storage period in colder climes, where minimal irrigation is used. A number of species are sensitive to dichlobenil including many of the deciduous azaleas both in the field and in containers (1, 4, 10). In the work reported here, *Rhododendron* 'Coccinea Speciosa' was injured and rooting of softwood cuttings was poorer following application of dichlobenil at 8 lb/A, but with lesser injury, rooting was unaffected at 4 lb/A (Table 2). We obtained no inhibition of rooting of cuttings with dichlobenil when we did not obtain concurrent plant injury due to excessive rates of application (Tables 2, 6).

Simazine is a widely used herbicide in woody plants for preemergence control of annual and perennial weeds. Many woody plants, particularly deciduous species, are sensitive to injury from simazine. However, studies in recent years have shown that low rates of simazine in combination with other herbicides that effectively control annual grasses, have a wide range of utility in field and container-grown woody plants (2, 4, 5).

Simazine is absorbed by plant roots and is translocated to shoots, where it inhibits photosynthesis and reduces carbohydrate levels (11). At sublethal dosages it has been reported to increase nitrate levels in plants (19). It does not directly affect root growth. Simazine is metabolized in plants; resistant plants tend to break it down more rapidly than susceptible plants (16). Perhaps this is why

Table 1. Herbicides tested for effects on rooting of cuttings from treated plants.

Common name	Chemical name	Trade name	Manufacturer
alachlor	2-chloro-2', 6'-diethyl-N-(methoxy-methyl) acetanilide	LASSO	Monsanto
bensulide	0,0-diisopropyl phosphorodithioate S-ester with N-(2-mercaptoethyl) benzenesulfonamide	BETASAN	Stauffer
chloramben	3-amino-2, 5-dichlorobenzoic acid	AMIBEN	Amchem
chlorpropham	isopropyl m-chlorocarbanilate	CHLORO IPC, FURLOE	Niagara
cycloprofulan	N-(cyclopropylmethyl) a, a a-tri-flouro-2, 6-dinitro-N-propyl-p-toluidine	TOLBAN	CIBA-Geigy
DCPA	dimethyl tetrachloroterephthalate	DACTHAL	Diamond Shamrock
dichlobenil	2, 6-dichlorobenzonitrile	CASORON	Thompson-Hayward
diphenamid	N, N-dimethyl-2,2-diphenylacetamide	ENIDE, DYMID	Upjohn, Eli Lilly
EPTC	S-ethyl dipropylithiocarbamate	EPTAM	Stauffer
nitralin	4-(methylsulfonyl) -2, 6-dinitro-N, N-dipropylaniline	PLANAVIN	Shell
norea	3-(hexahydro-4,7-methanoindan-5-yl)-1, 1-dimethylurea	HERBAN	Hercules
oxadiazon	2-tert-butyl-4-2'-4'-dichloro-5' isopropyloxyphenyl-1, 3, 4-oxadiazolin-5-one	RONSTAR	Rhodia
pronamide	N-(1,1 dimethylpropynyl)-3,5-dichlorobenzamide	KERB	Rohm & Haas
R-7465	2-(a-naphoxy)-N,N-diethylpropionamide	DEVRINOL	Stauffer
simazine	2-chloro-4,6-bis(ethylamino) -s-triazine	PRINCEP	CIBA-Geigy
trifluralin	a, a, a-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine	TREFLAN	Eli Lilly

Table 2. Effects of fall applied herbicides on visual injury and rooting of cuttings from treated azaleas — 1970 [1]

Herbicide	Rate a.i., lb/A	*Rhododendron 'Coccinea speciosa'*			*Rhododendron 'Harvest Moon'*		
		Injury [2]	No of Cuttings	% rooted	Injury [2]	No of Cuttings	% rooted
Untreated controls		0	53	57	0	28	36
simazine	1 5	0	64	73	—	—	—
	3	3	33	45	2	26	46
dichlobenil	4	4	88	68	0	25	72
	8	5	7	29	2	17	71
trifluralin	2	0	61	66	0	19	63
	4	1	81	62	0	27	81
nitralin	2	1	62	48	0	32	66
	4	3	60	78	2	27	63
diphenamid	5	1	60	73	0	29	52
	10	2	65	63	0	27	41
norea	4	1	79	58	1	26	69
	8	3	34	62	3	30	70
bensulide	8	0	62	77	0	24	38
	16	0	81	55	3	36	33
simazine + trifluralin	1.5+2	0	34	76	—	—	—
Average				62		27	57

[1]The herbicides were applied on 11-18-69 on plants established in April 1969. Softwood cuttings were taken on 6-6-70 and rooted under mist with 1% IBA. Norea was applied as a spray in 50 gal solution per acre, all other herbicides were applied in granular form. Weed control and injury evaluations in this experiment are published elsewhere (4).

[2]Injury to the plants were rated on a scale of 0 to 10, where 0=no injury and 10=dead plants.

Table 3. **Effects of herbicides on control of crabgrass and the rooting of *Rhododendron* 'Grandiflora' [1].**

Herbicide	Rate, a i, lb/A	Crabgrass control ratings[2]			Cuttings taken July 29, 1970		
		June 11	July 29	Sept 24	No of cuttings	Percentage rooted	Rooting score
Untreated controls		0	2 2	1.9	98	87	5.0
simazine	2	5 3	7 0	3 3	35	91	4.8
	4	7 0	7 5	4 0	47	96	5 3
dichlobenil	4	9 0	9 0	8 0	51	90	5.2
	8	9 5	9 2	9 3	51	84	4 7
trifluralin	3	9 8	8 8	9 5	52	79	4 7
	6	9 8	9 0	9.3	50	90	5 3
nitralin	3	8 3	6 7	8 8	51	80	4 8
	6	8 2	7 2	9 0	46	89	4 9
diphenamid	5	8 6	8 7	8.5	51	88	5.0
	10	9 3	9 5	9 2	52	69	4 3
R-7465	6	7 7	7 3	8 5	50	94	5 2
alachlor	4	9 2	8 5	6 0	49	94	5 1
	8	9 6	8 8	8 2	50	94	5.1
simazine trifluralin	1 5 + 3	9 6	8 2	8 7	49	84	4 8
simazine nitralin	1 5 + 3	7 7	8 3	8 3	48	88	5 2
simazine diphenamid	1 5 + 5	8 6	8 3	9 2	50	84	5 0
simazine alachlor	1 5 + 4	8 6	7 3	6 8	51	90	5 1
Average						87	5 0

[1] The herbicides were applied on 4-8-70 over plants established in 1969. R-7465 was applied as a spray. All other herbicides were applied in granular form. Certain plants treated with dichlobenil at 8 lb/A were slightly discolored. No injury was dectectable from the other treatments. Cuttings were dipped in 1% IBA and rooted under mist.

[2] 0 = no weed control, 10 = 100% control of crabgrass (Digitaria spp.). All plots were weeded after each rating.

Table 4. Effect of granular herbicides on control of weeds in containers and on rooting of cuttings from the treated plants [1].

Herbicide	Rate, a i , lb/A	Average No of weeds per gallon container [2] Crabgrass 8/4	9/1	Broadleaf 8/4	9/1	*Rhododendron* 'Boule de Neige'[3] Percentage rooted	*Hydrangea acuminata preciosa* [4] Percentage rooted	Rooting score
Untreated controls		25 0	1 5	4 5	3 3	51	86	4 8
simazine	1 25	6 7	1 2	0 6	0 7	62	86	4 8
	2 5	0 3	0 1	0	0 1	54	81	4 5
trifluralin	2	0 3	0 4	0 9	1 4	50	98	5 2
	4	0 1	0 2	0 6	1 3	54	86	4 8
nitralin	2	0 4	1 1	1 1	1 2	47	86	4 7
	4	0 2	0 1	0 6	1 2	67	92	5 0
alachlor	4	1 2	0 5	1 6	1 0	59	90	5 0
	8	0	0	0 5	0 3	78	87	5 0
bensulide	8	0 3	0 7	1 4	1 9	83	91	4 8
	16	0	0 1	0 3	0 7	91	86	4 8
DCPA	9	1 5	0 6	2 7	0 9	75	81	4 5
	18	0 4	0 2	1 8	0 6	80	71	4 3 *
simazine + trifluralin	1 25 + 2	0 1	0 2	0	0 7	74	90	4 6
simazine + nitralin	1 25 + 2	0	0 1	0 3	0 8	83	81	4 6
simazine + alachlor	1 25+4	0	0	0	0	91	90	5 0
simazine + bensulide	1 25+8	0 1	0	0	0 7	70	90	5 2
simazine + DCPA	1 25+9	0 1	0 1	0 1	0 1	82	82	4 6
Average						70	86	4 8

[1]The herbicides were applied 7-9-70. Rhododendron cuttings were taken 11-20-70, dipped in 1%IBA plus 5%Captan. Hydrangea cuttings were taken 10-6-70 and rooted without hormone.

[2]Crabgrass (**Digitaria spp.**) seeds were sown before treating 1 gal. plantless containers with the same soil mix as the plants were grown in. All weeds were pulled and counted 8-4-70 and 9-1-70. The soil mix was 1/6 sand, 1/6 sand, 1/6 perlite, 1/3 peat, and 1/3 humus by volume.

[3]The number of cuttings taken was 50 for untreated controls and 25 for each treatment.

[4]The number of cuttings taken was 120 for untreated controls and 60 for each treatment.

* Figure significantly less than untreated controls at 5 % probability level.

Table 5. Effect of herbicides on foliage injury, top growth, and rooting of cuttings from container-grown chrysanthemums — 1971[1].

Herbicide	Rate, a.i., lb/A	'Ruby Mound' Fresh weight			'Chapel Bells' Fresh weight		
		Injury[2]	Tops[3]	Percentage rooted	Injury[2]	Tops[3]	Percentage rooted
Untreated controls		0	121	77	0	160	100
trifluralin	2	2	138	70	1	138	97
	4	4	116	64	3	117 *	88
DCPA	9	0	134	80	0	136	89
	18	0	135	89	0	165	95
diphenamid	4	0	116	76	0	124 *	97
	8	0	134	31	0	111 *	92
cycloprofulan	2	1	137	76	0	152	96
	4	3	116	71	0	115 *	97
EPTC	4	0	139	75	0	137	93
	8	5	76 *	83	2	118 *	90
chloramben	4	0	116	77	1	132	97
	8	6	52 *	77	3	69 *	100
Average			118	73		129	95

1 Chrysanthemum rooted cuttings were planted in containers on 7-20-70 and treated 8-1-70 with herbicide sprays in 50 gal solution per acre. The soil mix was 25 percent loam, 50 percent peat and 25 percent perlite by volume. After harvesting top growth in October, 1970, 35-40 cuttings were taken from mature stems of each treatment and rooted in sand.

2 0 = no injury, 10 = dead plants.

no injury, 10 dead plants.

3 Mean of 4 units of 3 plants each.

*Values significantly different from untreated controls at the 5% probability level.

Table 6. Effects of one and two annual applications of herbicides on the rooting of softwood cuttings from treated azalea hybrids.

		1971[1]		1972[2]			
Herbicide	Rate, a.i., lb / A	R. Daviesii' Percentage rooted	R. 'Tunis' Percentage rooted	R. 'Daviesi' Percentage rooted	Rooting score	R. 'Tunis' Percentage rooted	Rooting score
Untreated controls		87	89	95	5.7	78	4.9
simazine	1.5	89	83	92	5.6	72	4.6
	3	92	83	82	5.2	73	4.6
trifluralin	2	98	81	92	5.6	86	5.2
	4	82	87	82	5.1	84	5.0
simazine + trifluralin	1.5+2	88	88	92	5.7	58	4.0
DCPA	9	92	85	91	5.6	81	4.9
simazine DCPA	1.5 + 9	91	79	78	4.9	82	5.2
bensulide	8	89	84	—	—	66	4.4
diphenamid	6	90	69	88	5.4	92	5.5
simazine + diphenamid	1.5+6	87	93	—	—	—	—
dichlobenil	4	90	92	98	5.9	92	5.4
pronamide	1.5	94	88	98	5.9	80	5.1
	3	91	88	—	—	—	—
R-7465	3	91	83	76	4.9	85	5.4
	6	—	77	—	—	77	4.9
Average		90	84	89	5.5	79	4.9
Least significant difference P=.05		N.S.	N.S.	N.S.	0.6	N.S.	N.S.

N.S. differences not statistically significant at P=.05

[1]The herbicides were applied on 12-10-70 or 4-5-71 and the softwood cuttings were taken in early June 1971. Rooting data from the fall and spring applications were averaged.

[2]Plants treated with herbicides on 12-10-70 were re-treated 12-13-71 and softwood cuttings were taken in June 1972.

All cuttings were rooted under intermittent mist after dipping in 1%IBA plus 5 percent Captan in 1971 and in 0.7 percent IBA and 10 percent Benlate in 1972.

Table 7. Effects of granular herbicides on control of seeded crabgrass and rooting of softwood cuttings from treated rhododendrons. [1]

Herbicide	Rate, a i , lb/A	No of crabgrass plants per gallon container	'PJM'		'Purple Gem'	
			Percentage rooted	Rooting score	Percentage rooted	Rooting score
Untreated controls		15 0	49	3 5	100	5 9
simazine	1 25	7 9	29	2 6	97	5 9
	2 5	5 9	54	3 7	98	5 9
trifluralin	3	0 1	42	3 1	100	6 0
	6	0 2	50	3 5	100	5 9
DCPA	9	0 8	41	3 2	100	6 0
	18	0 2	20	2 0	95	5 9
diphenamid	6	0 9	48	3 3	100	5 9
	12	0 8	14	1 8	97	5 9
chlorpropham	8	0 1	55	3 7	100	6 0
	16	0 2	57	3 9	98	5 9
R-7465	3	0 5	14	1 9	100	5 8
	6	0 2	25	2 5	100	6 0
oxadiazon	2	1 6	52	3 4	93	5 6
	4	0 9	41	3 1	98	5 9
simazine + trifluralin	1 25+3	0 1	56	3 3	98	5 9
simazine + DCPA	1 25+9	1 1	44	3 2	100	6 0
simazine + alachlor	1 25+4	0 3	45	3 2	100	5 9
	2 5+8	0 1	25	2 2	100	6 0
Average			40	3 0	99	5 9
Least significant difference P = 05			22	1 2	N S	N S

N S = Differences not statistically significant at P= 05

[1]The rhododendrons were planted into gallon containers on 4-20-72 and treated with herbicides 6-12-72. The soil mix was equal volumes of sand and peat.
Crabgrass (Digitara spp.) seeds were sown over 30 of the 54 containers of each cultivar. The cuttings were harvested from 'PJM' 7-26-72 and from 'Purple Gem' 8-8-72. Fifteen cuttings were taken from each of three replicates for treatments and 30 were taken from each replicate for controls The cuttings were dipped in 1% IBA, plus 20% Benlate, plus 30% Manzate, and rooted under intermittent mist. No injury was observed on any of the plants at the time the cuttings were taken

we found no effect of normal rates of simazine on rooting of cuttings. Even where simazine caused visual injury to the plants, rooting of cuttings was not greatly affected. McGuire and Pearson (15) reported that rooting of softwood cuttings of several container-grown plants was markedly inhibited by applications of simazine 30 days before harvesting of cuttings. Cuttings taken 80 days after application were less affected. A greater time between treatment and harvesting of cuttings would allow greater metabolism of simazine in the plant and might lessen its effects Where herbicides were applied 34 days before harvesting cuttings of *Rhododendron* 'PJM', simazine alone had no significant effects on rooting, but a high rate of simazine combined with alachlor reduced rooting percentage and quality (Table 7). From these varied results we can conclude that further investigation is needed, but there is little indication that simazine poses a threat to plant propagation.

Diphenamid, DCPA, and trifluralin have been widely used in woody plants for the preemergence control of annual weeds, particularly annual grasses. Diphenamid is absorbed by plant roots and translocated to shoots (8, 13), but DCPA and trifluralin are more tightly bound by roots and are translocated to a much lesser extent (12, 17, 18). All threee are inhibitors of root growth (3, 13, 21). Visual injury to the foliage of woody plants is seldom observed with these herbicides except at extremely high rates. *Hydrangea acuminata preciosa* is one of the few woody plants on which we have observed foliage injury with DCPA. DCPA and trifluralin are very insoluble in water and are more resistant to leaching in soil than is diphenamid. Resistance to leaching has made DCPA and trifluralin excellent for fall applications in the field (4) and for container applications (3, 5, 6). Twice normal rates of diphenamid, trifluralin, and DCPA have reduced the rooting potential of cuttings in several, but not all, of our experiments. Although combinations of DCPA or trifluralin with simazine applied in two successive seasons may have reduced rooting of deciduous azaleas, the reductions occurred in only one of two cultivars.

The experimental herbicide, R-7465, has proven effective against annual grasses, certain broadleafed weeds, and yellow nutsedge (*Cyperus esculentus* L.) in several of our experiments over a 3 year period. We have seen no injury from R-7465 on any of several species of woody nursery stock in the field or in containers. Nevertheless, R-7465 reduced the rooting quality in cuttings from *Rhododendron* 'Daviesi' in the field and *Rhododendron* 'PJM' in containers. Therefore, further attention should be given to the potential effects of R-7465 on rooting of cuttings.

Although the bulk of our information to date indicates that the herbicides widely used in nurseries pose little threat to plant propagation by cuttings, the occasional reduced rooting obtained largely with excessive dosages reinforces the need for proper application and particular caution in stock plants, especially in leachable soils or soil mixes.

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RALPH SHUGERT: That is some interesting information and, I might add, that there is also a paper on this same subject by John in the September, 1972, issue of *The Plant Propagator.*

Our next speaker will be telling us about the growing of *Betula* in a controlled environment. Dr. Don Krizek has spoken to us before and his paper caused some interesting comment and so we have him back again.

ACCELERATED GROWTH OF BIRCH IN CONTROLLED ENVIRONMENTS

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Abstract. The growth of paper birch (*Betula papyrifera* Marsh) and European white birch (*Betula verrucosa Ehrh.*) plants was greatly accelerated by growing them for 4 to 8 weeks during the seedling stage under controlled-environment conditions By providing plants with a "head start" at the seedling stage, and then maintaining them on long days, it was possible to obtain white bark on trees in 2 years rather than after 3 or more years

INTRODUCTION

During the past several years, a cooperative program has been carried out at Beltsville to determine the optimum environment for seedling growth of selected herbaceous and woody plants Some of these results wer presented at the 18th Annual Meeting of the Plant Propagators' Society (8).

These studies have demonstrated the feasibility of using controlled environments to provide a "head-start" for a wide range of horticultural species, including F_1-hybrid annuals (4, 6, 7, 8, 9, 15), vegetables (3, 4, 5, 15), and woody plants (10, 11, 12, 13, 18).

In this paper I will briefly describe some of the highlights of the research done since 1968 to accelerate the growth of birch by the use of controlled environments.

ENVIRONMENTAL SYSTEM

Initially plants were grown under precisely controlled conditions in experimental growth chambers (1, 4, 16). In 1970, a custom-made propagation unit was constructed by agticultural engineers Herschel H Kleuter and William A. Bailey. This facility (2) has resulted in only modest control of the environ ent and at far less cost. Plans of this unit[3] may be of interest to nurserymen.

To extend the time of treatment from 4 weeks to 8 weeks or longer, large commercial walk-in growth chambers have also been used (10)

[1]Plant Physiologist, Plant Stress Laboratory

[2]Mention of trademark name or a proprietary product does not imply its approval by the USDA to the exclusion of other products that may also be available

[3]Plan No 6101 — "Propagation Unit for Plants" may be obtained from the Extension Agricultural Engineer at each State University.

CULTURAL PROCEDURES

Plant material consisted initially (11) of European white birch (*Betula verrucosa* Ehrh), but during the past 3 years most of the work has been done with paper birch (*Betula papyrifera* Marsh) (10, 17).

In initial studies, seed were stratified at 1° C (34° F) for about 30 days, germinated on moist filter paper in petri dishes at 22° to 25° C (72° F), and selected for germination under a dissecting microscope when the radicle had begun to emerge. At that time, they were transplanted to 7.5 cm (3-inch) plastic pots containing a peat-vermiculite mix (sold commercially as Jiffy-Mix)[2] and placed in a greenhouse or growth chamber. The procedure proved to be a reliable method of assuring viable seedlings, but was too laborious to be useful

At present, the seed are planted directly in a shallow plastic tray of peat-vermiculite mix without prior stratification, then placed under mist in a propagation unit (2) or covered with plastic film and allowed to germinate in a controlled environment under about 1,000 ft-c (10.8 klx) of cool white fluorescent light.

Experimental treatment is usually begun when the first true leaf is 3 to 5 mm in length. At this time the seedlings are selected for uniformity, transferred to 7.5-cm pots of peat-vermiculite mix, and placed in a greenhouse or growth chamber. After 4 to 5 weeks they are shifted to 10 cm (4-inch) pots, and after 8 weeks to 15 cm (6-inch) pots. After 3 to 4 months they are transferred again to 20-cm (8-inch) or 25-cm (10-inch) pots.

TYPICAL RESULTS

Several studies were conducted on paper birch seedlings in a custom-designed propagation unit (2), which provided high light intensity (2,500 ft-c) (26.9 klx) and automatic watering, but otherwise only modest control of the environment. Day temperatures were 25° to 27° C (77° to 81° F), night temperatures 18° to 20° C (64° to 68° F). Relative humidity varied between 35 to 50% during the day and 45 to 65% during the night. CO_2 was either controlled at 400 ppm or remained near ambient levels (about 350 ppm). Seedlings were fertilized with an automatic watering system 4 to 6 times daily with 0.5 g/1 or 1.0 g/1 of 20-20-20 water-soluble fertilizer containing essential macronutrients and micronutrients

Plants grown for 4 to 6 weeks under these conditions and then transferred to a greenhouse under long-day conditions (natural daylight plus 200 ft-c (2.2 klx) of cool white fluorescent light from 4:00 a.m. until 8:00 p.m.) reached a height of 1 meter (39.4 in.) in 3 to 4 months from seed. Sample plants maintained under long-day conditions in the greenhouse during the first winter and transplanted outdoors as a clump in the spring when they were about 1½ years old, continued to grow rapidly and produced white bark the following winter when they were only 2 years old. These plants are now 3 years old, are nearly 4 meters tall, and have stems that are 5 cm in diameter at 30 cm above the ground.

When the time of controlled-environment treatment was extended from 4 weeks to 8 weeks, even more dramatic results were obtained with paper birch seedlings (10).

Plants were grown for 8 weeks from the cotyledon stage in a walk-in growth chamber or in a closely controlled greenhouse. Growth chamber conditions consisted of high light intensity (2,500 ft-c) (26.9 klx) provided by cool white fluorescent and incandescent lamps, a 16-hr photoperiod, 25/18° C (77° /64° F) day/night temperature, and ambient CO_2. Greenhouse conditions consisted of natural daylight supplemented by 200 ft-c (2.16 klx) of cool white fluorescent light, a 16-hr photoperiod, and 24/18° C (75° / 64° F) day/night temperature. Both sets of plants were fertilized 5 times daily with 0.5 g/1 or 1.0 g/1 of 20-20-20 water-soluble fertilizer.

Plants grown for 8 weeks under high light intensity weighed more than 40 times as much, were 6 times as tall, had twice as many leaves, and produced lateral shoots containing 17 times as much dry matter, as plants grown under low light intensity in the greenhouse.

CO_2 enrichment in the growth chamber may be used to provide an additional boost in growth. A preliminary experiment was conducted on European white birch seedlings under greenhouse and growth-chamber conditions (11). Greenhouse conditions consisted of a day/night temperature of 24/18° C (75/64° F), natural daylight (ca 12-hr photoperiod), and ambient CO_2 (ca 350 ppm). Growth-chamber conditions consisted of elevated day/night temperature (30/24° C) (86/75° F), high light intensity (2,500 ft-c) (26 9 klx) of cool white fluorescent and incandescent light (the latter providing about 20% of the total input wattage), and CO_2- enriched atmospheres (400 and 2,000 ppm). After 4 weeks, seedlings grown at 400 or 2,000 ppm CO_2 in controlled environments were nearly twice as tall as, and had several more leaves than, those grown in the greenhouse (11). Differences in leaf area and branching were especially marked between greenhouse and growth chamber-grown plants. Seedlings removed from the high CO_2 growth chamber at 4 weeks and placed in the greenhouse continued to show significantly more elongation during the next 4 weeks than greenhouse controls.

DISCUSSION

While the economic aspects of controlled-environment treatment must be carefully worked out to determine a practicable duration of treatment, it is clear that techniques for accelerating seedling production are now available to the grower of birch and other woody plants

The dramatic increase in seedling growth obtained by using high light intensity from the time the seeds are planted or at the cotyledon stage indicate that light is probably the most limiting factor in normal greenhouse production, and that the time to begin light treatment is early in the life of the seedling Other factors required for optimum seedling growth include warm day/night temperatures (about 25/18° C), long days (16 hr), good air movement, and adequate moisture and nutrition.

Our studies indicate that *Betula papyrifera* may be more responsive to light treatment than *Betula verrucosa*. Pinney and Peotter (14) have reported that *B. papyrifera* is a much more vigorous grower than *B. verrucosa* and *B. populifolia*. Such rapid-growing species of woody plants should be prime candidates for controlled-environment treatment, since they permit multiple cropping

The capital investment required to set up a program for accelerated culture of seedlings need not be exorbitant. The prospect of obtaining high-quality plants on a scheduled basis and accelerating seedling production affords the grower an unexcelled opportunity, whether he is starting woody plants, F_1 hybrid annuals, or vegetable seedlings.

ACKNOWLEDGMENTS

Grateful acknowledgement is made to Thomas S. Pinney, Jr , Evergreen Nursery Co., Sturgeon Bay, Wisconsin, for furnishing the seed used in these studies; Dr. Richard H Zimmerman, Fruit Laboratory, Herschel H. Klueter, William A. Bailey, and Robert C. Liu, Light and Plant Growth Laboratory, for use of controlled-environment facilities; and to Miss Wendy Chernikoff and Bernard Ford, for their assistance.

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RALPH SHUGERT· Dr Krizek, while you are up here perhaps you would comment on any further developments in the work you have been doing on crabapple

DON KRIZEK: The work on crabapple has been followed up by Dr Zimmerman. He has been using a combination of long day treatments and growth regulators to get flowers buds to develop at fairly young ages. This involves providing incandescent light at the early stages and then giving them either a cold treatment or hormone treatment (as a mixture of cytokinin and gibberellin) which then allows the buds to develop. He has been able to get flowers in 9 to 11 months The magic of getting early flowering is getting enough nodes produced and, with *Malus*, the magic number appears to be about 75 nodes

The best time to begin treatment is when the plants are very young. If you wait even 2 weeks it is too long. The proper time to start is when the seed are planted. There is also a minimum time which the plants must be treated in order to obtain maximum effect, it is possible that with *Betula* the time may be as little as 4 weeks We got a tremendous boost in growth between week 4 and week 6 - as much as 1 inch per day with an average of 1/2 inch per day growth over the 8 week period. This may be contrasted to 1/10 inch of growth per day in the greenhouse.

RALPH SHUGERT: Thank you, Don. You certainly have brought us up to date. There are certainly some interesting and exciting things happenning in the area of controlled environment growing

Our next speaker is Dr. Elton Smith who will discuss the use of plastic houses for accelerating plant growth.

PLASTIC STRUCTURES FOR ACCELERATED PLANT GROWTH

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The Ohio State University
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The use by the nursery industry of plastic covered storage houses for overwintering both container-grown and fall-harvested field-grown evergreens has become a standard practice in Ohio and in much of the northern United States. In recent years, some nurserymen have explored the aspect of utilizing basically the same structures with the addition of heat to grow certain nursery crops during late winter and spring.

At The Ohio State University a preliminary study was initiated to produce salable 1 gallon container grown plants in the shortest possible time in heated plastic covered structures.

MATERIALS AND METHODS

Cuttings rooted during the summer and fall of 1971 were potted into 1 gallon containers and stored in an unheated, unventilated plastic covered house. The storage house was covered with one layer of 4 mil. milky or white plastic. A select number of control plants of each species remained in this house throughout the study to simulate conventional winter storage.

On February 1, 1972, a majority of each of the plant species were placed in a 96' x 12' quonset -shaped, double layer, plastic-covered structure heated to 40° F. The outside layer was 4 mil. thickness, milky plastic, and the inside layer was 4 mil. clear with the films separated by forced air provided by a shaded-pole blower.

The heat was supplied by a natural gas-fired Reznor unit Model No. XB 150 with a 150,000 BTU rating. Every 7 days the temperature was increased 5° F until 70° F was reached in late March. The 70° F temperature was maintained until June 1, 1972.

This structure was equipped with a fan and shutter system to ventilate when the temperature reached 80° F. The heated and cooled air were transmitted through an 18" diameter perforated poly tube attached to the heating unit at one end of the house and to the shutter at the far end. The shutter was closed at all times except when the exhaust fan operated and brought outside air in through the shutter and poly tube.

RESULTS AND DISCUSSION

Most plants responded to the supplemental heat as indicated by the additional growth expressed in Table 1.

The greatest growth response to supplementary heat was noted with *Abelia, Ajuga, Euonymus, Hedera,* and *Pyracantha*. The two *Cotoneaster* species and *Pachysandra* responded to the addition of heat but not as markedly as the other species.

Table 1. Growth of rooted cuttings of landscape plants overwintered in two plastic covered structures. The figures represent the average dry weight of tops of 5 plants harvested June 20, 1972 ath the soil line.

Plant	Grams Dry Weight		Per cent increase
	Unheated	Heated	
Abelia x grandiflora	6	24	300
Ajuga reptans	3	12	300
Contoneaster apiculata	6	11	83
Cotoneaster divaricata	19	36	95
Euonymus kiautschovicus	5	25	400
Hedera helix	4	17	313
Pachysandra terminalis	4	8	60
Pyracantha coccinea 'Lalandii'	4	20	400

Table 2. Growth of rooted cuttings ove-wintered in two plastic covered structures and grown outdoors for one full season. The figures represent the average height or diameter of 5 plants measured on September 22, 1972.

Plant	Growth in Inches		Grade increase
	Unheated	Heated	
Abelia x grandiflora (D) *	26	36	Yes
Ajuga reptans (D)	14	16	Yes, June
Hedera helix (D)	25	37	Yes, June
Ligustrum obtusifolium var. *regelianum*	13	21	Yes
Pachysandra terminalis	6	8	Yes, June
Pyracantha coccinea 'Lalandii'	10	14	Yes
Viburnum rhytidophyllum	6	13	No

* (D) Diameter measurement, all others expressed in height

To determine whether an additional grade or size could be achieved with the supplemental heat, select plants were measured in September 1972 and these differences are expressed in Table 2.

The three ground covers *Ajuga, Hedera,* and *Pachsandra* in the heated structure were salable 1 gallon plants by June while most other heated plants had increased a grade or two by the end of the growing season in September. *Viburnum,* although more than doubling in size, was not considered large enough for sale and therefore not claimed to have gained a grade.

This technique of heating plastic-covered structures results in excellent plant growth with a number of species and should have application for producers of ground covers, lining-out stock, and container grown stock. To determine whether this concept of heating and ventilating is economically feasible for nursery crops produced in plastic structures will be studied in research now in progress.

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RALPH SHUGERT: Thank you very much, Elton.

We will move right on to our next paper which is entitled "Growing Nursery Stock on Organic Soils", and to tell us about this will be Jan Jansen.

GROWING NURSERY STOCK ON ORGANIC SOILS

JAN L. JANSEN

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Middletown, New York.10940

Growing ornamental plants on organic soils is not something that is uniquely new, nor is it something that has been done only on the North American continent.

