hand. This goes also for the other members up here who helped work out the program and decided on the facilities for us. Walter Van Vloten, I know, spent quite a bit of time on this. He decided on the recommendation of the Vancouver Airport Inn as having the most suitable facilities for our meeting; I think he made a very good choice. All the other members from this area that helped develop this program also deserve considerable credit.

I have known the moderator of our first session for quite a few years. We were graduate students together at Michigan State University. We are certainly happy to have him out here with us. He is Canadian; actually he is sort of a renegade member in that our boundary line goes to the other side of his province, but he claims that his conditions there in Saskatchewan are more similar to those of the East. So he went to the East and he conquered the Eastern Region and has become President. But he still is, I think, a Western member despite his conquering the East. So, Stu Nelson, we'd like to have you go ahead and get the program started.

MODERATOR NELSON: Thank you, Bob. Ladies and gentlemen, it is a real pleasure to meet with the Western Region. This is my first time to meet with your group; it is a particular pleasure for me that you have chosen to meet in Canada this year.

At this time we will call on the first speaker, a chap from British Columbia who has been a nurseryman, and propagator, as well as an orchardist, I believe; he certainly has a "grass-roots" approach to the fruit tree rootstock situation. I'd like now to introduce John Traas.

TYPES OF ROOTSTOCKS USED IN FRUIT TREE PRODUCTION

JOHN TRAAS
Traas Nursery
Langley, British Columbia

My earliest recollections of fruitgrowing date back fifty years. That was when Antwerp was bombed in 1918 and I was sheltered under one of the big fruit trees in my father's orchard. They were old and, of course, on seedling rootstocks. Ten years later, another remarkable feat happened when my father bought his first pears on quince. They were the most miserable looking trees I have ever seen but that was the beginning of a period when nurserymen began to grow trees on controlled understock. Some people called them dwarf, but that does not mean that they had to be below quality, as happened when my father bought his first shipment.

Many things have changed since then—the time when people planted trees thirty to forty per acre has long passed, and nowadays three to four hundred per acre is not uncommon! This is the time of wide variation of types, with many specific characteristics on different soils, under different climates and in different countries. It is with this in mind that we will attempt to look at this subject from three different points of view. First, what it means to the fruitgrower; second, what it means to the nurseryman; and third, what it means to the plant propagator.

Today, the modern fruitgrower has access to a number of magazines, periodicals, and books; if he belongs to a fruitgrower's association, he can exchange his practical experiences with those of other members. Fifty years ago he had to rely mostly on his own skill and intuition. Today he is more demanding, more informed, and certainly more choosey when he buys trees from the nurseryman.

If the grower plants 400 or more apple trees per acre, he wants trees on 'E.M. IX' roots. This gives him full production by the fifth year. Of course, he must pay a price for this quick production, either by staking every tree or by growing them in a hedgerow on a wire. People who prefer fewer trees per acre, but still want to retain high density planting, look for trees with a bit more vigour, which we find in 'M. 26', 'E.M. VII', 'E.M. IV', or 'M.M. 106'. We are not going to elaborate on all details of these stocks, presenting only a general outline.

In the more vigorous group, the apple-grower can do two things: he can plant very close on "spur" types, or "non-spurs" at a rate of 225 trees per acre. The modern fruitgrower looks in this vigour range for 'E.M. II', 'M.M. 104', 'M.M. 111', or 'Alnarp 2'. Rarely will people plant clonal rootstocks which compare in vigour with seedling rootstocks. Some modern growers have ten-year old spur types on seedling roots which are not at top capacity yet. This could be an indication that fruiting on a seedling rootstock takes longer than fruiting on a controlled growth understock. There are countless instances of trees in full bloom on seedling rootstocks—which have not yet passed the juvenile stage—with the result of a total fruit drop in June. Several old-country varieties are known for this bad characteristics; on dwarfing understock they give far earlier production. It is, therefore, no surprise that the modern fruitgrower has something specific in mind when he orders trees from the nurseryman. This results in a more diversified plant plan for different customers—different customers on different soils—different customers under different climatic conditions. There was a time that the fruitgrower was satisfied with any tree as long as there was a root under it—this time has long passed, and all for the better.

Let us now see how the nurseryman, hemmed in between the demands of the fruitgrower, and the sometimes restricted supply from the plant propagator, makes a living.

VERY DWARF

When the nurseryman contemplates his plans for a new growing season, he considers, of course, the possibilities of selling the plants he will grow. Therefore, he certainly does not want to bank too heavily on 'E.M. IX', the true dwarf. The root system is brittle, the trees fall over very easily in the nursery row, and the size of the tree is smaller than the other rootstocks. On top of this, the demand from the fruit grower is not heavy enough to go overboard on 'E.M. IX'.

DWARF (MEDIUM WEAK)

The next one in the vigour range a relatively new rootstock, is 'M. 26', a cross between 'E.M. IX' and 'E.M. XVI'. The large, shiny leaves show some similarities with the very vigorous growth of 'E.M. XVI', although the vigour is considerably less than that of 'E.M. VII'. Material is not plentiful yet and, therefore, 'E.M. VII' becomes his next choice.

SEMI-DWARF (MEDIUM)

This older rootstock type is still in demand, but not as heavy as ten years ago, despite some limiting factors. It performs very well with grafts of 'Golden Delicious', and, according to Dr. R. F. Carlson, also on spur types of 'Red Delicious'. It is, however, susceptible to collar rot. 'E.M. VII' is the first one in this range of semi-dwarf understocks.

In the same vigour range is 'M.M. 106', one of the promising types of the Malling Merton series, having superb growth, good anchorage, and early production. In some locations the susceptibility to collar rot is one of its limiting factors. Another factor which decides the choice of rootstocks for the nurseryman to offer is that some fruitgrowers prefer the compact trees—the so-called spur types, many of which are available as sports of 'Red' and 'Golden Delicious'.

SEMI-VIGOROUS (MEDIUM-VIGOROUS)

When the fruitgrower demands more vigorous trees, there is a choice of understock between 'E.M. IV' and 'M.M. 111'. 'E.M. IV' (or 'Holstein Doucin') is an old timer with several characteristics which warrant condemnation, but several superior aspects which make a reassessment desirable in this era of high density planting. The poor characteristics are a tendency toward leaning, great susceptibility to foliar deficiency, susceptibility to woolly aphid in the stoolbed, suckering, and virus infection of the plants. When clean material is available and if the fruitgrower should decide to grow trees in a hedge row, either on wire or stakes, the enormous productivity of trees on this stock will most certainly be a factor in giving 'E.M. IV' a place in trials. The moreso because it is one of the very few stocks which seem to be resistant to collar rot.

Automatically the nurseryman turns to 'M.M. 111' as his only other choice in this vigour range. It is rather strange that this new type from East Malling was hardly known or grown eight years ago. The absence of virus, combined with great drought resistance and, as an extra bonus, the early and dependable productivity makes this the most wanted type at the moment. According to the statistics, production is just under the top producers—'M.M. 106' and 'M.M. 104'. So far, it also claims the honour of being less susceptible to collar rot than the other stocks.

VIGOROUS

Following the classification of Prof. H. B. Tukey, the next group from which the nurseryman can choose is the vigorous group, including three worthy of consideration — 'E.M. II', 'Alnarp 2' and 'M.M. 104'. To begin with 'E.M. II', this is a very good understock, but it takes quite a time to develop good anchorage, due to the asymetrical root system which makes leaning of young trees not uncommon. It is a "dry" rootstock (which is not easy to bud). There are many satisfied fruitgrowers who had good results with this stock and are pleased with its performance, production-wise.

We spoke of a dry rootstock; 'Alnarp 2' from the Agricultural Research Station at Alnarp, Sweden, is the easiest to bud. It is relatively unknown, but fairly winter-hardy, and is available only in limited quantities.

During the last ten years, nurserymen have turned to 'M.M. 104' in increasing numbers. The best cropper, providing the best anchorage, and at the same time an early cropper, it is no wonder that many people have bought this understock as a finished tree. The susceptibility to collar rot is one of its limiting factors, although many satisfied fruitgrowers praise this understock very highly. It is not certain if collar rot is a primary or a secondary disease. Some claim that frost damage, coming first, makes invasion of the collar rot fungus easier. Incidentally in Europe collar rot in rootstocks is no problem, and when the plants were introduced from East Malling Research Station, immunity to collar rot was claimed.

VERY VIGOROUS

The very vigorous group, consisting of 'M.M. 109', 'M. XXV', 'Robusta #5, and seedlings, have decreased in importance because high density planting, using such stocks, is hardly feasible.

It has been the fruitgrower who has changed the pattern of the nurseryman by insisting on a specific variety grown on a specific rootstock. How much the clonal rootstocks have influenced the industry is shown by the fact that one of the largest nurserymen in the U.S.A. offers over twenty apple varieties in nine types, giving close to 200 combinations.

Time prevents me from elaborating on the clonal plum rootstocks which are a refined improvement over seedlings, especially for high density peach plantings. We also mention quince as dwarfing understock for pear, which could make high density planting for pears a distinct possibility. It would be good if a winter hardy quince could be found to give this point more impact. Close contact between fruitgrowers, nurserymen, and scientists can prevent a lot of mistakes; the more so because no one has found all the answers yet.

Finally, in what position does the plant propagator find himself? As a new Canadian from Europe, it took some adaptation for me to drop a cultural practice which was so contrary to the one we found here. The western countries of Europe, especially, grow high density trees on 'E.M. IX'. More than 90% of all trees sold in Holland are grown on this rootstock. A prominent Belgian plant propagator, who grows two and a half million plants a year, has two million plants of 'E.M. IX'. England has large acreage on 'E.M. II', 'IV' and 'VII', but has changed considerably over the last ten years to the new Malling Merton series, especially 'M.M. 106', '104', and '111', while this continent uses Malling Merton understocks to a far greater extent than does Europe.

It is the correlation between the demand of the fruitgrower and the willingness of the nurseryman to adapt to this new demand which is the guideline for the propagator. A more desirable thing would be that through close contact between the plant propagator, the scientists, and the plant breeders, a more reliable and, if possible, a more restricted choice of types would be feasible. One of the limiting factors so far has been the constant changing of types adaptable to different climates; another limitation has been the distribution of cleaner foundation stock but with undesirable characteristics or with the appearance of new latent viruses.

How much the plant breeder and propagator are subject to the changes of modern environment is clearly illustrated by the plant breeding of black currants at the Wageningen University, Holland. Twenty years ago, the most important characteristic was a long vine which was easy to pick; several promising varieties were discarded because of a lack of this feature. Now, with the mechanical shaking devices, emphasis is still placed on production but, just as important, on uniform ripening and on easy mechanical harvesting. Several older varieties returned to prominence lately because of this situation.

The same applies to the plant propagator. While fifty years ago all trees were sold on seedling rootstocks, there has been a gradual changeover in the last ten years to size-controlling rootstocks, with a sudden upswing in the more dwarfing understocks. The switch to high density plantings and to growing trees in hedgerows made this changeover necessary.

The demand for the smaller trees on a large scale is relatively new and the industry is still in a transition period. During our 12 years in Canada, the demand has switched from 'E.M. VII' to 'E.M. II' to 'M.M. 104' and '106', and now to 'M.M. 111'. The changes are not always gradual but sudden and this brings tension to the nurseryman who cannot supply trees on a recommended rootstock overnight. It also brings disappointment to the fruitgrower who cannot get what he wants. Several modern fruitgrowers, especially those with capacity to raise their own trees successfully, buy the latest recommendations directly from the plant propagators.

Summarizing, we can say that the transition is as confusing to the orchardists as it is to the nurseryman and as complex for the plant propagator as it is for the plant breeder who introduces new, promising additions to our already large range of rootstock types. We feel that a very sound policy is to stick to a rootstock which has given good results for the individual fruitgrower. The more material that is released, the more we need close cooperation between orchardists, nurserymen, and plant propagators. In closing, we express the hope that we, as plant propagators, may play our part in this important facet of the fruit industry.

MODERATOR NELSON: Thank you, John. I would like at this time to call on Mr. Herbert Frost, who is going to speak on "Growing Trees on Malling Stocks". Mr. Frost is from Frost Nurseries, Granite Falls, Washington. Mr. Frost:

GROWING APPLE TREES ON MALLING ROOTSTOCKS

HERBERT H. FROST
Frost Nursery
Granite Falls, Washington

Our nursery is located 40 miles northeast of Seattle, Washington, in the western foothills of the Cascade Mountains, where the soil and climate conditions are excellent for growing hardy trees. The soil is upland sandy loam with a pH of 5.5 to 6 and is rich in organic matter. The ground is prepared two years in advance of planting, with two green cover crops deeply plowed under. We add 400 lbs. of 10-20-20 commercial fertilizer per acre.

At this time we are growing apples on 'E.M. IX' and 'E.M. VII' understocks. The reason we have confined our growing to these two is that we sell primarily to retail stores; 'E.M. IX', a dwarf of 8 to 10 feet, and 'E.M. VII', a semi-dwarf—12 to 15 years ago all trees were sold on seedling rootstocks, there has been a gradual changeover in the last ten years to size-controlling rootstocks, with a sudden upswing in the more dwarfing understocks. The switch to high density plantings and to growing trees in hedgerows made this changeover necessary.

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We propagate our stocks as both mound and continuous layers. Our original stock came from Canada. We plant our tree understock in early spring with a mechanical planter spacing them 16 inches apart in rows 42 inches wide. All our budding is done in August. We do not irrigate; the trees develop an excellent root system and heavy caliper in one year through the deep plowing and constant cultivation. For weed control, we cultivate and hoe. However, we have used pre-emerge herbicides succssfully.

We follow a rigid spray program throughout the year. Part of this program includes the use of a dormant spray, Cyprex 65W, for scab and mildew, Rothane 50 for leaf roller; Captan as a fungicide, and occasionally malathion.

For the coming year we are including some of the Malling-Merton types; and if these prove satisfactory, we shall include them in our inventory.

MODERATOR NELSON: You know, 15 years ago—maybe a little longer—any researcher that couldn't answer a question would say it was "physiological". Well now I think the pendulum has turned enough that any time a researcher can't answer a question he sends the problem to a virologist. Dr. Maurice Welch is one of our leading Canadian virologists. It gives me great pleasure to introduce Dr. Welch, Head of the Plant Pathology Section, Canada Department of Agriculture, Summerland, B. C. Dr. Welch:

VIRUS-FREE ROOTSTOCKS

MAURICE WELSH
Plant Pathology Section, Canada Dept. of Agriculture
Research Station
Summerland, British Columbia

The problems that viruses provide for nurserymen are typical of the complexities that have been gradually overtaking propagators of fruit trees since the early carefree days when Johnny Appleseed was scattering his seeds along trails in the American wilderness. The complications began, of course, as growers recognized the superiority of certain seedlings and the need to grow them as varieties grafted on rootstocks. Even this was relatively simple for a time, when there seemed a need only for germination of randomly-collected seeds, and their topworking to the desired varieties. Now by contrast, the fruit breeder and the nurseryman must concern themselves with vegetatively-propagated as well as seedling rootstocks, which endow the trees with varying degrees of dwarfing, and provide other useful characteristics. Often a feet—are the most acceptable. We discontinued 'E.M. IV' because of its brittle roots. Our finished trees are never sold as whips, but are headed back at approximately 40 inches and are grown on as well-branched 2-and 3-year-olds.

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3- or 4-part tree is required to attain satisfactory tree shape, disease resistance and hardiness. To this must be added all the other precautions necessary to cope with soilborne insects, nematodes, crown gall, root rots and viruses. Not least among these accumulating problems are the proliferating quarantine regulations designed to guard against these pests and diseases; regulations that are restricting the movement of nursery stock from country to country and from region to region.

It seems almost ruthless to select one of these many vexations and stress its complexity and importance. Nevertheless. I have a specific assignment to discuss the significance of viruses in tree-fruit rootstocks and in relation to their propagation.

Most of you by now are familiar with viruses and their characteristics, to the extent that these are now known. It is only in the last 30 years that scientists have been able to study viruses in the laboratory, and by 1967 only a small proportion of the viruses that cause plant diseases can be isolated, purified and characterized. Those that have been so studied are complex nucleoproteins, not unlike some of the native proteins that occur in healthy plant tissues, except that the virus proteins have the ability, when introduced into living host tissues, of multiplying rapidly, upsetting the normal functioning of these tissues, and thus causing diseases. These characteristics of viruses have made them uniquely difficult to deal with. In particular, they are so intimately associated with the plant tissues that they cannot be killed or controlled without killing the tissues in which they occur. As they cannot be controlled by the means we use for insects, fungi or bacteria we must rely almost solely on preventive measures.

The seriousness of viruses in fruit trees can be illustrated by the records of diseases such as *peach mosaic, phony peach* and *little cherry. Peach mosaic* has required the eradication of hundreds of thousands of bearing peach trees in the southwestern United States. *Phony peach* has demanded equally extensive eradication programs in the southeast. The *little cherry* disease eliminated cherry growing in the Kootenay region of British Columbia, and is now known to occur commonly in several European countries, as well as in Australia and in Japan. We may be less familiar with other, even more serious diseases that occur on other continents. *Plum pox* has spread through millions of plum, prune and apricot trees in most European countries, rendering plum fruits unfit to eat. *Apple proliferation,* or *witch's broom,* spreads actively in orchards, occurs in most European apple-growing regions, affects tree growth, and causes fruit and foliage symptoms. The *Pfeffingerkrankheit disease* of cherry debilitates or kills affected trees and is soil-transmitted, so that re-planting with healthy trees is not possible. These are only a few of the viruses that cause obvious diseases, and that spread rapidly in orchards, transmitted by insects, pollen, or nematodes.

In addition to these viruses that cause spectacular diseases in certain regions of the world, there are a number of viruses that are distributed in fruit trees almost wherever they are grown, and are more insidious because they cause no symptoms on most commercial varieties of tree fruits. Usually these viruses do cause serious disease conditions on certain sensitive varieties, and almost all of them have significant, though less apparent effects, in reducing graft and bud union "take" in nurseries, and in reducing production of stoolbeds and seedling plantings. Many of them also reduce the vigor and productiveness of the infected trees.

The plant propagator must be especially concerned with this second group; the so-called "latent viruses". They obviously reduce the efficiency of his nursery operations. Perhaps more important, he is in a strategic position to assist in reducing the incidence of these viruses in orchard plantings. Indeed, unwittingly in the past he has been the most effective disseminator of latent viruses, because the use of infected propagating materials has accounted for most of their spread.

The first responsibility of the propagator is to obtain virus-indexed sources for rootstocks, bodystocks and variety clones. His second responsibility is to adhere to practices that will prevent virus infections occurring in his plantings.

Virus-free clones of most commercial tree fruit varieties are now available, or rapidly becoming available, through State or Provincial nursery improvement and certification programs. In the West there are such programs in California, Washington, and British Columbia. These schemes, designed to provide materials for the nurseryman, are supported by a Repository of virus-free materials, established with U. S. Congressional funds at Prosser, Washington. Virus-tested clones of all useful stone fruit varieties are held there in very strict isolation, and nuclear stocks are provided to Research Stations and Nursery Improvement Schemes in the United States and Canada. Virus-tested apple and pear clones are being added as rapidly as they become available.

Sources for clean understocks are more diverse and scattered. The problems differ for clonal rootstocks and seedling rootstocks. The clonal rootstocks most used are those for apple, which originated at the East Malling Research Station in England. The original Malling stocks were developed in a period when viruses were not known to exist in apple, and most of the more useful Malling stocks have subsequently proved to be virus-infected. When the East Malling plant pathologists became aware of the *apple mosaic, chat fruit* and *rubbery wood* viruses they indexed all their rootstock clones and found it necessary to re-clone a number of them. These were released as 'Malling IIA', 'M .IVA', 'M. VIIA', and 'M. IXA', certified as free from *apple mosaic, chat fruit* and *rubbery wood* virues. More recently, since means have been found to detect additional apple viruses, it has been demonstrated that 'M. II' and 'M. IIA' carry *chlorotic leaf spot* virus, and that the other stocks carry *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses. Most of the clonal rootstocks more recently released in England have a cleaner bill of health. 'Malling-Merton 104', 'M.M. 111' and 'M. 26' are characteristically free from known viruses, and 'M.M. 106' is frequently free. However 'M.M. 109' and 'M. XXV' contain *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses. Among clonal rootstocks for other tree fruits the original releases of 'Quince A', Myrobalan B', 'St. Julien A', 'Brompton' and 'Mazzard F12/1' have proved to be free from detectable viruses.

In recent years a new technique has been developed, by which viruses can be eliminated from plant tissues without killing the plant. Infected trees can be exposed to dry heat continuously for periods of several weeks. The buds that survive can be removed and applied to virus-free rootstocks. With luck, a few of the buds are then found to have been freed from virus infection. Such treatment has been given to the infected rootstock clones at various Stations in England and North America. It is a slow business but is proving rewarding. At one or more of these Stations there are now clean clones of all the Malling and Malling Merton series except 'M. IV' and possibly 'M. XXV'. 'M. IV' is now being subjected to treatment at the Plant Quarantine Station at Saanichton, B. C. Unfortunately, for various reasons, there is likely to be an interval of several years before any of these clean clones can be made available in quantity to the trade.

For seedling rootstocks there must be a clear distinction between apple on the one hand, and pear and most of the stone fruits on the other. The difference is in the occurence of virus transmission through seeds and pollen. So far, such transmission has not been demonstrated for viruses infecting apple, except one that seems to have little importance. Therefore viruses can be essentially ignored in selection of seed sources for apple roostocks. By contrast, in stone fruits, viruses of the *ringspot* and *sour cherry yellows* group are commonly transmitted through seed and pollen. In pear, at least one virus (*vein yellows*) is transmitted through the seed. This means that the only assurance of virus freedom in stone fruit and pear nursery trees lies in establishing special seed source orchards, planted with trees that are free from viruses, and indexed periodically to ensure that they remain healthy. A few such seed source orchards have been established in eastern, mid-western and western states. In British Columbia, seeds from virus-indexed 'Van' cherry trees are being propagated under the Budwood Certification Scheme, for use of commercial nurseries.

After the nurseryman has secured suitable sources of virus-free propagating materials there are several precautions that he must adopt to prevent infection of his plantings. One is to avoid doing any topworking in stoolbeds, and thus risk contaminating them. Another is to avoid re-budding of rootstocks on which buds have failed. Bud-failure is often a sign of virus infection in bud or rootstock, and in any case the second budding doubles the chance of introducing viruses. Stoolbeds and other nursery plantings should be kept far enough from older fruit trees to avoid the risk of root grafting, and thus of transmission of viruses through the grafts. He should avoid interplanting tree fruit materials with ornamental stock, especially ornamental *Prunus, Pyrus* and *Malus*, because these can serve as hosts for many of the same viruses, and usually have received less careful indexing. Finally the recent demonstrations that stone fruit viruses are transmitted in pollen makes it necessary that all blossom buds be removed each year from seed source and scion source trees.

A talk on viruses in tree fruit clones must include mention of regulatory measures, and the complications that they are providing for U. S. and Canadian nurserymen. Quarantine regulations and restrictions, of course, are designed to prevent the entry of new and serious diseases to a country or region. Many of our most destructive diseases and pests have entered North America in shipments of plants or trees from other continents. We have to be prepared to pay a price to ensure that we do not introduce additional virus diseases such as *plum pox, apple proliferation, Pfeffinger krankheit* of cherry, *chlorotic leafroll* of peach and apricot, and other equally devastating virus diseases that, so far, have not gained entry to the United States or Canada. For this reason the quarantine authorities in both countries have been tightening their import regulations during the last several years. During 1966 and 1967, U. S. authorities have been adding to their precautions still further by placing restrictions on the movement of tree fruit nursery stock from Canada to the United States. They have specified that the Canadian materials entering the United States must be certified by Canadian Plant Protection Division officials to be free from all the serious virus diseases occurring on other continents, and that apple stocks must also be free from the more commonly distributed *rubbery wood* virus. Some of the other commonly distributed latent viruses are not specified in the quarantine regulations. Apple stocks infected with *chlorotic leaf spot, stem pitting* and *Spy epinasty* viruses can still enter the United States from Canada. In addition, the Canadian nurseryman must practice all the various precautions I have mentioned in the operation of his nursery before his stock can be approved for entry into the United States. We must assume that if these precautionary meassures are required for nursery stock being imported to the United States from Canada, there will be increasing pressure for the adoption of all the same precautions by U. S. nurserymen producing stock for domestic and export sale.

In Canada we are now taking an additional precaution to ensure that the nurseryman receives clean varieties and rootstocks. The Tree Fruit and Grape Quarantine Station that was set up primarily to screen materials imported to Canada from other continents, also provides a service to Canadian plant breeders. All new proven varieties derived from their breeding programs can be submitted to the Quarantine Station for indexing to ensure that they are free from viruses at the time of their release to the trade.