Nurseries growing ornamental crops on organic soils have long been established in the various areas of Europe, with perhaps the most well-known area being the Boskoop region in The Netherlands. In the United States, many of our cutflower production areas in Florida are on muck. Greenhouse forcing azaleas are also grown in Florida muck and are subsequently shipped throughout the country.

Most research and production work, however, seems to have been concentrated primarily on edible crops, principally vegetables. In recent years, work has been done with the growth of blueberries and with turfgrass production on organic soils. Work done with doubling in size, was not considered large enough for sale and therefore not claimed to have gained a grade.

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Most research and production work, however, seems to have been concentrated primarily on edible crops, principally vegetables. In recent years, work has been done with the growth of blueberries and with turfgrass production on organic soils. Work done with ornamental shrubs and trees, however, has largely been limited to their use as windbreaks or hedgerows with limited information being available as to the possibility of commercial production of trees and shrubs on organic soils.

The Orange County mucklands are located in a rapidly spreading megalopolis only 50 miles from the center of New York City.

The lands totaling some 14,000 acres, more or less, have been primarily developed for vegetable crops. Onions are the primary crop totaling some 7,700 acres; lettuce is second, using 2,200 acres; celery third with 1,200 acres; and a rather recent major crop is the production of turfgrass sod, which has climbed to some 2,500 acres in the last 10 years.

Since onions, celery and lettuce have been the major commodities in recent years, we have seen large fluctuations in farm income and the creation of larger farms. The market continues to fluctuate and it was felt that possibly we ought to look at other crops to further diversify the marketing mix of the area.

What has been attempted in the last 2 years cannot be classified as pure research. All we have attempted is a feasibility study entitled, "Can We Economically and Competitively Produce Nursery Stock on the Orange County Muck?"

Working with a granular, fairly well disintegrated organic soil consisting primarily of residues of woody plants, both coniferous and deciduous, at least 30 feet deep; we set out to grow plants we thought might give us an indication of the chances of commercially growing nursery plants on these soils.

Soil tests on the plots indicate the major nutrient levels to be high. The soils tested pH 5.4 and consist of 85% organic matter as determined by loss on ignition. No lime or fertilizer were added, nor was any irrigation applied.

The following one-year liners were planted June 8, 1971:

Thuja occidentalis (globe)	*Forsythia intermedia*
Taxus cuspidata	*Rhododendron catawbiense*
Juniperus horizontalis	*Rhododendron (Azalea)* 'Hino Crimson'
Ligustrum obtusifolium var. *regelianum*	*Ilex crenata* 'Convexa'

Visual observations of the plants throughout the growing season showed average or better than average growth of all plants except *Thuja, Taxus cuspidata* and *Ilex crenata* 'Convexa', which performed very poorly.

None of the plants were harvested in order to evaluate winter damage; in particular, we wished to observe the amount of heaving damage the plants would undergo. As was expected, heaving damage was considerable on the shallow, fibrous-rooted plants. The deciduous plants and the *Juniperous horizontalis* wintered extremely well.

In June 1972, additional plots were planted. Again we used *Forsythia x intermedia, Ligustrum,* plus *Viburnum plicatum* var. *tomentosum* and *Euonymus alatus.* The plants were 1 year liners, cut back to 2 inches. At harvest in November, the forsythia numbered a minimum of 7 stems to a height of 30-36 inches, the privet numbered a minimum of 5 stems with a height of 30-36 inches, and the viburnum numbered a minimum of 4 stems with a height of 24-30 inches. All plants harvested were of saleable size.

It is our contention that the organic soils hold a considerable potential for growing certain genera of ornamental plants. The real potential may well lie in the production of bareroot deciduous shrubs where a 1 year liner can produce a saleable size plant in one growing season, be dug in fall either bareroot, or balled and burlapped, put into storage and be sold in late winter or early spring.

Of the evergreens, we evaluated juniper as being the most likely profitable crop of those tried. In two growing seasons, a 1 year liner can produce a 24 to 28 inch spread, compact, sheared *Juniperus horizontalis* 'Andorra'.

To date, our trials have consisted of a limited number of plants grown under the most adverse conditions. We think there is a potential even under such conditions. However, the potential should be even greater if good growing and management practices are incorporated.

In the future, we will be screening other plants and will incorporate good nursery practice in order to aid in the development of limited nursery production areas in the organic soils in our area.

JIM WELLS: I would like to ask about the rhododendrons; you indicated they did not do very well. I would have suspected they would have done very nicely on these soils. Would you please comment on this.

JAN JANSEN: The plants grew beautifully during the growing season, but primarily the problem was with the overwintering — there was considerable heaving. We put in some larger plants, 18-24 inches, and these suffered little overwintering damage, but the smaller ones heaved so badly that we just did not get much growth the second year.

RALPH SHUGERT: Thank you very much for the comments, Jan.

Our next speaker is certainly no stranger to us in the Eastern Region and he has made considerable contributions to the area of plant propagation and the growing of nursery plants. Dr. Sidney Waxman will discuss the effect of flowering on survival of 'Cornell Pink' rhododendron cuttings.

EFFECT OF FLOWERING ON SURVIVAL OF *RHODODENDRON MUCRONULATUM* 'CORNELL PINK'

SIDNEY WAXMAN

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Abstract. With most woody species, problems in propagating by cuttings lie in their ability to initiate roots. For some ornamental and forest species, however, the problem is that they have an extremely high rate of mortality after root initiation.

Mortality of rooted 'Cornell Pink' rhododendron cuttings is associated with anthesis. The greater the numbers of flowers blossoming on the cuttings, the greater the losses. Removal of the flower buds, at any time before blossoming, will enhance survival.

Cuttings taken early in the season had the lowest number of flower buds and, as a consequence, had the highest rate of survival. Eight-hour photoperiodic treatments inhibited flower bud initiation.

REVIEW OF LITERATURE

It is well known by propagators that when taking cuttings, one should avoid taking those having flower buds. The reason for this is that flower buds often have a depressing effect on root initiation (1, 5, 7).

For some species, especially those easy to root, the presence of flower buds does not appear to be a serious deterrent to rooting, while with other species, e. g. blueberry, the presence of flowers can mean the difference between success or failure (5, 6). With rhododendron the removal of the flower bud will greatly improve rooting over cuttings whose buds are not removed (1,2) while with blueberry, the initiation of a flower bud will be detrimental regardless as to whether it's removed or left intact (5,6).

The results of these experiments illustrate a somewhat different effect of flowering. In this instance, flowering does not affect rooting but it does determine whether the rooted cutting lives or dies.

The problem of overwintering rooted cuttings has been a serious one for a group of woody plants including: *Cornus florida, Acer saccharum, Acer palmatum,* certain species of rhododendron, and viburnum. Although most of these species can be propagated quite easily, they suffer high rates of mortality after rooting. For some species that are highly susceptible to winter injury, these problems can be solved by placing the dormant cuttings in heated coldframes or in cool greenhouses to protect them from freezing (3).

Another method of overcoming this problem is by the use of photo-periodic treatment. It has often been reported, especially for the deciduous azaleas, that survival can be assured by first encouraging new branch growth immediately after the cuttings have rooted and then overwintering them. This may be accomplished by subjecting them to long photoperiods (4, 8, 9, 10). Such treatment has proven to be most effective on cuttings taken early in the season from greenhouse-forced plants and then exposed to 16-24 hours of light daily.

The 'Cornell Pink' was used in this test because it fits within the category of plants that are difficult to propagate because they usually have low levels of survival after having been rooted.

The 'Cornell Pink' initiates roots easily; percentages between 80 and 100 are normally obtained. One of the problems of this plant is that its cuttings have the tendency to split while being overwintered. Splitting usually occurs during the first hard freeze.

One way to overwinter 'Cornell Pink' successfully is to illuminate it with incandescent light for 6 to 10 hr each night. Within approximately 5 weeks, the buds will become active and new shoots will be formed. Once the cuttings are forced into new growth, they may be handled in two ways: They may either be kept actively growing (under long photoperiods) throughout the entire winter and early spring; or they may be gradually hardened in late fall by turning out the lights and then overwintered in a heated frame or greenhouse where temperatures in the range of 35° to 45° F can be maintained. Although both of these methods have brought about a generally high rate of survival, they require a long period of time in the greenhouse and are, consequently, costly.

Another method of carrying them through the winter is to harden them off after rooting and overwinter them in a frame or greenhouse held at temperatures between 35° to 45° F. This method does not require the application of supplemental light and no additional leaf or stem tissue is produced. Cuttings handled this way survive the winter in excellent condition. However, periodic inspections of the cuttings in the heated frame found them living and healthy during January and February; flowering in March, but mostly dead by late April.

'Cornell Pink' normally develops foliage after flowering has taken place. In this test, however, the leaf buds did not expand and produce leaves, but remained dormant. With time the cuttings weakened and, as their food reserves dwindled, they died.

An experiment was carried out to determine the relationship between flowering and mortality, and incidental to this, to determine if the photoperiod and/or date the cuttings are taken has an influence on flower-bud initiation.

MATERIAL AND METHODS

On five different dates, 270 terminal cuttings taken from large field-grown 'Cornell Pink' rhododendrons were treated with Hormodin No. 3 plus Captan, and placed into three flats containing a 1:1 mixture of peat moss and perlite. Each flat containing 90 cuttings, was placed under a mist system and subjected to a long, short, or normal photoperiod. The normal-day group received normal daylight whereas the short-day and long-day groups received, each day, sunlight for 8 hr and were then shielded from the sun with a black cloth for the remaining 16 hr. During the 16 hr period, the long-day group was illuminated with low intensity incandescent light to extend the daylength to 24 hr.

The cuttings within each flat were divided into three groups. In the first group, the apical portions (where the flower buds originate) were pinched off on the day the cuttings were taken. In the second group, the apices were pinched on January 30th. At this time, all flower buds were fully developed but dormant. The flower buds of the third group were left intact and were permitted to blossom.

The percentage rooting was determined 90 days after each group of cuttings was taken. The percentage survival, based on the number of rooted cuttings, was determined several weeks after blossoming.

RESULTS

Rooting. In all daylengths combined, rooting percentages were somewhat higher on the cuttings that were initially pinched than those whose flower buds were left intact. Eighty-four percent rooting occurred on the pinched cuttings and 77% on the cuttings that were not pinched. The presence of flower buds is, apparently, not as detrimental to the rooting of *Rhododendron mucronulatum* cuttings as it is to the rooting of those other species (5, 6, 7).

Flowering and survival. The data presented in Figs. 1, 2, 3, 4 are representative of the groups of cuttings whose flower buds, where present, were left intact and permitted to blossom. The percentage survival was highest for those cuttings taken June 19 regardless of which photoperiodic treatment they were subjected to (Fig. 1). Survival of cuttings which were taken only 1 week later dropped to 36% (long-days) and to 35% (normal-days), while those exposed to short-days remained at a high level of 84%. For each succeeding date the percent survival decreased in the long-day and normal-day groups but remained high (except for the last date) in the short-day group (Fig. 1).

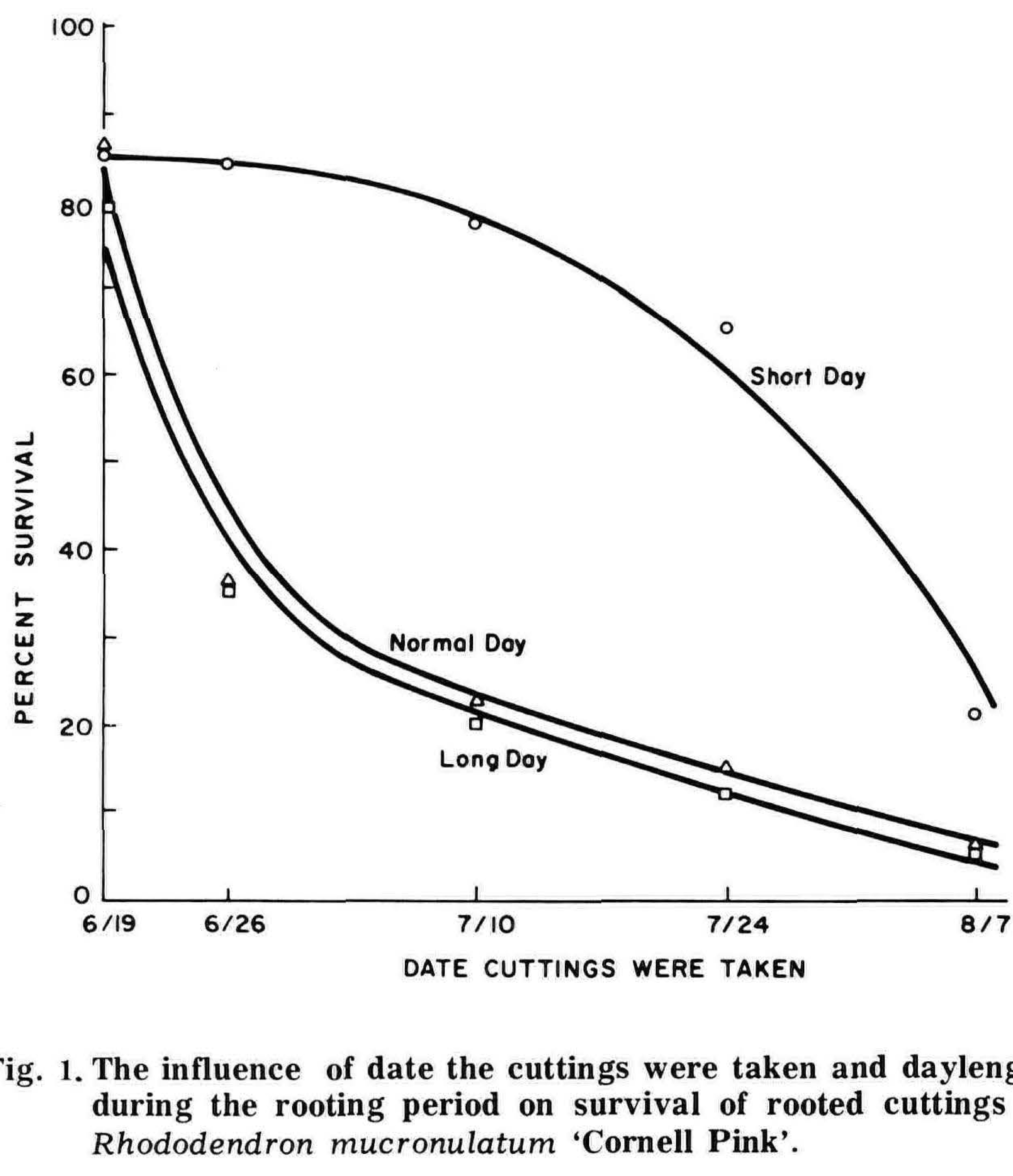

Fig. 1. The influence of date the cuttings were taken and daylength during the rooting period on survival of rooted cuttings of *Rhododendron mucronulatum* **'Cornell Pink'.**

Figures 2, 3, and 4 illustrate the extent of flower-bud development as a function of both date and photoperiod, as well as the percentage survival of rooted cuttings relative to the quantity of flower buds present. The number of flower buds initiated was lowest on the earliest date the cuttings were taken. With each succeeding date the average number increased to a maximum of approximately four flower buds per cutting.

Fewer flower buds were initiated in the short-day treatment than in either the long or normal-day treatments. This response was most pronounced in those groups taken on the first three dates (Figs. 2, 3, 4).

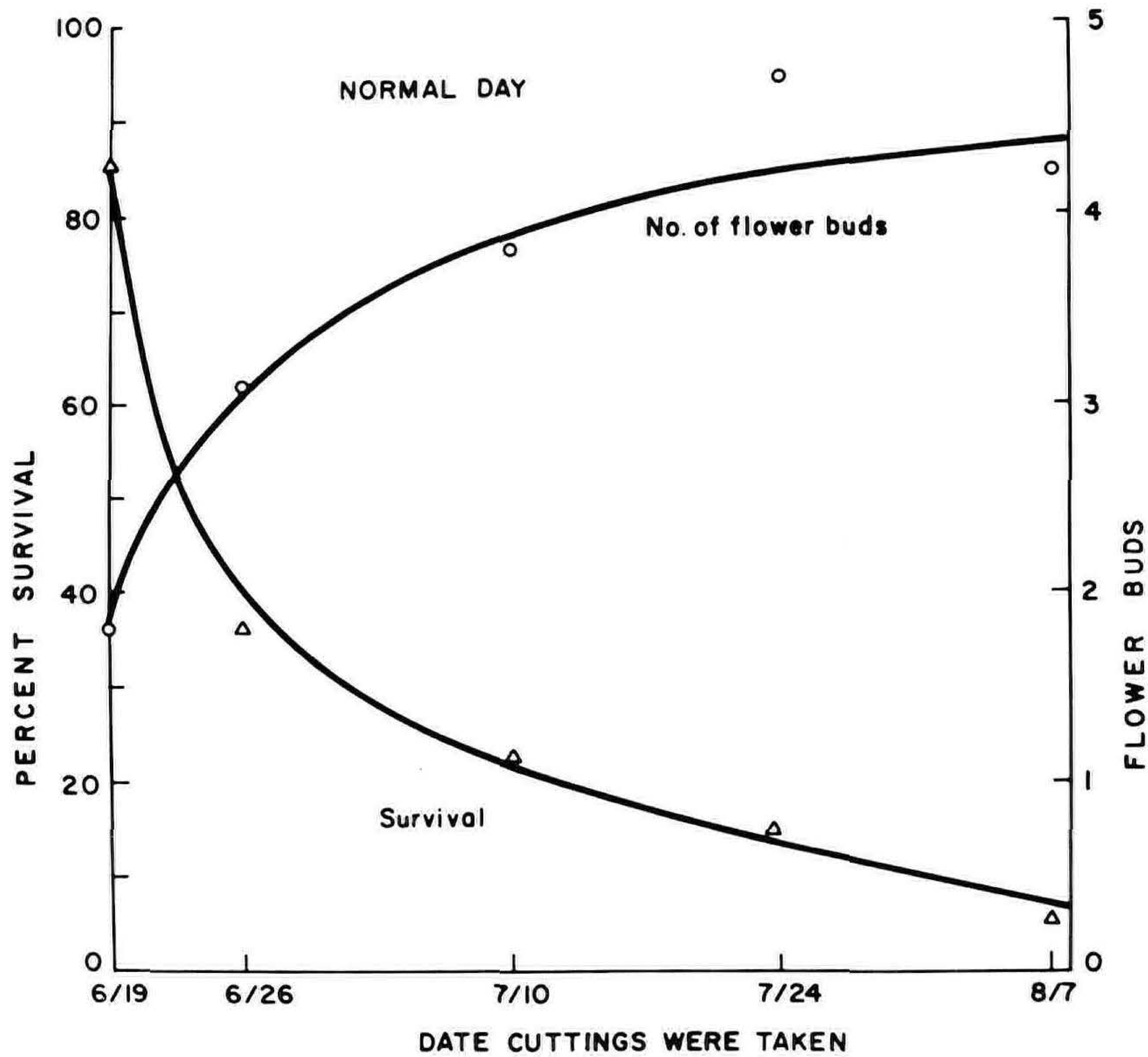

Fig. 2. The relationship between flowering and survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to normal photoperiods during root initiation.

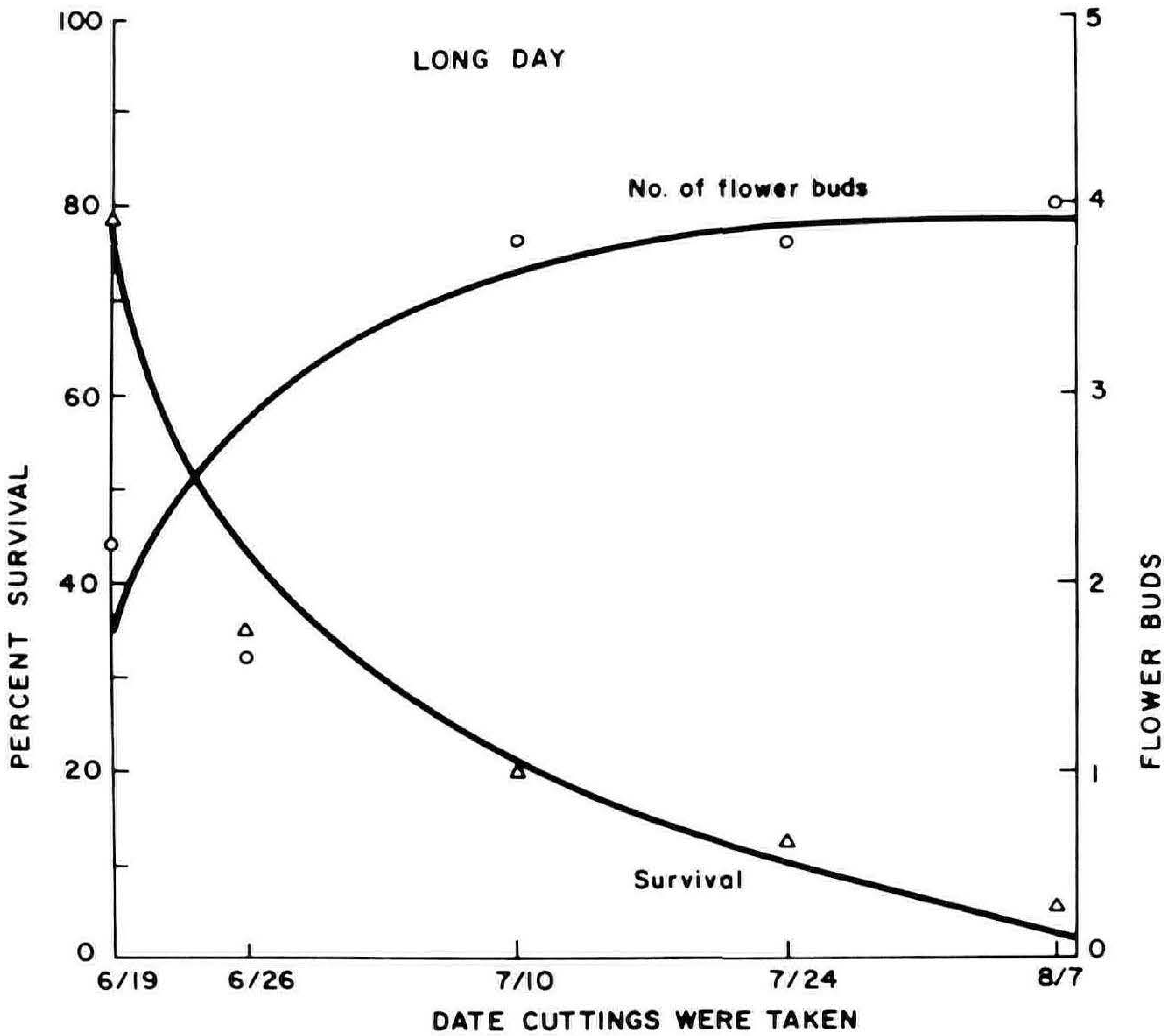

Fig. 3. The relationship between flowering and survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to long photoperiods during root initiation.

Survival was negatively correlated with flowering. With the increase in the number of flower buds per cutting, there was a corresponding decrease in the percent surviving.

Removal of flower buds resulted in an increase in the percentage surviving over those cuttings whose flower buds were left intact and permitted to bloom (Figs. 5, 6, 7).

DISCUSSION

Survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink' is apparently contingent upon the number of flowers that develop on them. With the increase in the number of flowers blossoming, there is a decrease in the chances for survival.

The normal sequence of growth of 'Cornell Pink' as it emerges from dormancy is to blossom first and then develop shoots and

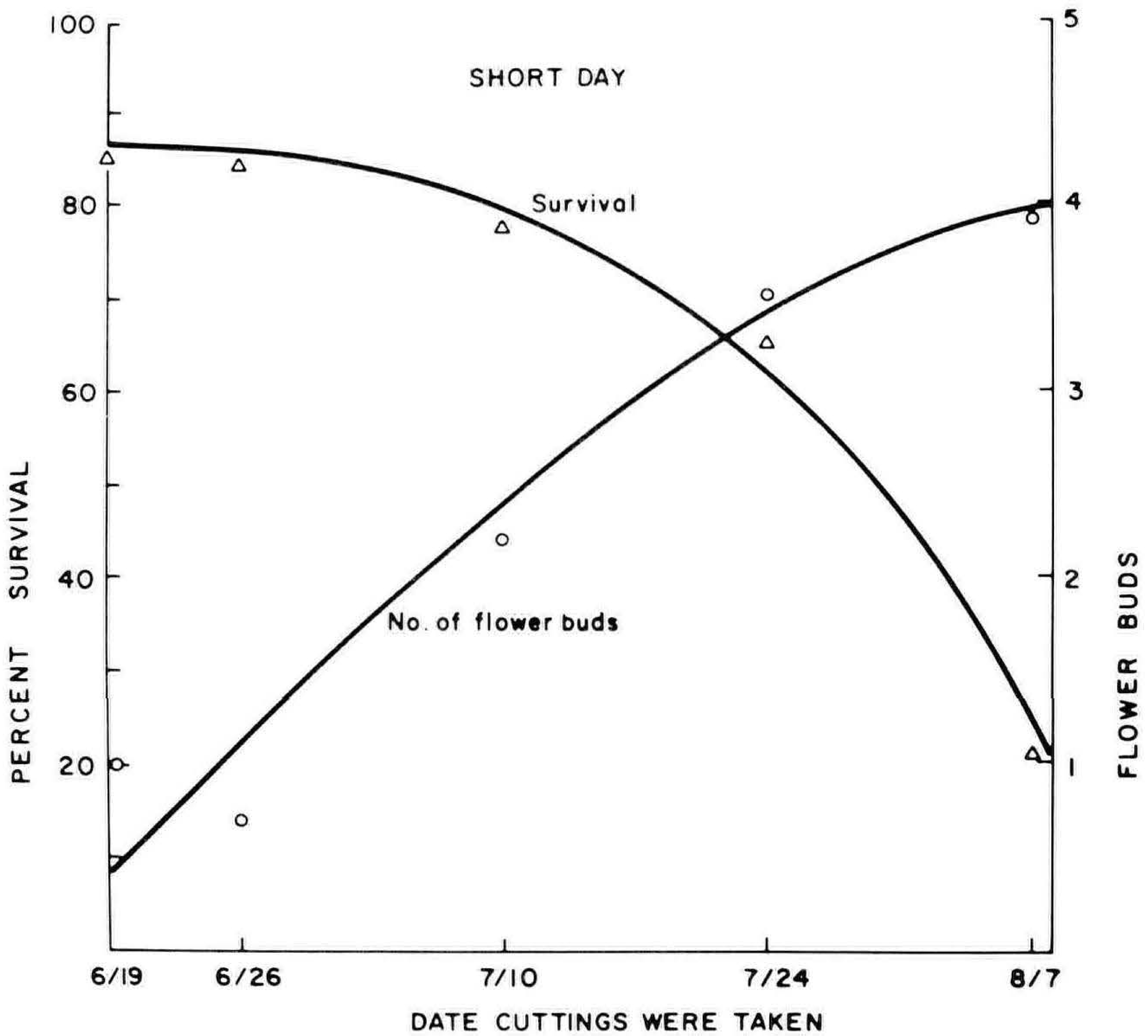

Fig. 4. The relationship between flowering and survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to short photoperiods during root initiation.

leaves. With rooted cuttings, only blossoming takes place; the vegetative buds remain dormant or, if able to expand, produce weak tissue which soon collapses. As a consequence, the cuttings, lacking foliage, are deprived of a source of energy that photosynthesis would have provided and subsequently die.

The threshold number of flower buds that determines whether or not the cutting will survive is three. The overall survival of those groups having an average of three or more flower buds per cutting was 25%, while those having less than three had 73% survival.

The first group of cuttings taken June 19 had the lowest number of flower buds and a high level of survival. With each succeeding date the cuttings were taken, the number of flower buds that developed on them increased and their chances for survival decreased.

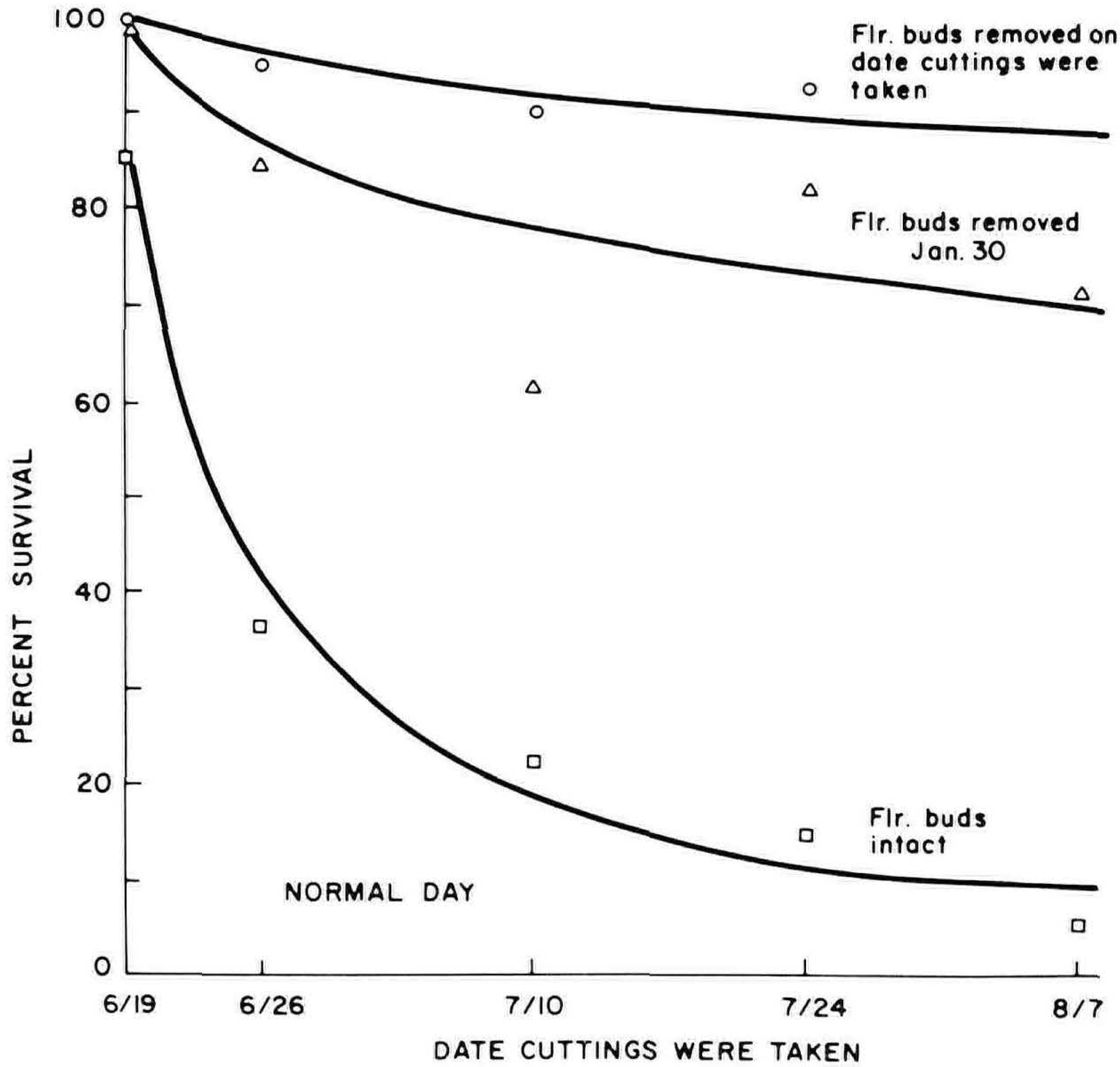

Fig. 5 The effect of the removal of flower buds on the survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to normal photoperiods during root initiation.