Viruses provide one other serious hazard for the propagator. This lies in the susceptibility of certain kinds of rootstock to viruses that are commonly distributed—but symptomless—in commercial varieties. This has been especially true of crab seedlings used as rootstocks, and crab varieties used as hardy body stocks. Recently we discovered at Summerland that the risk extends to seedlings of some commercial apple varieties, when we encountered *stem pitting* symptoms in a high proportion of 'Delicious' apple seedlings that were topworked with infected apple varietal material. The Ottawa Research Station has responded to this danger by co-operating with us at Summerland in screening to ensure that its new hardy size-controlling rootstocks are resistant to the common latent viruses occurring in apple.

The objective of plant breeders and plant pathologists is to eventually make available to nurserymen and orchardists a range of rootstocks that are not only virus-tested but also virus-resistant. Until this goal is attained there is urgent need for nurserymen to take all reasonable precautions for production of clean nursery stock. Obviously this is necessary, not only to protect the nurseryman and the fruitgrower from virus hazards, but to keep nursery stock moving freely between our two countries and the regions within them.

MODERATOR NELSON: Thank you, Dr. Welsh for a most interesting talk. We will move on with our program to the next speaker, who I met for the first time this morning, but I've read his writings and who, I am sure, does not need an introduction to the Western Region members. He is one of the workhorses in the organization, because anybody who is the Editor just has to be a real worker. I am sure the Editor puts long hours into preparing the wonderful Proceedings that comes out of our organization. So with that, I'd like to introduce Dr. Hudson Hartmann, Department of Pomology, University of California, at Davis who is going to speak on root initiation in hardwood pear cuttings. Dr. Hartmann:

ENDOGENOUS ROOT-PROMOTING AND ROOT-INHIBITING FACTORS IN PEAR CUTTINGS IN RELATION TO BUD ACTIVITY

M. S. FADL[1] AND H. T. HARTMANN
Department of Pomology
University of California
Davis, California

In studies of methods of propagating rootstocks known to be resistant to "pear decline", it was noted that hardwood cuttings of 'Old Home' pear rooted readily whereas such cuttings of 'Bartlett' were very difficult to root (3). It was determined in these tests that nursery trees of own-rooted 'Old Home' could be propagated easily by taking hardwood cuttings in the fall, treating them with indolebutyric acid (IBA), then storing them for about 3 weeks in damp peat moss at 70°F. for roots to become just visible before planting in the nursery. 'Bartlett' pear cuttings, however, if handled in this manner formed no roots. But if 'Bartlett' cuttings, after receiving the IBA treatment, were placed out-of-doors (in late fall or early winter) upright in damp peat moss over bottom heat (80°F.) but with the top buds exposed to the natural winter-chilling (40 to 50°F), roots would form in about 3 weeks. Cuttings with such incipient rooting, if transferred to the nursery row, would then develop into vigorous nursery trees by the end of the summer.

In the present study it was planned to determine, if possible, what differences existed between 'Bartlett' and 'Old Home' enabling hardwood cuttings of the latter to root so

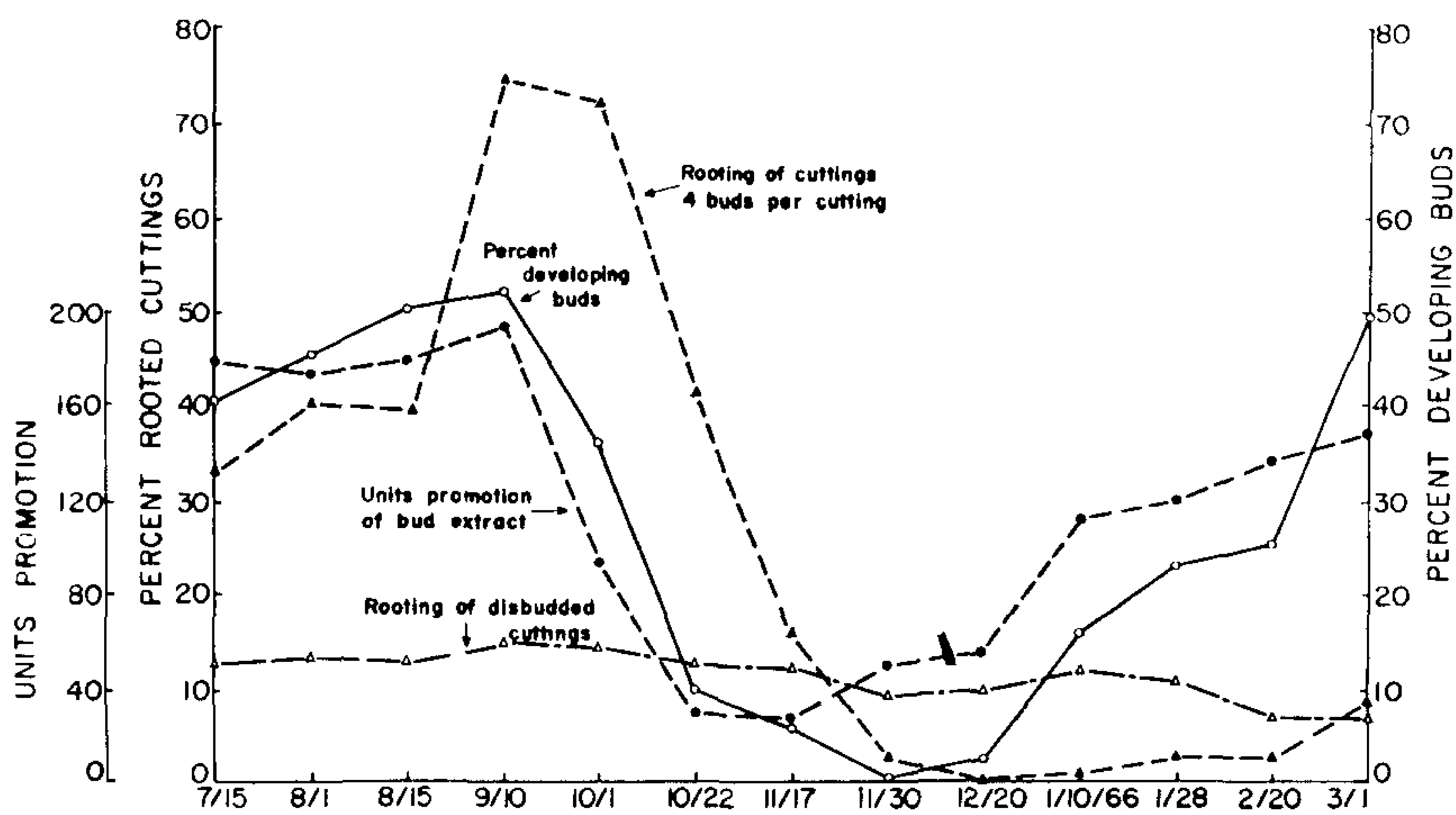

Figure 1 Effect of collection date on: rooting of 'Old Home' hardwood cuttings with 0 to 4 buds each, the percent of developing (sprouting) buds, and the "units promotion" of bud extracts. The extracts were bioassayed by the mung bean rooting test for calculation of the "units promotion" values

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much more readily, why chilling the buds of 'Bartlett' seemed to stimulate rooting, and why fall or early winter was an optimum time for taking the cuttings.

Figure 1 shows the changes in rooting obtained with 'Old Home' hardwood cuttings during the period from mid-July to the end of February and compares rooting of disbudded cuttings with those having 4-buds each. Also shown is the relationship between rooting and the potential physiological activity of the buds; that is, their ability to sprout when placed under optimum environmental conditions (2). Figure 2 (above) shows the effect of bud number on each cutting on the percent of cuttings rooting at different times of the year from October 1 to January 10 (2). It is apparent from these figures that with 'Old Home', the presence of buds stimulates rooting in mid-September when the buds are physiologically active but as the buds become deeper in the "rest" in mid-winter, their presence inhibits rooting.

With 'Bartlett' cuttings, on the other hand, (Fig. 2 - center), rooting is consistently low and the presence of any buds completely inhibits rooting. However, if 'Bartlett' cuttings are placed vertically over bottom heat with the top buds exposed to chilling (45°F), the picture is completely changed. Rooting is increased considerably and, except for the January and February collection dates, the presence of buds is not associated with poor rooting (Fig. 2 - below).

To study possible changes in the levels of naturally-occurring rooting promoters and inhibitors, or both, in the bases of the cuttings during the periods of active and inactive rooting, the mung bean bioassay as developed by Hess (4) was used after separation of the growth-active substances by paper chromatography.

'Old Home' and 'Bartlett' hardwood cuttings, about 20 cm long, were taken on September 10, 1965, from shoots produced that growing season. Samples, each consisting of ten 2.5 cm basal segments, were prepared from cuttings of both varieties as follows: (1) Cuttings taken immediately after collection from the trees (zero time). (2) Cuttings which had been stored in the rooting medium (moist peat moss) at 76°F for 24 hrs following treatment with 2000 ppm indolebutyric acid (IBA) in 50% (v/v) ethanol by the concentrated solution-dip method. (3) Cuttings which had been disbudded, (without IBA treatment) then stored in the rooting medium for 10 days. (4) Same as 3, but cuttings treated with 2000 ppm IBA. (5) and (6) Same as 3 and 4, respectively, except cuttings were stored in the rooting medium for 20 days.

Treatments 7, 8, 9 and 10 correspond to treatments 3, 4, 5 and 6, respectively, except that all cuttings had 4 buds each.

The excised basal segments of the cuttings were extracted with ethanol. For analysis, the extracts were concentrated to a final volume of 4 ml. Growth-active substances were separated by paper chromatography.

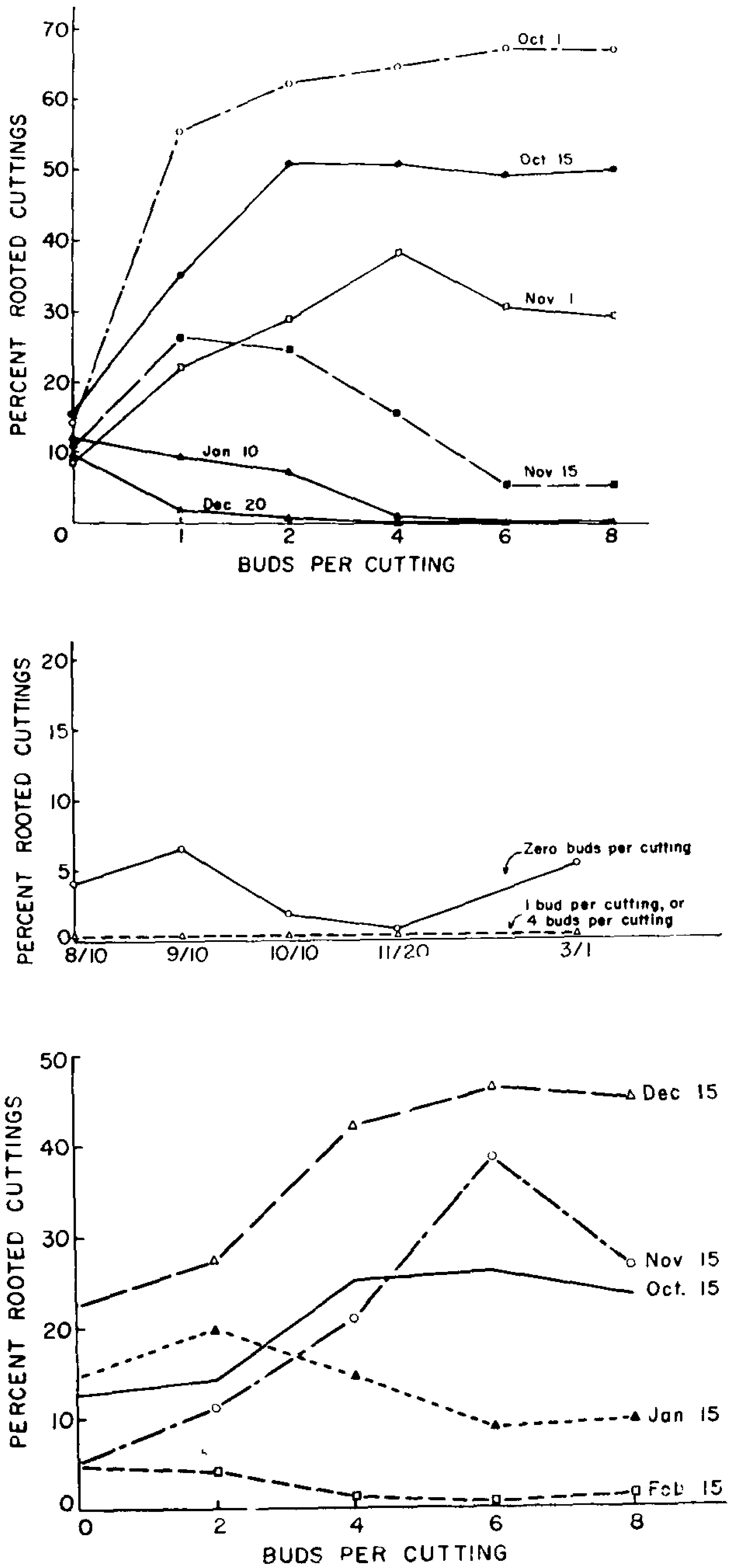

Figure 2. Relationship between bud number and rooting of hardwood pear cuttings. *Above*: 'Old Home' pear. *Center*: 'Bartlett' pear. *Below*: 'Bartlett' pear cuttings rooted over bottom heat with simultaneous chilling of top buds.

Paper Chromatography. A volume representing 250 mg dry weight of the extracted basal tissues was strip-loaded on 46.3 x 19.0 cm Whatman No. 3 MM chromatography paper. All chromatography was of the descending type, using isopropanol-water (10:1, v/v) as the solvent system. The chromatograms were developed uni-directionally for 14 hours until the solvent front was about 30 cm from the origin. The dried chromatograms were cut into 15 transverse strips of equal width; each strip was subsequently bioassayed by the mung bean rooting test. The paper strips above the origin served as controls. The chromatogram strips were transferred to 6.8 x 2.0 cm shell vials into which 10 ml of distilled water was added. An equilibration period of approximately 6 hours was allowed before mung bean cuttings were added.

Mung Bean Bioassay: Mung bean seeds were immersed for 5 minutes in a solution of 1 part Clorox (commercial hypochlorite) to 10 parts water, rinsed, and soaked in running tap water for 24 hours. Seeds were then planted and germinated. Five mung bean cuttings were placed in each vial, which also contained the chromatogram section. Distilled water was added daily to maintain the original water level throughout the rooting period. The number of roots on each cutting was counted after 6 days and the average number of roots per cutting was determined.

The results from the mung bean bioassays are shown in Figures 3, 4, 5, 6 and 7. In the histograms each column represents a chromatogram section, the origin being on the left. Those columns above the horizontal line (control) indicate promotion of rooting; columns below the line indicate inhibition of rooting. The promotion or inhibition obtained from each chromatogram strip was due entirely to material(s) present on that strip, since there were no external additives in the vials other than distilled water.

Mung bean bioassay of 'Old Home' pear extracts obtained at zero time (prior to IBA treatments) showed a zone of promotion at chromatogram strips 12, 13, and 14. 'Bartlett' extracts showed considerably less promotion in the same zones (Fig. 3, a and b). 'Old Home' extract obtained from the cuttings 24 hours after they had been treated with an IBA solution (2000 ppm), however, showed considerably increased promotion at the same zone (strips 12 to 14) while 'Bartlett' extract did not show as much increase (Fig. 3, c and d).

The rooting activity of extracts obtained from basal segments of *disbudded* cuttings, both treated and untreated with IBA, followed by storage in the rooting medium for 10 days, is given in Figure 4. Extracts of cuttings not treated with IBA (Fig. 4, a and b) showed much less promotion activity than did those obtained from IBA-treated cuttings (Fig. 4, c and d). Furthermore, extracts of budless 'Old Home' cuttings had less inhibitory and more promotion activity at strips 12 to 14 than did those of 'Bartlett' but, in both cases, the amount of promotion was relatively low. 'Old Home' cuttings prepared with such treatments (no buds and no IBA) root very poorly. On the other hand, 'Old Home' cuttings with 4 buds each, if treated with IBA, show very high rooting percentages, especially when taken in September (Fig. 1).

The activity of extracts obtained from similar *disbudded* cuttings, either treated or not treated with IBA, then stored

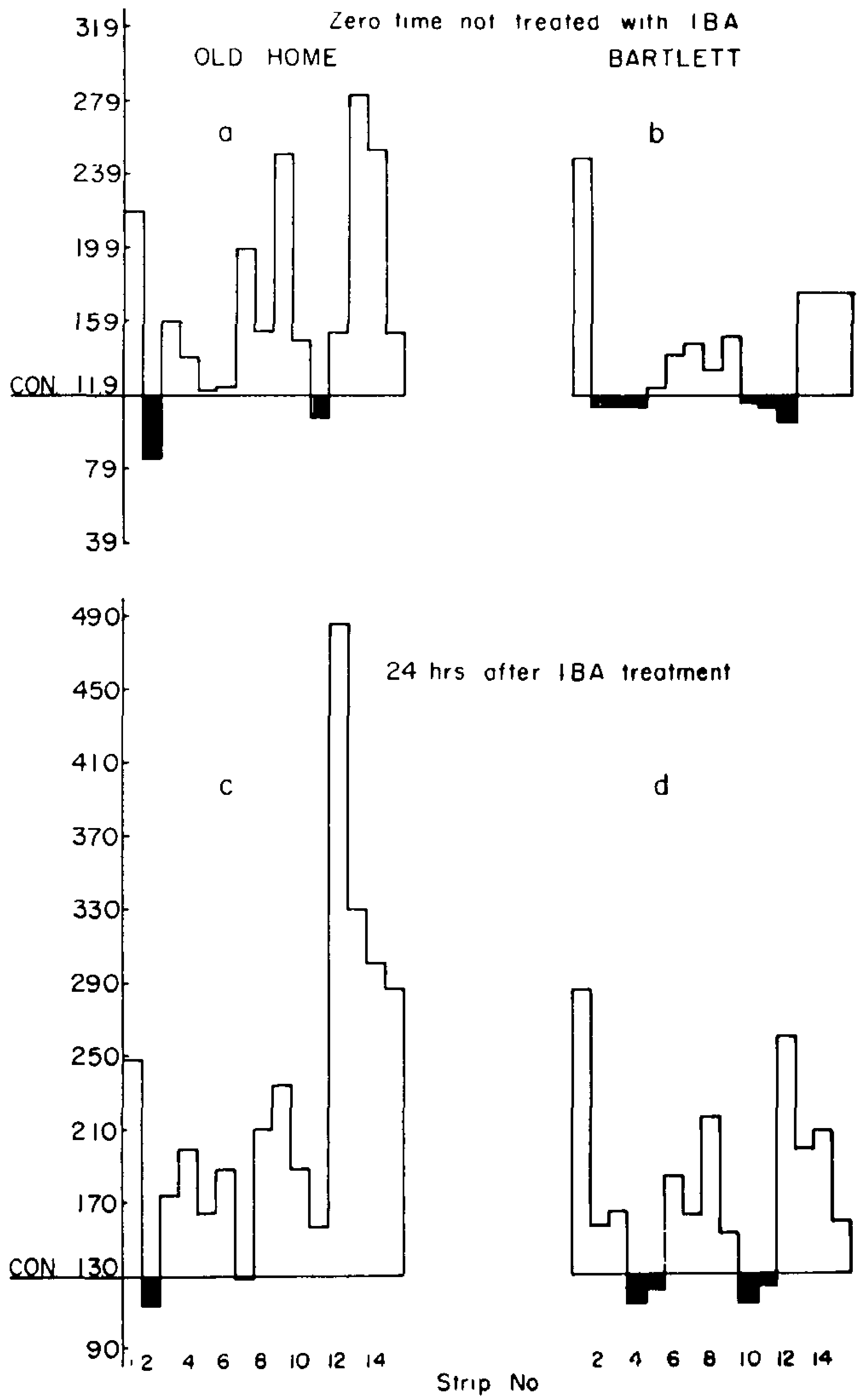

Figure 3 Histograms showing the root-promoting or inhibiting activity of diffusates from chromatogram strips tested by the mung bean bioassay Cuttings sampled on September 10 and stored in moist peat moss at 70°F CON = control, above control = promotion; below = inhibition Each chromatogram represents 0 25 gm of basal segments of cuttings.

in the rooting medium for a longer period (20 days) is shown in Figure 6. Extracts of disbudded cuttings, not treated with IBA, showed no inhibitory activity and, in the case of 'Bartlett' extracts, showed a considerable zone of promotion at strips 6, 7, and 8; a similar promotion effect is almost absent from 'Old Home' extract. It was noted previously that disbudded 'Bartlett' cuttings when placed to root, callus very heavily, and give about 6% rooting. Disbudded 'Old Home' cuttings, on the other hand, show a very low rooting percentage, if they root at all, and the basal tissues of most cuttings die during a period of about 25 days; this is the same behav-

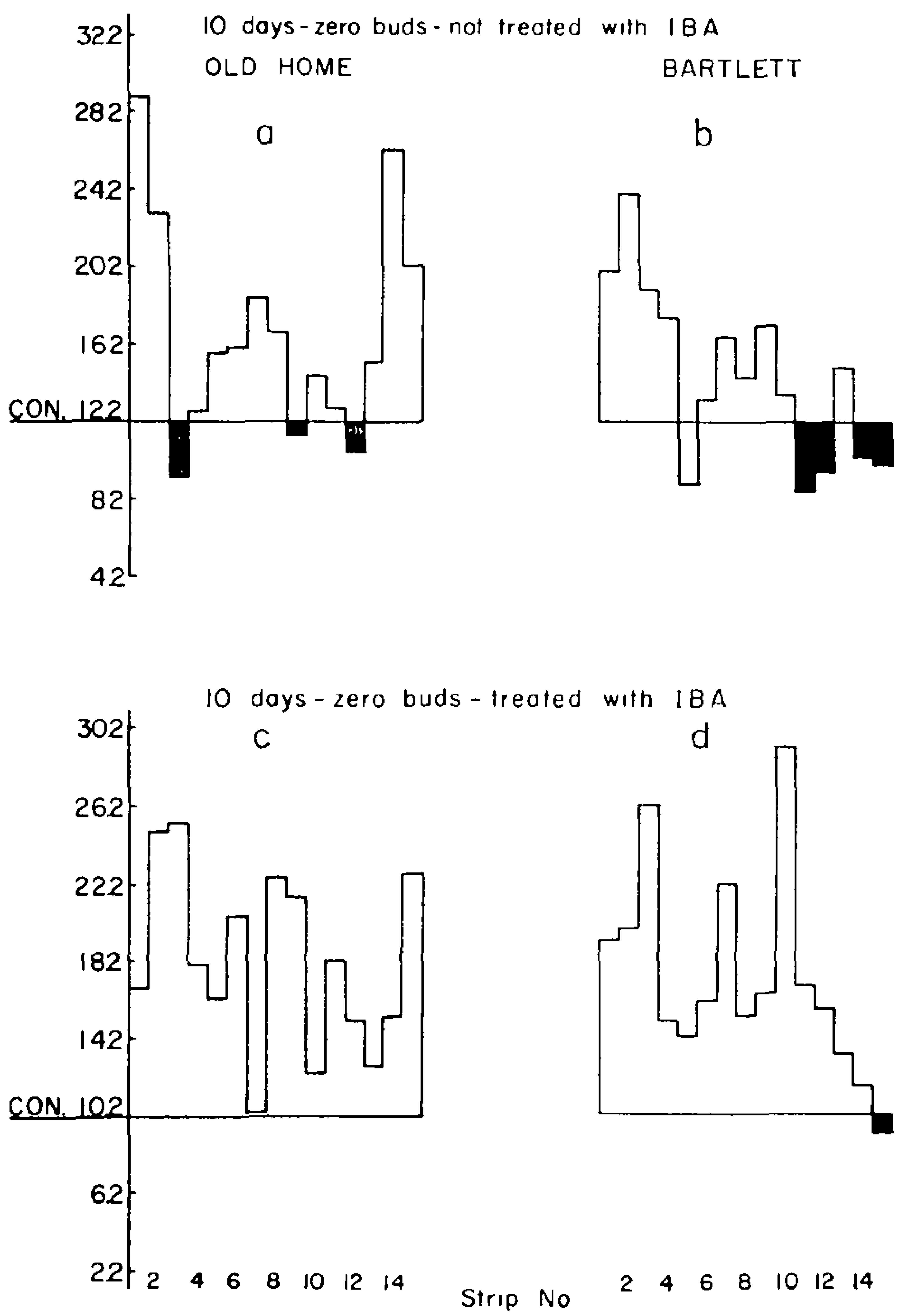

Figure 4 Histograms showing the root promoting or inhibiting activity of diffusates from chromatogram strips tested by the mung bean bioassay. Cuttings sampled on September 10 and stored in moist peat moss at 70°F for 10 days. Zero buds per cutting. Each chromatogram represents 0.25 gm of basal segments of cuttings

ior shown by 'Bartlett' cuttings which have buds and are treated with IBA.

In the mung bean bioassay only slight root promotion activity, but considerable inhibition activity, appeared in basal extracts from *disbudded* and IBA-treated 'Old Home' cuttings (Fig. 6, c). Root promoting activity in the bioassay with extracts of disbudded 'Bartlett' cuttings, at strips 12 to 14, was also low, whether or not the cuttings were treated with IBA (Fig. 6, b and d).

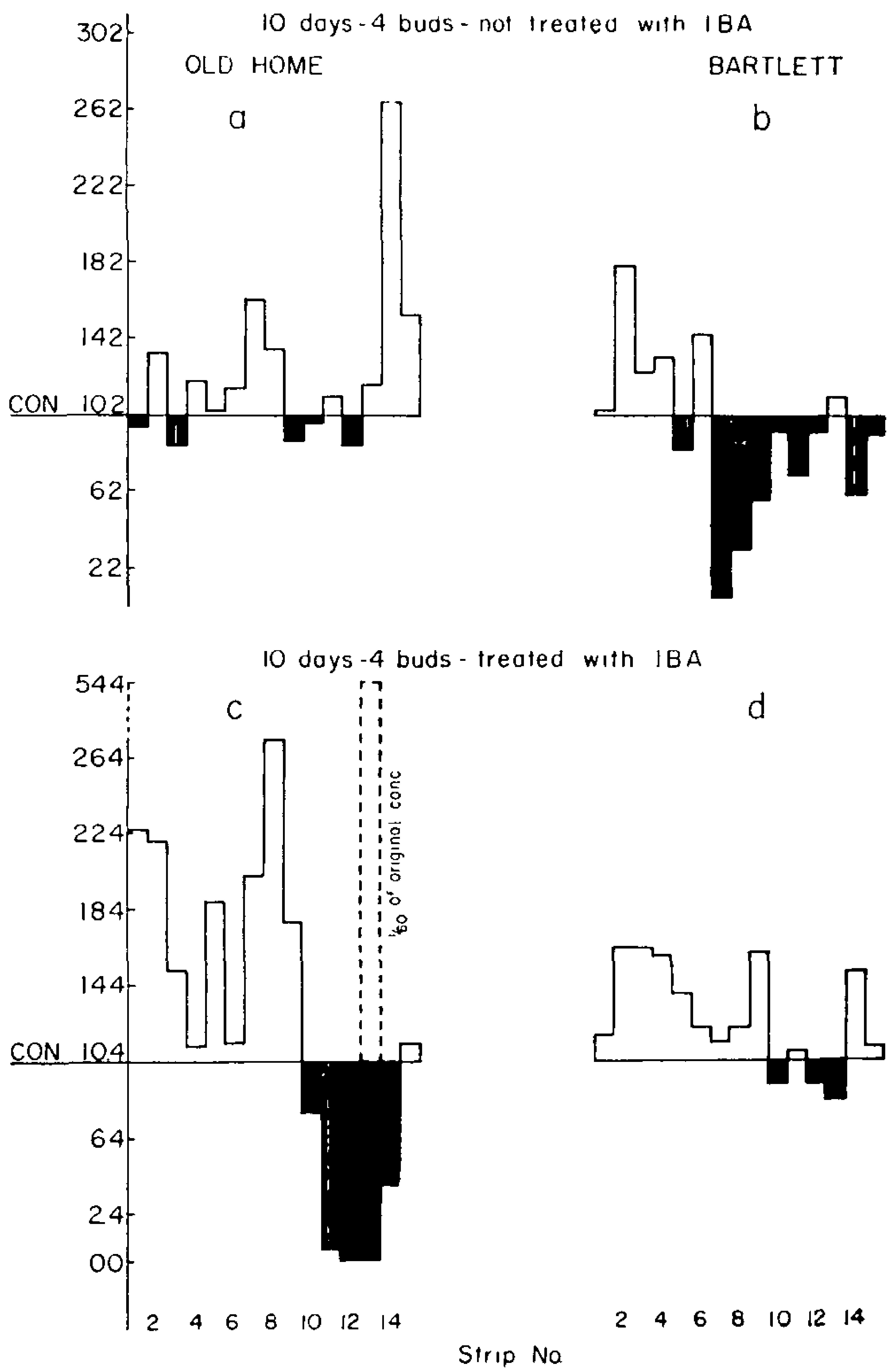

Figure 5 Histograms showing the root promoting or inhibiting activity of diffusates from chromatogram strips tested by the mung bean bioassay Cuttings sampled on September 10 and stored in moist peat moss at 70°F for 10 days Four buds per cutting Each chromatogram represents 0 25 gm of basal segments of cuttings

The biological activity in the mung bean test of basal extracts obtained from *4-budded* cuttings and stored in the rooting medium for 10 days is shown in Figure 5. If the cuttings were not treated with IBA a considerable amount of inhibitory activity was obtained from 'Bartlett' extracts (Fig. 5,

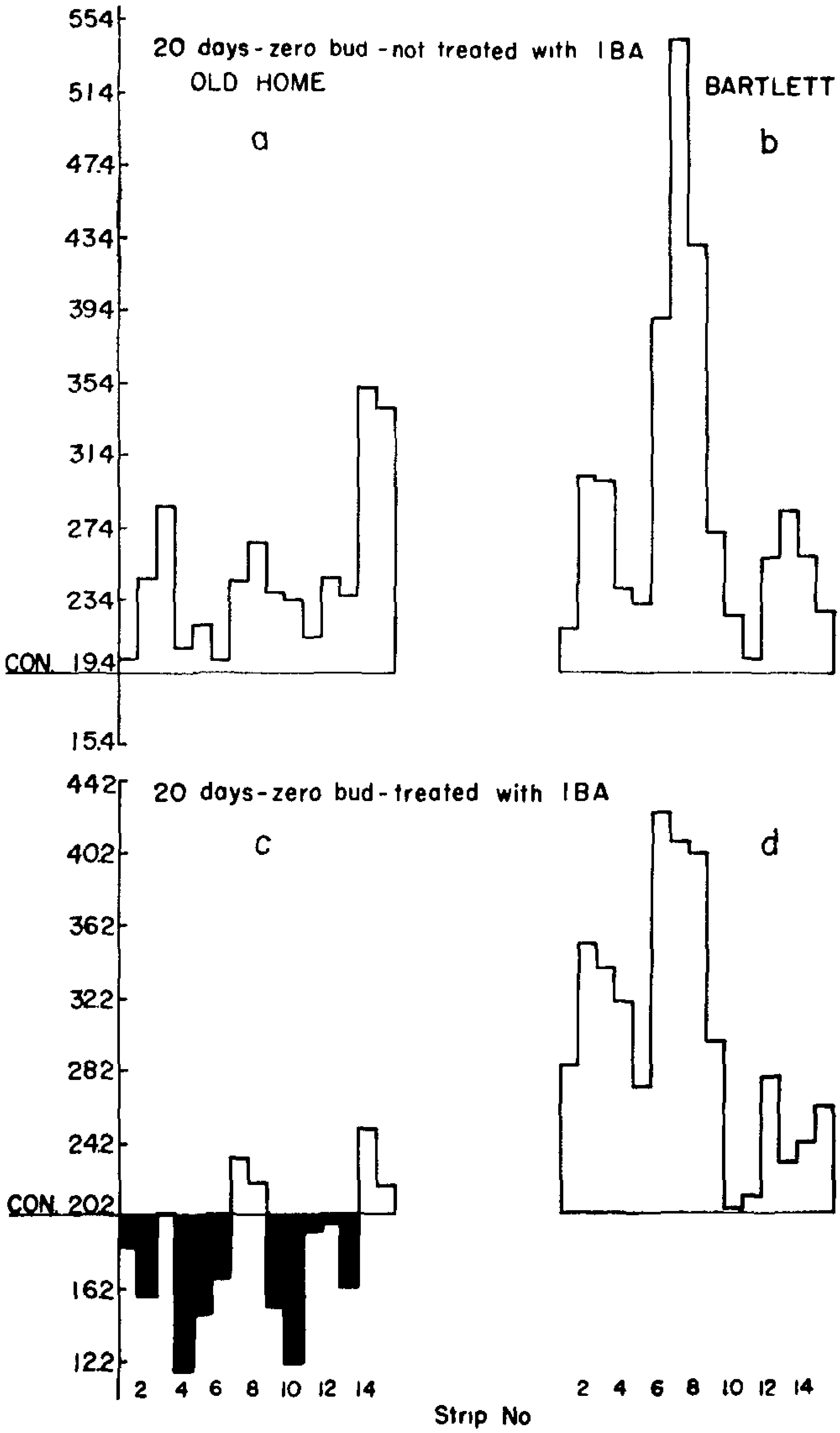

Figure 6. Histograms showing the root promoting or inhibiting activity of diffusates from chromatogram strips tested by the mung bean bioassay Cuttings sampled on September 10 and stored in moist peat moss at 70°F for 20 days Zero buds per cutting. Each chromatogram represents 0 25 gm of basal segments of cuttings.

b) but 'Old Home' extracts (Fig. 5, a), showed less inhibition.

Basal extracts obtained from 'Old Home' cuttings which had buds and were treated with IBA were expected to show a large amount of promotion, especially at strips 12 to 14, since cuttings treated this way and placed for rooting at this time of the year gave the highest rooting percentage obtained. The

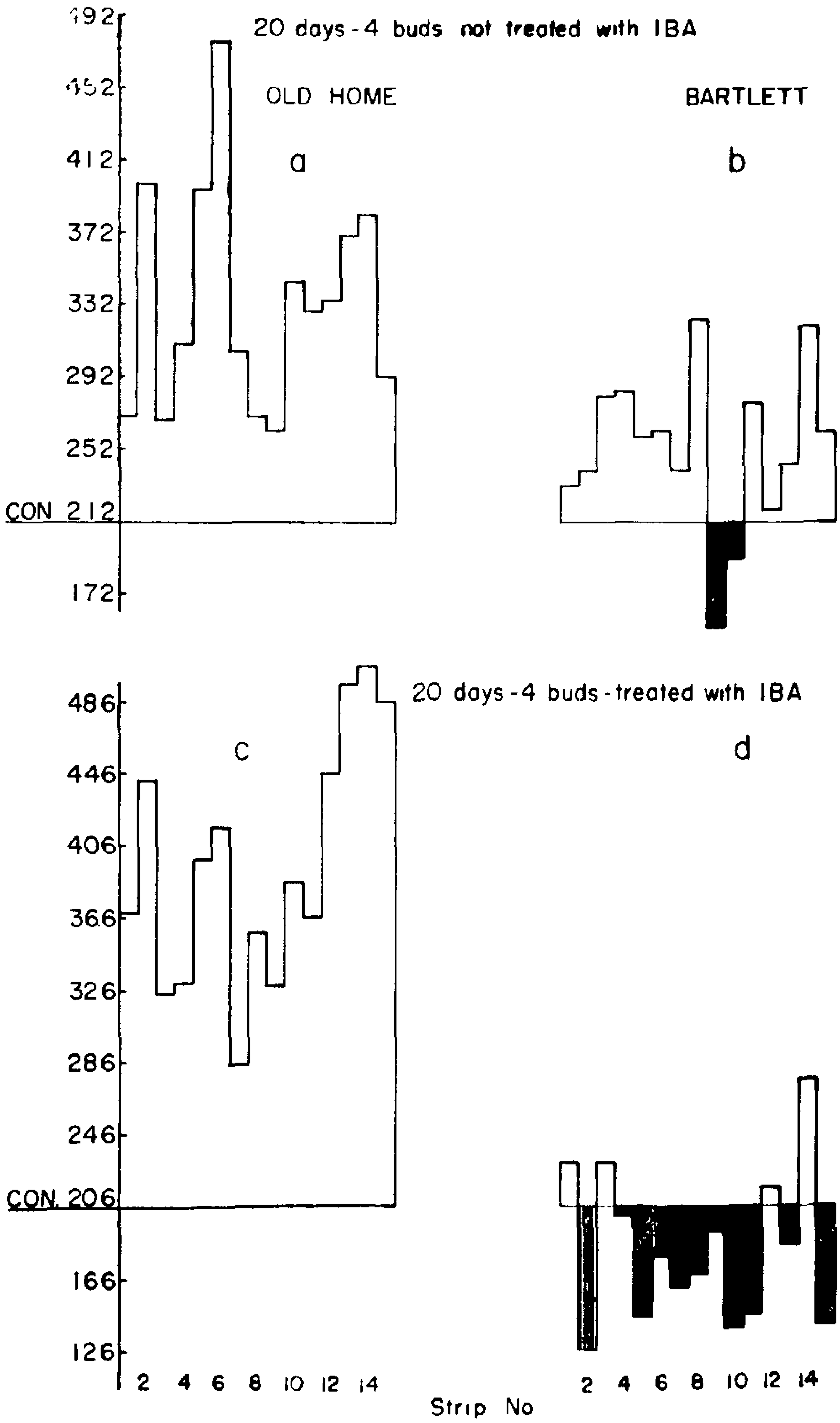

Figure 7 Histograms showing the root promoting or inhibiting activity of diffusates from chromatogram strips tested by the mung bean bioassay Cuttings sampled on September 10 and stored in moist peat moss at 70°F for 20 days Four buds per cutting Each chromatogram represents 0 25 gm of basal segments of cuttings

results shown in Figure 3, c support this prediction. However, rather than getting strong promotion where it was expected (strips 12-14), very definite inhitory activity appeared (Fig. 5, c). It was further noted that the mung bean cuttings used in the bioassay with these chromatogram strips not only did not root but showed a definite dark purple coloration in the veins of the 2 leaves. Since this was a rather difficult phenomenon to explain, it was decided to run a mung bean bioassay on a series of dilutions of the eluate obtained at these particular chromatogram strips, as well as on the remaining strips. As shown by the dotted bar in Figure 5, c, when an eluate from strip 13, where the inhibitory effect was most obvious, was diluted to 1/60 of its original concentration and applied to mung bean cuttings, considerable root promotion was obtained. The average number of roots was 54.4 per cutting in comparison with 10.4 for the control (Fig. 5, c). When the other strips (1-9) were tested with mung bean cuttings, however, a gradual decrease in root promotion took place as a result of the dilution.

The activity in the mung bean bioassay of extracts obtained from the bases of *4-budded* 'Old Home' and 'Bartlett' cuttings held in the rooting medium for 20 days (rather than 10 days), both treated and untreated with IBA, is shown in Figure 7. The activity of 'Old Home' extracts, especially those obtained from IBA-treated cuttings, at strips 12 to 14, showed about the same behavior as did the diluted eluates shown in Figure 5, c. There was a large zone of promotion at these strips, but the intense purple coloration noted earlier (after 10 days storage) did not appear in the mung bean leaf veins.

As Figure 7, d shows, considerable inhibitory activity appeared in basal xtracts of 'Bartlett' cuttings having *4 buds* each and treated with IBA. This behavior was similar to that shown in Figure 6, c for extracts obtained from disbudded 'Old Home' cuttings treated with IBA. In tests where root formation was measured, both types of such cuttings showed similar poor rooting.

The naturally-occurring, highly-active root-promoting substance which appeared in mid-September in the bases of IBA-treated 'Old Home' cuttings having buds has been studied further (1) and is believed to be an indole-phenol complex arising from the applied auxin combining with a phenolic substance coming from the buds on 'Old Home' cuttings at this time of year. Buds on the difficult-to-root 'Bartlett' cuttings, apparently not only do not produce this rooting factor, but produce strong rooting inhibitors.

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MODERATOR MAIRE: I am Dick Maire, from the Agricultural Extension Service, Los Angeles County, California, and am working with nursery production problems. I am very happy to be here to moderate the second session this morning. We are going to consider the subject of container production of nursery stock and we have a very fine group of speakers. To open, we have Dr. James Kelley. He is from the University of Kentucky where he has been doing work in ornamental research, as well as teaching, for the last ten years or so. He has done quite a bit of work with container production problems and is going to bring us up to date on some of his new ideas in container production of nursery material. The more we can learn about techniques in this field the better. Dr. Kelley:

CONTAINER PRODUCTION OF NURSERY STOCK

JAMES D. KELLEY
Department of Horticulture, Iowa State University
Ames, Iowa

The expanding use of containers for the production of nursery stock has created a need for more information regarding the production of woody plants by this method. Twenty years ago the growing of a plant in a restricted volume of soil was foreign to many nurserymen and many questions were unanswered concerning the cultural practices involved. Today we have a number of answers but still many questions remain to be answered.

Some of the biggest problems have been concerned with fertilization, growing medium, and winter protection. These are some of the items I would like to comment on today and hope that the results of our studies over the past few years may be of value to you in solving some of your production problems associated with growing nursery stock in containers.

Fertilization — Fertilization appears to be one of the least understood factors in growing plants in containers. The purpose of fertilization is to provide an optimum supply of nutrients in order for plants of that particular species to make maximum growth. Many times the desire for maximum growth leads to application of excessive amounts of fertilizer which can be as detrimental to growth as is a lack of fertilization.

Water soluble fertilizers are most commonly used for container-grown stock. However the development of various

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Water soluble fertilizers are most commonly used for container-grown stock. However the development of various sources of slow-release nitrogen have been of great value, particularly to the nurseryman with a limited number of container-grown plants.

Urea-formaldehyde was the first synthetic slow-release source of nitrogen. Since then several slow-release nitrogen sources have been developed, among them being ferrous-ammonium-phosphate, magnesium-ammonium-phosphate, and resin-coated fertilizers.

Among the plants we have used to evaluate the various sources and forms of nitrogen are: *Euonymus alata* 'Compacta', *Euonymus fortunei* 'Vegeta', *Azalea* 'Hino-Crimson', *Pyracantha coccinea* 'Lalandei', *Ilex crenata* 'Latifolia', *I.c.* 'Helleri', and *Prunus laurocerasus* 'Schipkaensis'. Generally one application of a slow-release nitrogen source will supply nitrogen for 3 or 4 months. Otherwise maximum growth can be obtained by frequent applications of water soluble fertilizers.

Soil mixes — We have tried soil mixes containing one-third each of soil, sand and peat; one-half each of sand and peat, and one-half each of peat and perlite. All mixes must receive applications of phosphorus, calcium and magnesium as well as nitrogen and potassium.

Good plants can be grown in all these materials. The factors to be considered in selecting a mix are: cost of materials, ease of handling, weight of finished plants (if shipped), and willingness of the operator to adapt to the requirements of a given mix, such as changes in watering, fertilizing and over-wintering practices.

Winter protection — Generally speaking some winter protection must be given container-grown nursery stock in areas where sub-freezing temperatures occur. The minimum protection is to place the containers can to can. This, however, is not satisfactory in most cases except for the hardiest of plants. We have found, as have others, that some type of plastic-covered structure gives the best protection for most plants.

We have used quonset-hut type plastic structures for a number of winters. These are supported by steel rods covered with fence wire, with a 4-mil layer of plastic over this. Early in our work, we felt that during warm winter days, ventilation was advantageous in order to reduce temperatures, since some days the temperature would run as high as 90°F within the structure. However, after a few years, it was easily seen that ventilation was detrimental to plant hardiness. This was attributed to the drop in relative humidity in the house. For example, once the structure is ventilated, moisture moves out of the house and then plants start to transpire rather rapidly even though the soil mix in the can is frozen and the roots are unable to absorb moisture. The result is burning and leaf damage to broad-leaved evergreens. We have found that the best method, under our conditions, is to keep the house as completely sealed as possible and—regardless of the temperature during the winter months—not to ventilate. In work with Japanese holly in regard to winter protection, it was found that plants on the outside rows or the perimeter rows in a bed are most subject to winter injury and were always the first to be injured or killed by low temperatures. It is particularly important that plants be placed can to can for maximum protection. Recent work in Virginia and Pennsylvania have shown the advantage of placing water within the overwintering structure. In Pennsylvania, after the houses were constructed for the winter, a plastic ditch was made in the aisle and filled with water. In Virginia, a much simpler method of using water to reduce injury in overwintering was to place two 55-gallon drums of water in each house. When temperatures within the structure reached 32°F the water freezes and heat is released. When ice thaws, considerable heat is required thus tending to produce a moderation of temperature in the house during the winter. In Virginia, houses were found to be between 5° and 10°F warmer when water was in the house.

Japanese yew in houses containing 100 gallons of water made approximately twice the shoot growth the following spring as plants that were overwintered in houses not containing water. Other plants produced a similar response when stored in houses containing water in 55-gallon barrels. Approximately 100 gallons of water/200 sq. ft. was found to be satisfactory in most cases.

In conclusion, I would like to say that our findings show that slow—release sources of nitrogen will supply nitrogen for a three to four month period and result in growth equal to that of plants receiving water soluble materials. Soil mixes should be considered from the standpoint of economy, since cultural practices can be modified in order to grow a good plant in most mixes. Winter protection should be in an airtight structure in order to maintain a high relative humidity and, in the case of broad-leaved evergreens, some shading is desirable in order to reduce temperature fluctuations and transpiration.

MODERATOR MAIRE: Our next speaker, Mr. John Massot, is going to talk about quality in container production. He has been a nurseryman most of his life and was raised in the nursery business in France. He has been in Canada quite a number of years, doing a good job of liner and general production in 1, 2, and 5-gallon cans. His nursery is in Richmond, B.C., only a couple of miles from here. John, will you come up now and tell us about quality in container production.

QUALITY IN CONTAINER-GROWN NURSERY STOCK

JOHN MASSOT
Massot Nurseries
Richmond (Vancouver), British Columbia

Container nursery stock is grown in an artificial manner in comparison with field-grown nursery stock and does, therefore, require more attention at specific times in order to produce a quality product, which will both sell and give satisfaction to the buyer.

What I have to say on quality is more or less the fruit of our own experiences over the last 8 or 9 years. I will indicate what we are doing and why we are doing it. Climatic conditions have to be taken into consideration; therefore, keep in mind that our ways of doing thinks have been geared to the climatic conditions in Vancouver, B. C., which may not be correct in a warmer, colder, or drier climate.

We started growing nursery stock in containers 8 years ago with only a few thousand 1-gallon cans to our present volume of over 100,000. In addition, we also grow a fair volume in 2¼", 3", 4" pots, 2 gallons and 5 gallons. We are not, by any means, a large producer of container-grown nursery stock, but we have always placed emphasis on quality and we are constantly trying to improve our methods to produce a better product.

I will divide my talk into two sections: (a) What you "must" do and consider in order to produce a saleable product, and (b) What you "may" do or "may not" do, or consider. This second section will often mean the difference between a *saleable product* and a *quality* product.

(A) *What you must do and consider:*

1. Soil ... potting mixes
2. Container
3. Liner
4. Watering
5. Fertilization
6. Control of insects and diseases

(B) *What you may or may not do, or consider:*

7. Pruning and pinching
8. Spacing
9. Weeding
10. Winter protection
11. Supervision
12. Timing

We have now a dozen points to consider; giving them all your best attention you must end up with a top quality product. On the other hand, you need to neglect or diregard only one of them and the result will most likely be a second or poor quality plant.

1. *Soil*: Soil is most important, as we all know, and more so in container growing where the plant's roots must develop in a very limited volume of growing media. We are using the U. C. Mix system and are satisfied with it.

The main components (peat moss and fine sand) are readily available in our area at a reasonable price . . . . which makes it even more attractive. At first we used a mixture of 50% sand and 50% peat. Mainly to reduce weight, we changed later to 75% peat and 25% sand. Results were excellent in both mixtures. Weight is always a problem and we are still looking for a lighter mixture.

2. *Container*: We mainly use metal containers which we like for their rigidity and easy handling. Some nurserymen prefer plastic. Cost is often a factor. Color is also important. We had more winter injury in black colored containers, which do absorb heat, than in silver colored, which reflect it. The container size must be proportionate to the size of the plant. Avoid containers with drainage holes at the bottom as the roots will grow through and stop drainage. Large side holes are better.

3. *Liner*: Always plant a strong healthy liner if you want a good product. The saying "a poor colt will never make a good horse" is quite applicable to nursery stock. A good, strong, healthy liner is the main key for eliminating losses and culls and for producing a uniform crop.

4. *Watering*: Watering is very important. It should not be overdone yet the plants should never be allowed to get bone-dry at any time. We use overhead sprinklers on a 4′ riser every 30 feet. The water is turned on early in the morning or late in the evening, when the air is calm, for even distribution of water. We turn the water on for about 1 to 1½ hours every two days during the summer months and only when necessary in spring and fall.

5. *Fertilization*: Proper feeding is one of the most important factors in the production of container nursery stock. We find it expensive mainly because we still do it by hand, going from pot to pot. We tried feeding through the irrigation line but did not find it satisfactory because the different varieties of plants we grow do not all require the same fertilizer.
Our fertilizer program is in liquid form, using 20-20-20, 27-18-9, also 12-25-25, according to the types of plants and the season at the rate of 3 lbs. per 100 gallons of water. We feed about every three weeks from spring until fall. We tried several formulas of dry fertilizers supposed to last 3 to 6 months, which would lower our cost considerably, but so far none of them could effectively replace our regular liquid feeding.