'Cornell Pink' rhododendron is apparently a "long day plant" insofar as its requirement for flower-bud development is concerned.

Exposure to short photoperiods apparently inhibited flower-bud development during its early stages. Exposure to long or normal photoperiods resulted in cuttings having twice as many buds as the short day-treated cuttings. The flower buds on cuttings taken as late as July 24 and August 7 were already well developed and were not influenced by short photoperiods.

Prevention of blossoming by the removal of the flower buds resulted in a high level of survival regardless of the photoperiodic treatment. This response substantiates the concept that the high levels of mortality that occur among rooted cuttings of 'Cornell Pink' rhododendrons are associated with flowering.

Elimination of the flower buds before flowering is equivalent to

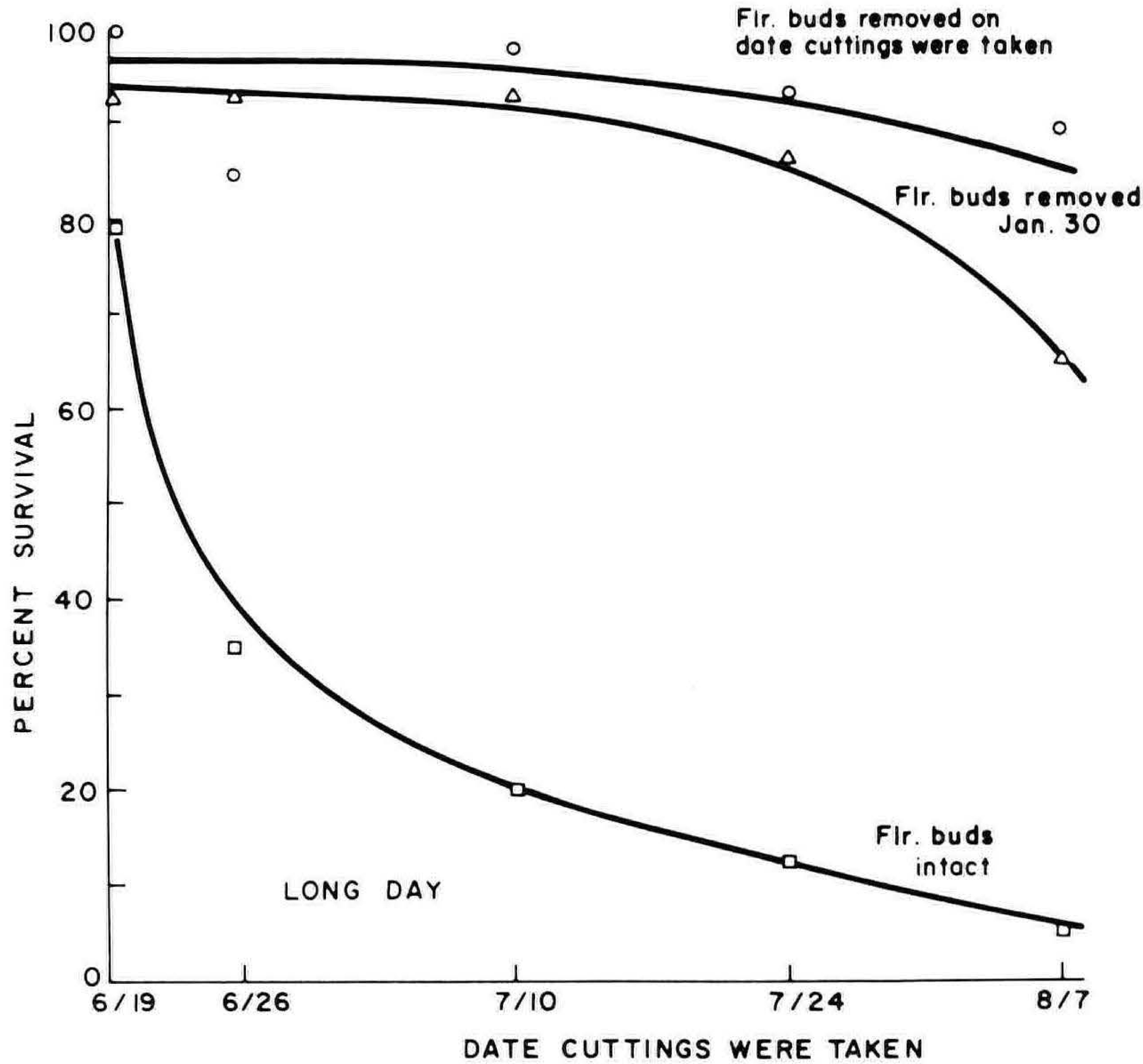

Fig. 6 **The effect of the removal of flower buds on the survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to long photoperiods during root initiation.**

the elimination of the factor(s) that prevent vegetative bud expansion and growth.

The factor(s) appears to be quantitative with a minimum of three flowers preventing leaf-bud growth.

CONCLUSIONS

The generally low survival rate of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink' is associated with flowering.

The factor(s) associated with blossoming is quantitive.

Vegetative bud expansion and leaf growth is unable to take place if three or more flower buds are permitted to blossom.

Flower bud development appears to have a long-day requirement.

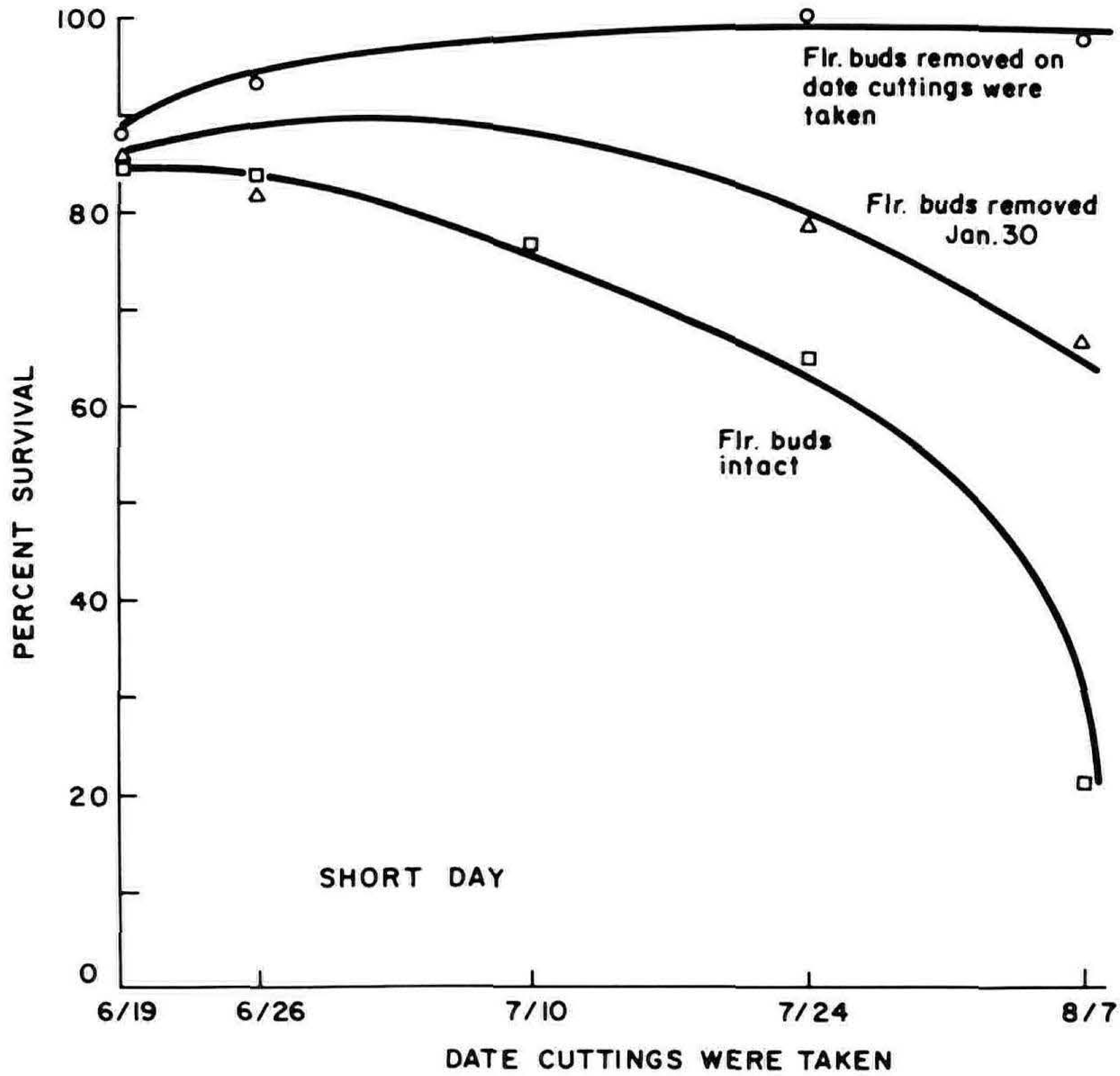

Fig. 7. The effect of the removal of flower buds on the survival of rooted cuttings of *Rhododendron mucronulatum* 'Cornell Pink'. The cuttings were subjected to short photoperiods during root initiation.

Relatively high rates of survival are attainable by:

1. Taking cuttings early in the spring before the flower buds are well developed.

2. Subjecting the cuttings to short photoperiods before the flower buds are fully developed.

3. Removal of the flower buds.

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JIM WELLS: Sid, I want to support entirely what you said. For years it has been our practice to take the terminal buds out of the cuttings of deciduous azaleas even though the cuttings are "butter-soft" when we take them. We find that this has a great effect upon the rooting and the subsequent development of the plant. Our cuttings are taken early in May, rooted by the first of July and immediately placed under supplemental light. We find it essential that there be no terminal bud because if it is left in they tend to form a flower bud right in the bench before they are moved and that is death. So I think it applies to a number of other plants in addition to 'Cornell Pink.

LES HANCOCK: I would also like to comment that I had trouble with *Rhododendron carolinianum* but I found that if you go over the parent plant a month before taking the cuttings and remove the terminal buds they rooted a lot better.

CASE HOOGENDOORN: Sid, do you apply lights to the cuttings when you stick them, or do you wait until after they are rooted?

SID WAXMAN: I have done both. It depends on which ones you are working with. Some are very slow to respond.

CASE HOOGENDOORN: I have found that the proper time to take cuttings of *Rhododendrons* such as 'Cornell Pink', is just when the first flush of growth is terminated. If the cuttings are taken then, they do very well.

SID WAXMAN: I have taken cuttings on up through August but I agree there are some varieties that are best taken just when the first flush of growth is terminated.

RALPH SHUGERT: Our next paper involves the vegetative propagation of sugar maple from cuttings. This paper is by John Donnelly and Harry Yawney.

SOME FACTORS ASSOCIATED WITH VEGETATIVELY PROPAGATING SUGAR MAPLE BY STEM CUTTINGS

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The Northeastern Forest Experiment Station project at Burlington, Vermont has, for several years, investigated methods of vegetatively propagating sugar maple (*Acer saccharum* Marsh.). These studies have been designed to produce a workable procedure for allowing propagators to vegetatively reproduce mature trees selected on the basis of high xylem sap sugar content. Although vegetative propagation of these "sweet trees" may offer obvious advantages to producers attempting to establish high-yielding sugar bushes, this species is quite difficult to reproduce asexually.

This report summarizes some of our findings and points out areas in which information is still lacking. The paper is divided into three major parts: 1) factors associated with development of adventitious roots; 2) methods of overwintering rooted cuttings; and 3) current propagation procedures.

FACTORS ASSOCIATED WITH DEVELOPMENT OF ADVENTITIOUS ROOTS

Seasonal changes in rooting response. Many species exhibit marked seasonal changes in ease of vegetative propagation (14). For some species, adventitious roots readily form on dormant, hardwood cuttings (11, 17, 19, 24, 26), whereas others must be propagated during the period of active growth (14). Rooting dormant cuttings offers distinct advantages; not only do they require less maintenance in the rooting bed, but also adventitious root formation during the winter allows the rooted plants to develop for a complete growing season before becoming dormant. This should improve subsequent vigor and survival of rooted material (16).

In an attempt to root hardwood sugar maple cuttings, we collected 60 cuttings at monthly intervals from each of six trees during the period mid-November through mid-March. At each collection date, half of the cuttings were immediately lined out in a heated greenhouse. The other half were stratified in moist sphagnum for 2 months at approximately 34° F and then inserted into the rooting medium. Although several broke bud, none of the 1800 dormant cuttings collected throughout the winter developed adventitious roots. Hartmann and Brooks (13) and Knight (15) reported similar results with cherry. Koelling (16) collected from 6 sugar maple trees at 2-week intervals during the period early February through mid-July. None of the dormant cuttings rooted, but almost 50% of the new shoots collected in early June developed adventitious roots.

In an attempt to correlate rooting response of softwood cuttings with phenological and physiological characteristics of the developing shoots, we collected 30 cuttings twice a week from each of four trees during the period June 2 to July 30 (5). The starting date was approximately 2 weeks after bud break. Twenty cuttings were lined out in rooting beds in the greenhouse after we had recorded their length and diameter. The 10 remaining from each collection were analyzed for starch, sugar, and nitrogen concentration. Average rooting response for the four trees increased from 16% on June 2 to 85% on June 23, and then decreased for later collections (Fig. 1).

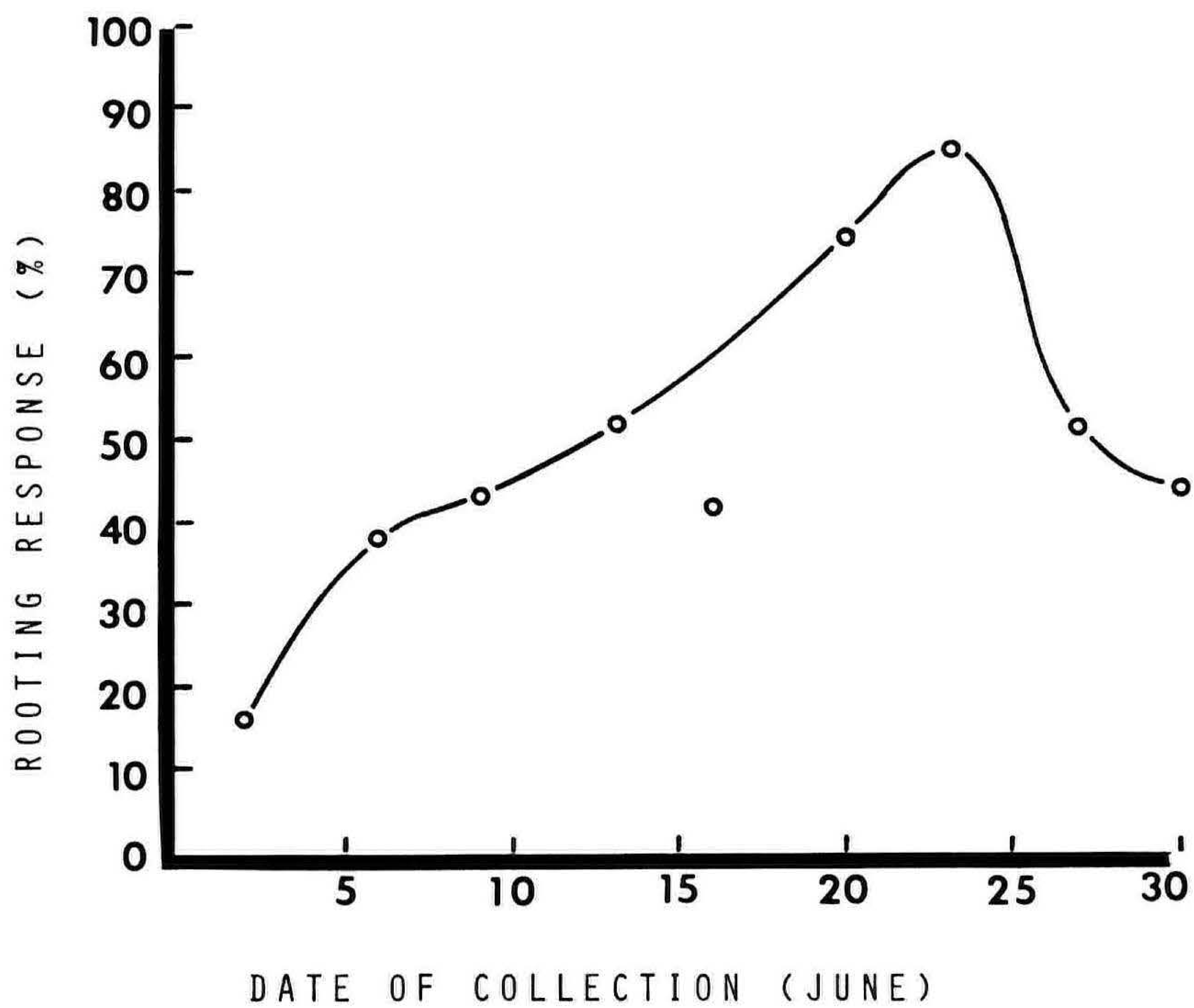

Fig. 1. Seasonal changes in average rooting of softwood cuttings from four mature sugar maple trees. From Donnelly (5).

The phenological characteristic of developing shoots most noticeably associated with rooting potential was the color of the developing shoot's terminal leaves. When a new flush of growth is produced each year, leaves at the shoot's base mature earlier than do those at the shoot tip. The date on which tip leaves appear mature in size and color coincides, approximately, with the date of maximum rooting potential. At this time, the shoot's stem is still green, and a new terminal bud has formed. This bud is approximately 0.1 inch long, and appears to consist of two dark brown scales.

The shoot's nitrogen and carbohydrate concentrations changed significantly during June. During the first half of the month, nitrogen and alcohol-soluble sugar concentrations decreased and starch concentration increased. During the latter half of the month, starch decreased slightly. Rooting potential increased while sugar and nitrogen were decreasing, but decreased approximately 1 week after these concentrations stabilized. We do not know if a direct cause and effect relationship exists between these observed chemical changes, and the shoot's potential for developing adventitious roots.

Effect of shoot size. — There are, of course, tremendous variations in the length and diameter of shoots on individual trees. For many species, large cuttings generally root better than do small ones (2, 20, 21, 25), and this relationship appears to hold for sugar maple (6, 18). We collected 300 cuttings from each of three trees, recorded their length and diameter, and lined them out in rooting beds (6). Cuttings from one tree rooted poorly regardless of size (only 1% rooted); for the other two trees, rooting response increaed substantially with increasing shoot length (Fig. 2). Also, for one tree, thick cuttings tended to root better than did thin ones. Therefore, it is recommended that propagators select sugar maple cuttings which are as long and as thick as possible. These recommendations, based on cuttings collected from mature trees, may not hold for juvenile material collected from younger plants. Morsink (18) reported that cuttings 35 to 55 cm rooted better than did longer ones.

Age of parent tree. For most species, age of the stock plant significantly affects rooting response (14). This is probably true for sugar maple also, but we have not tested the relationship because we have been primarily concerned with developing methods for vegetatively propagating mature trees. However, there are several recommended methods for stimulating juvenile wood formation on mature plants (14) and some of these should be tested on sugar maple in subsequent studies.

Genetic variability. Genetic variation in rooting response has been reported for several species including maple (3, 12, 23). We also have observed clonal variation in our recent studies. In our study to test the effect of shoot size on rooting response (6) we collected cuttings from three trees. All cuttings were treated alike, but the response varied from 1% to 61%. Two of these trees were growing on similar sites and within 100 yards of each other. However, only 19% of the cuttings rooted from one tree whereas 61% rooted from the other.

In the study in which we collected cuttings twice a week to test the effect of date of collection (5), there was relatively little difference between the 4 individual trees in peak response (70, 90, 90 and 100%). But cuttings from one tree rooted well over a period of 2 weeks whereas those from other trees only rooted well at one collection period (Fig. 3). Therefore, average response (average for all collection periods) ranged from 25% for one tree to 85% for another. These differences in the length of time plants retain their potential for developing adventitious roots may explain some of the tremendous clonal variability propagators have frequently observed when attempting to vegetatively reproduce selected plants.

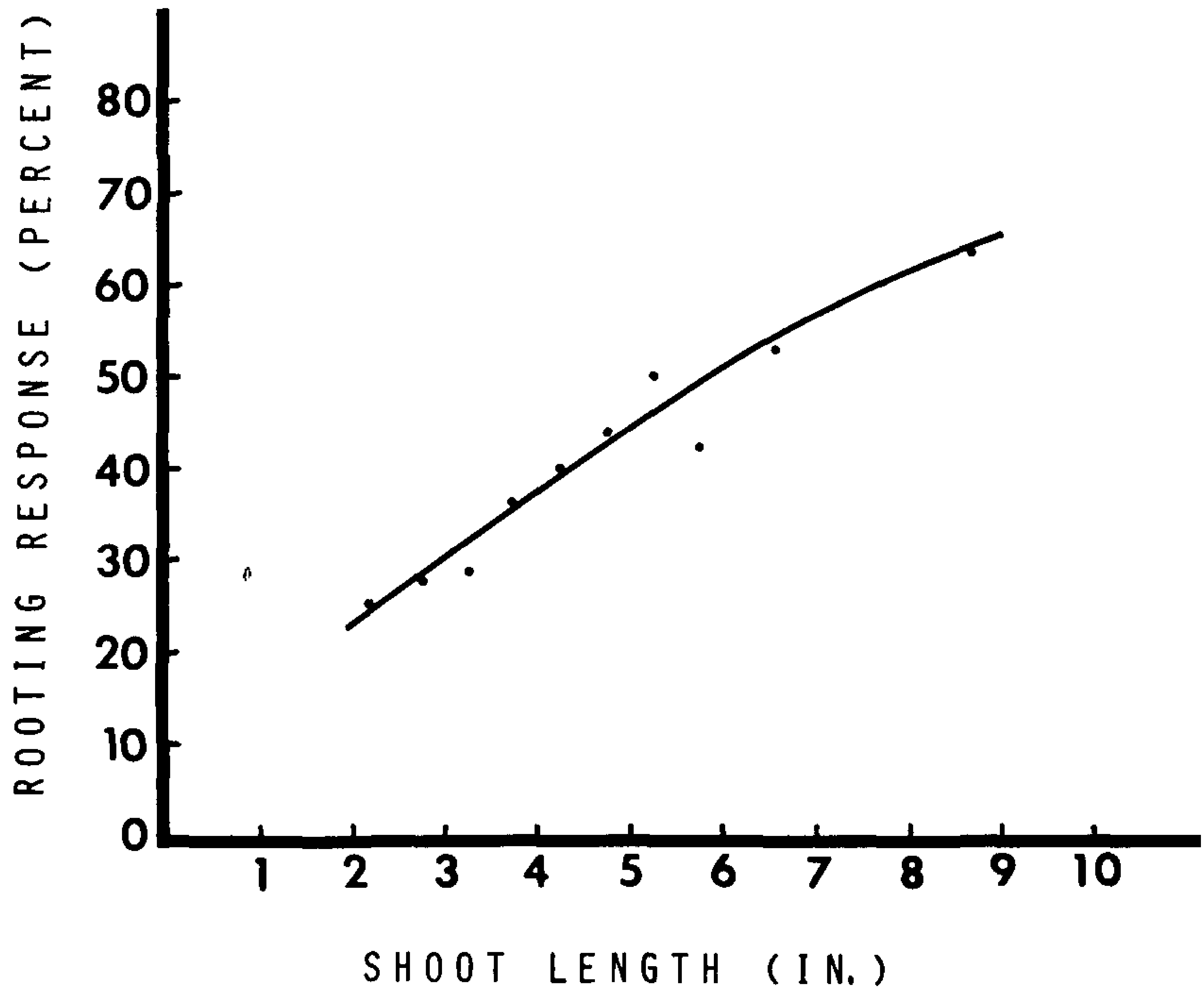

Fig. 2. Relationship between shoot length and rooting response of softwood cuttings from two sugar maple trees. From Donnelly (6).

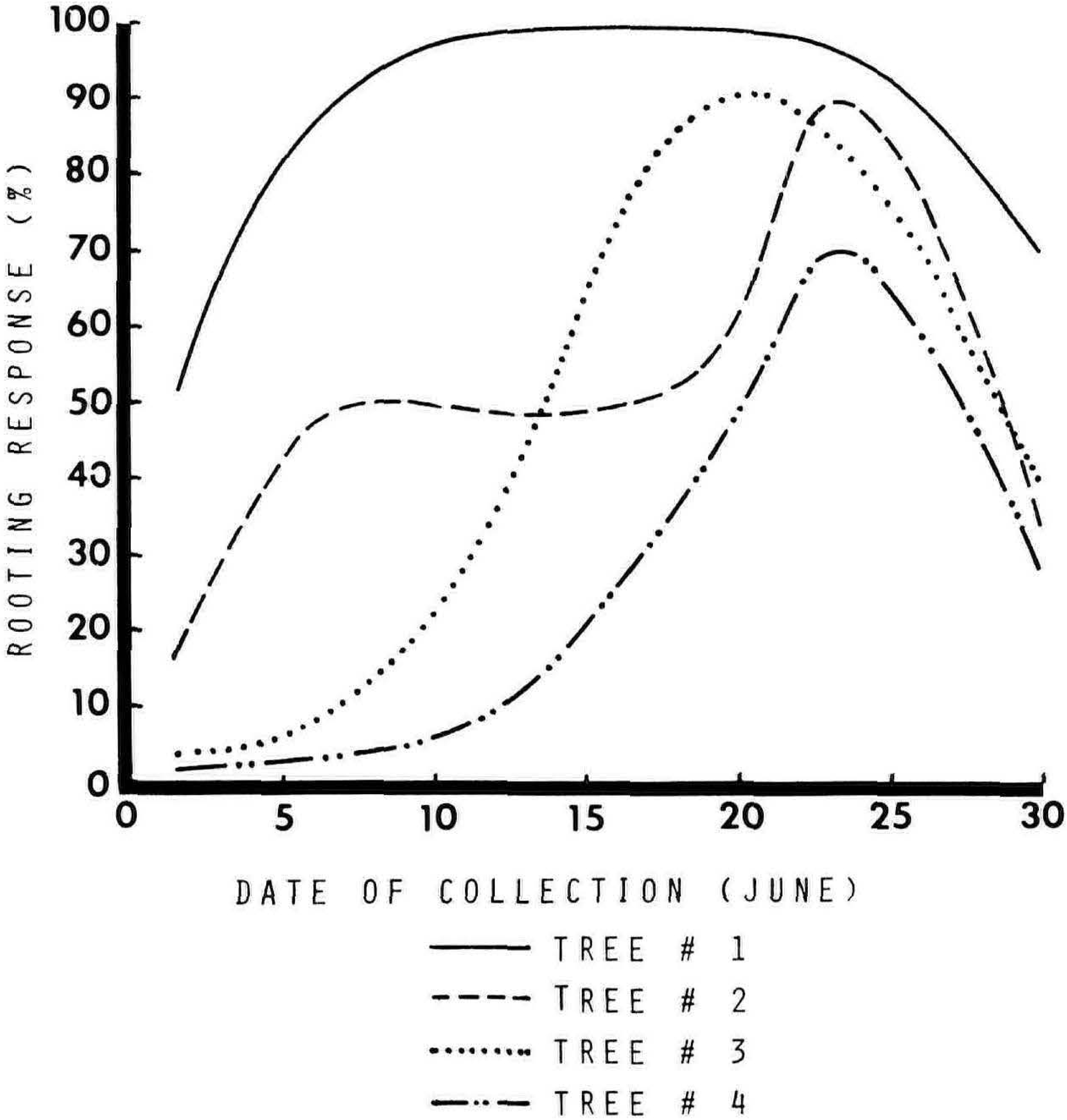

Fig. 3. Individual tree differences in the relationship between date of collection and rooting response of sugar maple cuttings. From Donnelly (5).

Effect of hormone concentration. It is generally recommended that stem cuttings be treated with some type of rooting hormone to stimulate adventitious root formation (14). We, therefore, tested the effect of several types and concentrations of hormones (4). Those tested were Hormodin No. 3, Jiffy Grow, Jiffy Grow diluted 1:1 with distilled water, diluted Jiffy Grow plus Hormodin No. 3, 0.5% IBA (indolebutyric acid) powder, 1.0% IBA powder, 2.0% IBA powder, 4.0% IBA powder, and distilled water (control). Twenty cuttings from each of three trees received each hormone treatment. When data from the three trees were lumped together and compared with controls, it appeared that undiluted Jiffy Grow and 0.5% IBA stimulated rooting; 1.0% IBA, 2.0 % IBA, diluted Jiffy Grow, and Hormodin No. 3 had no effect; and 4.0% IBA and the combination of

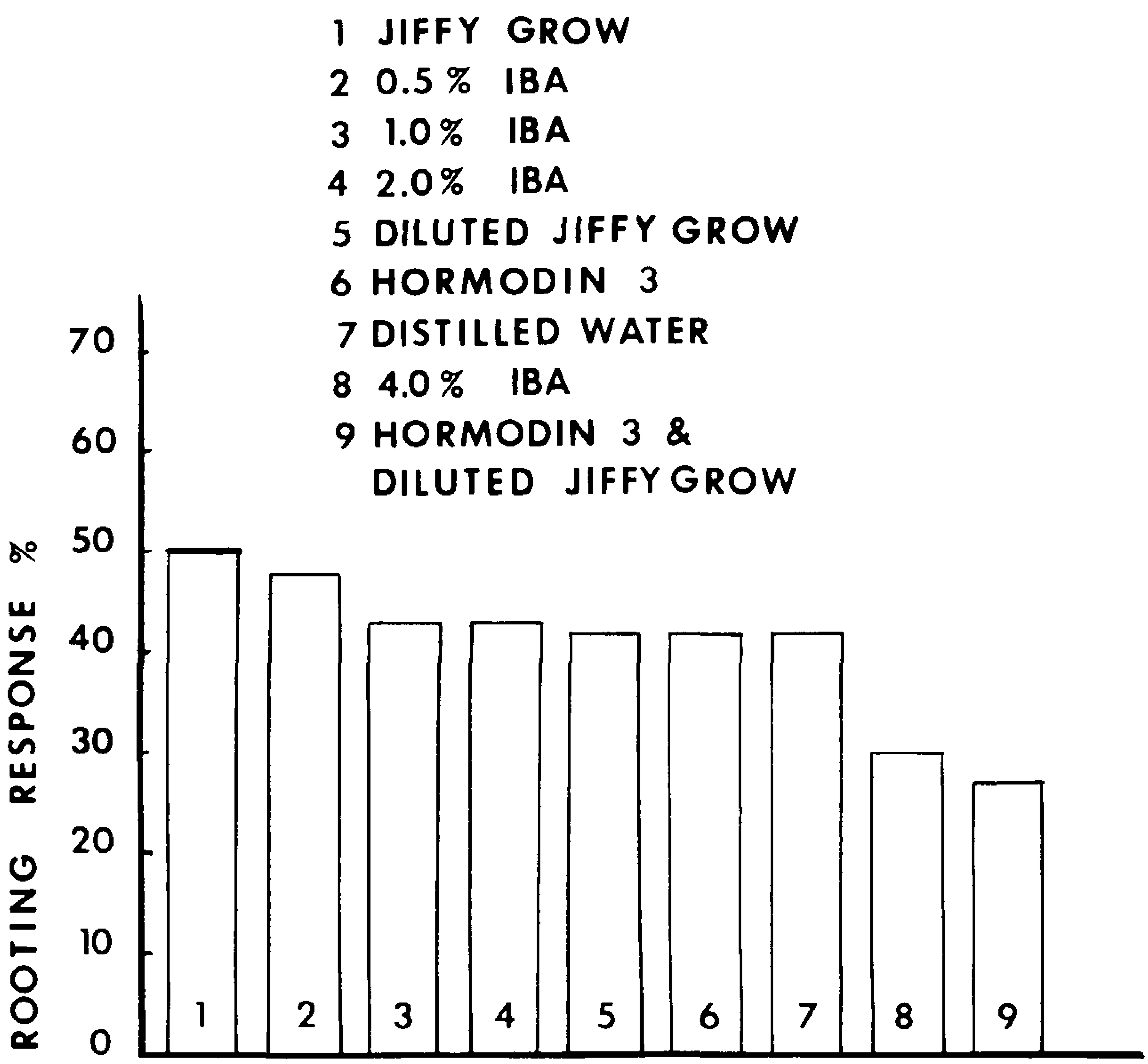

Fig. 4. Effects of different hormone treatments on rooting softwood cuttings from three mature sugar maple trees. From Donnelly (4).