6. *Control of insects and diseases*: Control of insects and diseases in container-grown nursery stock is essentially the same as for field-grown stock. Constant control must be exercised in order to keep damages to a minimum.

The 6 points above are essential in order to produce any kind of good, saleable, container-grown nursery stock. The following 6 points are not as important as the first for producing a saleable product but are, in my opinion, essential, when you are trying to produce a quality product.

7. *Pruning and pinching*: Plant a rooted cutting or a liner in the ground, give it enough room, keep it clean and feed it well and you have a fair chance that this plant will grow and develop more or less according to the natural habit of that particular plant. But when you plant the same rooted cutting, or the same liner, in a one-gallon can placed in a block of 500 or 5,000 and set close to each other you will not, in a great many cases, obtain a bushy, well-branched plant unless you prune it and pinch it as often as 2 or 3 times during one growing season. Pinching is one of the necessary things to do for quality, the difference between a plant grown in a container and pinched one, two, or three times during the growing season and a plant which had not been pinched is often the the difference between day and night, particularly with plants such as junipers, cotoneasters, pernettyas, etc.

8. *Spacing*: Spacing is almost as important as pinching for such plants as the junipers. Without the minimum of space they require they will very rapidly lose their natural shape, which makes them attractive and bushy. It is not always possible or economical to space every plant as they should be spaced. One example in our climate is the flowering shrubs. Space them as they should be and they will be flat on the ground after every windy day.

9. *Weeding*: Weedy nursery stock is never attractive; weed-free containers do add considerably to the quality of the product. We had a weed problem from seeds blown by the wind over our block of containers. The best solution we found was to cover the surface of the potting mix in the container with a layer of approximately ½″ to 1″ of fresh sawdust. The weed seeds do not germinate in this fresh sawdust, which eventually will decompose and serve also as a mulch.

10. *Winter protection*: Depending on where the nursery stock is grown, winter protection may or may not be necessary for various species and varieties. We usually move back close together any nursery stock which has been spaced during the growing season and we cover the outside rows with sawdust up to the top of the container to protect them from heaving and freezing. We protect the more tender material such as Jap. azaleas, camellias, aucubas, abelias, etc., by moving them inside shade houses covered with plastic.

11. *Supervision*: Supervision is an important factor in the production of quality nursery stock in containers. Too much supervision may become expensive, but too little or no supervision can also prove to be very costly. In

many of the points mentioned before, supervision is almost synonymous with quality in finding out quickly, and at the right time, what has to be done, and how it has to be done.

12. *Timing*: If timing is going to play a large part in the production of quality in container stock—as it really does—it is also the big key to larger profits. If what has to be done in the production of container-grown nursery stock is not timed properly, you can be assured that quality will be reduced as well as profits. On the contrary, if everything can be done at the proper time— whether it is planting, watering, feeding, spraying or dusting, pinching, spacing, weeding, and winter protection, you can be certain to harvest both quality and profits.

MODERATOR MAIRE: Our next speaker comes to us from Washington State University at Pullman. He has been there for a couple of years in research and teaching and has been doing considerable work in the ornamental field. He has been in the nursery business all his life, most of the time in Minnesota. He is going to talk to us this morning on soil temperature in container-growing. Dr. Charles Pfeiffer:

SOIL TEMPERATURE CONDITIONS IN CONTAINER-GROWN PLANTS[1]

CHARLES PFEIFFER AND ALAN PETTIBONE
Department of Horticulture and Department of Agricultural Engineering, Washington State University, Pullman, Washington

INTRODUCTION

Injury of container-grown ornamental plants often occurs during severe winters. Commercial nurserymen have long sought to prevent this loss by over-winter storage in protected areas, use of various mulches, or covering containers with polyethylene tents. Over-wintering problems have often limited the utilization of container-growing in northern climates.

Winter injury or death has been attributed to intercellular or intracellular freezing within the plant, tissue desiccation due to transpiration exceeding water absorption, a combination of these (5, 11), and the result of rapid temperature fluctuation of the tissue (9). Maximov (7) proposed that the question of temperature influence on the root needed further investigation. He postulated that plants from different ecological groups would respond differently. Later Doring (4) found woody plants with early spring leaf development and flowering were not influenced as much by soil temperature as plants with the late spring development.

[1]Scientific Paper No 3063, Washington Agricultural Experiment Station, Pullman, Washington, Project No 1289

The assistance of Mr Marlin Edwards for maintaining the temperature recording equipment used during this work is gratefully acknowledged

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This paper defines prevailing soil temperature conditions of container-grown plants in Western Washington.

MATERIALS AND METHODS

The experiment was established at Briggs Nursery, Olympia, Washington, on September 20 1966. The original design (Figure 1) consisted of 2 plots of 100 containers of 1-year-old

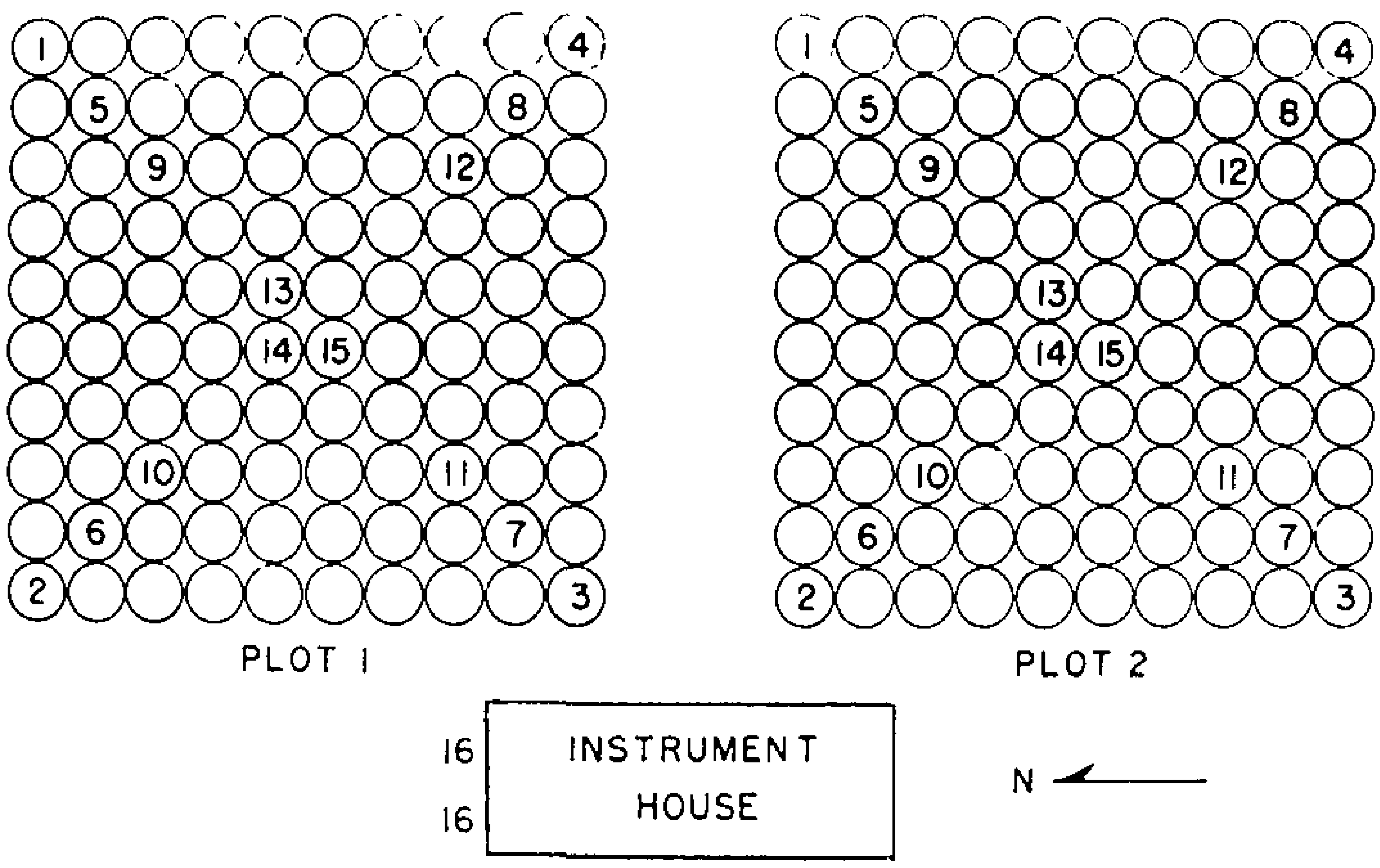

Figure 1 Plot layout and thermocouple locations

Juniperus sabina 'Tamariscifolia' grown in metal nursery cans situated pot to pot. The growing medium used in the container was a mixture of shredded hemlock bark (80%) and spent hops (20%). Two multipoint strip chart recorders, each equipped with 16 copper-constantan thermocouples (TC), were employed to record soil temperature data. Thermocouples were distributed within each plot (Figure 1) with point

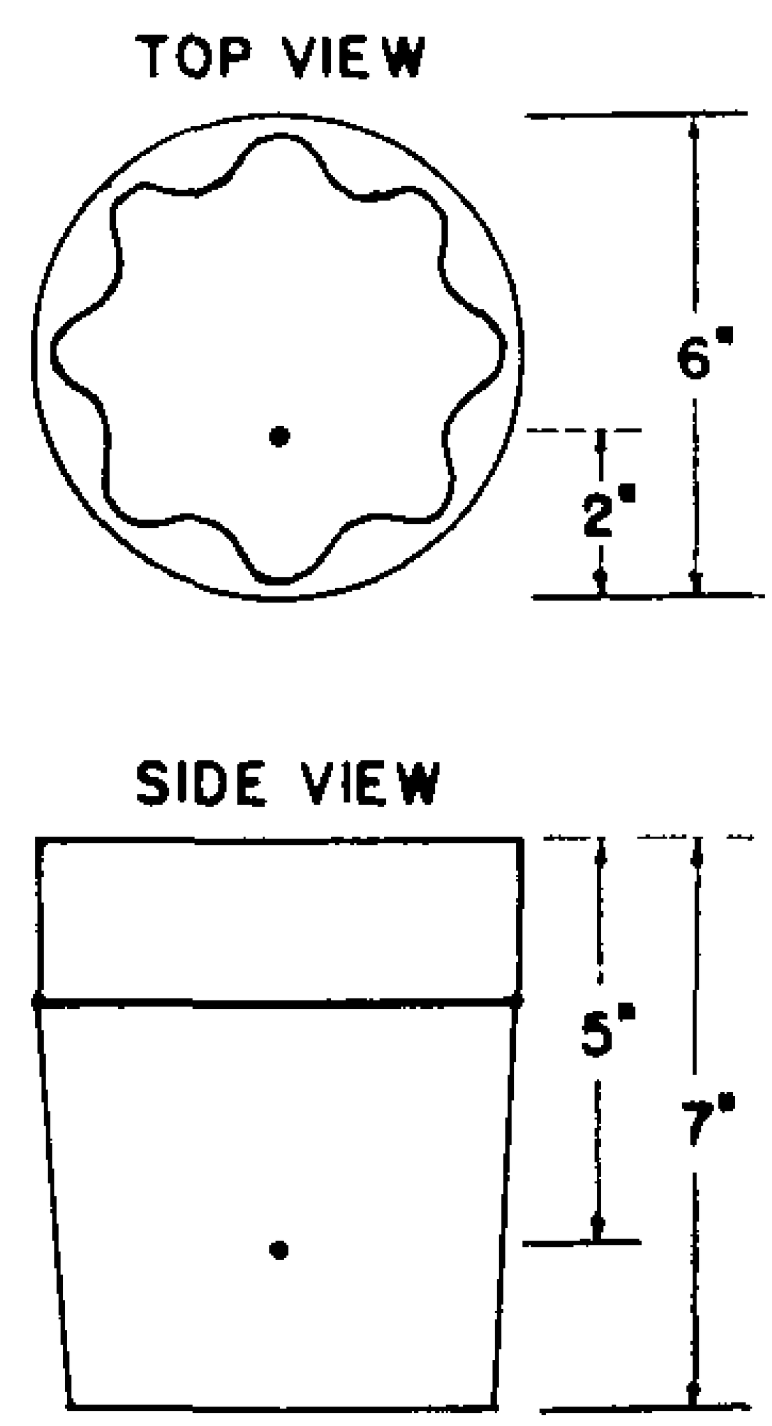

Figure 2. Thermocouple position in container.

16 recording air temperature at 16 inches above ground. Thermocouples were placed in each monitored container two inches in from the south side and five inches below the top edge of the container (Figure 2). Temperatures were recorded hourly. Plot 1 was covered with a polyethylene cover during the winter season to obtain the information regarding the variation of soil temperature between covered and uncovered plots of cans.

The first two-weeks data indicated the need for one additional plot which was established on October 13, 1966. This plot was established as the others with the exception that a single layer of reflective foil (asphalt coated Kraft paper covered on both sides with aluminum foil), the height of the cans, was wrapped around the periphery of this group of cans.

Thus a total of three plots were established. Plot 1 was covered with polyethylene, Plot 2 was left as an uncovered control and Plot 3 was left uncovered but had a foil barrier around the periphery.

RESULTS

Temperature data for thermocouples (TC) located in the middle of each plot (TC 13, 14, and 15) were no different than that recorded for the third row of cans (TC 9, 10, 11, and 12) in each respective plot. This observation held true throughout the investigation. Therefore, these data can be obtained by referring to plot temperatures recorded for the third row of containers.

The data for November 2, 1966 (Figure 3), a typical sunny fall day, illustrates the influence of solar radiation on soil temperature in the containers. The greatest temperature fluctuations occurred in the outer row of containers which had a southern exposure (Figure 3 Control TC 3, 4, 7, 8, 11, and 12). The magnitude of the temperature fluctuation was greatest in the outer row of cans but also carried over to the second row.

Early observation of this fact lead to the introduction of a third treatment with protective barrier around the periphery of Plot 3. The data (Figure 3 Barrier) illustrates how effectively this barrier reduced the magnitude of the temperature fluctuation on November 2. It also tended to stabilize the temperature throughout the plot. As a consequence, all the containers had a lower soil temperature than the control plot.

This winter was exceptionally mild. Seldom did the temperatures drop below freezing, but four representative days were selected to illustrate soil temperature observations (Figures 4 and 5). Delineation of data for all TC locations was not done since temperature patterns observed were similar to those previously described. Consequently, the remaining data compare container temperatures by rows (TC 4, row 1; TC 8, row 2; TC 12, row 3).

January 14, 1967 and February 17, 1967 (Figure 4) were cool, cloudy days, while February 15, 1967 and March 18, 1967

(Figure 5) were representative of bright, sunny days. As shown in Figure 4, soil temperatures were more uniform throughout the plots during cool, cloudy weather. The control plot was similar to air temperature, but both the covered and barrier plots were somewhat cooler.

Soil temperature measurements showed a different pattern during bright sunny weather. The barrier treatment (Figure 5) was not only effective in reducing diurnal soil temperature fluctuation in the outer rows of cans, but it also resulted in a more uniform temperature across the plot. Tem-

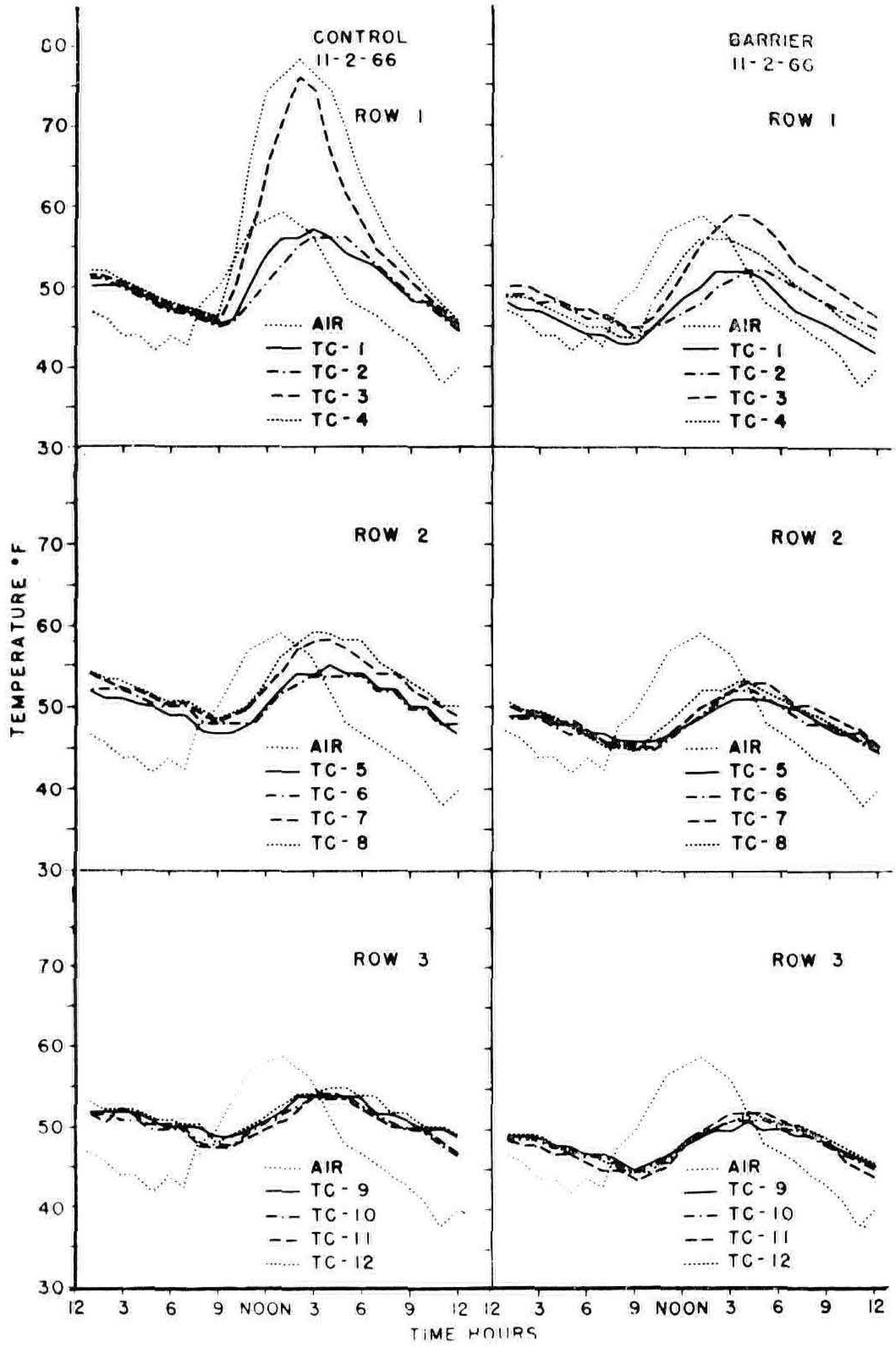

Figure 3. Comparison of temperatures recorded in different locations in an unprotected control plot and a plot protected by foil barrier on November 2, 1966.

peratures tended to be lower than in the other treatments, and the temperature differential within the plot was less.

Temperature fluctuation in the control plot on bright days was most marked in the outer row of containers. Although

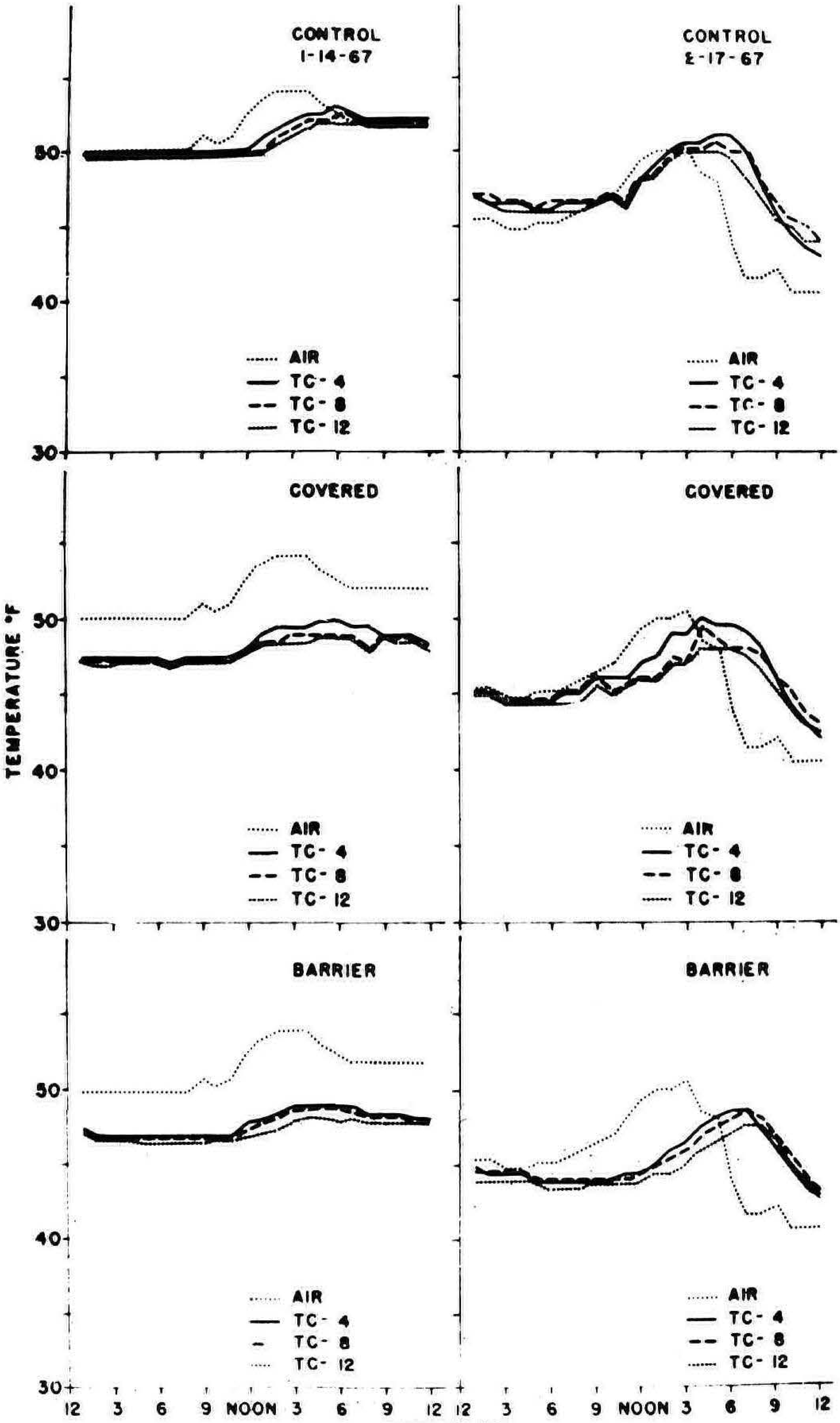

Figure 4. Diurnal temperature fluctuations recorded by rows for representative cool, cloudy days. January 14, 1966, and February 17, 1967. (row 1, TC 4; row 2, TC 8; row 3, TC 12).

the containers in the inner row were somewhat warmer than those of the barrier treatment, the differences were not great (3-5° F.).