Hormodin No. 3 plus diluted Jiffy Grow were inhibitory (Fig. 4). These differences, however, were not statistically significant because of the tremendous clonal variation in response. This became apparent when we compared individual tree response with various concentrations of IBA powder (Fig. 5). Cuttings from one tree rooted well (60%) without added hormones; hormones at any concentration retarded rooting. Cuttings from another tree also rooted well without hormones (60%); low hormone concentration stimulated further rooting, but high concentrations were inhibitory. The response curve for the third tree was similar to that from the second except that cuttings from this tree rooted very poorly (5%) in the absence of applied hormones.

The reason for these different responses to applied growth hormones is unknown, but it is hypothesized that they may be due to corresponding differences in endogenous auxin concentrations within the three study trees. Possibly, if auxin concentrations are low, applied hormones stimulated rooting; but if cuttings possess high concentrations of endogenous auxins, additional amounts might be toxic and inhibit rooting. The possiblility of genetic differences in the response of cuttings to applied hormones has been reported for other species (1, 7) and may have important implications in developing a program for vegetatively propagating selected hard-to-root trees.

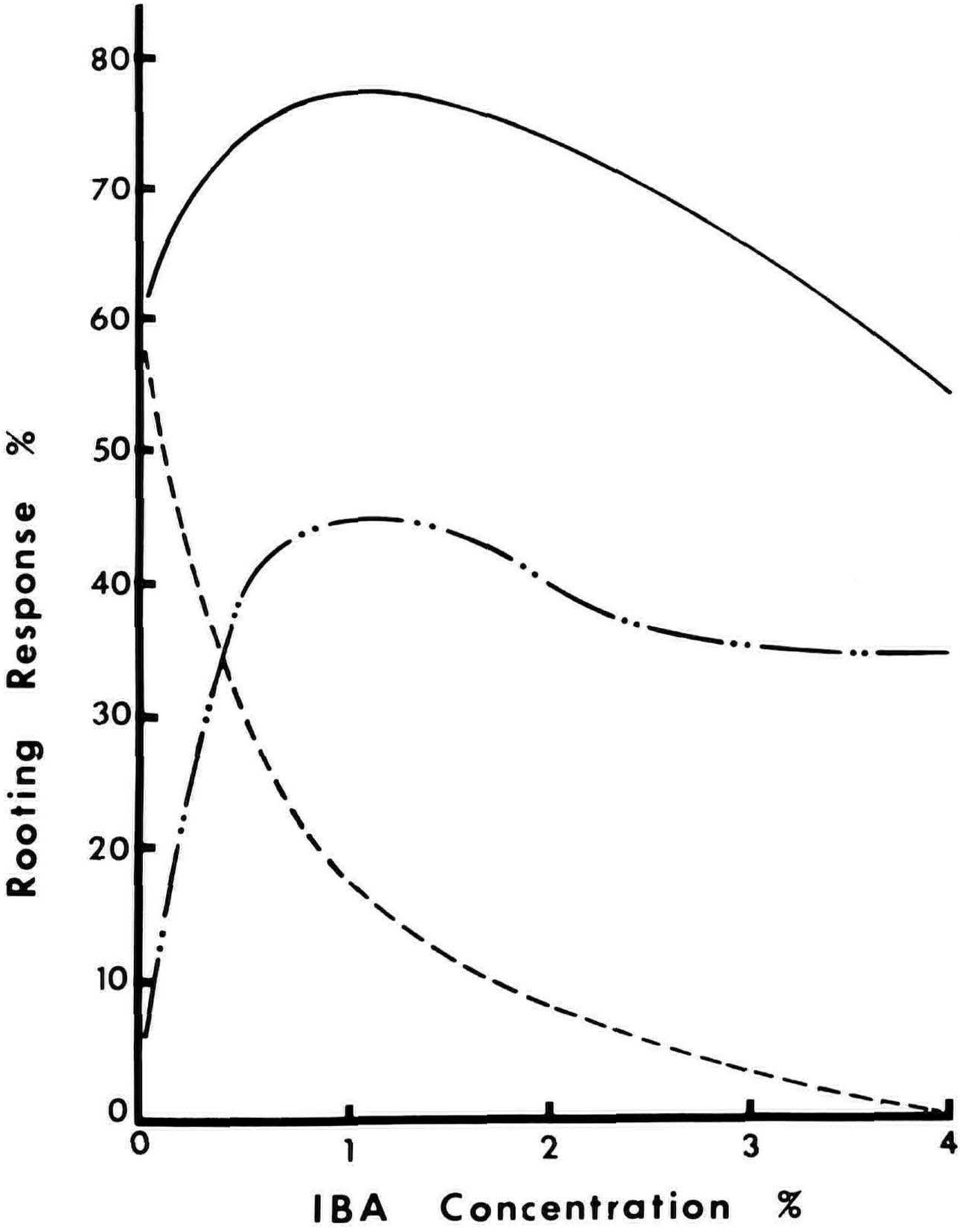

Fig. 5 Individual tree differences in the response of cuttings to various concentrations of IBA. Each line represents cuttings from a different tree. From Donnelly (4).

The significant clonal variability in rooting response observed in maple and other species may be due, at least in part, to different responses to applied hormones.

METHODS OF OVERWINTERING ROOTED CUTTINGS

Researchers have for several years been at least moderately successful in obtaining adventitious root development on sugar maple cuttings. However, most of these have failed to overwinter successfully (9, 10, 12). Therefore, in formulating a program for propagating sugar maple trees, refined methods for developing roots on selected cuttings has been only one of our objectives; a more formidable task has been to develop a method for successfully overwintering and establishing the rooted material. In attempts to improve overwintering survival, we have investigated the effects of "dormant feeding", root disturbance, and methods of storage.

Effect of dormant feeding. In late fall, rooted cuttings from four trees were watered with one of the following solutions: a) complete nutrient solution (half strength Hoagland solution); b) 2% sugar solution; c) nutrient plus sugar solution; d) distilled water (control). The solutions were added just before potted cuttings were transferred to a walk-in cooler in mid-November and stored at approximately 34° F for 2 months. At the end of this storage period, cuttings were removed from the cooler and placed in a heated greenhouse. Only 23 of the 292 rooted cuttings overwintered successfully and none of the treatments significantly stimulated survival.

Effect of overwintering storage method. In order to test the effect overwintering storage has on survival, 468 rooted cuttings were randomly assigned to one of the following treatments: 1) cuttings outplanted into the nursery in the fall; 2) cuttings potted in the fall, stored in a walk-in cooler at approximately 34° F, transferred to a heated greenhouse in March, and lined out in the nursery in June; 3) cuttings potted in the fall, stored in the walk-in cooler until May and then lined out in the nursery in June; 4) cuttings potted in the fall, stored in a root cellar, transferred to the greenhouse in March, and lined out in the nursery in June, 5) cuttings stored, unpotted, in the root cellar with roots "healed" into sand; cuttings potted and transferred to greenhouse in March and outplanted in June; 6) cuttings stored, unpotted in the root cellar, completely enclosed in polyethylene; cuttings potted and transferred to the greenhouse in March and outplanted in June; 7) same as treatment 6 except cuttings stored in the walk-in cooler rather than the root cellar. None of the cuttings outplanted directly into the nursery in the fall overwintered successfully (Table 1). For the other treatments, survival[1] varied from 32% (treatment 6) to 48%

[1]We assumed that cuttings survived overwintering storage if they were alive on August 1 of the year during which they were outplanted.

Table 1. Overwintering survival of rooted sugar maple cuttings — by overwintering treatment[1].

Treatment (see text)	Overwintering Survival Percent
1	0
2	48
3	48
4	43
5	38
6	32
7	37

[1]Approximately 65 rooted cuttings per treatment.

(treatments 2 and 3). The complete lack of survival for cuttings directly outplanted in the fall was somewhat surprising. In a preliminary study 14% of the outplanted cuttings survived and many grew quite well in the following summer.

Effect of root disturbance. We thought that lack of overwintering success might be due to excessive root disturbance when cuttings are lifted from the rooting bed. Although we generally space cuttings at intervals of at least 6 inches in the rooting bed, roots from adjacent plants may become intertwined and subsequently broken when the plants are lifted. We, therefore, tested to see if overwintering survival was increased by rooting the cuttings in individual containers. We collected 216 cuttings from each of four mature trees. One-third of these (treatment A) were lined out in rooting beds at 7- by 6-inch spacing. The remaining cuttings (treatments B and C) were rooted in individual 6-inch plastic pots filled with rooting medium. In late summer rooted cuttings from treatment A were lifted from the rooting bed and potted in 6-inch pots. Those in treatment B were repotted (rooting medium exchanged for potting soil), and those from treatment C remained in the rooting pots. All rooted cuttings were gradually hardened off and transferred to a walk-in cooler where they were stored for approximately 5 months at 34° F. Plants were lined out in the nursery in early May. Thirty percent of all cuttings rooted and were successfully overwintered (Table 2). Treatment differences were not statistically significant, but success was somewhat higher for cuttings repotted in the fall (treatment A and B). Thus, root disturbance due to lifting and repotting does not appear to be an important cause of overwintering mortality.

We might now point out some possible reasons for the high overwintering mortality of rooted sugar maple cuttings. We have long felt that mortality is due to the low vitality of cuttings when they enter fall dormancy (12). Observations have tended to sub-

Table 2. Percent of sugar maple cuttings which develop adventitious roots and overwinter successfully — by treatment of cuttings in the rooting beds[1].

Treatment (see text)	Establishment percent
A	34
B	32
C	24

[1]288 cuttings per treatment.

stantiate this hypotheses. In the "dormant feeding" study we analyzed a sample of the rooted cuttings for their fall concentration of carbohydrates and compared these data with those obtained form 1-year-old maple seedlings. The total carbohydrate concentration was over 20% dry weight for seedlings, but less that 10% for rooted cuttings. These low carbohydrate reserves may have been insufficient to support spring growth (12). This may partially explain why over 60% of the plants resumed growth after winter storage (bud swell was evident), but only 8% remained alive in early May.

Assuming low vigor (as reflected by corresponding low levels of carbohydrate reserves) is a major cause of overwintering mortality, we might investigate reasons for this lack of vigor. Vigor appears to be related to inherent conditions present within the shoot when it was severed from the parent tree, and is also, undoubtedly, affected by the propagation techniques (environmental conditions) employed after the shoot has been collected. We pointed out that certain cuttings (those of a given size or those from a particular tree) have a high potential for developing adventitious roots. These cuttings also seem to have a high potential for overwintering successfully. We collected cuttings from eight trees and found rooting response to vary from less than 10% to more than 90%. Only about 18% of the rooted cuttings form the "poor rooters" overwintered successfully, whereas 65% of those from the "best rooter" became established (Fig. 6). In other words, less than 2% of all cuttings collected from "poor rooters" became established in contrast to nearly 60% from the "best rooter." Similar results were observed in another study in which cuttings were obtained from four trees. Rooting percentage for one tree was substantially lower than that for the others, and the percent of rooted cuttings from this tree which successfully overwintered, as well as the average shoot growth and vigor[2] of established plants was much lower (Fig. 7). We have observed a

[2]Relative vigor based on subjective evaluation of 1 point for cuttings in "poor" condition, 2 points for those in "fair" condition, 3 points for those in "good" condition and 4 points for those in excellent condition.

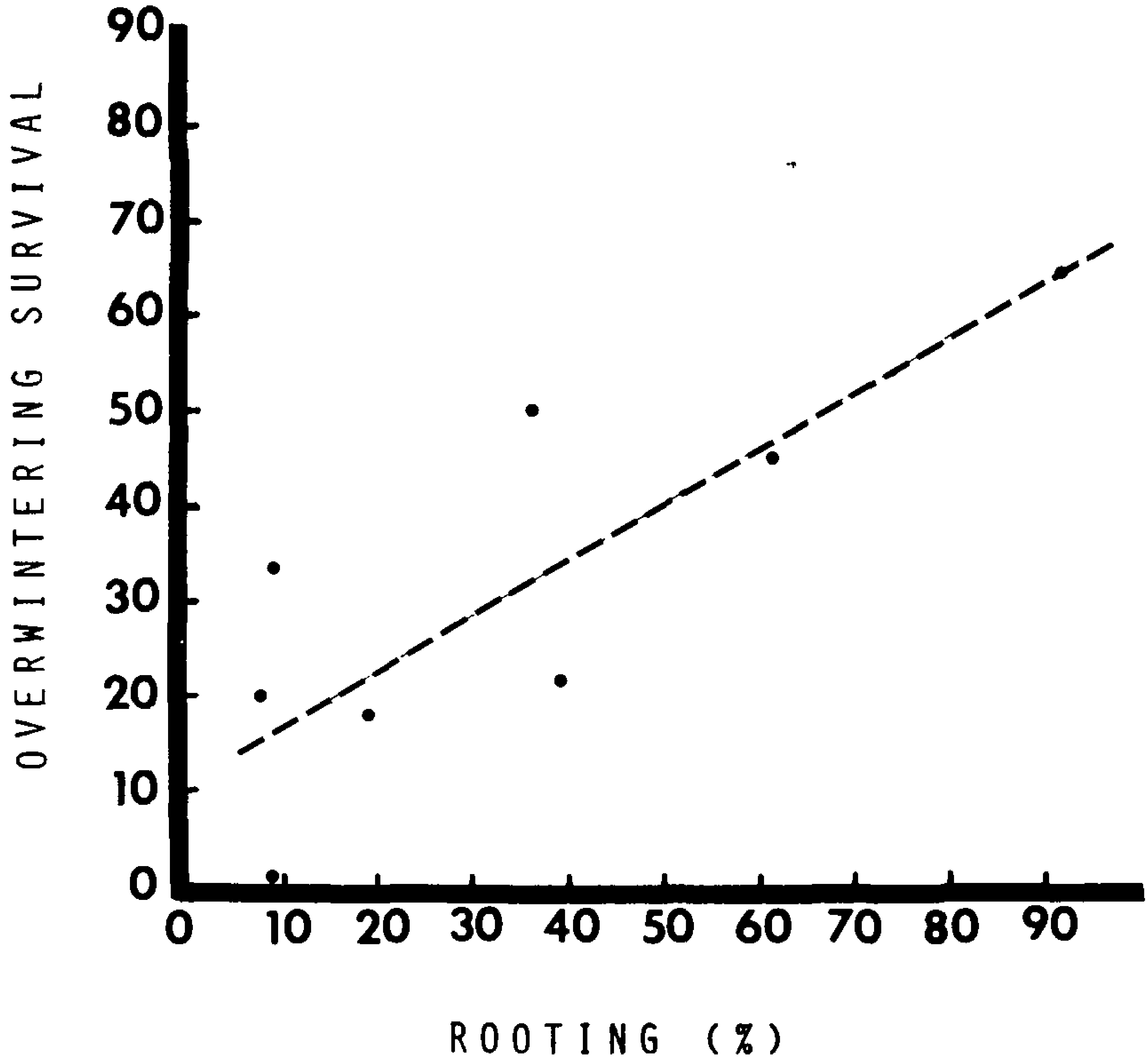

Fig. 6. Relationship between rooting response and overwintering survival of sugar maple cuttings.

similar relationship for shoot size. Not only do large cuttings have a greater potential for developing adventitious roots (Fig. 2) but also a greater percentage of the large rooted cuttings become established plants (Fig. 8).

Of course, propagation techniques, as well as inherent qualities, influence the relative vigor of the rooted plant. After we acquired a rooting greenhouse with relatively sophisticated environmental controls in 1966 and refined our methods for collecting and handling cuttings (as outlined in the next section), the quality of our rooted material improved substantially. And, as might be expected, a close correlation exists between overwintering survival and quality of the adventitious root system (Fig. 9).

Although we have not completely solved the problem of successfully propagating mature sugar maples, we are making progress. In an early report from our project (12) few of the collected shoots overwintered successfully, and in the 1965 "dormant feeding" study only 23 of approximately 2500 shoots (less than 1 percent) survived. This is in contrast with the 30 percent survival we have obtained in a subsequent study.

CURRENT PROPAGATION PROCEDURES

Some of the recommendations in this procedure are based on the results of studies previously discussed; others are based on generally accepted propagation practices.

We collect softwood cuttings when their terminal leaves appear mature and new terminal buds have formed. In northern Vermont, shoots generally reach this stage of development in mid-June, but

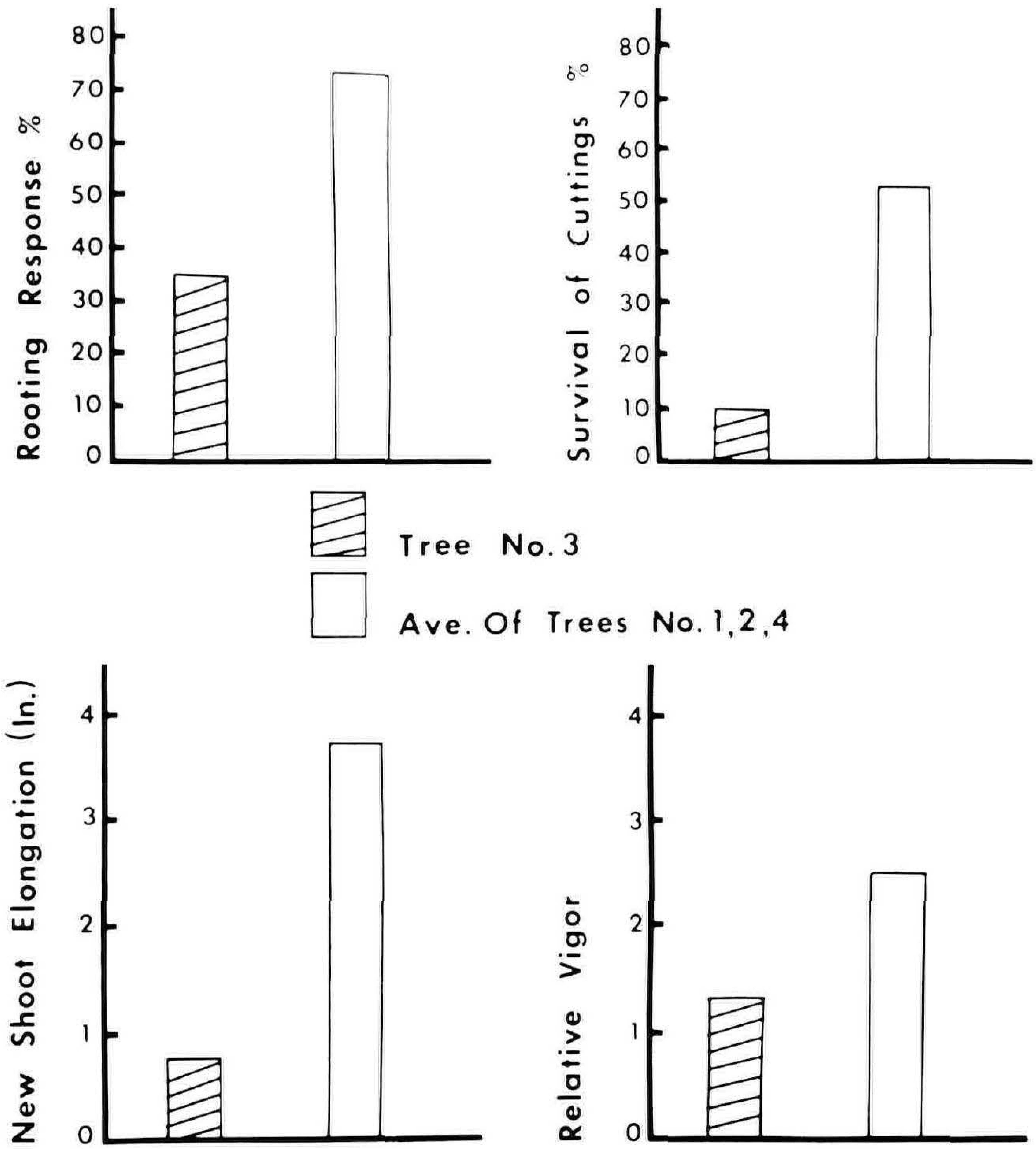

Fig. 7. Individual tree differences in rooting response, overwintering survival, new shoot elongation, and relative vigor of surviving plants.

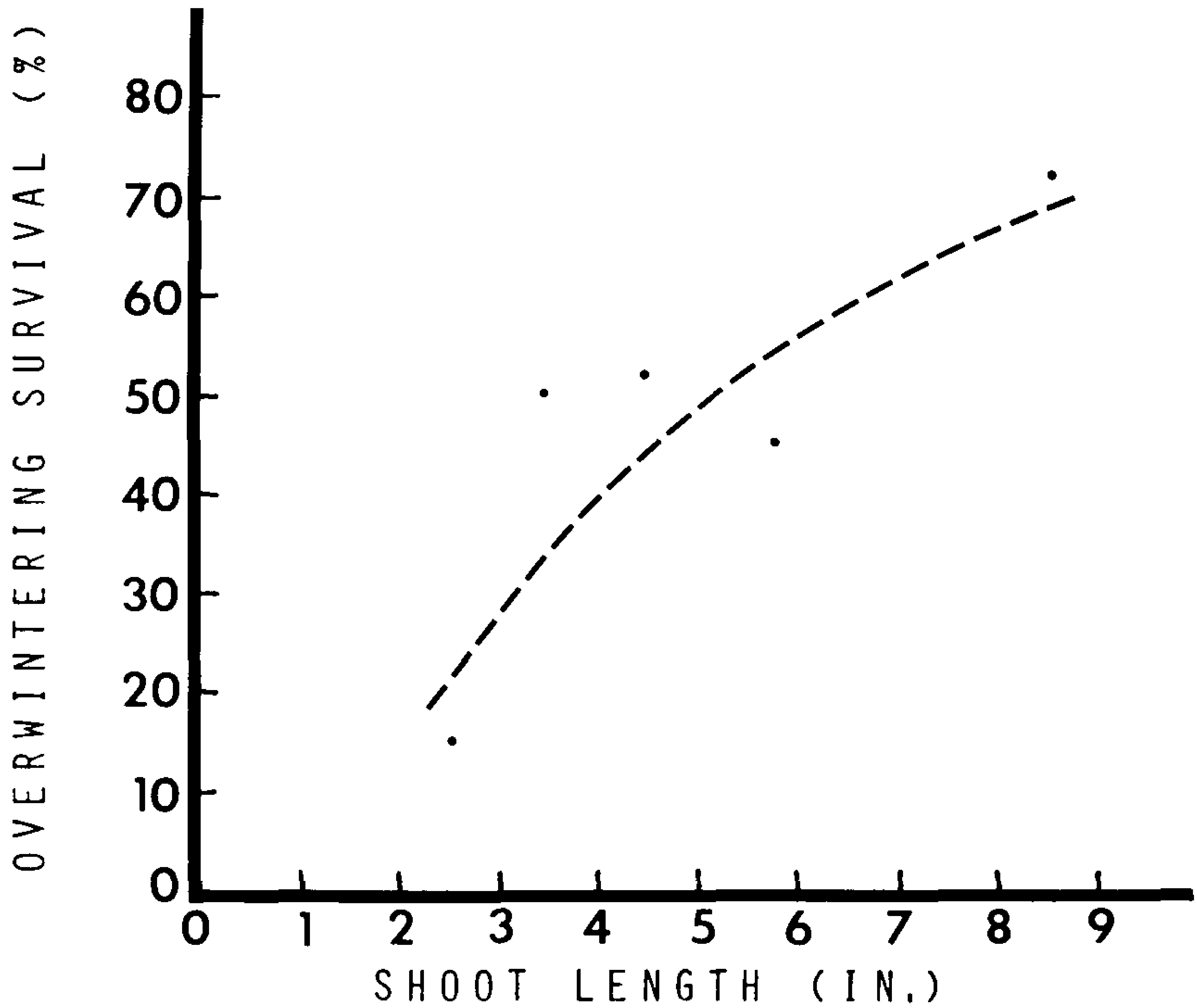

Fig. 8. Relationship between shoot length and overwintering survival of cuttings from one mature sugar maple tree.

this may vary by at least 2 weeks depending upon current-year weather conditions. Selected cuttings from mature trees should be as long as possible because of the relationship between shoot length and rooting response When clipping cuttings we sever them from the tree with a pruning pole and immediately cover with moist sphagnum enclosed within wet burlap or place them in a styrofoam cooler to prevent desiccation. We collect the entire current-year's growth plus a couple inches of older wood. In the rooting greenhouse, cuttings are prepared by removing the older wood, wounding the stem by making an approximately 1/2 inch long cut on two sides of its basal end, removing all leaves from the stem's lower 2 inches to facilitate sticking, dipping the cutting into Jiffy Grow and sticking it to a depth of 2 inches into the rooting medium (1·1 mixture of coarse perlite and shredded sphagnum moss).

Our primary rooting facility is a 20 x 60 foot greenhouse covered with clear polyethylene plus a layer of 50% saran shade cloth to reduce insolation. In order to further reduce overheating, the greenhouse is supplied with two coolers and two exhaust fans and a series of thermostatically controlled nozzles spray mist on the greenhouse roof. With this equipment we are generally able to keep

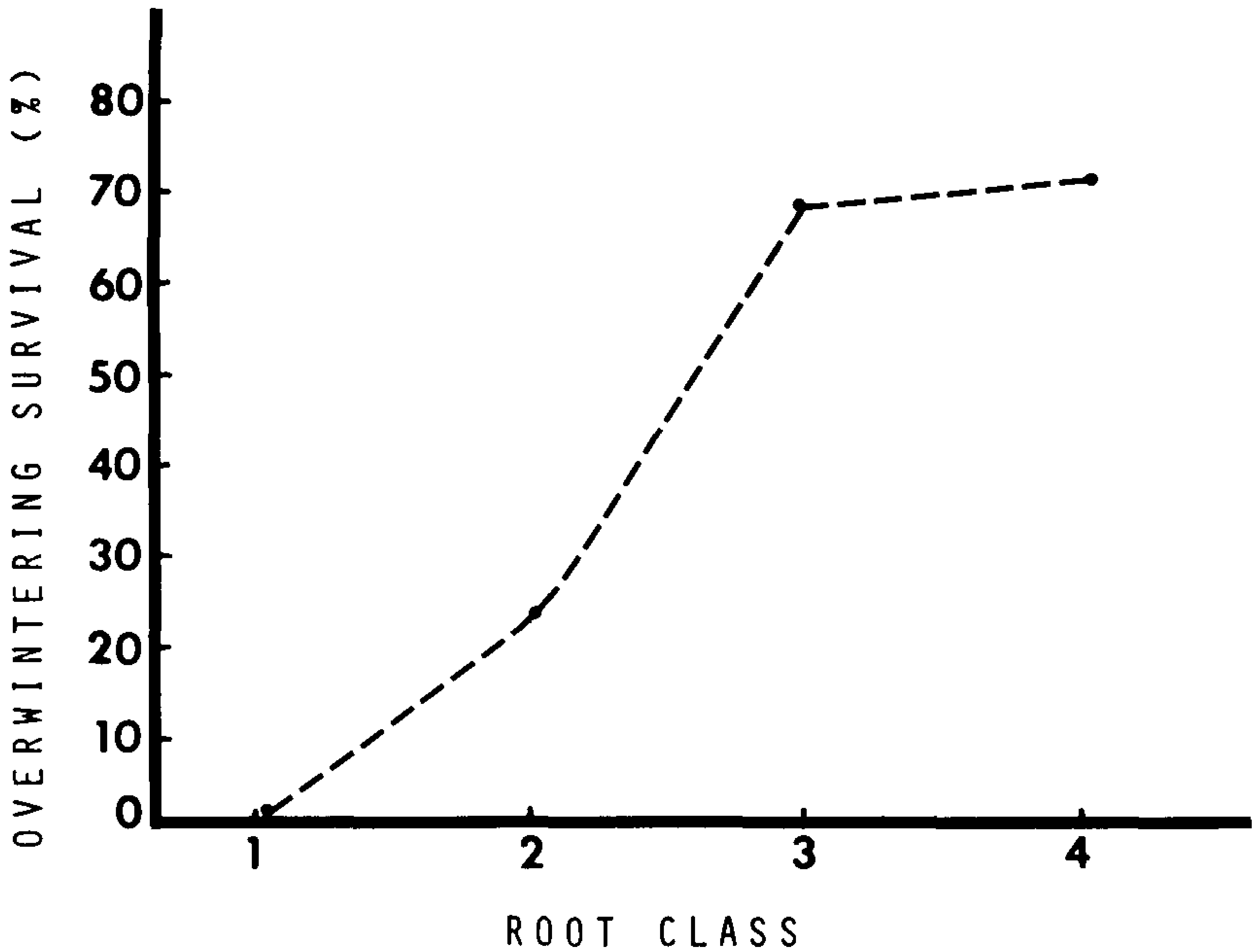

Fig. 9. Relationship between relative root quality (root class) and overwintering survival of rooted sugar maple cuttings.

maximum day time air temperature below 85° F. Electric heaters maintain a 60° F minimum night temperature. Temperature of the rooting medium is maintained at 80° F with thermostatically regulated heating cables. Cuttings are kept moist with an intermittent mist system automatically regulated by a MacPenny mist control. In recent studies we used clock timers set to apply mist for 3 seconds every one-half minute. Supplemental lighting, 150 watt incandescent lamps placed approximately 3 1/2 feet above the rooting beds, provides a 20-hour day length.

The three rooting beds are 4 feet wide and 48 feet long. Cuttings are lined out at a spacing of 7 x 6 inches (7 inches between cuttings within a row; 6 inches between rows). With this spacing the 20 x 60 foot greenhouse will hold approximately 2000 cuttings.

Adventitious roots generally develop within a period of 1 to 3 months. Our current method of preparing rooted cuttings for overwintering storage is to begin hardening-off procedures in early September by gradually cutting down on the rate of mist application and reducing the day length while plants are still in the rooting beds. Plants are lifted and potted in mid-September (approximately 3 months after sticking). The potting medium is a 1:1:1 mixture of perlite, loam and peat. Potted plants are kept in the greenhouse, the heat is turned off, and plants are hand watered when necessary. In mid-November plants are transferred to a walk-in cooler and stored at approximately 34° F. Physiological dormancy is broken within 2 months. At this time (mid-January) plants may be transferred to a heated greenhouse or they may be allowed to remain in the cooler until early May and then outplanted directly into the nursery.