Unlike the control treatment, the containers in the cover-

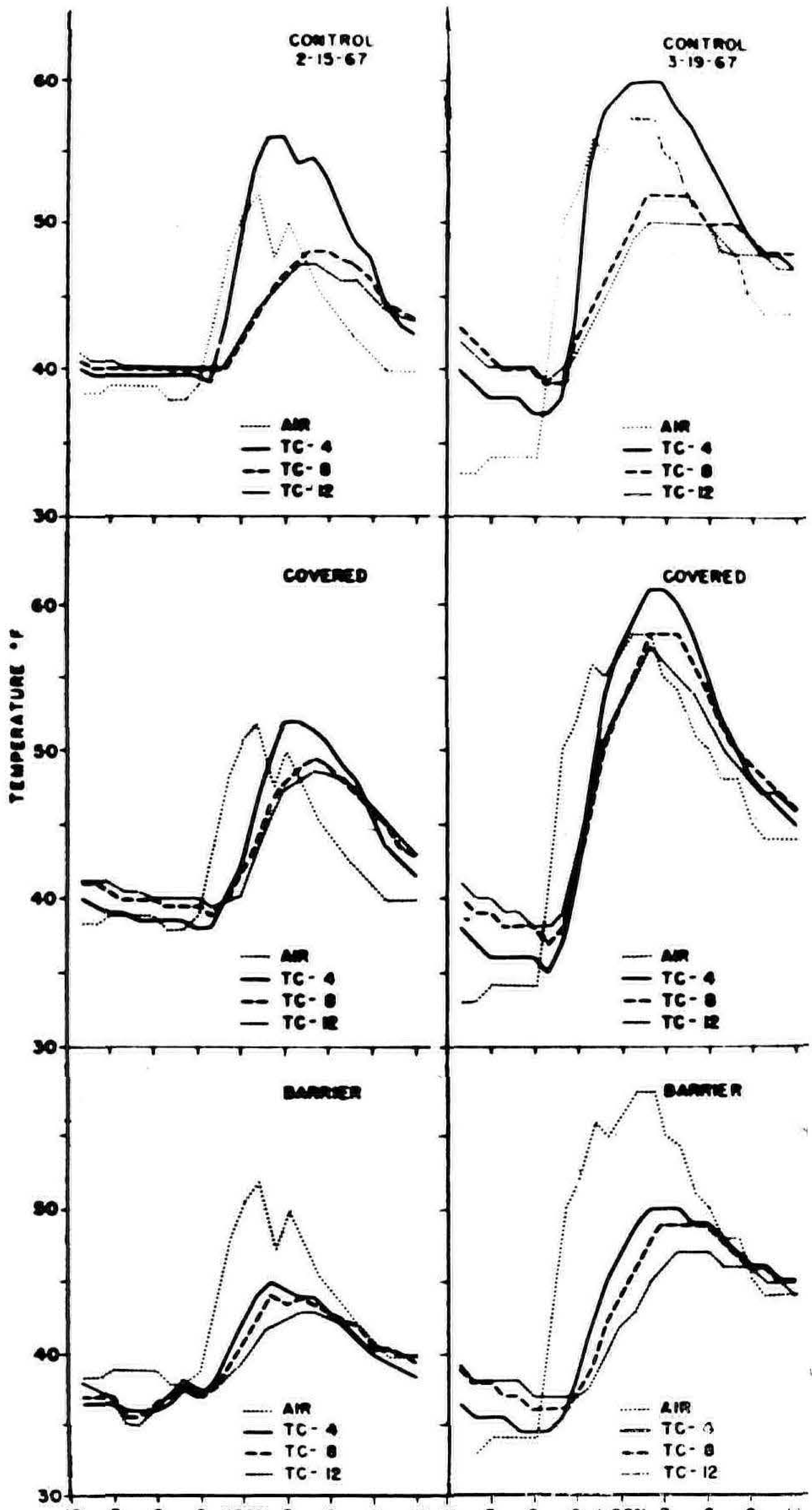

Figure 5. Diurnal temperature fluctuations recorded by rows for representative warm, sunny, days. February 15, 1967, and March 19, 1967. Row 1, TC 4, Row 2, TC 8, Row 3, TC 12.

ed treatment exhibited a more uniform temperature across the plot (Figure 5). The heat trapping effect of the polyethylene may have caused the greater temperature fluctuations which were observed across the entire treatment. Although diurnal temperature fluctuations were great, there was less variation due to position of cans in the plot. The rate of temperature rise was somewhat slower in the covered plot compared to the control plot (Figure 5), but the rate of rise and fall were similar. Thus both the barrier and the covering tended to even out temperatures across the plot.

DISCUSSION

Plants have the capacity to withstand very low temperatures when properly hardened (3, 5, and 6). However, it has also been shown that hardiness can be lost by even brief exposure to mild or high temperatures (8). One of the most critical effects of low temperature on plants is the rate of temperature fall (10). Rapid changes in temperature can cause more injury than slower rates (1, 2, 3, 5, 6, 9, and 11). As a result, temperature fluctuations may be a more critical factor in plant survival than the frequency or degree of low temperature.

Roots (5, 11) are more subject to injury from low temperature than either stems (1, 5) or leaves (5, 9). They are also more subject to injury from rapid changes in temperature (2,5). This suggests that injury to container-grown stock from temperature fluctuations may be greater to the root than to the rest of the plant. In this study, fluctuations in soil temperature were as great as, or greater, than air temperature, particularly in the outside rows.

The greatest diurnal fluctuation in temperature occurred in the outermost rows, particularly in those on the south side, when the containers were exposed to direct sunlight. This is also where the greatest amount of winter injury or loss of plants occurs. When containers are protected with a plastic cover, loss is found to be negligible.

It is of interest to note that the foil barrier resulted in as uniform a temperature throughout the plot as a plastic cover. If temperature fluctuation was the primary cause of injury and plant loss, then less injury would be expected from a barrier than a plastic cover. Results of this study showed that the differences in temperature between containers at any given hour was reduced by a plastic cover even though diurnal fluctuations were greater than either the unprotected control plot or the plot protected by the foil-barrier.

These results as well as the results from other studies on hardiness and injury (2, 5, 6, 8, 9, and 11) question the practice of covering plants with plastic to reduce injury. While a plastic cover may have other effects than those noted here, such as influencing evapo-transpiration rates and/or recovery from low temperature injury, an exterior foil-barrier such as used in this study appears to be superior at reducing temperature fluctuations.

SUMMARY

Soil temperature conditions occurring during the critical period for winter injury were studied. It was found that diurnal soil temperatures in the outer row of containers fluctuated greatly which would agree with injury observed to container-grown plants. While soil temperatures under polyethylene protection were as uniform as those with a foil barrier, the diurnal fluctuation was as great as the control plot.

A foil barrier showed less temperature variation within the plot and between plots than did other treatments. Therefore, if fluctuation of temperature is a critical factor, plants protected by a foil barrier should show less injury.

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MODERATOR MAIRE: I don't think I really need to introduce our next speaker. Everybody here knows him. He is in the nursery business right outside Vancouver, B. C., and has been for a long time. So, Walter, come up here and tell us about liner production. Walter Van Vloten:

FIELD PRODUCTION OF LINERS FOR CONTAINERS

WALTER VAN VLOTEN
Walter Van Vloten Nurseries
Haney, British Columbia

Our cuttings are rooted in a 100 x 15 ft. glass greenhouse. There are benches on both sides, leaving a wide center path so that a little carrier can go through for quicker handling of the flats. Under the bench are 4 two-inch pipes for hot water heat. On top are plastic heating cables six inches apart; these are protected by ¼-inch strips, four inches apart. These strips also permit the heat to be more evenly distributed; they also contribute to better drainage.

Our entire production of cuttings is rooted in what we call "deep flats"; they are 12″ by 18″ and 3½ inches deep. The bottom of the flat consists of four pieces so we have five openings where water can drain through.

Our rooting mix is a light one, 50% coarse sand, 30% yellow bulk peat and 20% coarse perlite. When the flats are filled with this mix, we then soak them in Panodrench, a mercury-base material (2 teaspoons per 3 gallons of water). In addition, all the cuttings are dipped in a Captan solution (6 tablespoons per gallon). For the large cuttings we insert 120 per flat. Junipers are wounded, but not the Thujas. Both kinds are dipped into Seradix No. 3, which is an IBA powder, 0.8%. It takes 4 to 6 weeks to root these cuttings using bottom heat at approximately 70° F, with a good water soak every four to six days, depending on weather conditions. We try to keep the tops as dry as possible and, therefore, do not use our mist systems in winter. Summer cuttings are treated in the same way generally except we use more peat in the mix and use our intermittent mist system. Our mist installation is somewhat different from those I have seen in other greenhouses. The main pipe, ¼ inch copper, runs on the back of the bench and the feeder pipes, ½ inch copper, are gradually bent up so that the mist nozzles are in the middle of the bench about one foot above the cuttings. With this system we have no continual dripping on the plant which occurs if the main line is right above the cuttings; we also eliminate stand-up riser pipes which are always in the way when the flats are moved.

After the cuttings start to root (that is, when we see the first root through the flat bottom) we move them to a finishing-off house. Here they start receiving mild feeding with a fish oil fertilizer (2-5-5) and a little Epsom salt (magnesium sulfate) to keep them growing.

In the meantime the growing fields are prepared as follows: They are plowed twice, disced once, then three tons of lime, in the form calcium carbonate, per acre are spread over the fields; this is rototilled in about six inches, then we add 200 lbs. of magnesium sulfate, 100 lbs. of potassium sulfate and

400 lbs. of 11-4-8 fertilizer per acre. This again is rototilled. After 14 days we harrow the land, so it is a little packed; otherwise it is too soft for the planting machine. As soon as we are ready to plant, a long (850 ft.) line is set out over the field. We use a double prism to make sure that we work at right angles. Under the tractor is a bar, which sticks out on the side and attached to this bar is a steel bar, which points down. This last one is movable and is put right above the line. The tractor, plus planting machine, is set precisely in line with this plant line and while the machine moves, this little bar is kept exactly above the line. This system works so well, that when we checked, after having planted 8 beds, we were not even one tenth of an inch off on a field 850 ft. long. The planting machine has handles on each corner to control the right depth of the planting wheel. We made side platforms to carry enough flats of stock to plant 850 ft. One man walks with the machine to determine if the wheels are giving the proper depth; he also supplies the girls with planting stock so we do not have to stop all the time. Empty flats are put on the roof of the machine. The planting machine is covered on all sides for protection against sun and wind. It takes us ½ hour to plant 3300 rooted cuttings and it takes another ½ hour to bring the machine back, straighten up plants, fill in an odd plant which was missed and switch over the plant line. So in 8 hours we plant approximately 25,000 plants. At the end of the day we put sprinklers over the new beds and give them six hours of water so they really get a good soaking. We irrigate these liners every 8 days, depending upon weather conditions.

After about 14 days we start cultivating with a steering control cultivator. One man sits on the back, right above the plants and by steering a little both ways, keeps the cultivator blades from pulling out the plants. Providing this is done regularly, so the weeds are kept small, this machine does a perfect weeding job on our high organic soil. Three weeks after planting, we treat the planting with Casoron at 6 pounds of actual material per acre. Except for certain weeds as sour grass and clover, we have good to excellent weed control. The advantage of Casoron above Simazine is that with Casoron we can keep on cultivating lightly.

During irrigation we apply about 5 pounds of Epsom salt through the line as we have a magnesium deficiency in our soils. We do not side-dress the first season. In late fall we spray Simazine over all our evergreens to keep any weed seeds from germinating during the winter. In April and May of the second year the beds are side-dressed with a fertilizer attachment on the cultivator. We use 400 pounds per acre of 12-4-8 with trace elements added. In May the fields are sprayed with copper sulfate to control twig blight and other fungi. Our sprayer is a simple pump on the tractor power take-off with two 45-gallon drums on a platform attached to the three-point hitch. On the platform a boom is attached which covers three beds. We spray a Diazanon-Tedion mixture if we suspect aphids and red spider are present. In June we start pruning the junipers heavily for the first time. In August we go through the beds again for a light pinching to secure good, dense, two-year liners of the 10 to 18 inch sizes. In winter we do our digging with a heavy, undercut, type digger, the sort which is extensively used in forestry nurseries. It is a blade which is moved by the power take-off and the plants are lifted out of the soil by bent-up steel bars.

Plants so propagated are excellent for putting in large containers for growing as specimen trees.

MODERATOR MAIRE: Thank you, Walter. Now Mr. Lloyd Smith of Pitt Meadows, B. C. will speak to us on container production of large trees. Mr. Smith:

CONTAINER PRODUCTION OF LARGE TREES

LLOYD SMITH
Pit Meadows, British Columbia

In this discussion of large trees, we shall be referring to trees of two-inch caliper and larger. Smaller trees are easily handled bare-root in the dormant season and we are all familiar with container-grown trees in sizes from 5 to 15 gallon. The successful moving of very large trees, either bare-root or balled and burlaped, during the dormant season, has been done for many years, so that we are not entering a new field. The increasing demand for large trees available for landscape development at all seasons of the year, prompted me to include large container-grown trees in my operation.

Perhaps, "Establishing Large Trees In Containers," would be a better title, as most of our large trees are field-grown first. However, as nursery stock planted in containers and grown for one or more seasons qualifies as "container-grown", our title may still be applicable.

Our containers are constructed from one-inch rough cedar lumber, metal-banded collapsible boxes. Loose bottoms drop in and are supported by cleats fastened to the bottom of the side pieces, and by the taper of the box. We find one-inch lumber adequate for boxes up to 36 inches in diameter. For larger boxes we use two-inch lumber. For a few very large trees we have used four-inch decking. Collapsible boxes are easily stored and quickly assembled as used. Special tools for tightening the bands are readily available.

Containers must be large enough for good root development. The rule-of-thumb we have been using is a one-foot diameter container for each inch diameter of tree.

2″ — 2½″ cal. tree	24″ box
2½″ — 3″ cal. tree	30″ box
3″ — 3½″ cal. tree	36″ box

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The planting medium we use is a U. C. type soil mix; 50% sand and 50% peat. The fertilizer incorporated in this mix is formula I (C), which supplies phosphate and potash with a moderate amount of nitrogen. This has given us excellent root development but does require supplemental feeding.

Trees planted in containers during the winter months—or early spring—are fed after good root action has commenced, or about the time new leaves are forming. We feed a balanced dry fertilizer and water it in. Soil mixes and fertilizer formulas are taken from the University of California Manual 23, "U. C. System For Producing Healthy Container Grown Plants". (Available for $1.00 from Agricultural Publications, Univ. of California, Berkeley).

A lighter mix would have some advantages. We have been thinking of using bark, and intend to work with it next spring.

Insect pests on container trees have been easily controlled with the use of granular Di-Syston applied in the early spring. Due to the limited root area, less material need be used than would normally be required for the same sized tree in the field.

Watering large trees in containers is one of the greatest problems. We found sprinklers unsatisfactory and have done it all by hand. Large, boxed trees use a lot of water on a hot, windy day. Our schedule is to water heavily by hand every day during hot weather, skip a day on some material during cooler weather, then twice a week later in the fall when the trees are becoming dormant, then occasionally, during the winter as the weather indicates. An automatic system of tubes with individual spray heads for every box, calibrated to the size of the box would certainly reduce the cost of hand labour, but I doubt would do as good a job as a skilled "water girl".

Containers up to 24-inch in diameter are moved and loaded by two men; larger ones, up to 36-inch diameter, we lift with the front-end loader of an ordinary farm tractor. Larger boxes require heavy equipment for moving and loading.

The successful production of good container trees requires careful attention to a number of factors.

(a) Use only healthy trees with a good root system—trees that have been carefully grown and root pruned during their development — or — container-grown trees that have been regularly moved upward in container sizes to avoid cramped or girdled roots.

(b) Always use adequate container size for proper root development.

(c) Provide careful watering at all times so that the tree never dries out or even suffers from lack of water.

(d) Grow the tree in the container for one growing season, or a minimum of three months, before moving it onto a job.

(e) Never grow a tree more than two years, or two growing seasons, before moving it to a larger container.

There is no limit to the size of a tree that can be boxed and moved; limitations are with equipment, restrictions with overhead wires, or the willingness for someone to pay the cost. Trees up to five- and six-inch caliper present no great problem in boxing and delivering on the site.

THURSDAY AFTERNOON SESSION

September 7, 1967

VICE-PRESIDENT TICKNOR: Our first session this afternoon will be on seed production of plants and will deal primarily with forest tree species. Our first moderator will be Mr. Ralph Jack of the Sierra Falls Nursery and Christmas Tree Farm, Silverton, Oregon. Mr. Jack, will you start this afternoon's program?

MODERATOR JACK: Our first speaker is Professor of Forestry, University of British Columbia, Vancouver, B. C. I would now like to present Dr. Philip Haddock:

THE IMPORTANCE OF PROVENANCE IN FORESTRY

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In order to be more certain of not being misunderstood, it is necessary to risk boring you by defining "provenance", at least as I intend to use the word. In forestry, it refers to the geographic origin of seed, or according to Callaham (1964) "the population of trees growing at a particular place of origin, and Wright (1962) "the original geographic source of a lot of seed (or pollen)." The term provenance should be restricted to the more or less precise origin of the naturally developed ("in situ") population from which the seed is directly derived. We need to recall that the phenotype, in contrast to the genotype, is what we have to deal with as our product. It is always the result of the reaction between the genotype and the environment. Failure to understand and appreciate this fact has been the cause of great misunderstanding, many errors in practice and much financial loss. It is probably unnecessary to stress these elementary matters to a group such as this, but perhaps the special nature of forest crops warrants some risk of repetition since some of you may not be familiar with the history of forestry and some of its special problems.

Callaham (1964), Langlet (1963), Lines (1965) and others have traced the historical background to the problems and nature of research in geographic variation in forest trees. These studies date back for almost two hundred years (Duffield, 1962). Perhaps educators and others not principally involved in this specialized research field may be as much at fault as any in the failure to recognize sufficiently the significance of within-species genetic variation. It would seem that practitioners have relied too greatly on the relative uniformity of morphological features used by taxonomists to distinguish between species and varieties and too little upon the demonstrably different but less conspicuous or less easily measured characteristics such as general physiology, phenology; particularly dates of bud setting and flushing; cold, heat, and drought resistance; susceptibility to insects and disease, growth form and wood quality. In fact, it may be true, as Langlet (1959) suggested, that "taxonomic subgroupings are then not only valueless (Langlet, 1934), but downright harmful (Huxley, 1939), since they suggest a non-existent homogeneity within conventional units which are in reality mere abstractions."

A related view is expressed and called to the attention of foresters by Duffield (1965) in his quotation from Ernst Mayr's work, "Animal Species and Evolution", to the following effect:

> ". . . All organisms and organic phenomena are composed of unique features and can be described collectively only in statistical terms. . . Averages are merely statistical abstractions; only the individuals of which the populations are composed have reality. . . For the typologist, the type is real and the variation an illusion, while for the populationist the type is an abstraction and only the variation is real. No two ways of looking at nature could be more different. . . The replacement of typological by population thinking is perhaps the greatest conceptual revaluation that has taken place in biology."

In the clear-vision of hind-sight, we may recognize that some of our mistakes have probably been due to this outdated typological thinking. Doubtless, we may conclude that, especially in species of such great geographic range as Scots pine (*Pinus sylvestris* L.) and Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), taxonomy has notably failed to serve silviculture effectively (Haddock and Sziklai, 1966). When scientists have disagreed or failed to perceive certain principles clearly, it may not be quite fair to blame now obvious mistakes on practicing foresters who should have known better. The reasons for our mistakes in the past have been many and varied and there is little point in dwelling on them at length, but in recollection they may serve as horrible examples to be avoided in the future at all costs.

The long rotations in forestry, common especially in the past, have prevented prompt evaluation and recognition of both the serious and less serious errors. The time factor has also been partly responsible for certain inadequacies in records and communications caused by changes in personnel, the interruptions of wars, fires, and all the other disasters that can befall hopefully long-lived plantations. It should also be recalled that foresters first observed some of the effects of provenance before the time of Darwin and Mendel (Langlet, 1963), and that European forestry practice was well developed before the rediscovery of Mendel's Laws by geneticists around the turn of the century. However, limited knowledge of forest tree physiology and the environmental sciences, as well as of genetics, combined with poor communiciations between botanist and forester, scientist and field man, have compounded the problem—and of course still hamper our progress.

One example may suffice to illustrate the magnitude of some of the losses represented by classic failures to consider provenance seriously. Farnsworth (1967) quotes a statement made in a paper presented by P. Bouvarel at the Sixth World Forestry Congress in Spain in 1966 as follows:

> ". . . it is evident that the failure or low productivity of certain reforestation programs are due to errors in the choice of seed. To quote one example among many, between 1870 and 1910 in France more than 50,000 hectares were planted with Scotch pine of poor race. The saving achieved on the cost of the seed, expressed in presentday values and capitalized up to 1960, represents 350,000 francs, against a loss in income, as compared with what would have been obtained with pine of good race (a greater quantity of better grade timber) of more than 300 million francs."

It is clear then that provenance is an economically important question in forestry, and has been for a long time.

An illustration of its immediate practical importance is found in the program reported by Schmidt (1967) involving a comprehensive provenance study in Douglas fir by the British Columbia Forest Service. We must know more about how far seed can be moved, since due to frequent conecrop failures, especially at the higher elevations now being logged, we cannot always use local seed in reforestation. Other recent references involving questions of provenance in this region include those of Ching (1965), Ching and Bever (1960), Silen (1966) and Douglass (1965).

Provenance questions are a part of the growing research efforts in forest genetics and tree improvement now gaining long-needed recognition. Duffield (1962) stated:

> "The rapid extension of tree improvement activities and forest genetics research marks a major turning point in the development of forestry. It marks, even more clearly than the increased interest in reforestation, the transition from the exploitative to the productive phase in forestry. It is a development as significant in the history of forestry as the change from hunting and gathering to farming and herding in the history of our species."

Some time ago Wakeley (1954) recognized the crucial nature of provenance research when he wrote:

> ". . . The inescapable conclusion is that selections and hybrids must be made separately, region by region, within the framework of geographic races. To the extent that this

is true, provenance studies designed to identify such races and define their territorial boundaries are fundamental to other phases of tree improvement."

The use of the term "race" raises problems such as whether or not certain recognized variation in populations is continuous or discontinuous. To explore this question is beyond the scope of my paper. Perhaps it is sufficient to note that as Burley (1965) concluded, concepts of clinal and ecotypic variation are not mutually exclusive.

In British Columbia, in matters of tree improvement research, early interest centered on the most valuable and traditionally useful tree in our trade, the Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco). Although questions of provenance are still many and we need much more knowledge, (Schmidt, 1967), tree improvement work has been well started in some regions of the province through intensive selection of individual superior phenotypes, progeny testing, controlled pollination, vegetative propagation, individual and species hybridization, and seed orchard development (Orr-Ewing, 1966), Sziklai (1964). Doubtless, provenance limitations will affect the usefulness of many of the improved forms we can expect to come from this research.

Lines (1965) has recently prepared an excellent general summary of the provenance topic to which I can refer you for more information of an historical nature. He notes that many countries have passed legislation aimed at controlling the importation of tree seed so as to assure good quality and accurate knowledge of origin (i.e. provenance). Lines concluded that it pays to spend up to fifty per cent more for better seed.

We are only just now getting around to facing the issue of seed certification in western North America. Undoubtedly, we need better seed regulation, and perhaps some legislation, but it is also true that wise legislation has been hindered or made impossible by insufficient knowledge of the provenance field in many if not all of our important forest tree species. Recent developments in this important aspect of the provenance question have been reported by Farnsworth (1967) and Rudolf (1966).

I will outline some of the things we do and don't know about provenance in relation to some of our local species. Much of this is the outgrowth of the use of our species as exotics in various parts of the world, but especially in western Europe.

As a consequence of experience, foresters have evolved the rule of thumb, "local seed is best" (Duffield, 1962). In many situations we are still following this essentially very conservative rule, but in the light of more recent studies, especially in Europe, we have felt it necessary to test the validity of this rule and of course the use of exotics implies that it is not necessarily valid in a great many cases. For many years now, the value of North American species and the importance of provenance in their use have been increasingly recognized by European foresters. In fact, very recently, members of research organizations have made expeditions to the Pacific Coast for the purpose of making their own accurately-controlled collections of forest tree seed, sometimes even going to individual seed tree collections for purposes of research. The ice age left Europe without a rich coniferous tree flora, so that exotics from western North America are now much sought-after. Because of their wide distribution, climatic adaptation, growth habits, excellent wood properties and freedom from serious diseases, some of the most desired species are: Sitka spruce (*Picea sitchensis* [Bong.] Carr.), Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco), and lodgepole pine (*Pinus contorta* Dougl.).

Some others, such as western hemlock (*Tsuga heterophylla* [Rafn.] Sarg.), western red cedar (*Thuja plicata* Donn ex D. Don.), and grand fir (*Abies grandis* [Dougl.] Lindl.) are also of interest, but are imported as yet largely on an experimental scale.

Sitka spruce is one of the most valued species and is used extensively by the Forestry Commission in Great Britain. It is also planted to a lesser extent in Ireland, Scandinavia, and Germany. It has been established that cold injury in the species is principally a problem of provenance (Haddock, 1966 citing Robak). Other evidence supports the importance of seed origin in Sitka spruce, and for some years the Queen Charlotte Island seed source has been sought for plantations in the colder areas of northern Europe to which the species is adapted. However, such broadly designated regions are no longer considered adequate. Increased attention is being directed to more precise provenance designations, because of the great topographic and associated climatic and edaphic variation in the environment. These factors are believed to have shaped the evolution and development of locally, genetically different populations over long periods of time (Burley 1965, Haddock 1966, and Haddock and Sziklai 1966).

Douglas fir was introduced more than a century ago to Europe by David Douglas. It is more demanding of soil than Sitka spruce and is also not so resistant to wind, so has found less general usefulness in Great Britain, but it is in great demand on the continent. Observers have long recognized that Douglas fir can be broadly divided into two major populations, sometimes given taxonomic status. These are variously known as the coast, "viridis", or "green" Douglas fir, and the interior, "glauca" or "blue", Douglas fir. Intermediate forms from the so-called "wet belt" of the Columbia Forest Region of interior British Columbia are of special interest to foresters in eastern Europe, whereas the coastal populations are those best suited to western Europe in general. The slow-growing, disease-prone continental, interior origins, especially those from the most arid sections, are of little interest and utility as exotics anywhere. In parts of Great Britain, The Netherlands, France, and Denmark, provenances of Douglas fir from western Washington have long been preferred.

Recent studies in North America are now recording in more detail the great variation which exists in Douglas fir both within small geographic areas and over the range as a whole.

More recently, interest in lodgepole pine has increased and the critical importance of provenance in this species is being recognized. The coastal populations, known generally as shore pines, have been given varietal status by taxonomists, but the variation in populations within this form has been proved to be of much silvicultural significance, (Roche 1962, 1963, Lines 1966, Feilberg 1964, Haddock 1966). The species has been widely planted in Ireland and in Great Britain, as well as less extensively elsewhere in Europe, and the so-called "green" or coastal form (shore pine) has also been planted in New Zealand (Duff, 1966), where it is superior to the interior populations. In Great Britain and Ireland, shore pine represents the preferred group of provenances, whereas further east and north more continental provenances prove superior. In Great Britain and Ireland, an extensively imported provenance of the coastal population has been proved to be inferior to other coastal provenances, at least on some sites (Aldhous, quoted in Haddock, 1966). However, much more research is needed before the full possibilities for this species can be realized (Hagner, 1967).

I must mention a subject probably of greater interest to some of you than what has been covered so far. Christmas tree culture is a bit of a no-man's land between the horticulturist and the forester. For many years the concept in this part of the world was that Christmas trees were to be grown on the poorest sites where trees, mainly Douglas firs, would be suitably bushy due to slow height growth with short internodes. Recently, this concept, long out-of-date elsewhere, has been challenged here. At the same time, an even more deeply-rooted prejudice against exotics is being questioned. Plantations of Scots pine (*Pinus sylvestris* L.) have been established for many years on an extensive scale in eastern North America, particularly in the Lake States and Ontario, where it is increasingly grown for Christmas trees. In fact, it is probably no news to those of you here that this species has replaced Douglas fir in many areas and is now the single most widely-used Christmas tree species in the United States! Explanations for this may vary, but in other species as well as in this one, the aim now seems to be to use good sites and the best seed from properly chosen provenances or even particular genotypes suitably adapted to the proposed growing site, with high quality trees assured by additional appropriate cultural practices.

As indicated by the studies of Douglass (1966, 1967)

Douglas firs and Scots pines are being grown rapidly on good sites with cultural practices such as pruning and shearing and when the appropriate provenances have been selected, valuable trees may be grown quickly (Douglass 1965, 1966, 1967).

The variation between and within Scots pine provenances has long been studied in Europe and documented there and in the United States by a number of workers (Langlet 1959, 1963, Wright and Baldwin 1957, Douglass 1965). Douglass, as many of you know, has evaluated Scots pine provenances grown in Olympia and has also provided recommendations for Douglas fir, Scots pine, and shore pine seed origins, and has provided instructions for cultural practices applicable in the Pacific Northwest. He concluded that future provenance testing in this region for Christmas trees should concentrate on the seed origins of Scots pine from southern Germany, France, and Spain. These appear to be the most promising here in respect to color, growth rate and form, and in adaptability to shearing.

In conclusion, the role of provenance and its importance in forestry are certain to increase in keeping with the growth of artificial regeneration in forestry practice and as an accompaniment to accelerating and more intensive research programs in forest genetics and forest tree breeding.

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MODERATOR JACK: Our next speaker is Dr. George S. Allen, Forest Research Laboratory, Victoria, B. C. He will speak to us on the important topic of stratification of tree seeds. Dr. Allen.

STRATIFICATION OF TREE SEED

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Stratification of seed that is otherwise difficult to germinate is a very old practice, probably pre-dating most of our agriculture and forestry texts and handbooks. It is an art developed from observation, experiment, and experience. To date it is not strongly science-based although its effects will undoubtedly be explained in due course in terms of removal of specific blocks to germination—the ultimate goal of the seed.

Stratification is one of a number of treatments commonly used to overcome seed dormancy. Such include the use of light or other radiation, the use of various chemicals such as thiourea, nitrates, ethylene gas, citric acid, and gibberellin, soaking in hot water and acids and many others. Some of these appear to be interchangeable. In particular, stratification can substitute for the others in many instances.

The suggestion has been made and generally accepted that the course of germination may follow one of several pathways, that blocks may be present in one or more, and these may respond to different kinds of treatment or be by-passed (E. H. Toole, 1961). Stratification—usually cold, sometimes warm, and sometimes a combination—results in a by-passing of other requirements and presumably of the related blocks.

It may be fortuitously, or more likely through long and rigorous selection, that many woody plants have acquired a system of alternative pathways from dormancy to germination. Whatever the cause, the process probably favors survival of the wild species. It takes care of some of the vagaries of seasons and environments to permit eventual germination and initial establishment under a variety of adverse or unusual conditions. Such conditions would probably often be unsuitable for seed provided with only one road to germination and one block that *had* to be broken down for germination to take place.

What is stratification?

Usually stratification implies a cold, moist treatment of seed for periods of a few days to as long as several months. The term is also used, however, to include a moist treatment at any temperature that will not normally cause germination. Thus, Mahlstede and Haber (1957) include both cold and warm treatments as well as the combination of cold and warmth used to overcome so-called "double dormancy". In the Woody Plant Seed Manual (U. S. Forest Service, 1948) also, the terms "cold stratification" and "warm stratification" are both used.

Variations in actual practice are several. What may be the original system of placing seeds between layers of moist sand or other medium in a pit in the ground, is still used, probably fairly commonly. Instead of being buried outdoors, the seed may be layered in a container placed in refrigerator, cold room, or root cellar. Often the seed is mixed with a moist medium, rather than layered, and placed in a rigid container or polyethylene bag and refrigerated.

Another modification is to pre-soak the seed, then dry its surface and place it in vials, jars, or plastic sacks. Mahlstede and Haber (1957) suggest that small lots of seed can be mixed with moist, shredded sphagnum moss and placed in a polyethylene bag at 41°F. Large lots of conifer seed can be stratified in cotton sacks separated by wet medium into layers, in barrels provided with good drainage (U. S. Forest Service, 1948). Any large-scale operation requires frequent checking of temperature and moisture conditions around the seed. Fine seeds have been placed between appropriate cloth material which is alternated with layers of stratification medium such as sand, peat, or vermiculite (Mahlstede and Haber, 1957).

What does stratification do?

Cold stratification is thought to break at least some forms of internal dormancy; that is, to remove or circumvent physiological blocks to necessary processes or events leading to germination. Little is known as to the nature of the blocks or even the processes, although some of the changes that take place have been determined (see, for example, Baldwin, 1942; Barton and Bray, 1967). Such changes must be preceded by activation of appropriate enzyme systems that direct metabolism along a successful pathway. Such changes may involve modification of substrates or removal or change of toxic or inhibitory materials, as well as activation of an enzyme system (E. H. Toole, 1961).

On the other hand, warm stratification, usually in combination with a cold period, is used to make the seed coat permeable for effective cold stratification to follow. Other treatments commonly used as alternatives to warm stratification include soaking in hot water or strong acid, and scarification of the seed coat. Stratification is often favored as the more natural method, probably less hazardous to both seed and user and adaptable to both small- and large-scale operations.

An interesting application of stratification by Hagner and Simak (1958) resulted in the further development of immature embryos of *Pinus cembra*. The best treatments involved the use of moist vermiculite at about 5°C. with the seed placed on its surface, embedded in it, or mixed with the medium. Over a 5-month period, some embryos grew from less than half to almost full seed length. Such a technique may have considerable value for far-north or high-elevation species or races whose seed often does not develop fully. Incidentally, Hagner and Simak used x-radiography to follow embryo development in individual seeds during treatment. They advocate use of the x-ray technique to diagnose immaturity of the kind reported.

Natural basis for stratification

H. I. Baldwin (1942), in his near-classic *Forest Tree Seed*, stated "Knowledge of the proper pretreatment to induce prompt and complete germination can best be gained by a study of the ecological factors affecting the seed in its natural habitat between the time of maturity and germination. With rare exceptions this has not been done. . . . . . . many things can be learned from a careful study of the life history of a seed". Baldwin's statement still holds after 25 years even though we have added to the species and varieties we can successfully treat to make them germinate. Many seeds still pose problems; such include sweet fern, the euonymuses, some hollies and honeysuckles, yews, California nutmeg and others (Mahlstede and Haber, 1957; U. S. Forest Service, 1948).

Very often, observations of seed behavior in field or nursery suggest whether stratification is desirable or necessary. Black cottonwood seed, for example, matures and is disseminated in early summer and germinates almost immediately or perishes. Willows are similar and so is sugar maple. Seeds having these characteristics are not likely to benefit from stratification or other treatment, but should be sown as soon as collected.

Western broadleaf maple, on the other hand, matures and drops its seed in late autumn; germination occurs the next spring. Seed with such characteristics usually responds to stratification if sown in spring, or to fall sowing if not treated.

A fairly large number of species, particular trees and shrubs, produce seeds that germinate irregularly over a period of two, three, or even four years. If sown in the late fall they may germinate mainly in the second year; if sown in summer they may germinate well the next spring. If we know this from experience or observation, we can be fairly certain that such seed requires compound stratification, that is, warm followed by cold. Temperatures commonly used during the warm treatment are 68-86°F. alternating (16 and 8 hours, respectively). Some, but not all, of this group drop their mature seed in summer when it is exposed naturally to a period of "warm stratification", then to one of cold. Examples of species whose seeds generally respond to double or compound stratification include (U. S. Forest Service, 1948): basswood or linden (*Tilia americans*), the ashes (*Fraxinus excelsior, F. nigra,* and others), Eastern red cedar (*Juniperus virginiana*), hawthorns (*Crataegus* spp.), American mountain ash (*Sorbus americana*), dogwoods (*Cornus* spp. except *C. nuttalli*), cotoneasters. Western white pine is reported to respond to compound treatment: 30 days at 24°C. followed by 30 days at 2-5°C. was most effective (Anderson and Wilson, 1966).

Many kinds of seeds are disseminated in the fall or early winter, lie exposed for several months, and germinate more or less completely the following spring. Such seeds respond well to simple cold stratification if spring sown; if fall sown they rarely require treatment. Many north temperate conifers are in this group. Although deep dormancy causing one or more full years' delay in germination is not characteristic of them, spring sowing without pretreatment usually leads to prolonged germination over the first season and a consequent lack of uniformity and often a high cull factor in the case of nursery stock. For this reason, most forest tree nurserymen practice stratification for some, if not all, of their species.

It is interesting to note that of some 80 groups of trees, mostly genera representing several species, cited by Mahlstede and Haber (1957), over 50 require cold stratification if spring sown, but 39 of those require no treatment if fall sown. Nine require double stratification and two respond to warm stratification alone.

Ecological significance of a stratification requirement

A number of authors have noted that geographically different sources of a species tend to have different germination requirements. Thus, Fowler and Dwight (1964) and Mergen (1963) found that seeds of *Pinus strobus* from southern sources required longer stratification than did seeds from northern sources. A generally comparable behavior seems to be true also for Douglas fir (Allen, 1960, 1961).

Noted many times is the fact that outdoor overwintering ("natural stratification"), or cold stratification, lowers the temperature required for germination by as much as 20° C, perhaps more. Such a mechanism serves to prevent germination during mild weather in fall or winter and to favor germination in the spring as soon as soil temperatures rise somewhat above freezing. This kind of response protects effectively against premature germination at a time when killing temperatures can still occur. Although it has no direct value as a protection against a severe drought following hard on germination, it favors early germination and establishment while soil moisture is still adequate; thus it probably has indirect protective value against drought most years.

Because naturally "stratified" seed has a much lower temperature requirement for germination, ecological studies that use spring-sown seed, untreated after dry storage, are likely to produce results that are difficult or impossible to interpret and apply to situations that actually occur in nature.

Technique

Most of the following remarks are based on experience with seed of western conifers, particularly Douglas fir. They are probably applicable in principle to many seeds that respond to cold stratification.

Various media have been used, as well as no medium, that is, so-called "naked stratification" (Allen and Bientjes, 1954). The latter consists of soaking the seed in water for a suitable time, removal of surface moisture by towelling or air-drying, and storage in loosely closed vials, bottles, or polyethylene bags.

Use of a medium provides a reservoir of moisture and probably helps to prevent heating. The disadvantage is that the medium and seed will likely have to be separated prior to sowing by mechanical means. With no medium, the seed is usually surface-dry at the end of stratification; sowing is easier. With or without a medium, periodic examination is desirable to ensure that moisture and aeration are adequte. With Douglas fir, presoaking of the seed for 24-30 hours at room temperature brings its moisture content up to 60-70 per cent (o.d.w. basis). Over a period of two or three months this will drop to 30-40 per cent. Within this range, stratification has proven fully effective, but not at lower moisture contents. In a study of loblolly pine, MacKinney and McQuilkin (1938) found that peat or sand wetted to 25, 50, 75, and 100 per cent of their moisture-holding capacities, were all equally effective in hastening germination. Such suggests that moisture limits may be quite broad and non-critical, particularly when a medium is used.

Some other characteristics of stratified seeds

Duration of the cold stratification treatment used depends partly on the objective of treating the seed. For testing at an optimal temperature, a relatively short period may be quite satisfactory. But the longer the treatment, the lower will be the temperature at which a given fraction of the seed will germinate. Hence, for field or nursery use, longer treatments more closely simulating natural overwintering may be selected.

In the case of Douglas Fir and the true firs (*Abies* spp.), for example, after extended stratification, many of the seeds will germinate near the freezing point and the radicles will continue to grow at that temperature (0-2°C.). Such behavior has been reported for a number of plants including grasses. After natural overwintering just below the soil surface, Douglas fir seed germinates in February or early March in this climate (Vancouver, B. C.) when near-surface soil temperature is about 10°C. or less. But no shoots appear above ground until daytime soil temperature is about 15°C. —a relatively "safe" temperature. Hence, the early germination or establishment resulting from fall sowing (or stratification if seed is sown early enough) might go unnoticed or be underestimated. It is doubtful that the alternatives to cold stratification have such marked effect upon the temperature requirement for germination.

Experiments with Douglas fir suggest that some 80-120 days of cold stratification fairly closely simulates 5-7 months of overwintering on the ground; the latter, of course, involves fluctuating moisture and temperature whereas the former is usually accomplished at constant temperature and either a constant or a slowly decreasing moisture content.

Another feature is that the longer the period of stratification (up to some limit, possibly 80-120 days), the more uniformly will the seed behave. Whereas untreated seed of individual Douglas fir trees may have median germination times of 5 and 30 days at 25°C. in somewhat extreme cases, such times can be brought to a low and similar level by cold stratification, usually of 80 days or longer. Extreme differences of this kind do occur within single lots of seed derived from a number of parents. Uniformity, often a most desirable feature in large-scale operations, can be promoted by long, cold stratification.

Although stratification does not harm high quality seed of species known to benefit, it may lower production from poor seed. In such cases, the longer the treatment, the greater the drop. Seed that reacts in this way is suspect and should be used as soon as possible and stratified for a minimum period.

Special applications

Stratification has some advantages for seed testing. Response will indicate the degree of dormancy and the treatment likely to be effective; but differences between laboratory and field conditions for germination should be kept in mind in interpreting the laboratory results. In many cases, cold stratification makes unnecessary other treatments for dormant or slow-to-germinate seeds and, in many seed-testing laboratories, is therefore used as a matter of routine.

For research, stratification has specific values:

a) For studies of the ecological requirements for germination, it provides seed that is similar physiologically to seed that was shed in the fall and overwintered on the ground; the artificial treatment, however, is reproducible.
b) For studies of the physiology of dormancy, it provides seeds whose dormancy has been broken, for comparison with untreated, dormant seeds.
c) For seedling studies of such things as growth, photosynthetic efficiency, and nutrition, it provides a way of producing relatively uniform experimental material.

Reversing the stratification process

The most effective stratification treatment for a given set of conditions can be worked out by laboratory experiment. Unfortunately, the predicted and planned-for conditions may not come about and ability to modify plans is highly desirable. For example, we might have a perfectly good 60-day treatment based on careful studies, only to find the nursery flooded on the planned sowing date. The question is: what can we do with the seed if we can't sow? — and what if anything can we do with leftover treated seed? The following comments apply to Douglas fir seed, both Coast and Interior sources; they probably apply to seeds of a number of other conifers that react favorably to cold stratification.

Good seed is durable if carefully handled; care is essential when the seed is moist and ready to germinate. It can be continued in stratification for months with little or no loss and will retain its readiness to germinate. Some seed may germinate at the low temperature but will remain viable if handled with care. Instead of being continued in stratification the seed can be dried down to 10 per cent moisture content or less (at room temperature and moderate relative humidity) and returned to cold storage. Another method is to expose the seed to the atmosphere in cold storage and allow it to lose moisture slowly. As the seed dries by either method it slowly loses its readiness to germinate and will go back into full dormancy in time. Field observations of seed prevented from germinating by sudden cold or drought generally support the above conclusions derived from laboratory studies.

Before concluding, I should like to stress the fact of biological variation among the seed of wild species. Prescriptions for seed testing or treatment may differ because the experimenters used material that differed in some important way(s). The history of the fruits or cones, and seeds, may be a factor; thus, the parentage the season's weather, the seed's maturity, the way it was handled from collection through extraction and cleaning, to storage may all have their effects. The need for replication is obvious. To give just one example, I once had a Douglas fir tree that produced seeds that were very slow to germinate when untreated. Dormancy in this tree's seeds lay largely in the endosperm membrane. If the membrane was punctured or cut anywhere on its surface, that seed germinated very rapidly, as if stratified. I thought I had a real discovery but seed from other trees nearby showed very little response to membrane treatment. The interesting finding was that all of the seed referred to responded equally well to cold stratification.

A final example taken from some nursery studies made in the early 1940's illustrates again the uniformity-promoting feature of cold stratification for Douglas fir. With spring sowing, seedlings from stratified seed began to appear above ground 2-4 weeks earlier than those from untreated seed; the treated seed completed its germination two months earlier, producing much more uniform and larger stock.

Conclusion. I have discussed some aspects of the practice of stratification and very little of the scientific base or interpretation. The reason is simple. Too little is known about dormancy as such or the action of various agents that remove or destroy the blocks to germination to overcome dormancy. Knowledge about these two aspects will almost certainly increase at about the same rate since they are so closely interdependent. Stratification is probably the most universal of the treatments used and, as such, is likely to figure importantly in future studies designed to shed light on dormancy and the processes that overcome it.

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MODERATOR JACK: Thank you, Dr. Allen, for a most interesting discussion. Mr. Jack Doty of Viewcrest Nursery, Vancouver, Washington, (not British Columbia) will now talk to us on field production of tree seedlings in Washington. Mr. Jack Doty:

FIELD PRODUCTION OF TREE SEEDLINGS IN WASHINGTON

JACK DOTY
View Crest Nursery
Vancouver, Washington

In growing seedlings we try to duplicate the processes which would come about naturally. Seeds have an inherent ability to hold back germination in the fall to avoid winter-killing. By stratification we gain a quick germination at mancy as such or the action of various agents that remove or destroy the blocks to germination to overcome dormancy. Knowledge about these two aspects will almost certainly increase at about the same rate since they are so closely interdependent. Stratification is probably the most universal of the treatments used and, as such, is likely to figure importantly in future studies designed to shed light on dormancy and the processes that overcome it.

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FIELD PRODUCTION OF TREE SEEDLINGS IN WASHINGTON

JACK DOTY

View Crest Nursery

Vancouver, Washington

In growing seedlings we try to duplicate the processes which would come about naturally. Seeds have an inherent ability to hold back germination in the fall to avoid winter-killing. By stratification we gain a quick germination at planting time. However, with some varieties we find that it is more advantageous to plant in the fall and germinate the seeds naturally.

Source of seed is a never-ending problem. Local seed crops are always the best, as they will have a higher moisture content and require less processing for germination. Imported seeds have to be fumigated; if moisture and temperature are high the methyl bromide will stop germination. In general, we have found that it pays to keep the seeds in transit the least possible time. Air shipment may seem rather costly, but it usually pays back dividends with better germination.

Seeds in the berry form will germinate better if the outer pulp is left in close contact with the seed during stratification. Probably the acid of the pulp helps to break down the outer layer of the seed for better water penetration. At seeding time it is essential to have the best possible conditions for germination. Soil temperature is very important especially if the seed is ready to sprout. Certain seeds bcome more able to germinate at a lower temperature the longer they are held in stratification. Many times it becomes necessary to move seeds from the stratification room in which they are being held at 36-41°F., to a lower temperature—just above freezing—until weather and other conditions favor field seeding. Therefore, it is important to time the stratification process so as to be ready at planting time.

To obtain the best seedlings, proper planting density is an important factor. Seeding density is determined by a cut test of the seed. The cut test is not always reliable, but is the best method we have so far. There are just too many varieties of seeds going in at this time to rely on a germination test for each one. Once the seed is in the ground, the pressure is on to obtain the best possible germination.

Conifer seed beds are prepared much like a new lawn. All beds are rolled prior to seeding. We fumigate our land with methyl bromide periodically. Conifer beds are fumigated immediately prior to seeding in the spring. This is a particular advantage as most all the germinating weeds are killed and there is no competition to the seeds.

Broadcast seeding is done with a 24″ Lawn Beauty Seeder. As our beds are 4 ft. wide, we make two passes per bed. Row seeding is still done by hand. Sometimes it is necessary to mix seed with sand, peat or sawdust to obtain a lighter density. We vary the pressure on the wheel marker to change the depth of the trench for different seeds. As yet, we have not developed a better method of covering than by hand.

When seed is in the process of germination, moisture content around the seed is very important. As most of our conifer seed is planted almost on top of the ground with only ¼″ sawdust mulch covering, it may be necessary to water for a few hours every day. As the roots grow down, less frequent watering of more quantity will do. Also we found that it helps to stabilize the sawdust mulch from wind blowing if it is not allowed to dry out.

Certain conifer seedlings, such as spruce, do better under partial shade the first year. Snow fencing was first used for shade, but plastic screening has replaced it due to less labor and storage problems involved. We use 2 x 2 stakes driven at 10 ft. intervals; a nylon cord is stretched between them with a staple to anchor the cord. The plastic is clipped to the cord with clothes pins every few feet.

Weeding has been greatly eliminated this season, especially with deciduous stock, by use of chemicals. The fact that seedlings usually take a few weeks to emerge above the ground is put to good advantage. By using a pre-emergence spray, such as Paraquat or mineral spirits, on the beds during this period we can eliminate most of our weeds. After germination is complete and the weeds are showing, the weeding crew moves in for a very thorough job. This is necessary as we immediately follow with a post-emergence spray such as Dacthol or Dymid, and water it in good. On fall-planted seeds, a post-emergence spray is a necessity. Mineral spirits is also used on conifers as a post-emergence spray when the seedlings are well established. In the fall of the year, when our one-year-old conifer seedlings are going into dormancy, we apply a 1 to 2 pound application of 80% wettable Simazine. This usually carries us through until well into the spring. At this time there are indications of the Simazine no longer being present in the soil, thus necessitating a through weeding. During this period of lesser rainfall, we apply Atrazine at approximately the same rate. Some clover seeds usually manage to get through the methyl bromide fumigation and we have been successful in eliminating them by this system. As most conifers are lifted the following fall and spring, further weed control may not be necessary.

After transplanting conifers, we immediately follow with an application of 2 pounds wettable 80% Atrazine. If stock is not being dug that fall, an application of Simazine may be necessary. I might add we only apply Atrazine and Simazine when we see that the prior application has lost its effectiveness. In our case it usually is about 6 to 9 months. As Simazine is more insoluble, we use it during the periods of heavy rainfall, Atrazine during the lesser rainfall periods.

I would like to give caution in weed spraying, especially with Simazine and Atrazine. It is very important that these chemicals be applied accurately. Calibration of equipment is a *must*. which we do periodically. It is necessary for one to find out what his limitations are by experimentation. Varying factors, such as soils and rainfall, will have an effect on the application rates. Constant agitation of the solution is essential for even distribution.

Insecticide and fungicide spraying is a necessary evil in our operation. We do not like to do it anymore than we have to. If we still had the predators around that we had 20 years ago, maybe insects would not be the problem that they are now.

At temperatures above 90°F, all forms of spraying should be curtailed. What some of us might call "spray injury" may be leaf tissue damage caused by rapid intake of moisture at these higher temperatures, especially if the moisture content in the leaf is low.

Our soil fertility needs are usually determined prior to seeding and taken care of in a pre-application. During the peak growing season ammonium nitrate is applied through the sprinkler lines at an approximate rate of 3 lbs. per 1000 gallons of water. Late summer application of a potash foliar spray for hardening-off seems to be advantageous.

In conifer seed beds it is necessary to get optimum growth to lessen the chances of "heaving" the first winter. The amount of food stored in the plant prior to harvesting has a direct bearing on mortality when it is transplanted. A good stored food supply will give it an added "boost" for quick spring growth.

Root-pruning this season was done in June with no adverse effects. Where possible, all conifer seedlings are root pruned yearly. In some cases stock is pruned as shallow as 2 inches. Limited root-pruning is done on deciduous stock where it is necessary to consolidate root growth.