We are currently testing a different procedure for treating rooted cuttings. As previously stated, adventitious roots may develop after 1 month, or may not form until at least 3 months after sticking. Because of this, we are experimenting with lifting and potting each cutting as soon as it has developed a 1/4 inch long adventitious root. After the rooted cutting has been potted, the surface of the pot is covered with a piece of stiff plastic and the potted plant is placed back under the mist. In this way, the plant's leaves are kept moist, but the soil does not receive an excessive amount of water. In early September mist applications are gradually reduced. By this time, an extensive root system has generally developed within the pot. These plants are then treated in the same manner as that previously outlined for those not potted until September. We have no data yet on overwintering survival for rooted cuttings treated by this method, but the plants currently appear to be in very good condition.

SUMMARY

In this report we have outlined some of our results from studies designed to stimulate rooting and overwintering survival of sugar maple stem cuttings. Studies designed to stimulate rooting have investigated seasonal changes in response, effects of shoot size, and effects of hormone concentration. Sugar maple cuttings root best if collected in late spring when elongation of the current-year shoot has essentially ceased and developing leaves appear mature in size and color. Considerable variation exists in the size of current-year shoots on a particular tree, and our findings point out corresponding variations in rooting response; for best results with mature trees propagators should collect cuttings that are as long and as thick as possible. We have obtained mixed responses with hormone treatments: for some trees, low concentrations of growth hormone appears to stimulate rooting; for others, hormones in any concentration are inhibitory.

In attempting to increase overwintering survival, we have tested the effects of "dormant feeding", methods of overwintering storage, and effects of rooting cuttings in individual containers to reduce root damage when plants are lifted and potted. "Dormant feeding", by watering rooted cuttings in the fall with sugar and nutrient solutions,

did not significantly stimulate survival. Neither did rooting cuttings within individual pots. In general, few of the rooted cuttings lined out in the nursery in the fall have survived. Survival is much better if cuttings are potted in late summer, hardened off, transferred to a cooler and stored at 34° F, and lined out in the spring.

Overwintering survival definitely appears to be correlated with relative vigor. Large rooted cuttings overwinter better than do small ones, those with a well-developed root system overwinter better than do those with small roots, and those collected from a "good rooter" overwinter better than do those from a "poor rooter."

Our goal has been to successfully root and overwinter 25 percent of the cuttings collected. We feel that with our improved greenhouse facilities and rooting techniques we can consistently attain this goal for cuttings collected from certain easy-to-root trees. For other trees, however, our success rate has been very low. Refinement of procedures to successfully propagate cuttings from these latter trees will be one of our objectives in subsequent investigations.

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RALPH SHUGERT: Thank you very much; that was certainly an interesting report

Our next speaker is another long time friend of the Society, Ray Halward; he is going to discuss the propagation of *Rhus aromatica* by softwood cuttings

PROPAGATION OF RHUS AROMATICA BY SOFTWOOD CUT TINGS

RAY E. HALWARD

Royal Botanical Gardens
Hamilton, Ontario, Canada

Rhus aromatica, a native shrub commonly known as fragrant sumac, has a wide range as its native habitat. It is found in Quebec, Ontario and at least 13 States from Northeastern to Southern to East-Central regions of the U.S. It is classed zone 3, on Canadian hardiness map.

CHARACTERISTICS

The fragrant sumac has small yellow flowers in clusters opening in May before the leaves unfold, followed by very attractive red fruits in summer. In the fall it is noted for its brilliant colour ranging from yellow-orange to scarlet. This colour is somewhat subdued by the hairy leaves. Its height varies from 1 to 5 feet depending on growing conditions, making it a multi-use plant. It is extremely valuable as a bank plant and ground cover in areas where low maintenance is required.

PROPAGATION

The shrub suckers freely suggesting layering or root cuttings are the best methods of propagation wherever sufficient stock is available. It is probably most often propagated by seeds which are usually quite plentiful.

This year our landscape department requested me to propagate about 500 fragrant sumac for a sand bank planting. This gave us the necessary incentive to try this plant from cuttings as we had only 2 large plants in our nursery. Being an advocate of mist propagation, I decided that we would try softwood cuttings first. On June 23rd, we stuck 750 wounded cuttings 3 to 4 inches in length in boxes in a sand-peat mixture (3:1) under intermittent mist, in a fiberglass house shaded with saran. Treatment consisted of 1% IBA plus Captan 50W 1:1 by volume on 450 cuttings and 2% IBA plus Captan 50W 1:1 by volume on 300 cuttings. One week later, June 30th, we had to restick the same cuttings as they were rotting at the base. From a total of 750 cuttings, we rooted 150 under mist.

I then decided to try another approach. On July 26th, we prepared the same mixture, sand-peat in boxes and stuck 360 fresh cuttings 4 to 5 inches in length, 120 per box. The cuttings were all treated with 1% IBA powder plus Captan 50W, 1:1 by volume. The cuttings were watered in and the foliage allowed to dry off, after which each box was sealed in plastic and placed on the non-shaded side of the fiberglass house. Temperatures frequently rose to 95° F during the sunny hours of the day. After one month's time, on Aug. 25th, the plastic was removed and the following results were observed. (The number of cuttings rooted in the 3 boxes were 87, 78, 63 respectively, giving an overall average of 63% rooting.) Our experience from the past summer leads me to believe that cuttings taken later will root better than cuttings taken earlier; also a higher rooting percentage can be obtained under plastic than under mist.

RALPH SHUGERT: Ray, I am curious as to why you were rooting *Rhus aromatica* rather than raising them from seed unless, of course, you were interested in propagating a specific clone.

RAY HALWARD: First of all, I did plant some seed just in case I could not root them but I was interested in seeing what could be done in propagating them by cuttings. I also thought it might be a faster way of raising some larger plants in a shorter time. One additional reason was that I could find very little written on the asexual propagation of this plant and I feel it is one of our better native plant materials.

RALPH SHUGERT: For those of you who may be interested in seed propagation of this plant, I would comment that it does come readily from seed. My experience has been that it requires no pretreatment and I prefer fall sowing. In the Plains States, to get the best seedling it should be left as a 2-0. With normal cultural practices, it should yield 50 to 60% 12 to 18 inch 2-0 seedlings and you can get up to 25% 2 to 3 foot seedlings at this same stage. If you are trying to reproduce a clone then it is, of course, necessary to go to some form of asexual propagation.

In closing this afternoon's program, I want to thank the members for their attention to the speakers and for their participation in the program and I wish to thank all of the speakers for a job well done. This concludes this afternoon's program.

THURSDAY EVENING SESSION

The twenty-second annual banquet was held in the Capitol Ballroom of the Hartford Hilton Hotel, Hartford, Connecticut. The following presentation was made by F.L. Steve O'Rourke.

STEVE O'ROURKE: Mr. President, fellow members and guests: The Award of Merit Committee which is composed of the last five members to have received the award is charged with the selection of an individual who has made significant contributions to the field of plant propagation and to this Society. Nominations are made by the membership and the award may not be given if in the opinion of the Awards Committee, none of the nominees meet these criteria. The Awards Committee has selected a recipient of the Award of Merit for 1972.

FRIDAY MORNING SESSION

December 9, 1972

The Friday morning technical session, which was preceded by the business meeting, convened at 10:00 a.m. in the Terrace Room of the Hartford Hilton Hotel. Mr. Lawrence Carville presided.

LARRY CARVILLE: The systems of watering in plant propagation is something with which we are all concerned. We know that there is a requirement for water in a medium without roots, but we also realize that water in moderation is a requirement of success in propagation. To apply water there is the outmoded system of the hand-held sprinkling hose, the bell jar, or modifications of these. We also have the more sophisticated electronic leaf and other types of electronic controls to keep the cuttings in a high humidity situation for plant propagation. We must be cognizant of the needs of the plant for water. What is the relationship between the medium, the plant, and the quality of water which we should be applying?

To begin this morning's session, we are going to have what would constitute a classroom lecture on soils, plants and water by Dr. Bob Langhans of Cornell University.

SOILS, PLANTS AND WATER[1]

ROBERT W. LANGHANS AND L. A. SPOMER

Cornell University, Ithaca, New York 14850

There are many differences to consider as one makes the transition from field to container growing. The soil is shallower, there is less volume, the soil is amended and watering and fertilization are drastically changed. You should have a basic understanding of the relationship of soil moisture and aeration. We will not give you any formula for a soil mix nor any water scheme or schedule. Unfortunately, each situation, each plant, each grower is a different problem and they can be solved usually in different ways. This is a management decision and it is up to the manager. We hope to give you the information for making the proper management decisions.

[1]The slides shown in this presentation were prepared by A. Spomer and V. Langhans and the information in the paper is from a series of articles on the subject by A. Spomer and R. Langhans published in the **Florists' Review**, Vol. 149, No. 3850: 63-64, 120; No. 3851:24-25, 61-64; No. 3853:32-33, 78-81; No. 3854: 36-37.

THE NATURE OF PLANT WATER

Water is the most important nutrient needed by plants for growth and activity. Plants consist almost entirely of water From 80 to 95% of the weight of actively growing plant tissue and of most herbaceous tissue (soft tissue such as leaves and flowers) is water. If a large tin can is weighed, filled with water and reweighed, it is found to contain about 90% water (by weight). Therefore, plants are literally living, growing containers of water. Water is more than just an inert filler in plants; it probably influences every plant activity. Plants not only contain a lot of water; they also often use hundreds of times this amount during growth. An herbaceous plant weighing 200 grams (one gram is 1/28 ounce) probably contains about 180 grams of water(90%) and may have absorbed over 100 times 180 or 18,000 grams during its growth, the actual amount depends on plant and environment. Plants and life in general cannot exist without water!

Plant water content averages about 90%; however, the actual range of water contents in different plant tissues can vary from less than 5% to more than 98%. Most plant water occurs in cells; water is found also in the cell walls and open spaces between cells. Living plant cells usually contain 95 to 98% water. The living part (protoplasm) usually consists of about 95% water, and the vacuole, a sap-filled cavity in the protoplasm, consists of about 98% water. Cell walls apparently have a relatively low water content, usually less than 40%. Water in the open spaces between cells (intercellular spaces) occurs as a vapor filling the spaces and may also occur as a thin film wetting cell surfaces. Intercellular water is normally a very small part of the total weight (about 0.002%). The actual amount of cell, cell wall and intercellular water depends on the plant species, tissue, growth stage and environmental conditions. Herbaceous tissues generally contain more water than woody tissues (90 vs 40 to 80%), younger, actively growing tissues, such as root and stem tips, usually contain more than older, nongrowing tissue (90 vs 70 to 85%), and vegetative tissues usually contain more than seed (80 to 95 vs 5%).

If all of the solid material in a plant could somehow be made invisible so that only the plant water were visible, it would be seen that the plant's form would not be visibly changed and that water actually forms a continuous phase throughout the plant. This continuous water phase is probably the most important aspect of plant water distribution. The behavior of water in plants is primarily due to this continuous water phase, which makes the plant little more than a water pipeline from the soil to the atmosphere. Water has very strong cohesive properties (molecules stick together strongly) The strong cohesive properties of water in this pipeline means that if water is pulled into the leaves, this pull is transmitted rapidly through the plant to the roots, in other words, water behaves almost like a chain or rope extending through the plant, and a pull or tension on one end is transmitted through the water phase to the other end. Water in one part of the soil-plant-atmosphere system therefore can rapidly influence water in the other parts; the water status of the roots can influence the water status of the shoot and vice versa.

Movement of Plant Water. The path of water through plants begins where it is absorbed from the soil and ends where it is evaporated into the atmosphere or incorporated into plant tissue. Water is absorbed from the soil through plant roots.

The root hair zone, just behind the root tip, seems to be the area most permeable to water; older root tissues often become water impermeable Water moves radially across the outside part of the root (epidermis and cortex) through cells, cell walls and intercellular spaces until it reaches the inside part of the root (endodermis and stele). Water movement across the endodermis apparently occurs only through cells and not through cell walls or intercellular spaces. The permeability of cells to water depends on cell physiological activity. The physiological activity of the root can therefore directly influence the rate of water absorption. Soil and plant nutrient, soil aeration, soil temperature, soil salinity, soil pH and soil pathogens all influence water absorption by affecting root physiological activity. Once water penetrates the inner part of roots and enters the translocation system (vascular system), it is easily and often rapidly translocated throughout the plant. Most of the water absorbed by plants is translocated to the leaves, where it evaporates or diffuses out of the leaf cells into intercellular spaces, through these spaces to tiny holes in the leaf surface (stomates) and out of the leaf into the atmosphere. Leaf surfaces are coated with a waxy, water-impermeably layer (cuticle); so water is lost from the plant almost entirely through the stomates. This evaporation of water from plants is called transpiration. Stomates on most plants open in the light and close in the dark or when the plant loses turgidity (wilts). The large, permeable surface of the leaf is very efficient for photosynthesis but is very inefficient in relation to water because it permits easy and rapid loss of water.

Since water exists in a continuous phase throughout the plant, a pull or tension exerted on water in one part of the plant is rapidly transmitted through the continuous water phase to other parts, resulting in a tendency for water to move into the part where the pull or tension is exerted. A general term describing the pull or tension which causes water to move is water suction (also called water potential, water tension, diffusion pressure deficit, etc.). The term **water potential**, which is analogous to water suction, has recently been adapted by researchers because it is a more precise term describing the status of plant water and will therefore eventually replace the older water suction terminology. In general, water moves from lower to higher suction (in the direction of the greater pull) Water suction in plants is primarily caused by the attraction of water to plant solids and solutes. When water is lost from the leaves by transpiration, the water suction in the leaves increases. Water suction in plant tissue also increases as cells accumulate salts and other soluble materials. When the suction in the leaves and other tissues increases, water begins to move into these tissues from tissues, such as the stem and root, which have a lower water suction. This water movement in response to suction differences is called passive water movement. Active water movement, which involves some sort of physiological pumping mechanism, has also apparently been observed in some plants but is apparently of minor importance in most plants.

Water movement in plants is controlled by soil, plant and atmospheric factors. Water loss depends on the tendency and ability of water to move from the plant to the atmosphere; this tendency is influenced by atmospheric water suction (relative humidity), plant water suction and plant stomates and cuticle. When the atmosphere is dry (low relative humidity = high water suction) and the plant's stomates are open, plant water loss will be high. Air movement also affects water loss. Water absorption depends on the tendency and ability of water to move from the soil to the plant; this is influenced by soil moisture availability, root permeability and plant suction. In general, water at the root surface will be absorbed when it is at a lower soil water suction than plant water suction.

Function of Water in Plants. Because plants consist almost entirely of water, every plant activity is probably influenced by water. Water has several direct functions in plants. Water functions as a hydraulic agent which maintains cells in a fully expanded condition (turgid) necessary for growth in size and for support. During growth, water enters cells, exerting pressure which stretches the walls, causing the cells to grow larger like expanding ballons. Water also functions as a solvent and transport agent in which all material, including nutrients, gases and plant products, move into and throughout the plant. Water is the main constituent of the cell protoplasm where it not only functions as a filler or dispersant but also as an important structural component. All life activities take place in this protoplasmic water solution. Proteins and enzymes are molecules in the protoplasm that regulate and direct life processes. Their functioning depends on the molecular structure. Water is normally bound to these molecules as part of their molecular structure. When water is withdrawn, their structure and function apparently change. Water also functions as a biochemical reagent in many physiological reactions. The most significant example is as one of the raw materials utilized by plants in the production of food (photosynthesis).

In addition to these direct functions of water in plants, water indirectly influences growth by helping to regulate plant temperature and conditioning the plant's environment (ie, soil physical, chemical and biological character).

Plant Water Deficiency. Plant water deficiency occurs whenever plants require or lose more water than they absorb over a period of time; this is often called plant water stress. Both water content and suction change during a plant water deficiency, and the size of their change depends primarily on the severity and duration of the deficiency. Water content changes are usually relatively small (5 to 15 percent), and water suction changes are often very large.

In general, during a period of plant water deficiency (water stress), plant growth processes are reduced directly or indirectly by a lack of water. A plant water deficiency affects growth in several ways; the overall effect depends on the severity and duration of the deficiency and on the plant species, part, growth stage and preconditioning. The initial effect of a water deficiency is a decreased water content or loss of turgidity and an increased water suction. This causes a reduction or stoppage or even reversal of expansion growth, loss of tissue support or wilting, closure of stomates which stops or slows carbon dioxide-oxygen exchange indirectly influencing photosynthesis and an increase, a decrease or no change in water movement, depending on the availability of soil water and on closure of the stomates. Most metabolic processes such as photosynthesis, respiration, protein synthesis and others are influenced directly or indirectly by decreased plant water content or increased plant water suction. Under prolonged or severe conditions of water stress, cells and tissue may be permanently injured or changed in other ways. Most plants adapt to repeated or prolonged water deficiency and become more able to survive subsequent periods of water stress. In some plants these changes may actually enhance product quality; water stress may result in higher sugar or other specific substance content, less succulent tissues, etc. Water stress also apparently sometimes hastens flower initiation, breaking of dormancy, flower development and onset of dormancy; delays flower initiation, flower development and breaking of dormancy; increases fruit size; decreases fruit size; changes plant morphology, and has many other effects, depending on the plant species and on conditions preceding, during and following the period of water stress. In all cases of water deficiency, however, overall plant growth is usually reduced.

THE NATURE OF SOIL MOISTURE

The soil is a kind of reservoir that stores water and other nutrients for plant use. Water is stored in this reservoir in three different forms; it is stored as solid, liquid and gaseous water. The solid form, called bound or hygroscopic water, is a thin water layer held so strongly to soil particles that it behaves like ice. The gas form is the humidity in the soil air. The liquid form, called soil moisture, wets particle surfaces and fills soil pores.

Soil moisture contains a small amount of dissolved minerals, gases and organic matter and is therefore also called the soil solution. The amount of dissolved material in the soil solution varies with soil physical, chemical and biological conditions and also with the addition of fertilizer and organic matter but is normally relatively small.

The amounts of solid, gaseous and liquid water in the soil depend on soil type and conditions. The solid and gas forms of soil water normally consititute much less than 1% of the total soil mass and are therefore not important sources of water for plants. Liquid water, however, often constitutes more than 30% of the total soil mass and is therefore the most important source of water for plant use. Liquid water is also the form that has the strongest influence on the soil physical, chemical and biological character.

Soil Moisture Retention. Water is held in the soil reservoir because it can stick to soil particles and to itself. The soil solution wets or adheres to soil particle surfaces and is also trapped or held in soil pores by a combination of adhesion to soil particles and cohesion to other water molecules. These cohesive and adhesive forces result in surface tension that forms a tightly stretched skin of water across pore openings. This surface tension skin tends either to hold water in or out of the pores. This combination of adhesion and cohesion of soil moisture, commonly called capillary activity, can also pull water into pores. Most water is held in soils by capillary activity.

The strength of soil water retention can vary tremendously between soils or within a given soil as conditions change. A measure of the strength of soil water retention is called soil water suction. The greater the soil water suction, the stronger that water is held in soils and the harder it is for plants to absorb it.

Suction. Soil suction is therefore a measure of the ease of water absorption by plants, called soil moisture availability.

Soil water suction actually is the combined result of different factors. Matric suction, the attraction of water to soil particles, and osmotic suction, the effects of solutes, are usually the most important suction components in relation to plants. Matric suction normally controls the physical status of soil water (movement, retention and content) and is therefore probably the most commonly measured component (measured with tensionmeters). Osmotic suction occasionally becomes dominant as demonstrated by the wilting of plants immediately following excessive soluble fertilizer applications or under high salt conditions. When this happens plants cannot absorb water from the soil and water may even be drawn out of the plant back into the soil (high salts may also have a toxic effect on plant growth not related to the osmotic effect).

Various terms commonly used to describe soil moisture retention are listed in part A of the Glossary. Since container soils are shallow, the term moisture equivalent usually has no practical application for these soils (explained in section on soil moisture distribution). Water retained in soils between zero suction (wet) and wilting coefficient (dry) can be absorbed by plants and is therefore available soil moisture.

Soil Moisture Content. Soil moisture content is the amount of water held in the soil reservoir. Water is held primarily in the soil pores; so the total amount and size distribution of soil pores, which are determined by soil texture and structure, affect the amount of water retained. Soils with smaller pores usually contain more water following irrigation and drainage than soils with larger pores. Finer-textured, less-compacted soils usually have greater surface area, greater total porosity and small pores and therefore greater water content than coarser-textured, more-compacted soils. Porosity is also usually greater in soils of one particle (clay or silt or sand) than in a well-graded soil (mixture of clay and silt and sand).

Soil texture and structure are not the only factors controlling soil water content. Matric suction is the primary factor influencing the water content within a particular soil. Two identical soils having different matric suction levels will contain different amounts of water. The relationship between matric suction and soil water content is called the soil moisture characteristic. As soil water content decreases, matric suction increases; as the soil dries, water becomes more strongly held. Each soil has its own specific moisture characteristic; this is probably the most important soil physical character a horticulturist can know.

Various terms commonly used to describe soil moisture content are listed in part B of the Glossary. All of these terms can be correctly used to describe container soil conditions except field capacity. Shallow field or container soils normally never reach field capacity during drainage (see section on soil moisture distribution). The soil water content between field capacity or container capacity and permanent wilting percentage can be absorbed by plants and is therefore available soil moisture.

Soil Moisture Movement. Only part of the water applied during irrigation stays in any single part of the soil; the rest moves or drains downward (called saturated or gravitational water movement). The gravitational force on water, its weight, pulls it downward, mostly through the larger soil pores. The rate of gravitational water movement depends on the size and total amount of soil pores; drainage is more rapid and complete in coarser-textured and less-compacted soils (ie, sand). Movement of the liquid water retained in the soil reservoir is called unsaturated or capillary water movement. Capillary suction forces can pull water in any direction through adhered water films and water-filled pores, always from areas of lower to areas of higher suction. The size of the water film, the amount of water-filled pores, the water path length (all depend on texture, structure and suction) and the suction gradient (part A Glossary) all influence the rate of capillary water movement. Capillary water movement is generally greater in wetter, finer-textured, more-compacted soils. Water movement through the soil as vapor is insignificant in relation to plant water use.

The initial distribution of water throughout the soil reservoir is by gravitational water movement during irrigation. Secondary or horizonontal distribution of water throughout the soil occurs by capillary water movement; this is how water absorbed by plants moves to the roots.

Soil aeration, which also influences poor water absorption, depends on the completeness of drainage; a well-drained soil will have better aeration than a poorly drained soil. In all of these ways, soil moisture movement influences soil moisture availability.

Soil Moisture Distribution. Water is not always distributed uniformly throughout a soil following irrigation. When a deep (field) soil is irrigated, it usually does not drain to a relatively uniform water content throughout most of its wetted depth (field capacity). Shallow container soils also drain to a certain water content following each irrigation, called container or depth capacity; however, in shallow containers the water content is different at different soil levels. When drainage from a shallow soil cease, the bottom of the soil is saturated (at zero suction) and the matric suction increases with height above the bottom (ie, at 10-cm height, matric suction equals approximately 15 cm water, etc.). In other words, immediately following drainage, the top of a shallow container soil is usually drier than the bottom. The actual distribution of water depends on the soil depth and the soil moisture characteristic.

Following irrigation, a coarser soil (sand) will probably be much drier at the top of a container than a finer soil (silt) and the coarser soil may not provide a good water supply for shallow-rooted plants whereas a finer soil probably will. A fine soil, however, might contain too much water, resulting in poor aeration; this, of course, depends on the soil moisture characteristic and soil depth.

THE NATURE OF SOIL AERATION

Soil aeration is the exchange of oxygen and carbon dioxide between the soil and aboveground atmospheres. These gases move in the soil primarily through the soil atmosphere; the soil atmosphere is the part of the soil volume not filled by solid or liquid phases. The solid phase (soil particles) does not completely fill the soil volume; openings left between particles are called soil pores. The liquid phase (soil moisture) adheres to particle surfaces and is held in the pores; the pores may be partly or completely filled with water. Aeration occurs primarily through nonwater-filled or open soil pores (the soil atmosphere or gas phase).

A microscopic view of the soil would show a network of interconnecting, irregular tubes or tunnels formed by soil pores honeycombing the soil structure. Oxygen and carbon dioxide move into, throughout and out of the soil through this pore network. Adequate aeration requires sufficient open or unblocked tunnels in the network to permit free gas exchange between the soil and aboveground atmospheres and free gas movement throughout the soil. Aeration tunnels can be blocked by soil particles or water. Most soils consist of a mixture of different-size particles; the proportions of the different sizes (percent of sand, silt, clay) determine soil texture. A packed, unstructured, single-particle-size soil contains about 27 percent (by volume) pore space. A packed, graded (mixture of sand, silt, clay) usually contains less pore space; this is the reason several particle sizes are mixed and packed to prepare strong, stable earth fill roadbeds and dams. This pore space reduction in a well-graded soil can be considerably modified by soil structure (grouping of individual particles into single, large particles or structural units). A compacted, well-graded, unstructured soil tends to have a large proportion of blocked or dead-end aeration tunnels. As soil water increases, open pore space decreases; smallest pores tend to fill first followed by increasingly larger pores until all are filled (saturated soil). Soil water, texture and structure interact to determine the rate of soil aeration. In general, aeration is greatest in uncompacted, well-structured, coarse-textured and low water content soils.

Soil temperature, soil biological activity, irrigation and aboveground atmospheric pressure changes also influence soil aeration. Temperature affects oxygen and carbon dioxide movement and biological activity. As soil temperature increases, gas exchange and biological activity increase. The rate of biological activity determines oxygen utilization and carbon dioxide production rates. In general, the higher the rate of biological activity, the higher the rate of oxygen utilization and carbon dioxide concentrations. Soil oxygen and carbon dioxide concentrations can each vary about 0 to 21% (the total of the two is always 21%) depending on aeration and biological activity. When a container soil (pot, planter, bench, etc.) is irrigated by flooding the surface, much of the existing soil atmosphere is purged or pushed from the soil by the water and replaced by aboveground atmosphere gases as the soil drains and dries. In some cases, a significant amount of aeration occurs by gases carried into and out of the soil, gases dissolved in irrigation water. Aboveground pressure changes — for example, those caused by turbulent air movement across the soil surface (wind pulses) tends to pump gas in and out of the soil. The relative importance of soil temperature, biological activity, irrigation and pressure changes to soil aeration varies from soil to soil and depends on plant and soil properties.

Soil Aeration and Plant Growth. Soil aeration affects plant growth dirctly by affecting root growth and physiological activity. Roots help support the shoot and attach the plant to its soil nutrient reservoir. Roots absorb all mineral nutrients and water used by the plant; root growth gives the plant a continuously expanding access to the soil nutrient reservoir, and root physiological activity determines mineral and water absorption rates. Roots act as storage organs and synthesizers of specific substances essential for normal plant growth; these root functions also are controlled by root growth and physiological activity. Roots are an extremely important part of the plant, and any factor affecting root growth and physiological activity ultimately affects the growth of the whole plant.

Normal root growth and physiological activity require a supply of oxygen and removal of carbon dioxide. All root functions require an energy source; this energy is provided by respiration (physiological conversion of plant foodstuffs). Oxygen combines with the food, resulting in the production of available energy, waste by-products (carbon dioxide and water) and other products. An oxygen deficiency retards respiration and root physiological activity. A high carbon dioxide concentration also retards respiration and may have a toxic effect on the roots. Some plants are capable of transporting sufficient oxygen for root respiration through the plant structure (leaves, stems, roots) from the aboveground atmospher however, in most cases soil aeration is the process responsible for oxygen supply and carbon dioxide removal from plant roots.

Two facets of soil aeration important to plant growth are: (1) The oxygen supply rate and (2) carbon dioxide concentration. Poor aeration can be defined as the limiting of root physiological activity or root damage due to deficient oxygen or excessive carbon dioxide. The limits of oxygen and carbon dioxide defining poor aeration in any specific situation depend on plant, soil and environmental factors. The severity of poor aeration damage to plant growth depends on the degree, duration and frequency of poor aeration and on plant species, growth stage, prehistory and aboveground environment. The damage is usually severest when poor aeration occurs during the early stages of plant (fruit, flower and leaf) development and when it is frequent or prolonged. Poor aeration symptoms include: (1) Shoot yellowing (chlorosis) caused by deficient mineral nutrient absorption or plant growth substance production; (2) wilting caused by deficient water absorption (espicially noticeable on sunny days following cloudy periods); (3) wilting during drought caused by shallow or reduced root growth; (4) abnormal, twisted shoot growth (epinasty), stunted shoot growth, and eventual tissue browning and death caused by a lack of water and mineral nutrient absorption; (5) abnormal root anatomy and morphology (abnormal multiple branching, growing up out of the soil, etc.), and (6) dead or injured roots. The overall result of poor soil aeration is reduced plant and crop growth.

Aeration may also influence plant growth indirectly by affecting the soil chemical character and by providing an environment favorable for undesirable soil microorganism (including pathogens) development.

SUMMARY AND CONCLUSIONS

Soil aeration is the exchange of gases, primarily oxygen and carbon dioxide, between soil and aboveground atmospheres. Soil aeration occurs through the network of interconnected open pores honeycombing the soil bulk. Soil texture, structure, moisture, temperature, biological activity and aboveground atmospheric pressure changes all affect the efficiency of the aeration network. The best aeration usually occurs in uncompacted, well-structured, low water content, coarse-textured soils.

Soil aeration affects plant growth directly by affecting root growth and physiological activity and indirectly by affecting soil chemical and biological character. Both the oxygen-carbon dioxide exchange rate and carbon dioxide concentration are important in relation to plant growth. Plant requirements for aeration vary with plant, soil and aboveground conditions. Symptoms of poor aeration depend on the plant and the severity of the poor aeration; in all cases, the overall effect is reduced plant growth and crop production.

It would be impossible to develop a cookbook prescribing cultural recommendations for optimum aeration in every specific situation. Not enough is known about plant aeration requirements, and it would be impossible to completely characterize all the plant environment factors which influence aeration. It is doubtful that an aeration meter will ever be developed to measure soil aeration in the same way a tensionmeter is used to measure soil moisture status. Adequate soil aeration in most agricultural situations is guaranteed through management practices developed primarily from practical experience. Because growing plants require both adequate soil aeration and moisture, certain soil conditions for crop production are sought, conditions which tend to maximize both soil moisture supply and soil aeration through soil modification (tillage and mixture) and moisture control (irrigation and drainage). The best approach to soil aeration management is to start with a good soil. Soil structure, texture and drainage should be developed or modified so the soil contains sufficient open pores after irrigation to ensure adequate soil aeration; for containers (pot, planter and bench) this usually means a coarse-textured or structured soil with free bottom drainage (container soils are normally much wetter than field soils following drainage. Irrigation frequently can then be adjusted to provide maximum water supply, without causing significant periods of poor aeration.

GLOSSARY A

Soil Moisture Retention Terms

Suction — the pressure (force per unit area) required to remove water from the soil (expressed in energy, work or pressure units). Atmospheric pressure is set equal to zero suction as a reference point. (Soil moisture tension, soil moisture stress and water potential are analogous terms often used.)

Centimeter water (or centimeter mercury) — a unit of pressure or suction equal to the pressure exerted at the bottom of a layer of water (or mercury) one centimeter deep (1 cm water equals the weight of 1 gm/cm^2 and 1 cm mercury equals the weight of 13.6 gm/cm^2).

Atmosphere — another unit of pressure or suction equal to about 14.7 pounds per square inch. One atmosphere equals about 1,033 cm water or about 76 cm mercury.

Bar — another unit of pressure of suction equal to about one atmosphere (actually about 0.985 atmosphere).

Water table a soil condition where the suction equals zero (the soil is usually saturated).

Moisture equivalent — a soil condition where the matric suction equals approximately 1/2 atmosphere or 500 centimeters water suction (laboratory approximation of field capacity).