Fall harvesting of conifer seedlings usually starts sometime in October, with harvesting of deciduous stock following around mid-November—after leaves have dropped. Stock is lifted with a crawler tractor equipped with lifting blade and fingers. Field transportation of stock is done in boxes or crates. Recently we eliminated field trailers by mounting semi-permanent pallets behind our tractors for better maneuverability. If possible we like to ship as we dig. Storage of seedlings can be a problem, especially with conifers. Deciduous stock holds well in cold storage. From the time the seedlings leave the field, until they are in the customers care, we try not to allow roots to dry out. By use of fogging nozzles connected to hoses, we are able to keep the roots moderately moist. Nozzles are mounted over each grading table and throughout all shipping and storing areas. Stock is kept cool as much as possible and remains in the grading room only a short time. Operations are speeded up by the use of roller conveyors and small pallets.

Standardization is important. Our seed beds are four feet wide, transplant beds, and row seeding beds are made up of 5 one-foot rows to make a four-foot bed. All but one of our eight tractors have their wheels set six foot on centers so as to straddle the beds. We use three types of irrigation which are all standardized to 50 ft. centers.

Mechanization has been the greatest asset in our business. However, one must also consider cost factors against hand operation. In developing our 5-row transplanter, we had to wait until our quantities were large enough to offset the initial investment in the machine. We hope to develop a universal seeder for next spring capable of handling all types of seed. Our present thought is to develop an endless belt for each of the five rows.

MODERATOR JACK: Mr. Eugene Baciu, Mistletoe Sales, Santa Barbara, California, has been collecting, testing and selling seeds for the past 18 years. He will talk to us now on the interesting subject of, "Hydro-seeding". Mr. Baciu:

HYDRO-SEEDING

EUGENE BACIU
Mistletoe Sales
Santa Barbara, California

Hydro-seeding, in essence, is the application of seed by high pressure water spraying. This is quite a simple and efficient method of getting a job done in a hurry.

Most of the work up to date has been done with sowing grass seed. This is done with hydro-seeding machines which have been built on several different carriers. Some small ones are built on two-axle truck chassis while others are built on trailers and semi-trailers. The tanks in which the slurry is mixed are of different sizes, as are the high pressure pumps. The tanks will hold enough mix to cover a given number of acres with so many seeds per acre.

The slurry is made of seed, water, fertilizer and mulch. The mulch may be made of different materials, such as grounded straw or hay, held together with oil or thin asphalt. However, the fact that straw is flamable makes it a distinct hazard. Some companies make a wood fiber mulch that holds together very well and its moisture retaining power is quite satisfactory. A relatively new mulch is fiberglass plus a light resin. Experiments are still being carried on with the fiberglass mix.

Many new highway areas are being seeded by this relatively new method, mostly because of the ease, speed, and efficiency with which the job can be done. As an example, a stretch of highway near Seattle was seeded in less than 22 hours and the area covered would be equivalent to more than 1,887 lawns. This is about one lawn per minute. Actual time per acre is about ten minutes, plus the time it takes to mix a new batch of slurry, plus the time for cleaning the equipment at the end of the day.

Planting of lawns, large and small, can be done with hydro-seeding. A 13 acre lawn was installed in four days using a total of 5,600 pounds of grass seed.

Now many landscaping jobs are having tree and shrub operation. In developing our 5-row transplanter, we had to wait until our quantities were large enough to offset the initial investment in the machine. We hope to develop a universal seeder for next spring capable of handling all types of seed. Our present thought is to develop an endless belt for each of the five rows.

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Now many landscaping jobs are having tree and shrub seeds added to the mix. The area along the new Oak Flat Road to Yosemite National Park was seeded with 14 different kinds of ground covers, plus many tree seeds such as pine, cedar, dogwood and bitter cherry. The germination of the tree and shrub seed was very satisfactory. The search for desirable shrub and permanent ground covers continues. For the East and Mid-West, a ground cover called crown vetch has been utilized which gives a quick cover plus purple, blue and white flowers.

In California some of the native plants that show great promise are California buckwheat (*Eriogonum*), (which does very well on deep soil cuts), salt-bush (*Atriplex* sp.), which is being planted in the drier regions (the right species of this would be very good in most of the states), rabbit brush, (*Crysothamnus*) grows in most soils just as does the *Atriplex*. Also *Penstemon* gives a very good splash of color when mixed in with other ground cover plants.

About the first plants with good flowers to make a showing on the steep rocky cuts that man makes in construction projects are the monkey flowers, (*Mimulus*) and the golden yarrow, (*Eriophyllum lantum*). They seem to do best under virgin soil conditions.

Landscape engineers and architects are looking for plants whose seeds will germinate readily and send down long roots in a very short time. It is also important that the plants live a long time, reseed themselves, and be fire-resistant.

Beautiful flowers or foliage with growth so thick that they crowd out all of the weeds and stabalize the soil would be characteristic of the perfect plant. I wonder if the Rock Rose (*Cistus villosus*) is such a plant? This is a young, growing business and much work and research has to be done to find the right plants for the right environment.

VICE-PRESIDENT TICKNOR: For our second session this afternoon we will have a very able moderator in Mr. Bruce Briggs. He is well known to our Western group. Bruce, will you proceed now with your part of the program?

MODERATOR BRIGGS: We have four speakers talking on the same subject—rooting and grafting—but in relation to different kinds of plant materials. Mr. John Eichelser, Olympia, Washington, will be our first speaker, talking on rhododendrons.

SIMULTANEOUS GRAFTING AND ROOTING TECHNIQUES AS APPLIED TO RHODODENDRONS

JOHN EICHELSER
Melrose Nursery
Olympia, Washington

The many rhododendron growers that are here today probably wonder why I have come to talk on grafting rhododendrons at a time when grafting has been almost completely abandoned in favor of rooting cuttings. Although the latter method is much faster and easier and takes less space then grafting on unrooted understock, I do not advocate such grafting as a primary means of propagating rhododendrons. Rather, it may be useful as a method of rooting those few varieties which we are always trying to root, but never with much success; or for propagating the few cuttings of a new and very choice variety received late in the year, with very hard wood, when the percentage of rooting might be low.

We use 'Cunningham White' for the understock because it roots very easily and, unlike *R. ponticum,* it has a high resistance to root rot, it does not sucker from the base, and it has been compatible with all varieties that we have tried grafted on it.

I would like to illustrate the actual process now with a few slides.

A cutting of 'Cunningham White' is selected which is, as nearly as possible, the same size as the cutting to be grafted.

A fresh cut is made at the base of the understock leaving a cutting about four inches long. A $\frac{3}{4}$ inch slice is removed from two sides of the cutting.

A downward slanting cut is made into the understock ending just above the wound, for inserting the scion.

The scion is cut in a long wedge shape to match the cut in the understock, leaving a scion about three inches long; it is inserted in the understock, matching the cambium layers on both sides.

The graft is wrapped in the usual manner with a rubber budding strip, the base dipped into Jiffy-Grow, and then inserted into the rooting medium—under mist and with bottom heat. It is desirable, but not absolutely necessary, to insert the cutting deep enough to cover the graft.

Plants raised by this method develop rapidly and, because of the very low graft, usually develop roots above the graft and become own-rooted plants. We have used this method successfully from November through March.

MODERATOR BRIGGS: Thank you John. Now Rudy Wagner, whom you all know, will talk to us on his experiences with hard-to-root conifers. Rudy:

SPEEDING PRODUCTION OF HARD-TO-ROOT CONIFERS

GOTTLOB (RUDY) WAGNER
C & O Nursery Co.
Wenatchee, Washington

As every propagator of conifers knows, there are many species and varieties of *Juniperus* which are slow and hard to root, and even if we succeed we likely have a plant with a poor root system. *Juniperus virginiana* is well known for this; even with all the root-inducing materials it is often impossible to get the needed fibrous root system.

The usual procedure in propagating such slow-rooting varieties is to graft them onto potted stock in late winter, but for this purpose the stock must first be grown from seeds or cuttings and at best this causes a delay of a year or two. Besides, the potted stock or the pre-rooting of the cuttings takes considerable greenhouse space, which increases the expense of the whole operation.

Much quicker results at much less expense can be obtained by taking cuttings of certain easy-to-root varieties, which have the tendency to develop a good root system, and grafting scions onto them immediately before they are placed in the rooting medium.

Easy-to-root varieties are *Juniperus chinensis* 'Hetzii', or *J. communis* 'Sueciea'. Both root quickly; cuttings up to 12 to 15 inches long, if taken at the most favorable time (which we find is during the winter months), root in five to six weeks.

Scions up to 15 inches long of various slow-rooting varieties of *J. virginiana, J. scopulorum,* or *J. communis* are side-grafted onto these above-mentioned cuttings.

The graft union should be about two inches above the base of the understock cuttings and the cuttings should be inserted in the rooting medium about four inches deep, or in such a manner that the graft union is completely, though loosely, covered by the medium; or in other words, the medium should extend slightly above the union.

The boxes containing the grafted cuttings are then placed on the greenhouse bench under intermittent mist with spray applied approximately 5 seconds every 5 minutes. It is important to make sure that the boxes drain well so that the bases of the cuttings do not remain wet for any length of time. No mist is applied during the night or in the daytime during very dull weather.

We find the month of January and the beginning of February to be the best time to propagate our junipers through grafting. By April the understock cuttings are usually well-rooted and the scions are firmly united with the stock. By this time the tops of the rootstocks can be removed and the new plant can then be potted and planted out in a cold frame, again deep enough that the entire graft union is completely covered. Some of the varieties which are slow to root from cuttings readily produce roots of their own just above the graft union after the top of the understock has been removed.

For propagators in northern regions it is not easy to follow this method of propagation. It is often impossible to gather conifer cuttings during the most favorable time because of deep snow and low temperatures. Where such conditions exist, one can make large cuttings of the easy-to-root varieties before the onset of bad weather and place them under mist and at low temperatures until the scions can be gathered. In the meantime, the cuttings will have produced callus or even be rooted to some extent. The scions can then be grafted on them. Such cuttings, even when kept all winter, need little greenhouse space—much less than potted stock.

In conclusion we recommend the following:

1. Timing. Taking the cuttings at the most favorable time (winter) to assure quick rooting.
2. Select an easy-to-root variety which also has the tendency to develop a good root system.
3. If large, long scions are used in grafting, we prefer the side-tongue graft because it makes a very solid union.
4. Good drainage of the grafting boxes and the use of a medium that drains easily is most important.
5. Bottom heat (70°F) is essential.

MODERATOR BRIGGS: Our next speaker is from Fremont, California, near San Francisco. Don Dillon, of Four Winds Growers, will talk to us on his citrus propagation procedures, Don:

SIMULTANEOUS GRAFTING AND ROOTING OF CITRUS UNDER MIST

DONALD DILLON
Four Winds Growers
Fremont, California

In order to simultaneously root and graft citrus successfully it is necessary to have the right climatic environment. All of our propagation is from mother-plant twigs; these mother plants are grown in the open air, without shelter from the elements. Having the right type of wood is essential. However, the simultaneous graft healing and understock rooting is done under controlled hot-house conditions.

An ample supply of the right hardened-off shoots of new growth are a "must" in successful twig grafting. Both scionwood and rootstock wood must be available simulaneously at the proper time. We grow our own original mother plants, both for rootstocks and for scions.

Our selections and methods are based on "research," if you will pardon our usage of this word with this definition —

cuttings readily produce roots of their own just above the graft union after the top of the understock has been removed.

For propagators in northern regions it is not easy to follow this method of propagation. It is often impossible to gather conifer cuttings during the most favorable time because of deep snow and low temperatures. Where such conditions exist, one can make large cuttings of the easy-to-root varieties before the onset of bad weather and place them under mist and at low temperatures until the scions can be gathered. In the meantime, the cuttings will have produced callus or even be rooted to some extent. The scions can then be grafted on them. Such cuttings, even when kept all winter, need little greenhouse space—much less than potted stock.

In conclusion we recommend the following:

1. Timing. Taking the cuttings at the most favorable time (winter) to assure quick rooting.
2. Select an easy-to-root variety which also has the tendency to develop a good root system.
3. If large, long scions are used in grafting, we prefer the side-tongue graft because it makes a very solid union.
4. Good drainage of the grafting boxes and the use of a medium that drains easily is most important.
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"If one appropriates another man's idea, that is stealing; but if you combine the ideas of many experts along with your own, that is research." We should confess plagarism in "twig-grafting." Dr. F. F. Halma and fellow member, Ted Frolich, both of UCLA, really taught us their methods. Ted not only grafts two twigs, he often sandwiches them 3 or 4 high in his researching.

We hold to this belief — to secure identical results and keep on producing identical results, we must use identicals — both rootstock and scion. While the specific scion strains are generally well known and recognized, this does not hold true with rootstocks. Citrus seedling rootstocks are quite variable. That is why we use shoots of rootstock mother plants, not seedlings, in our propagation. Most of our scion varieties are progeny of one mother tree of the variety. To a lesser degree, this is true of our rootstocks. Our objective is to have every twig-graft, both rootstock and scion, the progeny of a specific mother plant. Conditions change, however; the development of nucellar strains are causing the abandonment of old-line strains. The California citrus industry now is committed to a long-range program of producing indexed, disease-free trees.

In grafting and rooting citrus simultaneously, our propagators go into our mother blocks and cut twigs of scion wood and understock, using the last growth cycle. Leaves are retained on both scion and stock. When the twigs are grafted and ready to be flatted these plants are, on the average, 12 inches long. Our propagators gather their own wood each morning; never is the wood allowed to dry out. The twigs are always kept moist and when they are brought into our propagating room they are dipped into a fungicide solution containing ½ cup P.C.N.B. and 2½ cups of Captan (40% wettable powder) in 20 gallons of water.

After the preceding preparations have been made, our propagators start making their grafts. The cut for the splice graft is ½ to ¾ inches long at about a 30° angle. After the graft has been made, it is tied with a rubber band. The grafted twigs are put back under mist. After making the grafts, our propagators dip the plants into the fungicide again before "stumping" them. The cut on the base of the plant is made square, dipped into a "hormone" and flatted up.

The "hormone" we use is from a formula given to us by Mr. O. A. Matkin, head of the Soil and Plant Laboratory, Inc., Orange, California. At one time we used Hormodin No. 3, or indolebutyric acid in a liquid formulation. The hormone we are now using consists of:

1.0 gram indolebutyric acid
25.0 grams fermate
99.0 grams talc

We find this to be cheaper and it works just as well, if not better than, the hormone preparations previously used.

During the course of the day, if any twig is dropped or has fallen to the floor, it is always put back through the fungicide before it is returned to the working bench. Flats used to carry or hold plants while flatting or when grafting, and containers used for the hormone are dipped in fungicide before being put away for the day. All excess hormone is thrown away every day.

Our grafting room is maintained in a state of "kitchen cleanliness." Access is limited to people who work there. At the end of each day's work, the grafting room is thoroughly cleaned. All prunings and left-over wood are discarded. The mist case in which twigs and completed twig-grafts are held during the day is scrubbed, using 16 ounces of 25% Clorox in 2½ gallons of water. The table and counter tops, which are covered with vinyl linoleum, are scrubbed with the same solution. All tools are cleaned and stored in lined drawers. The floor is scrubbed, even the windows are washed daily. When all this is completed we can go home.

Hot-House Propagation Operation

We have adopted the U. C. system for container-grown plants, as discussed in University of California Manual 23, as the foundation of our growing operation. We are convinced that mother blocks of clean planting stock are essential for a sound growing operation. This is the first principle to support the production of quality nursery stock. The second principle is proper soil treatment. We use a modified U. C. soil mix, in that we use redwood sawdust instead of peat moss. The soil mix is an essential part of our operation. The last principle is proper sanitary practices. We make a real effort here also. All of these practices are necessary. They are goals. We recognize that in some of our practices we are a little short and that constant improvement is necessary. In this work we are regularly assisted by Mr. Matkin, one of the authors of Manual 23.

Incoming water for the mist beds, either clear or fertilized, passes through Monarch, 100 mesh strainers. We use normally-open solenoid valves since we have found it is better to have continuous water on the twig-grafts than none at all in the event of a power failure. We use General Electric silicone cables for bottom heat. Each bench has it's own HSC-5 thermostat, pilot light, and circuit breaker.

Our timer was inspired by discussions and papers we heard at the first Western Region, Plant Propagators' meeting at Asilomar in 1960. We use a 24-hour clock to control two six-minute timers. The pins on the 24-hour clock can be set for 15-minute intervals, and the 6-minute clocks at any 5-second intervals. By proper placing of the pins, any combination of mist duration and interval can be programmed. Like other propagators, our controls must allow great flexibility yet provide a high degree of reliability. By the use of relays, the 24-hour clock prevents the chance of continuous misting in the event that the 6-minute clock were to stop for the night in an open (misting) position.

We have recently added a 1¼ H.P. 3600 R.P.M. motor and pump to increase our mist line pressure to 140 P.S.I. A 120-gallon tank under air pressure maintains even pressure. This increases nozzle velocity and creates smaller droplets. These absorb more heat and tend to hang in the air longer. This allows us to reduce the mist duration and increase the mist intervals. We use a Monarch No. 3.0, 120°, oil-burner type nozzle. These would produce 3 gallons of water per hour if allowed to run continuously. They are also fitted with 100 mesh screens. Our lines are ⅜-inch copper tubing. We use Imperial fittings. Our ten benches have individually controlled water lines which are mounted on the ceiling rafters. The lines are located along the front edge of the bench with the nozzles pointing down. Any drip falls in the aisle. Benches are raised, 36 feet long, 3 feet wide. Heating cables are buried in 3 inches of gravel, covered with hardware cloth. After treating the wire mesh and wood benches with copper naphthenate, empty 18 x 18 inch flats are placed on the bench and filled with rooting media. We use coarse grind vermiculite of the type used for insulation fill. The twig-grafts are dipped in hormone and stuck.

When the mist is on it is impossible to see the other end of the greenhouse—40 feet away. Small droplets will still be in the air when the next cycle begins. While this seems like an excessive amount of water, please keep in mind that until the graft has healed, the scion has no contact with the moisture in the rooting media. It is suspended in mid-air, supported by the understock and has no other contact except the atmosphere around it.

When the graft union has fully healed and the understock rooted, the bottom heat and the mist line are turned off. Sometimes, though the plants are rooted, we must wait until the graft has healed. The flats are left to harden off for a period of several days to two weeks, depending on variety. We do not use peat or other types of pots. The roots are straight and uncoiled. Trees are planted directly into one-gallon cans, bare-root.

It is our aim to produce good-tasting, full-sized fruit on a dwarf tree whose ultimate size has been controlled by the interaction of rootstock and scion. These trees are produced from carefully selected twigs, grafted under kitchen-clean sanitary conditions, then rooted and healed simultaneously under conditions of intermittent mist.

MODERATOR BRIGGS: Our next speaker has a little different problem, one which may be a lot more difficult than the others. To tell you about this is Dr. Holger Brix, formerly of Denmark. He acquired his early education there but came to the United States where he got his doctorate at Texas A and M University. He is now with the Forest Research Laboratory Victoria, B. C. Dr. Brix.

ROOTING OF DOUGLAS FIR CUTTINGS BY A PAIRED-CUTTING TECHNIQUE

HOLGER BRIX
Department of Forestry and Rural Development
Forest Research Laboratory,
Victoria, British Columbia

A study of rooting of Douglas fir cuttings was undertaken two years ago because vegetative propagation of Douglas fir by grafting had not been entirely satisfactory. In recent years much overgrowth of rootstock by the scion has become apparent resulting in poor growth and eventual death of the tree. A barrier to translocation of assimilate from the plant top to the root seems to develop at the graft union and leads to starvation of the rootstock.

Chemical treatments have not been consistently successful in rooting Douglas fir cuttings from mature trees. Other workers have found, as we have, that indolebutyric acid (IBA) will induce rooting in cuttings from old trees but the results can not consistently be replicated in other years and with other trees. Mechanical aids, such as wounding, have not improved the results. On the other hand, cuttings from seedlings of Douglas fir root fairly readily even without chemical treatments. It, therefore, seemed worth testing whether cuttings from old trees could be induced to root by grafting cuttings from young trees onto them.

At the end of March, 1966, 60 cuttings from mature trees (80-100 years old) and 60 cuttings from 5-year-old Douglas fir seedlings were grafted together in pairs. Hereafter, for convenience, these are referred to as "old" and "young" cuttings, respectively. Only the last annual shoots were used and they were cut to a length of about 3 inches. The cuttings were side-grafted for a length of about 1 inch at the base of the stem and held together by elastic bands. The basal ends were cut flush after grafting. This is referred to as butt grafting. The paired cuttings were set with the base in 50 ppm IBA for 24 hours and thereafter placed in a rooting bench with perlite and kept under intermittent misting. The graft union was completely buried in the rooting medium. After 17 days in the bench the union between the paired cuttings was sufficiently strong to permit removal of the elastic bands. Since the basal growth of the cuttings is considerable, the bands are removed as soon as possible to avoid constriction.

During the first 2 months in the bench 17 pairs rooted; after 3½ months 28 pairs had roots and 54 pairs had roots the United States where he got his doctorate at Texas A and M University. He is now with the Forest Research Laboratory Victoria, B. C. Dr. Brix.

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During the first 2 months in the bench 17 pairs rooted; after 3½ months 28 pairs had roots and 54 pairs had roots after 6 months. Out of the 54 pairs with roots, 50 had roots on the young cutting, 20 had roots on both the young and the old and 4 had roots on the old ones only. This gives a rooting percentage of 40 for the old cuttings and 83 for the young. Cuttings from old trees did not root better than 30% when set alone and such a high percentage was an exception. It would, therefore, appear that the young cutting had a stimulating effect on rooting of the old cutting.

To test this further, more experiments with paired cuttings were performed in the spring of 1967. Three different types of grafts were tried. One type was the butt graft used the previous year having the basal ends of the paired cuttings cut flush. In another the young cutting was side-grafted to the old cutting leaving ¼ inch of the old cutting below the union. In a third type, the old cutting was grafted to the young leaving ¼ inch of the base of the young cutting below the union. All paired cuttings and the individual control cuttings were treated with a 24-hour soak of the basal end in 100 ppm IBA. One-half the cuttings were set in sand and the other half in an equal mixture of sand, perlite and peat moss. The success of rooting for the different types of grafts could depend on whether the presence of an inhibitor, or the lack of a rooting promoter, was responsible for poor rooting in the old cuttings since the rooting regulator might concentrate in the end of the cutting forming the base.

The results with paired cuttings have not been as good this year as in 1966. It may still be too early (mid-August) to predict the final outcome but to date only 10% of the old cuttings have rooted when grafted to young cuttings (type 3 above) and only one out of 50 have rooted when the old cutting formed the base of the pair (type 2 above). The latter result was also obtained with the butt-grafted pair. The rest of the paired cuttings look healthy and it is hoped that more will root. None of the single cuttings from old trees have rooted, so pairing with young cuttings seems to have had some beneficial effect. Cuttings from young trees have also rooted poorly this year with a percentage of 28 to date while a percentage of over 80 rooted last year. This may explain why the paired cuttings have not given better result although the cause of the generally poor rooting this year is not known. Cuttings collected in March have rooted better than those collected in February or in April. The rooting mixture has been superior to pure sand.

Results obtained with paired cuttings of Douglas fir are promising enough to warrant further study of this approach to rooting of cuttings from mature trees. The technique could be of value as a research tool and also for large- scale rooting until chemical treatment of single cuttings becomes more successful. Furthermore, there is the possibility that the roots formed on the young cutting in the grafted pair will adequately support the old cutting without the difficulty of overgrowth encountered with Douglas fir when the conventional type of grafting is used.

MODERATOR BRIGGS: We will now open the session for questions. Who has the first one?

BILL CURTIS: Don Dillon, what was the proportion of PCNB and Captan in your fungicidal cutting dip?

DON DILLON: One-half cup PCNB and 2½ cups Captan (40% wettable) in about 20 gallons of water.

RALPH PINKUS: In dipping your cuttings, you said you use 1 gram of IBA crystals and 99 grams of talc. What other ingredients were in the mix?

DON DILLON: Fermate, 25 grams.

VOICE: Dr. Brix, what was the rooting medium you used in your tests with Douglas fir?

DR. BRIX: Either pure sand, or 1/3 each of sand, peat moss, and perlite.

JOE WHEAT: Working with Douglas fir, I have found that using very much peat moss in the mix will kill the young tissue.

DR. BRIX: We have found the same thing with Douglas fir; half sand and half peat moss is too much peat.

BRUCE BRIGGS: We tried using just a piece of stem, without leaves, for the understock on unrooted rhododendron grafts but came up with a blank.

DON DILLON: I might suggest you try keeping leaves on the understock. We found in citrus that this is the key to the whole thing. It requires full-sized leaves — we don't cut our leaves back at all — and we have to have the leaves on both pieces to really do the job. If leaves are present on the rhododendron understocks, you might find that there is enough stimulus from them to get rooting.

HOWARD BROWN: A question for Rudy; do you cut your conifer understocks back completely in 6 weeks?

RUDY WAGNER: The understocks are cut back as soon as they come out of the rooting bench — just before potting.

WALTER VAN VLOTEN: A question for Don. You say you use IBA, talc and fermate. Why do you use talc? Why don't you use just IBA and fermate?