Wilting coefficient — a soil condition where the metric suction equals approximately 31 atmospheres (31,000 centimeters of water suction) (laboratory approximation of the permanent wilting point).

Suction gradient — a soil condition where one part of the soil has a lower suction than another part (water flows along a suction gradient from lower to higher suctions).

GLOSSARY B
Soil Moisture Content Terms

Water content — the amount of water in a soil (usually a percentage based on soil dry weight, soil wet weight or soil volume).

Saturation — a soil condition where the pores are filled with water (the suction usually equals zero).

Percent pore saturation — the percentage of the soil pore volume which is water-filled.

Field capacity — the water content of a deep (field) soil after 48 hours' drainage without any other loss of water (a characteristic of each soil).

Container capacity — the water content of a container soil following complete draining without any other water loss (an analogue of field capacity except it is a characteristic of both the soil and the container).

Permanent wilting percentage — the soil water content at which a plant can absorb sufficient water to keep from wilting even in a water-saturated atmosphere.

Water-depth ratio — the volume of water contained per volume of soil.

LARRY CARVILLE: That was an excellent presentation of some basic information about soil, water and aeration of the growing medium. This talk outlines many things which we should be thinking about in our own growing operations. Since all of the papers this morning deal with water, I am going to ask that you hold all questions until the end of the morning session since some of the speakers may cover questions which you would direct to Dr. Langhans.

Our next speaker is from Greenleaf Nursery in Oklahoma, where we will be visiting in two years; he is Dave Morrison and is going to tell us about their operation with overhead watering of containers.

OVERHEAD WATERING OF CONTAINERS

DAVID L. MORRISON

Greenleaf Nursery Co.
Park Hill, Oklahoma 74451

INTRODUCTION

Greenleaf Nursery Co. is headquartered approximately 70 miles southeast of Tulsa and has a new division in Texas about 70 miles southwest of Houston. Both nurseries are exclusively producing container grown ornamentals, growing both conifer and broadleaved evergreens, trees and shrubs. The practical aspects of overhead watering presented in this paper will be those gained from past experience at the Oklahoma site but will to an extent apply to both areas.

There are a number of factors affecting our particular situation that should be kept in mind when considering our method of irrigation. First, there is as much as 125° variation in our temperature, ranging from -15° F to 110° F. This forces us to use two differing overhead systems from season to season since we must overwinter our stock. Secondly, our growing season lasts from April to mid-October. Third, there are approximately 100 acres of container stock that is exclusively overhead watered unless problem areas arise. Probably most important is the fact that we have an almost unsurpassed source of water from Lake Tenkiller. The water has a conductivity of 0.19 millimhos/cm and thus presents no salinity problems in itself.

EQUIPMENT

We are presently using two 60 h.p. Berkeley electric pumps that have a combined capacity of 1,500 gal/min. There is also a standby propane powered Hale pump that is used in the event of a power failure or problems with one of the electric units. By this spring the pumping system will be expanded to include three electric pumps and a larger standby unit.

The pumps push the water through an 8" aluminum line up the hill from the lake to the container area. The mainline is divided into three seperate sections so that each section can be isolated and repaired without shutting the water down on the other sections. This feature is of great importance during our extremely hot summer days when a shut down of the whole system for 6 hours could be disastrous.

The irrigation lines going to each block are 4" aluminum lines in 40' lengths. A 4" gate valve controls the flow to each block from the mainline. The block themselves are set up so that the Rainbird sprinklers are at the corners of a 40' x 42' rectangle. This represents a minor imperfection, but the 42' is the lateral 1" line and is used for simplicity's sake since it represents two standard 21' joints of galvanized pipe.

At the end of the 42' lateral line is a "T". One leg of the "T" goes to a 3/4" faucet or hose bib and the other leg holds the 3/4" riser. The faucets are placed on each lateral line as a source of water at planting time so that a hose can be attached to thoroughly hand water everything after planting. They also serve as the means for draining the lateral lines of water during the winter in order to keep the lateral from bursting.

Atop the riser is a ½" gas valve and the Rainbird sprinkler. The gas valves have been in use only about 2 years at Greenleaf. They have proved very worthwhile despite their cost of almost $1.00 apiece. Their uses are practically limitless. They are used to shut off the water to a Rainbird so that it can be removed and unstopped without turning off the entire block or getting soaked. They are also useful in controlling the water in an area that needs to be run drier. The area can be run for a short time and then turned off while the remainder of the block continues to run. They are useful for turning off a riser for short periods of time if a shipping crew needs to pull an order off a block on which the water is running.

The Rainbirds we use are generally of three different types. Our standard is the No. 20 full circle with an 11/64" orifice with screw adjustment. We use this model and orifice in our normal summer watering. On certain varieties of trees that require more water we will use a 7/32" orifice. The others presently in use are the No. 20 with a stainless steel deflector, which is used in the overwintering houses to obtain good coverage at the base of the "A" Frame; and the No. 35 part circle which is used to control water in problem areas. The No. 35 is installed to control water in The No. 35 is installed at a point so that by adjusting the arc of its circle the water can be withheld from an area that is too wet. Used in conjuction with the quarter turn shut off's this can be very effective in drying an overwet area.

When all this equipment is functioning properly together we will be running approximately 1,500 gal/min with a pressure of 35 psi at the sprinkler head. The flow will be almost 5 gal/min per head with an 11/64" orifice or a rainfall equivalent of 0.3 inches per hour.

SEASONAL WATERING

During the hot summer months the irrigation pumps are usually turned on at 6:00 a.m. A typical watering schedule would then be carried through the day as follows:

First, the saleable sized conifer either in 1, 2, or 5 gallon size that is susceptible to *Phomopsis* twig blight is watered. This practice is done so that these plants will not have wet foliage overnight, thus eliminating the damp conditions that encourage the twig blight. After about 2 hours another set of saleable age conifer and possibly a block or two with hollies are run. By 11:00 a.m. the time has come that we have to begin watering trees, pyracantha, and some deciduous shrubs. The middle of the day is then completely occupied with watering these items. Later in the afternoon the young conifers are watered along with some of the young hollies and trees that require little daily water. The early evening sees the water returned to the large trees. The rest of the day's watering allows the waterman to rewater any items that may be running drier. The pumps will then be turned off at about 9:00 p.m.

This schedule allows us to water every plant on the nursery once daily for 1 to 4 hours depending on its needs. This does not mean to say that we indiscriminately water everything on the nursery whether it needs it or not. The watermen will be checking the soil moisture content at different points on a block from one to two times daily. Therefore, they will determine the amount of time required to bring the soil to optimum moisture content and water that block accordingly. We are constantly striving to avoid overwet conditions as well as dry. The overwet condition leads to excessive leaching, retarded root growth, and an increase in root diseases.

The whole basis of our system is based upon constant checking of the soil moisture level. This cannot be stressed too much. Probably as much as one half of our watermen's time is spent in checking the moisture level in the containers. Experience has shown that you can not play "catch-up" with overhead watering during our hot summers. Therefore we feel the time spent in checking moisture is well invested.

Fall is a transition period when the main problem is to begin to harden the plants off by first withdrawing the fertilizer and then decreasing the amount of water available so the plant will be hardened off to tolerate the winter temperatures.

It is also at this time of year that we build our overwintering houses and thus the plumbing setup on the irrigation system must be changed to fit the "A" frame houses. The change is a very simple one and requires approximately 8 man hours to completely convert a block to four overwintering houses. The center risers on the 4" line are removed and an elbow and tee replace the collar between the two joints of pipe in the lateral 1" lines. An extra riser is then placed in this tee so that the system now has two rows of risers parallel to the 4" line at a distance of 21' on each side of it. The spacing from riser to riser down the aisle of the house is now alternately 19' and 21'.

Once the deflectors are installed in place of the regular orifice in the Rainbird, the irrigation system is ready for winter.

During the winter much of the overhead irrigation done is for thawing purposes. This is due to the fact that the changes in temperature in our area are sometimes quite drastic. One day might see the temperature hover between -5° F and 0° F and the next day will have bright sunshine and 55° F. Therefore we put as our first priority the thawing of the soil in any containers that might be frozen. We also want to keep a fairly good moisture content in the can after thawing because of the tendency of the soil to dry with each freeze.

Our normal winter watering will be done almost any day that the temperature is above 35° F. Most of the plant material outside the overwintering houses will have to be watered once a week. That inside the houses will be watered twice a week if necessary. Once again, this is not a rigid schedule, but is based solely on plant needs.

During the winter the total irrigation system must be drained every time it is used. All pumps, the mainline, 4" lines, and lateral lines are drained after each use to prevent freezing. We are lucky to have gently sloping terrain so that gravity will do much of the work of draining the system.

ADVANTAGES OF OVERHEAD WATERING

1. Overhead watering cools the plant foliage and decreases the amount of wilt on the plants during hot weather.
2. Tremendous savings in labor over handwatering.
3. Less maintenance with solid set irrigation system than with plastic "spaghetti" system. Also our system of overwintering and the rabbit population would make a "spaghetti" system useless.
4. Can be used for frost protection in the event of an early frost before our tender items are overwintered.
5. Keeps dust down on the roads and off the plant material.
6. When the water is running the whole system is easily checked by routine visual inspection.

DISADVANTAGES OF OVERHEAD WATERING

1. Can cause an increase in foliar diseases.
2. Daily overhead watering makes it extremely difficult to carry on an effective pesticide spray program.
3. There is a tremendous investment in irrigation equipment and plumbing supplies.
4. With so much water falling on the blocks, herbicide leaching is a problem which leads to difficulty in weed control.
5. There are problems with erosion from runoff on sloping ground.

6. Difficulty in coordinating work load and water schedule especially during warm weather and heavy shipping periods.

CONCLUSION

We feel that our overhead watering system is the backbone of our plant cultural program. The system is definitely not perfected, but so long as we can continue to produce the type of plants that we have in the past then it is by far the best system for our situation.

LARRY CARVILLE: Thank you, Dave, for taking us to Greenleaf Nurseries and showing us your system of watering. Our next speaker needs no introduction. He is our own Jim Wells, who is going to tell us about his experience with wetting agents and watering.

USE OF A WETTING AGENT TO HELP CONTROL THE APPLICATION AND USE OF WATER

JAMES S. WELLS

James S. Wells Nursery
Red Bank, New Jersey 07701

Good growers have always realized the vital role that water plays in their daily operation, but it is comparatively recently that we have come to know with some degree of certainty how water can affect a plant, can control its development and can change the final result substantially. This we now know to be true in every phase of plant growth.

Our main crop, of course, is rhododendrons, and we have always been aware of the need to control the frequency and quantity of water and to provide growing conditions which would allow surplus water to be removed as quickly as possible. This is true in field culture and even more important in container culture. The need for controlling the growing medium, whether it be in the field or in a can, to as close to field capacity as possible under wet conditions is, of course, based upon the effect of surplus water on the development of the rhododendron wilt disease, *Phytopthora cinnamomi*.

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Our main crop, of course, is rhododendrons, and we have always been aware of the need to control the frequency and quantity of water and to provide growing conditions which would allow surplus water to be removed as quickly as possible. This is true in field culture and even more important in container culture. The need for controlling the growing medium, whether it be in the field or in a can, to as close to field capacity as possible under wet conditions is, of course, based upon the effect of surplus water on the development of the rhododendron wilt disease, *Phytopthora cinnamomi*.

With the high temperatures which are almost inevitable in the growing medium in the can, the need for limiting the application of water and, when applied whether naturally or artificially, to bring the growing medium to full field capacity rapidly is of paramount importance.

Two years ago, while attending the Concord Meeting, we found ourselves seated at the same table with Bob Oechsle, representative of Aquatrols Corp. of America, producers of Aqua-Gro, and he took the opportunity to explain to us in detail what he thought a wetting agent could do, and why we ought to be using it. Simply stated, his arguments were these: if the growing medium is treated with a wetting agent, a relatively small amount of water applied to the top of the growing medium will rapidly disperse through the whole mass and bring it it an even state close to field capacity. If inadvertently a surplus of water is applied, this surplus would rapidly drain out. It was his contention that by using a wetting agent we would attain two things:

1) we would maintain in containers field capacity by the application of one third less water at any given time.
2) if too much water was applied, either naturally or artificially, it would rapidly remove itself by natural drainage through the medium and out the bottom of the can.

These arguments fitted in with what we believe to be an important factor in the growing of our crop in containers and we decided to test this material thoroughly. We learned that it could be obtained in dry form. The wetting agent in this instance is sprayed onto fine vermiculite and when this material has dried, the vermiculite can be mixed with the growing medium and the wetting agent will naturally disperse through the mass in the same manner as if it had been applied in liquid form.

We had a rather remarkable demonstration of the effect of this material when we first commenced to use it. We had mixed up a large heap of peat and grit, our standard growing medium, which had been thoroughly mixed with the tractor bucket. We then obtained the dry Aqua-Gro and commenced to mix in the required amounts and did so to one half of the large heap. At the end of the working day, therefore, we had two fairly substantial heaps of peat and grit resting on the black top. These were conical in shape and were 6 or 7 feet high, each containing probably 20 cubic yards of material. One heap had received Aqua-Gro and the other had not. That night we had a brisk rain with about an inch of water falling through the night. The following morning we commenced work and, using the tractor bucket, dug into the heap which had not received any Aqua-Gro. We found that the rain had penetrated the peat and grit for about 2 feet, but that beyond this point, the center of the heap was quite dry. Examination of the adjacent heap, which had received Aqua-Gro showed that the whole mass was uniformly moist, right to the bottom of the heap.

We commenced using Aqua-Gro 2 years ago, first by dry mixing the material into our canning mix; everything that we canned received this treatment. In addition to this, we have been pursuing a sanitary procedure which requires a regular application of Benlate-Truban. This has to be applied at about 8 week intervals. To this mixture of Benlate-Turban we have also added the required quantity of Aqua-Gro. The crops that are in containers receive essentially three treatments — one at the time of mixing and canning, and at least two further liquid treatments during the growing season.

We believe that this has substantially reduced the amount of water that we have had to apply at any one time. It has allowed the cans to drain out far more rapidly after the application of water,either naturally or artificially,and results have, in our opinion, been quite substantial. It is one additional measure leading to the degree of control of the rhododendron wilt disease.

We believe also that wetting agents have a real value in the successful reestablishment of container grown plants in their final growing position. There is no question that the education of the customer to deal with this problem is going to be a continuous one and this education must flow from the grower through the retail outlet to the final consumer.

We are all agreed, I think, that at the very least the rootball of the container grown plant should be disturbed and loosened at the time of planting, but if the growing medium in the container is also treated with a wetting agent, then the flow of water into and out of this mass is greatly facilitated and the chances of the plant drying out completely in its somewhat isolated mass of special growing medium is much less. All the experiments, therefore, suggest that there is an accumulated value in the use of a wetting agent in all aspects of plant propagation, production, and growth.

LARRY CARVILLE: Thank you, Jim; the use of wetting agents certainly seems to fit into the systems of watering. Our next speaker is Ralph Freeman; he is going to discuss some of the aspects of water quality which we should be thinking about in our operations.

HAVE YOU CONSIDERED WATER QUALITY?

RALPH N. FREEMAN

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The importance of water in plant growth is becoming more appreciated by horticulturists. Today's concerns are not only quantity of water but also quality. Experience has shown that there are great differences in the chemical composition of waters from various sources. Even though water may be perfectly clear, there may be chemical substances dissolved in it that are injurious to plants.

If a water supply is contaminated with a large supply of dissolved chemicals, there is usually a method to counteract this problem. This paper has been prepared to acquaint plant growers with some to the problems that could and have been experienced by many people and to describe, in some cases, remedial action. Finally an orderly sequence of steps is suggested to help correct a suspected water quality problem.

SOLUBLE SALTS

The term, total soluble salts, refers to the presence of dissolved ions in water. A few of the salts in this category are sodium, potassium, calcium, nitrates, phosphates, sulfates and chlorides. High concentrations of ions in the water can damage plant roots, especially if they accumulate in the soil. Symptoms are expressed as chlorosis or yellowing of the leaves, wilting, leaf burn or necrosis, stunting of the plant, slow growth of seedlings or cuttings, death of the plant, and poor seed germination. If soluble salts are high, a complete water analysis will help determine the ion or ions causing the problem(s).

The total soluble salt content of water can be determined by using a Solu-Bridge, Model RD-B15 (Beckman Instruments, Inc., Cedar Grove, New Jersey) Interpretations of total soluble salt content of irrigation water used for growing plants are found in Table 1

Numerous studies have been conducted to determine the effect of various salts on plants. California studies on azaleas (15), China asters (8), and geraniums (11), using sodium and calcium chlorides at high levels had symptoms appear as slight to severe chlorosis of lower leaves, leaf drop and/or necrotic spots. They also showed some varieties are more tolerant to salts than others (11, 15) Excess salts in gardenias resulted in spotty chlorosis and some marginal leaf burn (15).

In azaleas, Pearson (16) reported saline waters produced a bushy, compact azalea plant whereas the habit of growth on plants irrigated with waters of less salinity was not as compact. In Rex begonias the amount of chloride in the leaf tissue increased as the salt content of the soil increased. Under potted conditions, not only Rex begonias but also azaleas showed marked sensitivity to saline accumulations.

Table 1. Interpretations of total soluble salts content of irrigation water as measured by Model RD-B15 Solu-Bridge (Laurie, Kiplinger and Nelson, 1968).

Solu-Bridge Reading	Interpretation
0.00 — 0.25	Excellent
0.26 — 0 75	Good
0.76 — 1.50	Fair
1.51 — 2.00	Permissible
2.01 plus	Excessive (too salty)

Pearson also showed, in the leaf tissue of the Rex begonia the chloride, sulfur and potassium content increased in a 3 month period when plants were irrigated by sprinkling the leaves or applying water to the soil surface. In this study, four different waters were used.

Seed will not germinate properly when soluble salts are too high. This has been reported for many types of seed. Some of them are salvia and verbena (6), alyssum (5) and snapdragon (18).

The effect of increasing salt content on the rooting of fuschia cuttings has been studied. Sodium chloride was added to waters to increase the dissolved solids to 1200, 1500 and 2000 ppm. More than 90% of the cuttings rooted with the more saline waters. However, the number and vigor of the roots in the sand medium decreased as the concentration of salts increased, and some leaf abcission occurred (16).

Hairy-leaved plants such as Rex begonia and some azaleas may be injured by moderately saline waters as a result of sprinkling plants as a method of watering (16).

Experiments on fuschias have shown that roots of potted plants watered with high-calcium waters usually extend throughout the soil mass. With high-sodium waters, the roots are less vigorous and occur more in the upper two-thirds of the pot. Pearson (16) suggested the difference in roots is due to a subnormal nutritional level of calcium or unfavorable soil structure caused by sodium.

HARDNESS

Hardness is caused by dissolved mineral compounds such as calcium or magnesium carbonates, sulfates or chlorides.Most wells yield water with some degree of hardness. Characteristics of hardness are numerous, including high soap and detergent requirement, spotting of dishes and glassware, bathtub ring, scale deposits in plumbing systems, and skin irritation and dryness

The degree of hardness is measured in "grains per gallon" (gpg) or "parts per million" (ppm). Seventeen ppm equals one gpg. A descriptive classification of hardness is found in Table 2. Treatment should be considered if water contains over 6 grains of hardness per gallon. To select the correct size of treating equipment, the degree of hardness must be determined. When selecting equipment to reduce the water hardness, it is essential to select the proper type so sodium is not involved. For example, the Zeolite process for softening water employs base exchange. Zeolite is a granular material charged with sodium. The calcium and magnesium ions in the water passing over the Zeolite are absorbed, and sodium ions go into solution in their place. The sodium in the water results in "softer" water. However, sodium added to the soil, as a result of irrigation, actually destroys the soil structure and de-flocculates or puddles the soil giving it a poor physical condition. In addition, sodium is then used in the plant in place of calcium and forms sodium pectate between the cells which causes the cells to adhere to each other poorly and the roots disintegrate (17).

Table 2. A classification of water hardness.

Description of Water	ppm[a]	gpg[b]
Soft	0-17	0-1
Slightly hard	17-50	1-3
Moderately hard	50-100	3-6
Hard	100-200	6-12
Very hard	200-500	12-30
Extremely hard	over 500	over 30

a/ ppm denotes parts per million

b/ gpg denotes grains per gallon

Another method used to obtain soft water is the de-ionization process. This provides for removal of the calcium, magnesium, and sodium by substituting H-ions. Here, water passes over an adsorptive medium charged with the H-ions, which adsorbs the calcium and other elements, liberating the hydrogen (17).

Complete de-ionization will occur when this water is passed through a second filter charged with OH-ions, which replace bicarbonates (HCO_3), chlorides (Cl), and sulfates (SO_4). The result is first a surplus of H-ions, then OH-ions to form water. This process should be satisfactory for removing salts from water to be used for plants. It is, however, the most costly (17).

ACID WATER

Acid water occurs in and around areas where there is little or no lime in the rock formations from which water is derived. Acid water is corrosive and dissolves metal components of the water system, including the pump, iron and copper piping, unlined pressure tanks and plumbing fixtures. It can cause water to be rusty when the plumbing system contains steel pipes, and it may leave blue-green stains in systems with copper piping.

The symbol, pH, is used to denote the degree of acidity or alkalinity. Values 7 to 0 are increasingly more acid, with 7 being neutral. Values from 7 to 14 are increasingly more alkaline. The most desirable range is about 7.0.

Acid water generally isn't a problem to the plant grower because it can be counteracted by the use of limestone in growing media. The grower of ericaceous plants desires a low pH anyway; and in areas of acid water, he generally adds some limestone ($CaCO_3$) or gypsum ($CaSO_4$) to supply some calcium for plant growth.

ALKALINE WATER

Many areas of the United States have alkaline water, that is, water with a pH above 7.0. Numerous water supplies range between 7.0 and 9 0. Where the pH is over 7.0, problems may arise with some growing plants.

To resolve a problem caused by too much alkalinity, acid can be injected into the irrigation water. The most commonly available acid is 75% food-grade phosphoric acid. Tayama and Staby (20) reported arsenic toxicity on carnations and azaleas from contaminated phosphoric acid. Therefore, it would be advisable to use the food grade. In some cases, 66° Baume sulfuric acid may be used.

To determine the amount of acid to use, a water analysis is needed and the milliequivalents of bicarbonates and carbonates per liter or hardness must be known. Based on this information, it can be calculated how much acid to use per 1000 gallons of irrigation water Before use, the acid-treated water should be tested. If the pH is too high or too low, adjustments can be made downwards or upwards to attain the desired pH.

Tayama and Staby (20) also reported that phosphoric acid can be mixed in most fertilizer solutions without having some of the elements precipitating from the solution. As a further insurance to avoid precipitation, it would be wise to select a double-headed injector so the fertilizer and acid would be physically separate in concentrated form. This type of injector is carried by suppliers as a standard stock item.

BICARBONATES

Lunt et al. (14) observed a depression in iron accumulation in azaleas when bicarbonates were high. This response may have been due to either the action of bicarbonates or to the hydroxyl ions. On a variety of plants bicarbonates have been found to depress the absorption of iron, and in some plants seem to favor the accumulation of monovalent cations (13, 21).

NITRATES AND NITRITES

In Wisconsin, a study by Crabtree, showed that 55% of the 242 private wells tested contained a nitrate level of 45 ppm or more. He also found nearly 70% of 82 wells contained a nitrate level of 45 ppm or more at one time or another within the period of testing, and about 45% of the wells contained in excess of 45 ppm nitrates throughout the year. In this study, the nitrate concentration in the ground water was highest following wet periods and lowest during dry periods with only a few exceptions. There was no clearly defined relationship between high nitrate concentration and depth of wells examined.

However, Crabtree (3) found that, unlike nitrate, nitrite variation showed some relationship between concentration and well depths, with the highest incidence of nitrite concentration occurring most commonly in shallow and dug wells immediately after heavy precipitation. He concluded that the type of well construction (dug, dug and drilled, or drilled) had no significant effect on nitrate concentrations in the wells sampled during the study period. This was partly due to the great majority of wells sampled being old installations constructed prior to the establishment of state well construction codes, which were inadequately cased or curbed for the most part.

Shaw and Wiley (19) in California showed significant variations in levels of the nitrate ion concentration can occur in analysis of water samples collected from the same well. Variations seem to be associated with at least two factors: (i) the time lag between sampling and actual analysis and (ii) time of continuous pumping prior to sampling. A nearly two-fold increase in the level of nitrate ion concentration in water samples from Well 1 occurred after 4 hours, during which the pump was not running, and a 3½-fold increase occurred after 24 hours which pointed to a multiple aquifer source of water. The change in nitrate ion concentration, with time after sampling, suggested that some undetermined factor is involved that changes nitrates to some other form of nitrogen.

Ewart (6) reported verbena and salvia seed require very low nitrate levels for proper germination.

IRON WATER

Red or rusty water can be caused in several ways. If the water has an acid reaction, corrosion in the plumbing system can give the water a rusty taste and color even though the source contains no dissolved iron. The treatment is to neutralize the water to or near pH 7.0.

Dissolved iron in the form of ferrous bicarbonate is a common occurence in ground water supplies. In the ferrous or dissolved form, it is colorless and tasteless; but when exposed to air, it takes up oxygen and changes to ferric hydroxide, a rusty precipitate which is unsightly.

Another cause of rusty water is bacteria. These are living organisms that feed on the well casing, piping, etc. with which they come in contact. They not only damage the water system but add to the iron content of the water. They result in a slimy accumulation in the pipes, etc.

For farmstead and health purposes, quantities of iron greater than 0.3 ppm are objectionable. Plants can probably tolerate much higher levels.

In many areas the presence of iron in the water can be a problem. This is particularly observed in the propagation bench where cuttings are being bathed in a fine mist of water. The iron salts dissolved in water precipitate out when mixed with oxygen. The iron deposits seldom, if ever, cause injury but are more unsightly than anything else.

To remove or control iron, water softening equipment, an oxidizing filter, chlorination-filtration, or a phosphate feeder can be used. A simple oxidizing system is described below. Each method has advantages and limitations.

A simple device which can be used to eliminate the iron from water is similar to a shower in the bath that sends out a very fine mist of water in an umbrella-like pattern a few feet above a sand filter. A windscreen is generally placed around the spray to insure the water falls through the air to the top of the sand filter. The air / water mixture results in oxidation of the water-borne iron ions, and the dark brown iron oxides settle out and are trapped in the fine sand. The resultant relatively pure water percolates through the sand to a storage tank or cistern which will then be used as the water supply. From time to time the sand filter should be backwashed with the de-ironed water floating the iron up through an outlet above the sand.

BORON

Boron is a nutrient required in very small amounts to insure proper growth and development of plants. Occasionally, a greenhouse water supply is found that contains an excessive amount of this element. Davidson (4) indicated it is unusual for excessive amounts of boron to occur in water supplies east of the Mississippi River. However, such waters have been found in New Jersey, Ohio and Illinois (7). Where boron was a problem in excess amounts, it was primarily found in well waters. Occasionally a municipal water supply will have an excess amount. In roses it has been determined that an excess of 0.4 ppm in the water supply may be toxic and result in a marginal leaf scorch.

According to Davidson (4) there is no practical method for treating water to lower the boron content. Demineralizers will not remove boron. The only solution is to acquire another water source. The boron content available to the plants in soils can be minimized by leaching. It is slightly soluble. Also, by keeping liberal amounts of calcium in the soil, the boron is replaced by the calcium on the soil colloids.

Studies by Kofranek, et al. (10) revealed boron levels of 4.8 ppm in the nutrient solution caused poinsettias to develop an interveinal leaf chlorosis, and marginal leaf scorch followed by leaf abcission. It was also found that high boron levels have less effect on plant size than do high salinity levels. The boron accumulation was in the lower leaves.

Symptoms of boron toxicity in azaleas first show as a slight chlorosis and as time progresses, marginal burning and necrotic spots develop on the lower leaves first, then continue to progress to the younger leaves (15). These workers also demonstrated that 'Sweetheart Supreme' is more sensitive to excess boron while 'Mrs. Fred Saunders' was more tolerant to high levels.

SODIUM FLUORIDE

Many municipal water systems are adding sodium fluoride because of the beneficial effect it has in preventing or reducing cavities in teeth. The amount added is very small, usually about 1 to 2 ppm. Many untreated water supplies contain larger amounts from natural sources and do not injure plants.

CHLORINE

Chlorine is found in most municipal water supplies in amounts of 0.1 to 0.6 ppm with a maximum of 2 ppm. The amounts of chlorine reported as necessary to induce injury to greenhouse plants are 5 ppm for sand; 50 ppm for loam soils; and 10 ppm for cut flowers. It is therefore easy to see why water that is safe for drinking is considered suitable for plants.

If chlorine is a constituent of water, a portion of the dissolved chlorine is vaporized from the water before it reaches the soil. This is particularly true if a water breaker is used or a nozzle that breaks up the water.

MARGINAL MINERAL DEPOSITS

Sometimes a marginal mineral deposit will occur on the foliage of plants not being watered overhead. It is possible that exudation from hydathodes will dry at the leaf edge causing crystals of solids in the plant fluid to accumulate. This is not too common and would occur under conditions of high humidity at night and early morning, followed by a rapid drop in humidity at midday.

ALKYL BENZENE SULFONATE

There has been considerable seepage of domestic waste water from thousands of cesspools on Long Island which has contaminated the shallow ground water in many intensely developed surburban areas. Very high concentrations of constituents such as chloride, nitrate, sulfate, phosphate and bacteria are commonly found in ground water polluted with cesspool effluent.

Foaming of ground water withdrawn from the upper glacial aquifer has occured, and in 1961 several flower growers in the Bellmore-Wantagh area of Long Island indicated that their well water was foamy when it came from the faucet. Tests showed that the water had 1 to 2 ppm alkyl benzene sulfonate (ABS), the active surfactant ingredient in many household detergents. As a result of this concern, Bing and Boodley (1) conducted a study to determine if ABS in the water affected the growth of plants in greenhouse soil.

Preliminary experiments with ABS showed no consistently adverse effects on the growth of chrysanthemum, carnation, snapdragon, fuschia, lantana, nephthytis, philodendron, peperomia, and dracena. The soils were treated with 0, 25 and 50 ppm ABS solutions, which are much higher concentrations than could be expected to occur in water available to plant growers. They concluded that water containing enough ABS to be declared unsafe for drinking or cause foaming is probably not harmful to most plants.

Movement of ground water contaminated with ABS on Long Island is about 1 foot per day. ABS is a moderately stable chemical compound and may remain in the ground water for long periods of time. Without additional input of ABS, natural dilution could reduce the concentration of ABS below detectable levels.

SULFUR WATER AND BLACK WATER

Water which containes sulfides yields an offensive rotten-egg odor, has an objectionable taste, and is corrosive. In combination with iron, ferrous sulfide (FeS) gives the water a black color. Treatments for sulfur water or black water include an oxidation-filtration method or aeration. The aeration process is expensive due to the equipment needed, and the water is exposed to the contaminating influence of the atmosphere.

SEDIMENT AND TURBIDITY

In addition to dissolved gases and minerals, water may carry in suspension other foreign material such as clay, rock flour, silt, and organic matter. In size these impurities may range from colloidal particles that remain in suspension for days to coarse sandy material that settles rapidly. The objectionable aspects of waters of these types are undesirable color and taste, and wear and tear on pump impellers and other water treatment equipment.

If correction cannot be obtained by improving the construction of the water facility, some type of filter is needed to separate the suspended matter from the water. A slow sand filter is preferred where adaptable. A second choice should be a pressurized type filter containing graded sand or the replacable cartridge type containing a porous ceramic or fibrous filter element.

POLLUTION DUE TO INDUSTRIAL WASTES

On Long Island the pollution of shallow ground water with industrial wastes is a serious problem in some areas. In 1962 in the south Farmingdale area, the shallow ground water contained as much as 3.7 ppm of cadmium ions and 14 ppm of hexavalent-chromium ions. The US Public Health Service (1962) established drinking water standards for these two ions. They indicated that concentrations of chromium in excess of 0.05 ppm and cadmium in excess of 0.01 ppm are objectionable.

The hexavalent chromium and cadmium were introduced into the shallow ground water as a result of the discharge of industrial metal-plating wastes into shallow recharge basins. The body of shallow ground water contaminated was about 4000 feet long and had a maximum width of approximately 1000 feet. It had a rate of southward movement of several hundred feet per year, and some of the contaminated ground water was discharging into Massapequa Creek.

The effects of cadmium and chromium ions on plant growth are probably unknown, but this is a good example of what can happen to a water supply through carelessness. In this case it has been estimated that the time required for all detectable traces of the contaminants to disappear may be several tens of years or more (2).

SALT WATER INTRUSION

Overdevelopment of ground water in Kings and Queens Counties on western Long Island has resulted in widespread lowering of water levels, 35 feet below sea level. As a result, a landward hydraulic gradient developed causing salty water to invade the fresh-ground-water reservoir. Since the late 1930's, net ground-water withdrawals have decreased in Kings County, and ground-water levels have recovered substantially.

In Nassau County and southwestern Queens County there are three major tongues or wedges of salty water. The deeper wedge has moved inland in response to local ground-water overdevelopment an average of 1000 feet since the early 1900's. The intermediate wedge has not moved as far inland since that time (2).

CONCLUSIONS

This paper was prepared to make plant growers aware of some of the common water problems. In some cases corrective action was suggested. The corrective methods described are not absolute. Since each situation is different, the remedial measures suggested by experts in the field of water quality may be similar to or different from those mentioned.

If you suspect a water-quality problem, there is an orderly sequence of steps that should be followed for the most satisfactory and economical results. The steps are as follows:

1. Obtain a complete analysis of the water, both bacterial and chemical. The results will indicate what is causing the objectionable characteristic(s).
2. Try to eliminate the cause if possible. If this is not a surface problem such as a broken seal on the casing or a lack of surface drainage away from the wellhead, proceed to step 3.
3. Remove the impurities from the water. This is accomplished by filtration, neutralization of alkalinity or acidity, oxidation or other methods. The conditioning of water to remove harmful chemicals may be necessary in some situations, but the feasibility of water conditioning must be determined from a special study of each individual case.

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LARRY CARVILLE: Thank you very much, Ralph. We have time for a few questions.

JIM CROSS: I would like to ask Dave Morrison what type of probe he uses to determine the quantity of water in the soil.

DAVE MORRISON: We use a probe made by Oldfield Apparatus Company, Oldfield, Wisconsin. This equipment pulls a core of soil which we inspect visually and our water men know from experience what the condition of the core should be for the proper water quality.

LARRY CARVILLE: I wish to thank all of the speakers on this morning's program for a group of papers which were well presented and had a wealth of information in them.

FRIDAY AFTERNOON SESSION

December 9, 1972

The afternoon session convened at 1:30 p.m. in the Terrace Room of the Hartford Hilton Hotel with Mr. Michael Johnson presiding.

MIKE JOHNSON: The purpose of this symposium is to compare how three East Coast nurseries propagate rhododendrons and grow them on in containers.

As the three of us give our individual papers, it might be well to keep a few things in mind in order to put our different methods into perspective. One of the most obvious differences between our three operations is the nursery location. The Conard-Pyle Company, represented by Dick Vanderbilt, is the most southerly, being in the general area of Wilmington, Delaware. The Wells Nursery, represented by Jeremy Wells, is in central New Jersey. Summer Hill Nursery is in southern Connecticut. I was quite surprised, however, when looking up the average number of frost free days for the three different areas, that we only vary about 5 days. The length of the growing season is a factor that is not as great as one would think from looking at a map. However, I am quite sure that there are some differences in the overall climatic factors between the three areas and, no doubt, the other two nurseries have much higher summer temperatures than we do at Summer Hill, and an early unusual freeze would be a bit more likely in Connecticut.

Another factor is that Conard-Pyle and Summer Hill have been growing rhododendrons in containers for a number of years whereas the Wells Nursery, although growing other items in containers for quite some time, are only now getting into full scale production of container-grown rhododendrons and, therefore, perhaps have a little different outlook on things at this time.

As to our original methods of setting up container operations, keep in mind that Conard-Pyle is an old established nursery with larger capital resources than the other two nurseries; that can make a big difference on how things are done initially. Also, at the Wells Nursery, rhododendron is King, being the major part of their production and they are treated a bit differently than at Conard-Pyle or Summer Hill, which produce many other species of plant material, and where rhododendrons sometimes have to be worked in around another crop.

The first speaker will be Dick Vanderbilt from the Conard-Pyle Company, followed by Jeremy Wells from the James S. Wells Nursery— and I will speak last. After the presentations we will open the floor to discussion.

RHODODENDRON PRODUCTION SYSTEM AT THE CONARD-PYLE COMPANY

RICHARD T. VANDERBILT

The Conard-Pyle Co.
West Grove, Pennsylvania 19390

Our rhododendron production system was discussed in detail at the 1967 meeting. We have made some changes since and I am sure that our system is about to undergo more changes in the near future. We maintain a separate, but unequal, stock block for cutting material. We aim for good growth, but a low level of nitrogen in the cutting when it is stuck. We are using both single and multiple cuttings depending on available stock.

Cuttings are stuck in peat pots, 2½" extra deep. When we transplant we are very careful to remove this pot completely. We have found that peat pots can cause a lot of grief later on if we do not do this. Even when the rhododendrons appear to be aggresively rooting out of the peat pot, they are making a circular root system that causes them to be pot bound and most reluctant to go into a new medium. The reason we stick with peat pots is to do away with hauling medium in and out of the houses.

We transplant in December or January into a 48 fluid ounce plastic container. It is actually a container made for Riccota cheese which you may have seen in supermarkets. It is 7" deep and the roots use all of it.

After transplanting, we chill the plants for 40 days, trying to stay under 40° F but taking what we get in the way of sun heat. After the chilling period, we raise the heat to 65° F night and use cyclic lighting. We begin constant feeding at this time. In the transplanting mix of 75% peat and 25% perlite we add 3 lbs. of dolomitic limestone. This helps prevent an ammonia build up by enabling nitrifying bacteria to go to work because of the rise of the pH.

We can the plants in June, into a 3 gallon Swiss cheese pot. We are now using a mix of 60% peat moss, 40% sand. It is in this area that I believe we might change our system. Impressive work is being done by Dick Bosley, and separately by Drs. Hoitink and Gardner, in the use of hardwood bark as the major component. Bark is producing fantastic root systems for these people, better than anything I have ever seen with peat moss. Dr. Hoitink is filling a 3 gallon Swiss cheese pot with roots in 3 months. It looks to me that a 55 gallon drum would be the logical container for a 2 year old! We maintain our feeding at 100 ppm N P K until the plants are sold a year from the next spring. We are using Benlate and Truban as drenches and find them useful. Our spray program includes Manzate D, Phaltan, Diazinon and Kelthane. The rest of our system is the same as I described at the 1967 meetings.

A SYSTEM FOR PRODUCING RHODODENDRONS

JEREMY WELLS

James S. Wells Nursery Inc.
Red Bank, New Jersey 07701

As we are a specialist grower, our problems are unique. We have three major cash crops: rhododendrons, deciduous azaleas and evergreen azaleas; 95% of our income comes from these crops. Thus, it is imperative to keep certain production procedures definite in our planning:

1. The plants must be alive, healthy and in good salable condition at the end of the growing season.
2. The crops must be sold at a variety of ages and sizes.
3. Management must carefully plan to see that the first two criteria are met with the least amount of expenditure in labor, time and money.

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2. The crops must be sold at a variety of ages and sizes.
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The control of disease has become very important throughout every phase of rhododendron production, especially propagation. Strict sanitary procedures, plus the use of certain chemicals, has produced a great reduction of disease incidence. Our propagation takes place between May and December. When the propagation houses are empty in April, we wash them down with a solution of chlorine granules in water. The houses are then fumigated with formaldehyde at the rate of 1 gal of 100% concentrate per 50 gal of water. They are then sealed for 24 to 48 hours and are aired for an equal amount of time. Fifty percent peat and perlite is placed in the benches and again formaldehyde is sprayed lightly on top of the medium. Houses are then sealed and aired for 24 hours, respectively.

There are approximately 25 to 30 different hormones used in our propagation. These have been developed over years of testing and observation; the proper hormone is used on a variety to produce the highest percentage of root initiation. The basic hormone is indolebutyric acid plus other hormones, according to the variety being treated, plus a 5% Benlate fungicide additive. After wounding, the cuttings are stuck into containers, flats or benches under intermittent mist, the initial mist period being 6 sec every 3 min. The mist is applied according the conditions of the day; clear, sunny days will have more mist than dull, rainy days. Our mist is controlled by a time clock; it is a Tork unit with a 24-hour clock and a 6-minute timer. An electronic leaf unit is used during the summer in our outdoor mist beds. The cuttings are watered-in with a solution of Benlate-Truban fungicides in water which are mixed at the rate of 6 oz/100 gal of water. These two fungicides are an important part of our sanitary procedure both in the greenhouse and container area. Root initiation should take place within 5 to 6 weeks and cuttings should be ready to move within 8 to 10 weeks. During this time the cuttings will be weaned until misting is approximately 6 sec. every 18 min. After 10 weeks, all cuttings which are ready to be moved will be placed in 4 inch cedar flats containing a peat and perlite mixture, the ratio being peat; perlite, 2:1. Any cuttings that do not have a proper root ball will be re-stuck into the rooting medium, hopefully to be ready within another month. All flatted cuttings will be watered-in with Benlate-Truban and with 2 lb of 20-20-20 fertilizer per 100 gal of water. It is at this point that our production methods deviate into two different paths.

CONTAINER OPERATION

Because of our moderate size, we find that not only are we maintaining a container operation as well as a field operation, but that we are intermingling the two in order to follow land rotation procedures. Because field work can only be done in frost-free conditions, we try to do as much of our canning in mid-winter, requiring all plant material, containers and canning mixes to be available ahead of time. Plastic houses must also be available to take the newly canned material. All rhododendrons are canned into a peat-grit mixture at the ratio of 60% peat to 40% grit. The mixture has 5 lb of lime and 24 oz of granular Aqua-gro wetting agent per cubic yard. Any mixture that is to go into 1 gal cans will have 6 lb. of powdered superphosphate incorporated into it. Older plant material that will be canned into larger containers will have 6 lb. of coarse MagAmp fertilizer incorporated into the mixture. All plants will be treated with Benlate-Truban fungicide after canning. The plants are then placed in plastic houses on a gravel base with a permanent overhead watering system. At the beginning of the growing season the plants will be fed through a proportioner with an injection ratio of 1:200. The plants are fed every watering with 20-20-20 soluble fertilizer at the rate of 200 ppm nitrogen. With our proportioner this figures to be a stock tank of 83 lb fertiler in 50 gal of water. Our liquid feeding is mostly done in the late afternoon, early evening or early morning. At these times, weather conditions are such that the calm air will allow for even distribution from the overhead sprinklers. Our feeding schedule continues throughout the summer, changing according to the needs of the plants. This is determined by a weekly soil test that is sent to a laboratory telling us all required statistics and giving us the proper information for future feedings. Fertilizing ends in the early weeks of September.

FIELD OPERATION

We maintain a land rotation for our field crop. The one-acre blocks that will take our liners and 3 yr old plants will be rested for one season. In this time, manure and two summer cover crops of Sudan grass and one cover crop of winter wheat are incorporated into the land. In the spring, the land for our liners is prepared by fumigation with Vapam. This takes place at least 4 wks before actual planting. Two or three weeks after fumigation, the land is opened up to allow aeration of the fumigant and to permit the construction of the raised beds. This is accomplished by first marking out the acre for all walkways between beds. Then a specially constructed plow secured on the back of the tractor plows the walkways out, raising the beds. We try to maintain 34 to 36 beds, 150 feet long per acre block. The beds are then smoothed and rototilled in order to get them into a friable planting condition. A dressing of 5% Benlate is then put on the top of the bed and it is then marked out with specially constructed markers so that we can plant approximately 1200 liners per bed. Two men work on either side of the bed and plant to the center; this reduces compaction and allows the young liners to re-root rapidly. All young liners are shaded as they are planted with a 50% lath shade with these units remaining for one full season and being removed at the beginning of the second season.

The planting of larger material takes place in the same manner with the following exceptions: One, we do not provide shade; two, the plants are planted in the fall; three, the plants will remain in the field for a period of 3 yr as compared to only two for the liners.

Weed control is very important in any nursery. It is of vital importance to us because we do not have the large amount of labor to control it by hoeing. All field areas that remain undisturbed over the winter are treated with Casoron at the rate of 100 lb/A. In early April, we begin a very intensive program with 5% Dacthal granules. They are applied at the rate of 4 lb/1000 sq. ft. every 30 days; this rate is lower than the recommended dosage. This procedure is done because we feel it to be very important to be constantly observing the conditions surrounding the crop so that no problems will catch us by surprise. We maintain this schedule of weed control on containers and field plants expecting about 85% control of weeds; in the field the remainder are killed by the use of Paraquat in knapsack sprayers. The remainder in containers are removed by hand.

The control of insects is also important. We follow a very stringent spray program, spraying every 30 days from March 1 through September 30. Included in this spray are two to three general insecticides, two fungicides including Benlate, as well as chelated iron and manganese, and soluble 20-20-20 fertilizer. Additional chemicals may be added at certain times to control specific insects.

SYSTEMS FOR RHODODENDRONS

MICHAEL D. JOHNSON

Summer Hill Nursery, Inc.
Madison, Connecticut 06443

At Summer Hill rhododendron production accounts for about 40% of our business. We are at present propagating between 60 and 80 thousand rhododendrons a year. This involves 14 varieties of Catawbiense hybrids and seven varieties of what we call small-leaf varieties, such as 'Purple Gem' and some of the Carolina hybrids. These are all produced from cuttings taken primarily in October. We also grow a relatively small quantity of Carolina rhododendrons which are propagated from seed. However, I will not get into our seedling production as it is such a small item with us.

Our rhododendrons are sold as three basic size crops — 1 gal containers, 2 gal containers and half-bushel baskets. It all starts, of course, with propagation. We do not have a stock block but take our cuttings from 1 and 2 year old plants that are in production. We feel this gives us a far superior cutting to cuttings taken from old stock plants. They usually root readily and we shape our plants that are in

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Most of you saw our propagating houses on the tour. They are cement block houses, 11 ft wide, with two 4 foot benches and a 3 ft aisle in the center. They are covered with Amerex UV polyethylene which allows good light intensity. We use mist, run by a time clock, approximately 6 sec every 6 min. Our rooting medium is two parts German peat to one part coarse perlite. The medium is about 5 inches deep with bottom heat; we try to keep it about 75° F. However, we will, on occasion, push the bottom heat up to 80° F if rooting appears to be slow.

Some of these cuttings should be rooted well enough so that we can start transplanting in January. We continue to transplant, as the different varieties are rooted well enough, right through February. We transplant the cuttings into the same medium (2 parts German peat to 1 part coarse perlite) in larger polyethylene-covered houses. Catawbiense hybrids are spaced approximately 4 inches apart — small-leaf varieties, closer together, depending on their size. 'Purple Gem' are generally put in flats — 48 to a standard 20 x 14 in. flat. All the other varieties, however, go into benches that are about 5 inches deep. We keep these houses at approximately 40° F until the end of February when we push the heat up to 70° F. We are looking for one flush of growth and no more, as our 4 inch spacing will not allow it.

All these rooted transplants will be moved into 1 gal containers in June. The medium in the can is one part Canadian peat and one part coarse sand. Catawbiense hybrids are spaced in beds — five plants across a 4 ft bed. They are given no shade and, although the leaves do sunburn to some extent we find in our climate that shading is not necessary. The small-leaf varieties are placed out in beds, can-to-can, as the growth the first year does not warrant spacing. These are shaded for 2 to 3 weeks with snow fence, as the shock of coming out of the greenhouse can be a bit too much for them in certain years. All plants are pinched between flushes of growth or, in the case of the small-leaf varieties, sheared with hedge shears.

These plants are fertilized, as are our 2 and 3 year old plants, through irrigation water once a week. We mix our own fertilizer using urea, mono-ammonium phosphate amd muriate of potash. The rates of the different materials vary with the time of the year. In early spring before growth starts, and in the fall, the rate of urea will drop as low as 30 lb/A. However, in early summer when growth is optimum we push the urea up to 80 lb /A/wk. Mono-ammonium phosphate remains standard at 50 lb/A/wk throughout the season, but muriate of potash is raised from 25 lb/A/wk early in summer, to 50 lb/A/wk during late summer and fall. Irrigation is from a pond and can be daily during the middle of the summer, depending on weather conditions, and is of course reduced in the fall as needed.

Many of the Catawbiense hybrids are sold in 1 gal cans at the end of this first year. However, the great majority are transplanted the following spring into 2 gal cans or half bushel baskets. The mix for the 2 gal container is the same as the 1 gal , that is, 1 part Canadian peat to one part coarse sand. They are handled the same way as the 1 gal container, pinched after the first flush of growth and, of course, spaced further apart. Some varieties should be well budded at the end of the second year; however, we sell our 2 gal cans as vigorous 2 yr old and do not promise buds. The balance of the 1 gal containers go into half-bushel baskets. These are baskets made specifically for this purpose by the Marshall Basket Company, Marshall, Texas. They are treated with copper naphthenate and we expect them to last 2 years The medium we use in the baskets is different from that used in plastic containers. It is 2 parts native peat, similar to what is known in the trade as Michigan peat, and 1 part sand. Since the native peat has a very low pH, we add 5 lb of lime per yard and, since there is also a very high weed content in the native peat, we mulch our baskets with an inch or so of sugar cane. These are placed basket-to-basket for the first year in beds that will allow them to be covered by a 14 ft quonset without moving the baskets. They are pinched as needed and a good many of our cuttings come from these plants, thus shaping them before their final growing season. The second year in the basket, they are spaced approximately 2 ft apart and should give us well-budded plants up to 2-½ ft, depending on the variety.

Small-leaf varieties, are handled exactly the same way except they remain in the 1 gal can for a second year and a larger proportion of them are sold in this size. For instance, all our *Rhododendron impeditum* are sold in 1 gal.

In regard to winter protection, all these rhododendrons are covered with polythylene in mid-November. We use clear polyetheylene but give it a light coat of latex paint as soon as the greasy sheen is washed off. Most of our quonsets and A-frames need one or two irrigations throughout the winter depending on weather conditions that particular winter Our houses are sealed houses with no ventilation in order to conserve moisture. One problem we've had in certain winters is an excessive build-up of moisture on the leaves of certain varieties. This can be disastrous if the temperature drops very low while the leaves are in this condition. We find that by venting each end of our quonsets when we see this condition starting, we manage to get the water out of these leaves and solve the problem. Using overhead irrigation, as we do, insect control can be somewhat of a problem as we are constantly washing insecticides away with each irrigation which means we have to keep our eyes open and spray a bit more often than under normal field conditions. Diseases, fortunately, have not been a great problem for us as yet. We have had some trouble with *Phytophthora cinnamomi*. However, this seems to be definitely related to the aeration of the medium. The only variety that we've had real trouble with is *Rhododendron laetevirens*, (R. Wilsonii). We have tried using some bark in the medium; however, the results so far don't seem to warrant a change from our present methods.

We do not use any herbicides on our containers and rely on hand weeding to keep the containers clean. However, we do use a great deal of Simazine, Treflan and/ or Casoron around the outside of our container area in order to keep down the weeds that would be producing seeds that would blow into the containers and, as I stated before, we also use sugar cane mulch on the baskets.

We do not believe that our method is perfect or the right one for everyone else to use. There are improvements we would like to make but in some cases we cannot because of our limited space or conflicts with the production of other items. We feel that what we are doing now is the right method of production for us, although 2 or 3 years from now we might be doing things quite a bit differently.

MIKE JOHNSON: Now that the three of us have had our say, we will give you a chance.

PETER VERMEULEN: I would appreciate having you and Dick comment on your systems of cutting choice.

DICK VANDERBILT: As I stated, we maintain separate stock blocks and we stop feeding in the middle of July. By doing this, the cuttings have hardened off by the first of September and we can go in and cut whatever we need for cuttings; we do not have to wait for the tissue to harden off any more. We handle the stock block so as to get long cuttings and a lot of multiples. The stock block will set flowerbuds in July. We go through and knock out the flowerbud and get two, three and sometimes four breaks on the cuttings. This gives us a branched rooted cutting; if I did this on my saleable plants I soon would not have any. I believe I can bud the saleable stock better and root the cuttings better by treating the two on different programs.

MIKE JOHNSON: I do not use a stock block because I feel it takes up too much room and, with the type of terminal cutting we get from container-grown plants, we get more buds around the terminal. I have observed where they do use a stock block they take cuttings from the lateral parts of the stock plant and may have only two buds, whereas terminal cuttings from our container stock will have as many as seven or eight. In addition, our system helps us in the shaping of our plants With our system our houses are so full of other materials that we cannot start sticking rhododendron cuttings until October. By this time, the wood is ready and it works out as a nice progression for us

JEREMY WELLS: I feel that Dick and Mike are too concerned about their type of cutting. We get the wood which is good at the time it is ready, I think this is the most important thing. I am not too concerned where it came from, whether it be a stock plant or a container plant. Then one must carry on with good growing procedures to get a saleable plant.

JOHN AHRENS: Mike, would you comment on the weed control you use in your ponds?

MIKE JOHNSON: At one time, our pond got so weedy that we could hardly get water out of it and so we called on John Ahrens for his advice. He advised using Casoron at the rate of 200 lb/A of water. We apply this with a cyclone seeder from a row boat in November. We now use it on all four ponds and have no weed problem with them. The residue remains in the water for about 3 months and so this must be done at a time when the pond is not going to be used for irrigation.

ARIE RADDER: What about copper sulfate for weed control?

JOHN AHRENS: Copper sulfate is strictly for algae control and Casoron is strictly for higher plant control.

GIED STROOMBEEK: Mike, you mentioned the effectiveness of your spray program was reduced by the amount of irrigation you have to use, I have been using a new sticker which I feel is quite effective since it seems to cut down the frequency of applications required by almost one-half. It is called Newfilm 17 and is made by Miller, the same people who make Vapogard.

CHARLIE SCHEER: I believe the active material in these compounds is pinolene, a resinous material which forms a vapor-proof coating

JIM CROSS: Would one of you on the panel who is using Benlate and Truban comment on the rates at which it should be used?

DICK VANDERBILT: We use Benlate at the rate of 8 oz / 100 gal once a year. We now use Truban emulsified which we feel is superior to the wettable powder. I believe the rate we use it is 32 oz / 500 gal and this is applied every 6 to 7 weeks.

JEREMY WELLS: We feel that there are two times when it is particularly important to use Benlate and Truban. The first is when the unrooted cutting is stuck into the bench or container and the second is when the rooted cutting is moved to either containers or flats.

BRUCE BRIGGS: Have any of you on the panel tested either Benlate or Truban at one half the rate — that is, about 3 oz / 100 gal?

JEREMY WELLS: We did not test it as such, but we did use the material at one half the rate and it did seem to be effective for us.

BRUCE BRIGGS: When taking your cuttings do any of you on the panel pinch out the terminal bud to give branching when the cutting roots?

JEREMY WELLS: We try to remove the terminal bud on all of our cuttings because we get much better rooting and we have a branched plant when the cutting does root.

HARVEY GRAY: I have removed the terminal bud for the past 15 years but recently I began allowing the bud to break and grow out to about 3 inches and then pinching it back close to the cluster of leaves, all of the encircling buds will break and we get a very well branched plant.

ARIE RADDER: I wish to make two comments. Someone mentioned that Phygon is no longer available, but this chemical is now available from Niagara under the name Dichlon. We also tried Newfilm 17, but found it very expensive. Miller makes another compound called Miller's Aid; we found this nearly as effective and less expensive. Also, I should comment that in a publication I received from Boskoop they report that there is some caution needed when fungicides and hormones are mixed for rooting. They find that under certain circumstances, these materials used together can reduce or slow up rooting; they use bottom heat of 64° F for the initial rooting and when the cuttings are callused or rooted, they increase the bottom heat temperature to no higher than 67° F.

WAYNE MEZITT: Mike, with all of the work which John Ahrens has done, why do you not use herbicides in your containers?

MIKE JOHNSON: Basically, we are still afraid of them and if we can get by without using them I would just as soon do that.

JEREMY WELLS: Two or three years ago I looked over our records and found that we were spending between $10,000 and $11,000 for labor to pull weeds and still had a lot. We had used Casoron on containers but we were afraid to apply it in March when they would be under poly so we went to Dacthal. It does not give us complete control, but one man can go out and pull the weeds which are missed from 10,000 cans in 4 hours. This is a considerable saving over what we were doing. We used the 5% granular material at a rate of 4 lb/A every 30 days.

MIKE JOHNSON: We are going to have to cut off questions at this point. Any further questions can be put into the Question Box.

At this time, we are going to have papers by Bruce Briggs and Dr. Wott concerning how to attract young people to horticulture. Bruce will discuss this from a nurseryman's view and Dr. Wott will discuss it from a University view; we will begin with Bruce Briggs.

ATTRACTING YOUNG PEOPLE TO HORTICULTURE — FROM A NURSERYMAN'S VIEW

BRUCE A. BRIGGS

Briggs Nursery
Olympia, Washington 98501

As a nurseryman, I am interested in attracting young people to horticulture for more than one reason. First, as potential customers, as citizens who are sympathetic to our industry's goals, and as citizens who are concerned about creating a better life in a better world. Then, I would also like to interest more young people in continuing further research in horticulture and in becoming an active part of some segment of the industry.

As members of the I.P.P.S., we can go back to our motto "To seek and to share". We can start by seeking more knowledge, better techniques, additional applications and new fields of endeavor. We can share this knowledge, the materials with which we work, and our own enthusiasm for horticulture. We can use the current interest in ecology to advantage and share our knowledge with those from other fields who have just recently jumped on the ecology bandwagon. By serving on planning boards for parks, cemeteries, highways and cities, we can help create beautiful surroundings in our communities. We can bring our children into an environment made more pleasant and interesting by the presence of trees, shrubs and flowers We can, in a sense "condition" them to want and to expect these beautiful surroundings wherever they may go.

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Briggs Nursery
Olympia, Washington 98501

As a nurseryman, I am interested in attracting young people to horticulture for more than one reason. First, as potential customers, as citizens who are sympathetic to our industry's goals, and as citizens who are concerned about creating a better life in a better world. Then, I would also like to interest more young people in continuing further research in horticulture and in becoming an active part of some segment of the industry.

As members of the I.P.P.S., we can go back to our motto "To seek and to share". We can start by seeking more knowledge, better techniques, additional applications and new fields of endeavor. We can share this knowledge, the materials with which we work, and our own enthusiasm for horticulture. We can use the current interest in ecology to advantage and share our knowledge with those from other fields who have just recently jumped on the ecology bandwagon. By serving on planning boards for parks, cemeteries, highways and cities, we can help create beautiful surroundings in our communities. We can bring our children into an environment made more pleasant and interesting by the presence of trees, shrubs and flowers We can, in a sense "condition" them to want and to expect these beautiful surroundings wherever they may go.

Then start working with youngsters at the earliest possible age, — at home and in pre-school, kindergarten and grade school classes. Share with them the thrill of seeing a seed sprout, of seeing a flower turning into a seed pod, or of seeing a bulb coming to life and flowering. Have plants and flowers inside and outside the home. Give green and growing gifts. Promote the use of plants in schools, stores, restaurants and public buildings. Offer school and other youth organizations field trips to nurseries, greenhouses, arboretums and parks. Furnish them the raw materials and the know-how for small projects. Stir their imaginations with something new and exotic and motivate them to seek out more information. Share with them your enthusiasm and pride in your industry.

Schools are traditionally short of funds and supplies. We can help bridge this gap by working on advisory boards in planning the science facilities. Often schools do not include horticultural programs because they think in terms of elaborate and costly greenhouses beyond their means. We can work toward getting good basic laboratory areas which are adaptable to more than one science subject. Then we can show them how to get the students involved in building their own poly houses, propagating benches, heating and cooling systems, etc. We can contribute without too much cost some plant materials: soil, pots and the use of small equipment. We can use our know-how to help them structure workable projects. We can help set up plantings in the available areas which can be used as small arboreta or areas from which to collect specimens for the botany classes. We can provide help with the landscaping when it must be done on a small budget. We can help "build-in" horticulture as a part of everyday life in other than science classes, such as in health, home economics, psychology and sociology, art and interior decoration.

In our local junior high school, we have a vocational career week in which students may choose a field of interest and actually work several days in the operation. Students who have come to us through this program usually have had very little horticultural background but invariably develop enough interest to request part time jobs after school and during vacations. Even slow learners may find that special interest which may motivate them with an effort which, in time, will reward them with a productive place in society.

For two summers, we have worked with a special group of slow learners from our local high school. With the cooperation of the school system and the federal government, and the excellent direction of two very understanding teachers, 14 students spent 8 weeks working at our nursery for 6 hours each day. We had practically no discipline problems and the honest effort put forth by these children was an inspiration to our more gifted workers. Some of the students were able to work under our supervisors and some functioned well only under their own teachers. These teachers analyzed the various jobs, wrote specifications, then measured achievement in speed and quality against the norm of our regular workers (1). Since then, we have employed several of these students on a part time basis and others have moved on to successful employment in other fields.

In the high school, the vocational agriculture teacher is usually very receptive to help and is often also the sponsor of the Future Farmers of America group. A Vo-Ag teacher in our state arranged a regional horticultural contest which has become an annual affair. Our chapter of the Washington State Nurserymen's Association has helped put on this contest by furnishing plant materials for the plant identification test, by helping write the test questions, and by having several nurserymen present on a Saturday to conduct the contest. Ribbons for the winners created enough incentive for quite a keen competition among the participating high schools.

The increased emphasis on horticulture in the lower grades of recent years has naturally resulted in more students looking for additional courses to pursue on the junior college and vocational school levels. The Vocational Education Act of 1963 set up federal funds which could be used to help set up vocational programs of ornamental horticulture. In 1964 and 1965 the American Association of Nurserymen sponsored a study to foster greater industry-university cooperation with the goal of improving the image of the nursery industry and of upgrading the industry itself. The project was titled Project BIG to implement Better profits, Improved image, and Greater personal satisfaction. A number of A.A.N. and I.P.P.S. members participated in this project, with Tom Pinney as chairman.

By the way, for those of you who may not be familiar with the work of the A.A.N., we recommend it as a source of information on almost every aspect of the horticultural trades (2). They have published promotional hand-outs in cartoon form and color books for the younger set, career phamphlets for the students, courses of study for the teachers, and studies of operational problems for the tradesmen. They have actively promoted horticulture to the public through such projects as Youth Gardens and "Green Survival".

A major problem in setting up additional horticultural programs in high school and junior college has been the lack of teachers with adequate horticultural knowledge. In our state, the W.S.N.A. cooperated with the state Coordinating Council for Occupational Education in conducting a survey to determine the needs (3). A number of meetings in Washington and Oregon were held to help retrain some of the agriculture teachers form the traditional general farming practices to more specific information on horticultural crops. Nurserymen helped in the training at special night and summer vacation sessions. With the limited trained teachers available, it became expedient to work toward creating a few well distributed programs with some depth, rather than attempting to put a smattering of horticulture in every community college.

In the upper levels, part time and summer work programs can provide an interesting exposure to horticulture for the student and provide seasonal help for the nurseryman. With the high school and junior college students, we try to break up a day of routine work such as weeding, with something more interesting. We find that boys of this age group usually prefers heavy lifting type work or using equipment, while the girls usually do better with the small and detailed work around the greenhouses. We ask them to do a good day's work, but try to give them an attainable goal and something more challenging to think about.

We have had summer programs for college students for several years. This can result in college credit with the cooperation of the schools. In summarizing our experiences with students at this level, we would advise: 1) have a minimum of three students, all from different schools; 2) give them as wide a variety of work experience as possible; 3) require them to work to achieve on a level with your regular personnel; 4) conduct frequent question and answer sessions; 5) take them to as many open houses, field days, and nursery meetings as possible; 6) help them meet and have an opportunity to talk with people from all segments of the horticultural field.

You people teaching and writing in the universities, and you businessmen conducting successful enterprises, perhaps do not realize how much it means to these people to have the opportunity to meet you and to talk over their problems and their aspirations. Meeting a professor, such as Dr. Hartmann, can put new meaning into his fine book on propagation. Having a discussion with a professor such as Dr. Tukey can help bring fragmented ideas into sharper focus, and meeting an industry leader such as George Oki can help students better define their goals.

Yes, I do believe that we can best accomplish our goal of attracting more young people to horticulture by following our own motto "To seek and to share". For in seeking, we can open new fields and opportunities for these students to pursue, and in sharing, we can pass on to them the knowledge and technology of our generation and create an enthusiasm and vision to carry them on beyond our present day accomplishments.

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ATTRACTING YOUNG PEOPLE TO HORTICULTURE — FROM A UNIVERSITY VIEW

JOHN A. WOTT

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What is horticulture? Bailey describes "horticulture" first of all, as "the cultivation of a garden or orchard"; then secondly "the act of growing fruits, vegetables, and ornamental plants". Thus literally, horticulture means "garden culture". How do we interest young people in "garden culture"?

HISTORY

Historically, the region of Mesopotamia was one of the cradles of horticulture. The valley of the Euphrates became the land of palms, dates, figs and, in short, "The Garden of Eden". Tree worship or dendrolatry grew up here because the palm meant so much in the lives of the people for food, fuel, shelter, textiles, drink, etc.

Archeological records from Assyria show symbolic religious use of pollen and pollination methods; in short one of the phases of the Chaldean culture. The Chaldeans were followed by the Assyrians and Babylonians who extended their civilization into Egypt. The Babylonians cultured the beet, lettuce and radish. Wheat and dates were agricultural staples and rent for land planted with dates was worth five to seven times land in wheat.

The Phoenicians were important in establishing contact with the rest of the world, even to England. This trade was valuable as a means for the dissemination of seeds, plants, and horticultural products.

In 6000 B.C., Crete was inhabited by cave dwellers who had no form of agriculture except cattle raising. But about 3500 B.C. trade

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In 6000 B.C., Crete was inhabited by cave dwellers who had no form of agriculture except cattle raising. But about 3500 B.C. trade with Egypt began and we found bean, fig, plum and quince were being cultivated.

The Greeks were influenced by the Cretes. Not a rich country, Greece flourished by trading. Wine, olive oil, and flowers became very important commodities for the Greek's luxurious life.

Theophrastus Erocos, a pupil of Plato and later Aristotle, is noted as the greatest botanical writer prior to the 16th century. He gave accounts of strange plants in quite academic fashion in an attempt to classify them. He studied leaves and roots and noted that leaves were of some benefit other than for shade and the roots served as more than just anchors. He described the apple, pear, cucumber, and pomegranate.

He was also noted for his propagation techniques. He used asexual propagation methods, wrote of the variation of seedlings which produced fruit inferior to the mother fruit and advocated the removal of dead wood only except when trees were old and poor. He mentioned grafting.

Much later (65-68 A.D.) Diascorides, a Greek in the Roman Army, worked as a surgeon. He wrote concerning the use of plants for their medicinal purposes. His work was considered an authority for 1500 years. He recommended herbs for deadening pain.

The Romans, too, were keenly interested in horticulture. Virgil's four books of Georgics in verse represent the best literature on Agriculture. He mentions cleft grafts, budding, and some grape varieties. The purpose of the works was to encourage a "back to the farm" movement to try to eliminate some of the excess population of Rome, a government propaganda move.

Then we skip rapidly through the Dark Ages — 450 A.D. to 1440 A. D. — during which learning and knowledge decreased.

In Europe, beginning with the 1500's, again an interest in plants by druggists and doctors for medicinal purposes began to flourish. We have many references or "herbals", the books written to describe and reference plants, but from the medicinal viewpoint. Many herbals also contained information on the culture and propagation of these plants.

From this wealth of plant information several systems of classification were developed. The Linnean, or Artificial system, was developed by a Swedish doctor, Carolus Linneaus, who at the age of 32 was already the author of 14 botanical works.

Thus we see horticulture's original meaning was concerned with the basic production of fruits, vegetables, and ornamentals. Today we know it to be much more complex.

PRESENT

Horticulture is either a vocation or an avocation. It involves the propagation and use of plants and their products, exclusive of agronomic and forestry crops. The diversity of horticulture crops is staggering, — asparagus, flowering dogwood, pineapple, peonies, poinsettias, catnip, and bonsai Horticulture is an exciting and dynamic field.

We must realize that the abundant supply of fresh fruits, vegetables, flowers and ornamental plants in our supermarkets and nurseries just didn't occur like magic. Fifty years ago, few Americans could eat fresh strawberries in the winter, buy sweet corn in March, enjoy potted chrysanthemums for table centerpieces on the Fourth of July, or plant a dwarf fruit tree in their penthouse garden. These "miracles" are the result of the study and practice of horticulture.

The science of horticulture has taken the worm out of the apple, the scab off the pear, the mildew off the rose and the seed out of the watermelon Scientists in the field and in universities have created new plants and new varieties to improve the appearance, taste and nutritional value of foods, to add color to fruit tree blossoms, and to nurture trees along city sidewalks and in public parks and forests.

Horticulturists have designed storage facilities which provide year-around seasonable fresh fruits and vegetables, bring flowers into bloom for off-season enjoyment, improve fruits so they can be harvested more efficiently by mechanical means, lengthened the planting season of ornamental trees and shrubs so, in some areas, planting can continue anytime the ground is not frozen.

A new type of horticulturist, in great demand today, is the landscape manager. This person must combine the knowledge of plants, art and design to plan functional, aesthetically appealing landscapes and then he must have the capability to efficiently manage them. In many of our urban landscapes, it is truly a challenge to get plant material to thrive or grow, let alone survive.

A comparatively new field, and one with which many horticulture departments have been actively involved is landscape architecture. Landscape architecture is the planning and design of the physical environment of man as it relates to the land, how it is shaped and changed, and the placement of structures and objects upon it. Landscape architects combine their knowledge of horticulture, design and natural sciences to creatively relate land, water, buildings and plants into pleasant and functional environments where people work and play. In short, the landscape architect is a professional who is dedicated to environmental improvement through planning and design related to the land. The student who enters this field must be interested in art, mechanical drawing and plants.

OPPORTUNITIES

Professionally trained people are needed to fill jobs in every horticultural specialty. As a nation and as individuals we are becoming increasingly aware of the importance of plants to life on the earth. Our rapidly expanding suburban population and our increased leisure time have all boosted the size and scope of the horticultural industry. Economic experts expect the volume of garden center and nursery business to more than double to over $8 billion by 1980. This will provide many opportunities for horticulturally trained people capable of assuming scientific, technical and managerial responsibilities.

Garden centers, nurseries, and suburban horticulture will need more qualified managers for retail outlets, better prepared writers and editors for garden pages of the local newspaper and for specialized publications, and qualified teachers and extension agents who can help individuals and communities improve their environment. Also barely touched are programs with low-income, inter-city groups and horticultural therapy.

There's a great need for qualified growers of plants in all phases of horticulture. A recent article in *Weeds, Trees and Turf* points out that one large Florida-based foliage plant grower is currently doubling his space of 30,000 sq. ft. to acclimatize trees and tropical foliage plants for use in interior landscape plantings and covered malls.

Today, the need is greater than ever before for ambitious, industrious, intelligent and concerned horticulturists and landscape architects.

UNIVERSITY TRENDS

Let me use our own Department of Horticulture at Purdue University, as an example. We have programs in teaching, research and public service on fruit, vegetable and ornamental crops, including those for residential plantings. We have both undergraduate (4 year) and graduate curricula. The undergraduate offerings are divided into Horticulture and Landscape Architecture options, with certain courses offered on regional campuses and at Vincennes University (a 2-year university).

Even in Indiana, the conservative Midwest, noted for its corn, hogs, wheat and soybeans — there is greater interest in and concern for that part of agriculture which embraces horticulture. We too are becoming more urban. Our growers are close to large population centers which puts us in a relatively favorable competitive position for the production of such bulky and highly perishable products as potted ornamental plants, and certain fresh vegetables and fruits. We anticipate a substantial increase in service interprises such as landscape maintenance, food processing, farm marketing of horticultural products and the professional services of landscape architects.

Specifically in our teaching program we have experienced major increases in student enrollments. During the past nine years (1962-71), student numbers in courses offered by Horticulture have tripled, majors have increased almost five fold, and service course enrollments have increased three fold. Growth has occurred proportionately in the Horticulture and Landscape Architecture options and resulted in a three fold increase in teaching (FTE) needs. Additional increases are seen throughout the next 15 years.

Through the years, the university approach has become more scientifically and theoretically minded. We've had a general reduction in laboratory or "practice" courses, mainly for two reasons. An inflated economy has forced the curtailment of large laboratories with much equipment and also there is the feeling that that such "practice" is much better handled in the field under expert supervision.

Also in some instances some of the basic horticultural information and techniques are being taught in botany, e.g., seedling growth, planting, etc. At Purdue, the basic botany courses are taught in an audio-tutorial laboratory where each student is required to take a series of mini-courses. Such courses can be reviewed or perhaps even written by the horticulture staff.

There is also an increasing percentage of horticulture students who have little or no experience or background in horticulture. Somewhere in their training they must be taught to grow plants if they are to be capable of commanding an acceptable job upon graduation.

Another trend is to abandon the crop-oriented course for the discipline-oriented course covering all horticultural crops, with such courses as "Physiology of Horticultural Crops" and "Genetics of Horticultural Crops". Our department is still floundering over this particular problem, as I suspect many others are.

All institutions have a basic "core" or general college curriculum for all incoming freshmen. Often these are the standard requirements of English, math, chemistry, etc. The student often waits until the second or third year before beginning work in the desired speciality. The School of Agriculture at Purdue has reduced this core requirement and now encourages the student to take several freshmen agricultural "electives" during the freshman year so he can choose his major early in his study.

Recently as a part of a School of Agriculture long-range planning review, our department outlined the following goals:

1. Development of opportunities for dual majors in horticulture and allied fields such as education, turf, community development and (4-H). Several other universities already have this option.
2. Development of a Cooperative Intern Program to broaden and strengthen training in undergraduate curricula. (We have had several students already involved in this "field practice".)
3. Development of better mechanisms to assist in student placement to ensure maximum employment opportunities for graduates. (The role of extension specialists, agents and industry must be emphasized here.)
4. Development of opportunities in graduate education in Vocational Horticulture to meet the training needs of educators in extension and secondary school programs. Expansion of intensive summer courses will be required.
5. Broadening of service courses. Increased interest is anticipated in service courses in floral art and residential horticulture. (We have just split our one course dealing with both aspects into two separate courses.) Courses on these subjects should also be offered through the Division of Continuing Education (adults).
6. Continued support of sub-baccalaureate programs at regional campuses or other state institutions.

INDUSTRY SUPPORT

What can industry do to support horticulture? Industry — individuals, businesses and organizations alike — need to encourage and support horticulture training programs wherever possible. This means support for the university level in teaching (training), research and public service needs. It also means supporting vocational training whether it be in Vocational Horticulture or other agricultural training programs. Teachers and counselors are anxious for information concerning the horticultural industry. Don't be afraid to invite classes to your business or go into the classroom and tell your story. Assist youth programs such as 4-H, scouts, junior achievement, etc. Our horticulture 4-H projects are big sellers for urban as well as the rural children. We've found youngsters who take a 4-H project in horticulture are more apt to use this in later life than one who raises a steer or grows soybeans. When asked, serve on advisory councils, school boards and tell the horticulture story. Being aligned with agriculture is not always desirable since many people sometimes "look down" on agriculture. But show them you are a professional, whether in horticulture or agriculture.

Industry needs to demand qualified personnel in all areas of teaching, from the university level through secondary school. Demand that Vocational Horticulture teachers are trained in horticulture. You don't teach horticulture the same way you teach vocational agriculture. Encourage dual teacher training programs in horticulture and education.

Encourage a close relationship with the extension horticulture personnel in your area or state. Consult with them regarding problems, and tell them what your needs are. Likewise work with the interested civic groups such as garden clubs, etc. You never know what indirect influence you may have on some young person. Public service people work with many who consider horticulture an avocation, including children.

Industry can help support the increasing need for landscape foreman and managers. Many of you are incorporating such personnel into your present operation. Other operations will spring up independently. Too many people today have the technical horticulture background, but lack the managerial ability on marketing and managing. Encourage these youngsters to obtain this training.

And lastly, we must realize that horticulture is a profession. We know that ours is a materialistic society; to most of our young people money is still important. We discourage young people from going into horticulture when we hire a young man to hoe weeds at $1.25 per hour and his best friend can make $3.25 painting houses or working in a factory.

We must recognize that salary is important, no matter at which level you are working. The most recent survey (1972) of agricultural graduates with a B.S. indicates an average starting salary of $8650. This is an increase of $3180 since 1962. This year starting salaries will range from $7000 to over $10,000. We presently have a new graduate who will be receiving nearly $10,000 in his first job.

SPECIFICS AT PURDUE

We try to encourage participation in horticulture at Purdue in the following ways:

1. Staff members take an active part in on-campus career days for high school students.
2. We've developed a slide set showing some of the careers in horticulture.
3. We've tried to disseminate information to counselors, and worked with teachers, extension agents, etc. in horticulture programs with all ages of youth.
4. We try to plan exciting field trips for classes. Funds are the limiting factor

5 We are trying innovative teaching methods — audiotutorial set-ups for teaching plant materials, and a new self-guided walk-around campus tour with a recorder for plant material study.

6. We have an active Horticulture Club which makes and sells over 6000 gallons of cider each fall, stages a public horticulture show for 6000 people yearly and takes a 10-day expense paid trip to some southern horticultural region (Florida, Texas) each year.

7. We have an active program in home horticulture which reaches many people through publications, exhibits and mass media. A new course in this area has drawn much student interest.

SUMMARY

In summary, there is a challenge and a need for young people in all areas of horticulture, whether it be from the vocational or avocational viewpoint. I encourage all of you to present yourself as a dynamic professional. After all, we've been growing and nurturing plants for many, many years.

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HAROLD TUKEY: I think these two talks demonstrate that there are some things we can do to attract young people to horticulture. I believe this aspect of a profession, as John mentioned, is important. It is not only the young people we must convince, but in many cases it is their parents who must be sold that this is a respectable profession for their children to be in.

At this time we come to a section of the program which has come to be standard and that is, Al Fordham's New Plants Forum.

AL FORDHAM: We do have a few new plants to show you and because of the lateness of the hour, we will begin with the first speaker, Ed Mezitt, who has some selections of rhododendrons which he has made.

ED MEZITT: Rhododendron 'Balta' is a hybrid resulting from a cross I made a number of years ago between Rhododendron 'PJM' and .*R. carolinianum var. album.* It has the vigor and hardiness of 'PJM'. Its winter foliage is a bright green and its blossoms are pure white, becoming blush-toned as they age. The flowering time of 'Balta' follows 'PJM' by a few days although this spring they flowered almost simultaneously. Only four clones were selected from several thousand plants and this one appears to be the most promising.

Rhododendron 'Wally' is a clone of a group I have been growing as "Shrimp Pink" hybrids. It is from a cross I made between *R. mucronulatum* 'Cornell Pink' and *R. carolinianum* var. *album.* The beautiful large-headed pink flowers are produced profusely on this very vigorous plant. It needs pruning after flowering to keep it compact during its early growth. The foliage is narrow but a pleasant green and evergreen, though not heavy. Plant and flower buds are very hardy here in central Massachusetts. Flowering date is between that of its parents.

AL FORDHAM: Wayne Mezitt has a *Taxus* and an *Enkianthus* he would like to tell us about.

WAYNE MEZITT: *Taxus baccata* 'Fowle' was found as a seedling in the 1930's at the Fowle Nurseries, Newburyport, Mass. It was unnoticed for many years and was then sparsely propagated because of its coarse root system when grown from cuttings. More recently, grafting was tried on good rooted varieties of *Taxus* and this has been successful. The original plant, now about 4 ft high and 8 ft in diameter, is at the Arnold Arboretum.

This clone is exceptional because of its dwarf habit and midget boxleaf foliage. The winter color is superior to most Taxus varieties. It produces annual fruit and requires no pruning. Even though it appears to be a dwarf, it grows relatively fast; a 12-15 inch plant can be produced within 5 years. It is an excellent subject for shaping into forms becuase of its rigid branching characteristics.

Enkianthus campanulatus is a deep pink-flowering, second generation hybrid of a pink flowered selection. It is exceptional landscape plant with an ultimate height of 10 ft, with long-lasting buds and flowers and spectacular, persistent, red, orange and yellow fall foliage. The upright habit of young plants changes to a more spreading, artistic form when mature. It is easily propagated from seed or cuttings.

AL FORDHAM: Pete Vermeulen would now like to tell us about some rhododendron selections he has made.

PETE VERMEULEN: This is a Dexter hybrid selection which is 37 years old and has failed to bloom only one year. It is a compact low grower which blooms in our area in late April or early May which is about 1 to 2 weeks ahead of most rhododendrons and it propagates readily from cuttings. It is quite hardy and has taken temperatures down to -20° F. The name is 'Pink Sparkler'.

AL FORDHAM: Dick Jaynes has another *Kalmia* selection which he would like to show us at this time.

DICK JAYNES: *Kalmia angustifolia* 'Hammonasset' is a clone selected from a wild population of sheep laurel for its rich, bluish-rose flower color and relatively compact growth habit. Based on the Nickerson Color Fan the predominant color in the open flowers is strong purplish red (7.5RP 4.5/12). The color in the center of the flower is lighter. The plant is floriferous, performing best in full sun. It flowers in June at the same time mountain laurel is in bloom. Like other sheep laurel this selection is stoloniferous and can effectively be used as a ground cover. Its native habitat is a moist site (nearly swamp condition) but given a mulch, such as wood chips, it thrives in normal garden soils with a pH of 4 to 5.5. The mature height, grown in full sun, is 20 to 25 inches.

Satisfactory rooting has been obtained with semi-hardwood cuttings taken in late summer or early fall, treated with a solution of 1 part No. 2 Jiffy Grow to 2 parts water, and put under mist or plastic. Vegetative shoots with no flower buds root more readily than shoots with flower buds.

The Indian name 'Hammonasset' was suggested for this plant by Mike Johnson of Summer Hill Nursery. The original plant was found in 1961 in a population of some 300 flowering sheep laurel within a few hundred feet of the Hammonasset River in Madison, Connecticut.

AL FORDHAM: Carl Gullo had a couple of slides he wanted to show, but he had to leave early so Dave Dugan will show them for him.

DAVE DUGAN: This is a *Taxus* which came from a batch of seedlings of probably *T. cuspidata* 15 or more years ago. This plant has never been sheared and you will note that it is about 6 feet high and about 18 inches through, a very narrow columnar habit. It carries good dark color all winter.

Carl also has selected this rhododendron which is quite fragrant. It is an annual bloomer, blooms heavily with an exceptional fragrance and is quite hardy.

AL FORDHAM: Doug Weguelin has a few slides he would like to show us of some English plants.

Editor's Note. Doug Weguelin showed slides of a hybrid **Mahonia**, **Cotoneaster** 'Donner's Gem', **Genistra cinerea**, **Chaenomeles**, and **Buddleia** 'Opera'.

FRIDAY EVENING SESSION

December 9, 1972

PLANT PROPAGATORS' QUESTION BOX

The question box session convened at 7:30 p.m. in the Terrace Room. Dr. William Snyder presided as moderator.

MODERATOR SNYDER: Good evening, ladies and gentlemen; since you are all familiar with the Question Box session we will not waste time with formalities but we will begin with the first question. What is the background and history of *Taxus* 'Taunteni'?

CASE HOOGENDOORN: It came from Taunten, but I believe it originally came from the Arnold Arboretum.

MODERATOR SNYDER: Mike Johnson, while at your nursery, I noticed that the roots on your azaleas only went down about halfway in the can, what is your explanation?

MIKE JOHNSON: I am not sure. Most varieties do tend to go down but we have noticed that on *Rhodendron vaseyi* roots rarely go down very deep in the can. For some reason the roots stay rather shallow; it may need more aeration and this may be one which we should grow in Swiss cheese cans.

MODERATOR SNYDER: Would *Quercus palustris* grow better if inoculated with mycorrhiza, given an acid soil condition?

RAY HALWARD: I would guess that seedling oaks would develop mycorrhiza in time.

MODERATOR SNYDER: Does anyone have recommendations for propagation of redbud by cuttings?

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DON KRIZEK: Dr. Lewis Gregory at the Plant Growth Regulator Lab, USDA in Beltsville, Maryland, is doing some work on the propagation of this plant. He has some easy-to-root and some

Editor's Note. Doug Weguelin showed slides of a hybrid **Mahonia**, **Cotoneaster** 'Donner's Gem', **Genistra cinerea**, **Chaenomeles**, and **Buddleia** 'Opera'.

FRIDAY EVENING SESSION

December 9, 1972

PLANT PROPAGATORS' QUESTION BOX

The question box session convened at 7:30 p.m. in the Terrace Room. Dr. William Snyder presided as moderator.

MODERATOR SNYDER: Good evening, ladies and gentlemen; since you are all familiar with the Question Box session we will not waste time with formalities but we will begin with the first question. What is the background and history of *Taxus* 'Taunteni'?

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DON KRIZEK: Dr. Lewis Gregory at the Plant Growth Regulator Lab, USDA in Beltsville, Maryland, is doing some work on the propagation of this plant. He has some easy-to-root and some difficult-to-root clones and is looking at the anatomical responses. For further information, he could be contacted.

MODERATOR SNYDER: What is the best method for winter propagation of bearberry?

AL JOHNSON: Cuttings taken last year from the wild rooted very well. They were rooted directly in 1 inch peat pots to prevent transplanting shock later. They were placed in a moist chamber without supplemental watering.

BRUCE BRIGGS: On the West Coast we find that there is a problem when cuttings are put under the mist. They root very easily if they are stuck in sand or perlite and left outside, unattended; about April they will all be well rooted.

F. GOUIN: I know two growers who are doing quite a bit of propagation of bearberry; they take cuttings in February, no bottom heat, intermittent mist 3 seconds every 6 minutes, and they are getting 100% rooting.

K. PREUDHOMME: We take cuttings from September through November. They are stuck in a sandy medium without bottom heat or intermittent mist, but we do sprinkle them three times a day; we get 100% rooting.

MODERATOR SNYDER: Can *Acer griseum* be grafted or budded and what can be used for an understock?

CASE HOOGENDOORN: I have tried about a half a dozen understocks, but nothing works. Roger Coggeshall, when he was at Arnold Arboretum, tried 28 different understocks, but nothing worked.

JOERG LEISS: It can be grafted on *A. triflorum* but it is as hard to get as is *A. griseum*.

RAY HALWARD: I think it can be started from cuttings taken early in the season from young plants. I reported this in The Plant Propagator about 1957. I had only 11 cuttings, but 8 of them did root.

MODERATOR SNYDER: When planting container-grown nursery stock, is it best to disturb the root system?

ANDY LEISER: In California, we find that it is best to cut the ball of roots as it comes from the container three or four times. This will induce new breaks and help to get new roots pushed out into the native soil. In planting, the native soil material should be back filled in and puddled to force the native soil into the cuts so that when the roots grow out they will immediately grow into the native soil. The first few weeks after planting is critical since all of the water which the plant can obtain must come from the root ball which was taken out of the container.

LUDWIG HOFFMAN: We have found it is important to plant the ball about 1 inch deeper than it was in the can. If this is not done, the exposed light weight mix dries out readily and many plants will be lost.

MODERATOR SNYDER: Jim Wells, does the reduction of surface tension with a wetting agent cause more complete drying of the soil?

JIM WELLS: Yes, I think so.

MODERATOR SNYDER: What is a good way of propagating *Philadelphus coronarius* 'Aureus'; it seems they do not get a good start in our mist beds.

DICK CROSS: We take the cuttings about mid-July when they are a little hard, treat them with Hormodin No. 2 and stick them in the house under mist. They are left there until they go dormant at which time they are dug and stored in plastic bags in our root cellar and in the spring they are lined out.

DAVE BAKKER: We use the same procedure except we use Hormodin No. 3 and move the cuttings out to a bed which is heavily fertilized with MagAmp as soon as they are rooted. The bed is heavily shaded and we try to get about 8 inches of growth yet that same year.

MODERATOR SNYDER: Has anyone propagated tree peonies successfully by any method other than grafting?

DALE CHAPMAN: I know of one grower who sets them very deeply in a rather light soil and then propagates them by division. It is not very fast, but it works for him.

MODERATOR SNYDER: What is the best method of propagating blueberries?

K. PREUDHOMME: We take the cuttings in June and treat them with Hormo Root C. They are stuck in a sand-peat medium under mist of 10 seconds every 6 minutes. We get 100% rooting.

MODERATOR SNYDER: Dr. Waxman, how much Captan do you use with Hormodin No. 3 to root azaleas?

SID WAXMAN: I use 1 part Captan to 9 parts Hormodin.

MODERATOR SNYDER: Jim Wells, are you aware of the effects of Aqua-gro on decreasing the growth of plants treated with it?

JIM WELLS: No, I am not.

BILL MORSINK: A graduate student has recently completed some work using this material and he has found growth depressions on several woody and non-woody plant species as a result of using Aqua-gro at rates from 0.5% to 6%.

Editor's Note. A lengthy discussion was held concerning the advantages of using various wetting agents as an addendum to spray materials or adding it to the water to improve wetting of the growing medium. In all instances, growers reported beneficial results from the use of wetting agents provided the concentration was kept very low, with a range of 0.001 to 0.3% most often reported as used.

MODERATOR SNYDER: How can I root a clone of *Cornus alternifolia?*

BILL MORSINK: We have taken cuttings in August and it roots 100%.

MODERATOR SNYDER: How do you root *Amelanchier?*

JOERG LEISS: It can be rooted by taking very soft cuttings in June and treating with No. 3 powder, it takes about 8-10 weeks to root.

MODERATOR SNYDER: What is the best method of propagating *Cornus canadensis* and how can the plants be established as a groundcover planting?

H. RHODES: The best method of propagating is by layers. We have no trouble establishing them on our soil, which is a light sandy loam.

MODERATOR SNYDER: How can I successfully vegetatively propagate *Picea breweriana*?

BRUCE BRIGGS: On the West Coast, we have grown it from cuttings treated much the same as you would other spruces. Hardwood cuttings in our area would be taken in early spring just as the cold weather is over, or taken in summer as softwood cuttings.

MODERATOR SNYDER: What is the cause of rosetting on the new growth of deciduous azaleas, primarily the Mollis hybrids?

JIM WELLS: This could be a natural fasciation, or it could be damaged from insects, somewhat like aphids.

ANDY LEISER: The Mollis hybrids are particularly susceptible to calcium deficiency which causes a cessation of growth in the terminal portion and the leaves get smaller and narrower and cup towards the lower surface. Calcium sulfate (gypsum) will correct this.

MODERATOR SNYDER: Andy, you mentioned using gibberellin to break dormancy of *Ceanothus*; what was the concentration and how long was the soak?

ANDY LEISER: GA_3 was used at the rate of 200 to 400 ppm. The seed are soaked for 24 hours and must be dried for an additional 24 hours after soaking. If they are sown immediately and watered, the watering seems to wash the gibberellin out and the effectiveness is partially lost.

MODERATOR SNYDER: This year I used Benlate in my hormones instead of Captan and my rooting percentage has dropped; can anyone explain this?

DICK VANDERBILT: I have never been an advocate of Benlate in hormone mixtures since it has always depressed rooting for me.

LARRY CARVILLE: I think you have to be very careful when you use Benlate in your rooting hormones to not use too high a bottom heat. We start ours off at 64° F and then gradually move it up to 68° F. We have been using this quite successfully now for 4 years.

JIM WELLS: We are using Benlate at 5% and I think some of the problem is that people are using more than this amount. I had one grower tell me he was using equal quantities of Benlate and hormone. This would give 25% Benlate and 0.4% IBA. We have tried 10% Benlate and it did reduce rooting.

MODERATOR SNYDER: I have been grafting *Pinus cembra* and *P. parviflora* on *P. strobus*. These take all right, but after about 2 to 3 years they all gradually die. Does anyone have an explanation for this?

JOE CESARINI: These are easy grafters and the only explanation I can offer is that *Pinus cembra* is a true species and used to be grown from seed. It is possible that you have a clone which is slightly different and is causing your problem.

PETE VERMEULEN: These varieties are particularly sensitive to air pollution damage; it is possible that this is causing some of the problem.

MODERATOR SNYDER: How do you clean *Sophora japonica* seed, and is there any need for scarification?

NED RADER: We soak them, clean them by hand and then sow them. There is no need for scarification.

BILL FLEMER: We also soak the seed for 24 to 48 hours in warm water and then clean them by hand. This is a difficult and messy job because the seed coat makes a soapy kind of solution. There is no need for scarification, but they cannot be sown and left out over winter; the seed are somewhat tender.

MODERATOR SNYDER: Since the Solatrol provides the highest correlation between mist application and cutting water loss of any mist controller, why has it not gained the acceptance of nurserymen that it has received by floricultural propagators?

SID WAXMAN: As the question indicates, this is an excellent controller and I can think of only two problems. The first is the cost as compared to other controllers, the Solatrol costs about $135 and it must be checked out at least once a year to make sure that it is operating properly and this adds to the operational cost. If it is not maintained, it will not operate properly.

MODERATOR SNYDER: What is the best conductor of heat from electric heating cables to plastic flats and trays of poly pots?

Audience responses: Sand. Pea gravel. Imbed it in concrete and set the trays or flats on the concrete.

MODERATOR SNYDER: Pine seedlings possess a tap root; with the trend toward rooting *Pinus* varieties no tap would occur. What effect will this have on plants after several years growing, i.e. their likelihood of being blown over in heavy winds?

ANDY LEISER: I think that the tap root condition occurs primarily in the juvenile phase; as the trees get larger the tap root is replaced by a lateral root system. I have seen many large pine trees in forest areas which have been blown over and none of these have any indication of a tap root system at this large stage.

MODERATOR SNYDER: Has anyone experienced any problem from treating the soil with simazine inside a can house rather than using black plastic?

ARIE RADDER: We have used it and it works very well.

JOHN AHRENS: The only problem I can forsee is that the plants in the cans might root through to the soil and pick up some of the simazine, which would cause some problems.

MODERATOR SNYDER: This takes care of all of the questions, the hour is late, and if you have a question you did not get to ask you will simply have to wait until next year's Question Box.