DON DILLON: The talc is just a filler. We buy IBA crystals from Eastman Kodak Co. and have them ground into a powder by our local druggist and he mixes it with talc, but it's just a filler.

WALTER VAN VLOTEN: We do the same, except we only use Captan powder plus IBA crystals.

BURIED—INARCHING

JOE WHEAT
Tree Improvement Laboratory
Industrial Forestry Association
Olympia, Washington

With the exception of easily-rooted species, such as the poplars and cryptomeria, vegetative propagation of forest tree species is practical only where clonal material is advantageous in tree improvement and similar research programs. Only in recent years have vegetative propagation techniques—long familiar to horticulturalists—been applied to many of the coniferous forest trees. So far, grafting has been the most common method of propagation, since many conifers are very difficult to increase by cuttings.

In the Pacific Northwest, Douglas fir is receiving the most attention from research and tree improvement workers. This species has proven to be very easy to graft. However, with the older grafted seed orchards (some now 10 years old), losses due to incompatibility between stock and scion have been of serious magnitude. Recent studies by Dr. Copes gives us hope that grafting may become practical in the future.

However, another way to beat a problem is to avoid it. A clone can also be maintained by cuttings. Repeated trials have shown that cuttings from Douglas fir trees of cone-bearing age are extremely difficult to root, though there are some exceptions. In contrast, cuttings from seedlings or very young trees may root relatively well.

Without knowledge as to what the seedling possesses that enhances rooting, or what the mature tree may have as an inhibitor, the buried-inarch has been developed in an attempt to transfer root-initiating ability from the seedling to the mature tree cutting by forming a temporary union between the two. Romberg in 1942 reported (3) success with a similar technique on pecan. Kemmer in 1958 was using the buried-inarch with apples (2). Since then Jaynes has been successful with chestnuts (1), which have a rooting history very similar to that of Douglas fir.

The buried-inarch might be described as a cutting with the upper portion grafted to a seedling stock and the lower portion in soil or a rooting medium. One or more buds must be present on the upper portion of the cutting. Buds may not be necessary for rooting, but are essential for any future top growth. As a case for this point, one can cite the rooting of budless pine needle fascicles. Union with the stock is easily made by shaping the top of the cutting into a wedge and inserting this into an upward cleft cut into the side of the stock at the desired height. Other grafting techniques may work equally as well. The graft union is secured with conventional budding bands and sealed with grafting wax.

My first attempt to root Douglas fir through buried-inarching was in 1963 (4). Rooting success was about 30 per cent. In 1966, 328 buried-inarches were made using 16 clones. Overall response again was about 30 per cent, though success within individual clones varied from 0 (one clone) to 70 per cent. In both trials high mortality of cuttings during the rooting period greatly affected the results. It is felt that with proper care these losses could be held to 10 per cent. This would increase rooting to about 40 per cent with no other improvements in technique.

The time of year the buried-inarching is done may be as important as it is with conventional cuttings. Though not all periods have been investigated, greatest response has been from January through March. Little rooting takes place before five months, with the peak of rooting occurring between six and eight months. Lifting of one trial after nine months appeared to be somewhat premature.

Hormone treatments of cuttings with commercial dusts of 0.3 and 0.8 per cent indolebutyric acid have shown no effect on root formation.

Several procedures were tried for making buried-inarches. The most convenient and practical was the use of 2-0 stock in gallon containers. A month or more prior to grafting, the stock was potted with positioning of stock well to one side to make room for a 3-inch peat pot set flush with the soil surface. In applying the buried-inarch the butt of the cutting is in the peat pot which is then covered with horticultural-grade vermiculite and wetted. Other rooting media may be as good, though peat moss in any concentrated amount will kill a Douglas fir cutting.

Size of cuttings was best between five and seven inches in length. With Douglas fir and some other species, care must be taken to make cuttings only from orthotropic growth. Success in rooting may be greater with cuttings from lower and more pendulous branches, but it may take many years for them to be freed from the branching habit of growth.

Greenhouse facilities are very desirable for this work. At Nisqually, Washington, buried-inarches made in mid-winter are moved into a lath house by May. Extra precaution is necessary to guard against drying conditions and wind movement of the buried-inarch.

In conclusion I feel that the technique described is economically practical for production of Douglas fir clones in tree improvement and research programs, though there is much room for improvement. Rooting percentages possibly can be increased through manipulation of heat, light, moisture, growth regulators, etc. The possibility exists of abbreviating the process by grafting scions from seedlings onto the mature-tree cutting.

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4 Wheat, J G 1964 Rooting of cuttings from mature Douglas fir *For Sci* 10 319-320

VOICE: At what stage do you cut off the rootstock?

JOE WHEAT: When I investigate the grafts in the fall — October and November. If the inarch is rooted, then I remove it; I don't bother to cut it. I just take them and tear them apart. It is removed then because it will have its own foliage by then and will have an active root system started. I would almost prefer to let the inarches go 12 months because I feel that there are some that were starting to root that I would not have lost if I had left them a little longer. I have to jump ahead a little bit because I want to get them out of the lath-house before winter and back into the greenhouse.

VOICE: Could you use two or three inarches on one root-stock?

JOE WHEAT: You could on some of the huskier ones. Actually I use two. I find I have better results with ordinary cuttings, or with these inarches, by using a sterile medium, something like clean masonry sand or vermiculite, rather than soil. They will root directly in soil but there is a larger initial loss, just as with ordinary cuttings, because of the pathogen problem in unsterilized, normal soil.

MODERATOR DOUGLASS: The next speaker, unfortunately, is absent today. Dr. Oscar Sziklai is in Europe attending the International Union of Forestry Research Organization. However, Dr. Phillip Haddock, University of British Columbia, has kindly agreed to give Dr. Sziklai's presentation on grafting techniques in forestry. Dr. Sziklai is associate professor at the University of British Columbia, teaching forest genetics.

GRAFTING TECHNIQUES IN FORESTRY

O. SZIKLAI
Faculty of Forestry, University of British Columbia
Vancouver 8, British Columbia

Apomixis is a general term used for all types of asexual reproduction that replace or substitute for sexual methods. Agamospermy includes all types of apomictic reproduction in which embryos and seeds are formed by asexual means. In the case of vegetative reproduction, the propagules are not produced from seed but as a result of cell multiplication by mitotic division. Most plants have the capacity to reproduce vegetatively from roots, stems, branches and leaves; and even in a few cases, the propagules occur within the inflorescence as is the case in vivipary.

Layering, rooting and grafting, as different means of vegetative propagation, have been widely used in horticulture

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Layering, rooting and grafting, as different means of vegetative propagation, have been widely used in horticulture from ancient times. Rooting is the most widely used method of asexual reproduction in forestry practice. Rooting by stem cuttings, mainly in the genera *Populus, Salix* and *Platanus* is a well developed practice in intensive forest management. Layering is of a more limited application and is used mainly in experimental studies when other means of vegetative propagation are not successful.

The importance of grafting in forestry practice originated from a recent development of forest genetics and forest improvement. Selection of desirable phenotypes of certain species in the forests necessitated the propagation of the "plus trees" into a more accessible environment than those in which the plus trees were standing. "Clone banks" and later "seed orchards" were established. Homogeneous sites were selected to provide a basis for objective evaluation of phenology and growth characteristics of clones. These "clone banks" and "seed orchards" were also more ideally suited for carrying out controlled pollinations than the ortets from which the scions were collected.

Dr. Syrach Larsen's pioneering work on grafting Scandinavian forest trees in the middle 1930's was the beginning of the realization of the importance of grafting in forestry. This trend was further intensified by work in Sweden, in the Southeastern pine region and in the Douglas fir region of North America. Grafting is now widely used in forestry practices mainly for the following purposes (Wright, 1962): — to facilitate controlled pollination, to hasten cone production in selected breeding programs, to produce species hybrids, to determine total genetic variance, to preserve superior germ plasm, and to provide genetically uniform material.

The following three basic types of grafting are recognized (Mergen, 1954) depending on the genetical constitution of the scion and the rootstock:

(a) autoplastic grafting: scion and rootstock are of the same genotype.

(b) homoplastic grafting: scion and rootstock belong to the same species but differ genotypically.

(c) heteroplastic grafting: scion and rootstock differ genetically and belong to a different species, genus, or even family.

Of the above-mentioned three types, homoplastic grafting is the most widely practised in forestry, while the other two types — autoplastic and heteroplastic — have a more limited application, mainly in research work. Interestingly enough, Dr. Klaehn's survey on grafting methods on forest trees conducted in 1962 (Stairs, 1964) gave an amount of 800 interspecific and approximately 160 intergeneric and interfamily heteroplastic graftings.

> "As to the success of grafting, the main skill is to join the inward part of the scion to the sappy part of the stock, closely but not too forcibly; that being the best

and most infallible way by which most of the quick and juicy parts are mutually united, especially towards the bottom." (Evelyn, 1663).

This old, but not outdated statement, emphasized the importance of cambial union of scion and rootstock, as one of the cardinal requirements for successful grafting. Fulfilling this requirement, numerous grafting methods have been developed.

Garner (1958) listed 46 different methods (Fig. 1, 2, 3). Nienstaedt *et al.* (1958) mentioned only 13 of them applied in forestry practice. (Table 1).

Table 1 The main divisions of grafting methods and the number used in forestry

Type of Grafting	Number	
	Listed by Garner	*Used in forestry*
Approach grafting		
a) True approach grafting	5	2
b) Inarching	2	1
c) Bridging	1	1
Detached Scion Grafting		
a) Bud grafting	9	2
b) Inlay grafting	4	1
c) Apical grafting	12	2
d) Side grafting	8	3
e) Bench grafting	5	1
Total	46	13

The characteristic feature of approach grafting is that the two plants brought together retain parts above and below the union. After union formation, the stem portion of the rootstock above the grafting point and the root part of the scion below the grafting are cut off. The spliced approach graft has limited application in forestry, on birches and other species difficult to graft.

Seed production could be obtained on detached branches, as demonstrated by Johnsson (1951) in *Salicaceae, Betulaceae,* and *Ulmaceae* families, using bottle grafting. Mirov (1940) successfully used inarching on white pines, southern and northern hard pines and on spruces, while Graves (1948) recommended it for hardwoods. Nienstaedt and Graves (1955) also used inarching to bypass diseased stem portions of chestnut. Diller (1958) for the same reason, worked with bridging.

Bridge grafting is selected mainly for species such as white pines and southern hard pines that are difficult to graft.

Detached scion grafting is less cumbersome than approach grafting, consequently a large number of different techniques are currently practised. Nienstaedt *et al.* (1958) listed nine different methods of these used in forestry.

Shield budding is practised mainly on hardwoods, but it is also used on white pines and northern hard pines. In patch budding, part of the rootstock is replaced by the same size of single bud, removed from the scion. Success is most likely if both scion and rootstock are the same age. The technique is used in hardwood, northern and southern hard pines.

Among the different apical grafting methods, the spliced graft and the wedge or cleft graft are techniques frequently employed in forestry. The ease of making cut surfaces on the rootstock and on the scion, and the excellent knitting in splice grafting, would lend the method to wider application than exists at present, but because of the difficulty of tying, the weak union, and the equal diameters needed of rootstock and scion, this method is not applied frequently in forestry. It is used mainly in the grafting of hardwoods, but northern hard pines, and recently Douglas fir in British Columbia, also have been grafted by this method.

The wedge or cleft graft is a preferred method of grafting in forestry. The ease of application and the good knitting result in the wide use of this method among hardwoods, pines and Douglas fir. Orr-Ewing and Prideaux (1959) recommend using veneer crown graft, a modified version of wedge graft, for Douglas fir when the rootstock and scion are not equal in diameter.

The side cleft graft, veneer side graft, and side tongue grafts are the three mainly used side grafting methods in forestry (Nienstaedt *et al.* 1958). White pine is grafted by all three grafting methods. Only side cleft and veneer side grafts are used in the case of southern hard pines. Northern hard pines are grafted with veneer side and side tongue grafts, while veneer side graft is used in the case of spruces.

Bench grafting applies to any grafting processes performed on bare rootstock and scion regardless of the technique used. Without proper environmental conditions the bench graft, when it is completed on the stem portion of the rootstock, is seldom successful. On the other hand, if the grafting involves roots, the survival may be quite high. One method of x-cutting or root approach graft described by Jackson and Zak (1949) was used successfully in *little-leaf* disease study of shortleaf pine.

During the previous part of my presentation I briefly described the different grafting methods practised in forestry. Unfortunately, it is difficult to attach to these grafting methods a frequency number which should express how often they are used in practice. But as a rough estimation on how frequently the different grafting methods are used in forestry, I would like to refer to Table 2, which is based on Klaehn's survey on interspecific heteroplastic grafting.

Table 2. Frequencies of the basic type of grafting methods in the case of inter-specific grafting; based on Stairs (1964) report

Genus	Basic type of graftings (after Klaehn[1])									Total
	1	2	3	4	5	6	7	8	9	
Gymnosperms										
Abies	53	25	—	3	—	5	—	—	—	86
Cupressus	—	—	—	—	—	1	—	—	—	1
Larix	28	14	—	1	—	3	—	—	—	46
Picea	33	16	—	1	—	4	6	—	—	60
Pinus	77	36	—	29	—	96	1	2	—	241
Pseudotsuga	2	2	—	—	—	—	—	—	—	4
Total	193	93	—	34	—	109	7	2	—	438
Per cent	44.1	21.2	—	7.8	—	24.9	1.6	0.4	—	100.0
Angiosperms										
Acer	8	—	—	14	2	—	5	—	3	32
Alnus	11	—	—	4	—	—	5	—	—	20
Betula	1	—	—	—	—	—	5	—	—	6
Caragana	—	—	—	—	4	—	—	—	—	4
Crataegus	—	—	—	—	—	—	—	—	1	1
Castanea	1	—	2	—	4	1	11	—	—	19
Eucalyptus	—	—	—	—	—	4	—	—	—	4
Fraxinus	6	1	—	4	2	1	1	—	2	17
Juglans	—	—	1	—	—	1	1	—	1	4
Liquidambar	2	—	—	—	—	—	—	—	—	2
Populus	6	1	1	7	39	6	3	—	—	63
Prunus	3	—	—	—	—	—	1	—	7	11
Quercus	—	5	—	—	—	76	—	—	10	91
Salix	—	—	—	—	2	—	—	—	—	2
Sorbus	—	—	—	—	—	—	—	—	47	47
Tilia	4	—	—	—	—	—	—	—	21	25
Ulmus	5	—	—	6	1	1	1	—	—	14
Total	47	7	4	35	54	90	33	—	92	362
Per Cent	13.0	1.9	1.1	9.7	14.9	24.9	9.1	—	25.4	100.0

[1]Basic type of graftings (after Klaehn).

1 — side graft
2 — veneer graft
3 — T-graft
4 — bottle or approach graft
5 — whip graft (splice graft)
6 — cleft graft
7 — triangle graft (inlay graft)
8 — succulent graft
9 — budding

Bridge (approach) grafting (4) is used in 7.8% of the cases in Gymnosperms and 9.7% in Angiosperms, playing only a limited role in both groups compared to the detached scion grafting methods.

Bud grafting (9) was reported only in Angiosperms with a frequency of 25.4%. Inlay grafting (7) is used more frequently in Angiosperms (9.1%) than in Gymnosperms (1.6%). Apical grafting (5) and (6) is the most frequently applied method in Angiosperms with 38.9% while in the Gymnosperms it is used with 24.9%. Side graftings (1), (2) and (3) take up the largest percentage (66.3%) in Gymnosperms but only 16% in Angiosperms.

The techniques listed above, as used in grafting of forest trees, form only one of the steps required to obtain successful grafts. Certainly, the importance of providing uniform contact between the cambia of rootstock and scion is not disputed at all and the grafting methods listed here serve the purpose effectively. But there are other aspects of grafting which are also important: — selection of rootstock, collection and storage of scionwood, time of grafting, rootstock-scion relationships at the time of contact layer and callus formation, and the time of callus differentiation.

For successful grafting, besides the more desirable techniques, the last-mentioned points should be considered. Although information on them is sketchy at this time in relation to forest trees, we hope that research projects currently under way on this topic will soon provide the answers.

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MODERATOR DOUGLASS: Our next speaker is Dr. Donald L. Copes, Associate Plant Geneticist, Pacific Northwest Forest and Range Experiment Station, Corvallis, Oregon. Dr. Copes has worked during the past three years primarily on grafting incompatibility in Douglas fir. This mysterious and aggravating factor has been a major bottleneck to foresters and researchers in establishing seed orchards, clone "banks", breeding archives, and other forestry endeavors which involve grafting. Some of the finest Douglas fir clones thus far discovered simply won't live with their rootstocks. Discovering the reasons for the incompatibility, and hopefully finding some solutions, has been handed over to Dr. Copes.

GRAFTING INCOMPATIBILITY IN DOUGLAS FIR

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Grafting of Douglas fir (*Pseudotsuga menziesii* [Mirb.] Franco) started commercially on the West Coast in the late 1950's with large-scale grafting in clonal seed orchards. Scions collected from superior tree selections were grafted upon wildlings or nursery-run seedling rootstocks. No attempt was made to identify parentage of the stocks or to graft scions upon clonal stocks. Graft mortality from incompatibility became evident as early as the following spring. Each year since that time, mortality has continued with delayed symptoms of incompatibility. Continuing incompatibility losses in the first grafted clones and in later grafts have caused seed orchardists to become increasingly aware of the severity of the problem.

To point up the incompatibility problem, let me repeat graft survival data from three seed orchardists of Oregon and Washington. Mortality from purely technique failures—that occurring during the first 2 or 3 months after grafting—was excluded from data. In one orchard, 1,622 grafts were made; 6 years later only 46 percent were still alive. In a second orchard, only 57 percent of 766 grafts survived 8 years after grafting. A third orchard was reported to have 78 percent of 671 grafts alive after 4 years. The values for these three orchards do not represent all the losses that will occur; many surviving grafts have visible external symptoms of incompatibility. For example, a 100-graft sample from the second orchard revealed that 35 percent of all living grafts had scion overgrowth symptoms. All overgrown grafts will probably die soon. The graft incompatibility problem has become so severe that the practicability of establishing future clonal orchards is in question.

Although pomological literature has numerous papers describing many types of incompatible conditions, little information was available in 1964 about cause and development of symptoms of incompatibility in forest trees and about internal anatomy of Douglas fir grafts. Nor was it possible to correlate Douglas fir condition to that reported for other species in pomological literature. This study was started in 1965 to determine what anatomical symptoms were correlated with scion failure. Primary purposes of this paper are to describe symptom development in grafts from 2 days to 4 years old and to determine what possible cause or causes are responsible for symptom initiation and development.

Materials and Methods

A greenhouse study was designed in which periodic graft sacrifices were made at graft ages of 2 days to 2 years. At date of collection, sample size ranged from 4 to 44 grafts. Graft union collections were made the first year at 2, 4, 7, 10, 14, 17, 21, 24, 28, 31, 35, 38, 42, 49, 56, 70, 84, 90-105, 170-180, 220-230 days after grafting. Collections in the second year were made at 13, 15, 17, and 19 months after the date of grafting. Sacrificed graft unions were prepared for microscope observations by embedding in paraffin, rotary microtome sectioning, and staining with safranin and fast green. Both transverse and longitudinal sections were examined under a light microscope at 30-800 X.

Scion material came from 20 clones selected from among the most and the least compatible clones known to Oregon and Washington seed orchardists. Grafts were made in March of 1965 and 1966. A standard top-cleft or similar top graft was used both years. All grafting was done by the author. A number of autoplastic grafts (grafts with scion and stock of identical genotype) were made so that graft unions without stock-scion interaction could also be examined.

Grafting was done in a greenhouse on 2-0 Douglas fir seedling stocks. Seed sources of stocks were at 4,000-foot elevation on Mount Adams, Washington, in 1965 and at low and medium elevations in the Willamette Valley, Oregon, in 1966. Except for the interval from October to March, grafts were grown in a greenhouse from time of grafting until final sacrifice. From October to March, the grafts were placed outdoors for winter chilling.

In addition, dead or dying incompatible grafts, ranging in age from 1 to 4 years, were collected from seed orchards. Many of these grafts belonged to the same clones which were grafted for greenhouse study. Orchard graft unions were cut, unembedded, with a sliding microtome. The same safranin and fast green staining schedule was used for both orchard and greenhouse grafts.

Results and Discussion

First-Year Symptom Development. First detection of a graft incompatibility symptom was at 84 days. The symptom developed as deposits of suberin in intercellular spaces of the bark's cortex. Suberin is a fat or waxlike substance normally found in cork cells of Douglas fir's outer bark. The incompatibility symptom occurred only in tissue areas where stock and scion cells merged. This symptom was present in only 1.5 percent of grafts under 106 days old (Table 1).

Examination of grafts 170 to 180 and 220 to 230 days old revealed a higher percent of grafts with suberin zone initiation and a larger suberized tissue area than was found in younger graft unions. Although 1.5 percent of all grafts were suberized at 2 to 105 days, 62 and 33 percent of compatible and incompatible clones, respectively, in 170- to 180-day-old clones and 83 and 86 percent of compatible and incompatible clones, respectively, in 220- to 230-day-old clones were sub-

Table 1. Development of graft incompatibility symptoms in compatible and incompatible clones, by age and date of collection.

Graft age	Scion clone type	Graft with suberin zones initiated	Grafts with xylem wound areas	Suberin penetration into phloem or cambium
			Percent	
2-105 days (Mar.-June)	compatible and incompatible	1.5	—	0
170-180 days	compatible	62	—	0
(August)	incompatible	33	—	7
220-230 days	compatible	83	—	8
(October)	incompatible	86	—	51
13-14 months (Apr.-May)	incompatible[1]	100	—	91
15 months	compatible	33	33	0
(June)	incompatible	100	50	0
17 months	compatible	75	0	0
(August)	incompatible	80	40	0
19 months	compatible	86	50	14
(October)	incompatible	85	31	15
1-4 years	compatible and incompatible	100[2]	100[2]	100[2]

[1]Only incompatible clone grafts had died or were dying at this time.
[2]Signifies grafts grown in seed orchards.

erized. In addition to having a higher percentage of grafts which initiated the symptom, the 170- to 180-day collection had grafts with deeper penetrated bark areas than earlier collections. For example, 7 percent of incompatible clone grafts had suberin penetration to the phloem or cambium, whereas none of the earlier collections had penetration beyond the cortex. The 220- to 230-day-old grafts showed deeper suberin penetration than the 170- to 180-day-old grafts—51 percent of the incompatible clone grafts had been penetrated with suberin from cortex to phloem or cambial regions (Table 1). More than half the grafts from that collection date had suberin areas in cambial tissues. Tissue necrosis was found in both 170- to 180-- and 220- to 230-day collections. Necrotic cells were located near suberized tissues.

Development of suberin zones seemed correlated with periods of cambial activity. Deeper penetration occurred during periods of slow cambial growth. Suberin zones were generally restricted to cortex areas during times of high cambial activity, such as occurred through spring and early summer months (2- to 105-day collections). When cambial activity ceased, or was very slow, suberin zone penetration progressed from the phloem-cortex boundary to phloem and cambial regions.

Little difference existed between percent of compatible and incompatible clone grafts which ultimately initiated suberin zones. Much of the fluctuation between clone types within collection periods could probably be explained by small sample size variation. The chief difference between clone types was depth of suberin penetration during fall and winter months (220-20 days to 13 months). Usually, compatible clone grafts were not as deeply penetrated by suberin as were incompatible clone grafts. This could easily be seen in the 220- to 230-day-old grafts (Table 1). Only 8 percent of compatible clone grafts had suberin penetration of phloem or cambium, yet 51 percent of the incompatible clone grafts had penetrated that deeply. Unequal penetration between clone types is an important fact to remember when the second symptom of incompatibility is described later.

Both compatible and incompatible clones developed some grafts with or without suberin zones, but no suberin zones were ever found in autoplastic grafts. This indicated that the physical act of grafting did not cause suberin zone initiation, but stock and scion tissues of different genotypes were necessary before the zones would appear. The incompatible clone group was found to be antagonistic to more stock genotypes, or more susceptible to the incompatibility factor, than was the compatible clone group. Since all scion clones were found at times to be incompatible, it was concluded that only degree of compatibility varied between and within the two major clone groups.

Formation of cambial unions was not necessary for suberin zone initiation. Grafts with both cambial and cortex unions and with only cortex unions were found capable of suberin initiation. Some dead grafts collected in 1966 did not form cambial unions before death, yet they developed suberized zones in all cortex union areas. This indicated that the physical structure of the union had no role in symptom initiation.

Second- to Fourth-Year Symptom Development. The 13-month collection, 4 weeks after the grafts were returned to the greenhouse, revealed more cambial activity in the stock than in the scion. Uneven initial periods of springtime cambial activity are normal for Douglas fir grafts. Stock tissues were juvenile, and scions were usually collected from 40- to 150-year-old trees. The normal timing in seed orchards was for stock branches to burst vegetative buds long before scion branches. The same situation also occurred with greenhouse grafts grown in pots. Even though stock tissues began development earlier than scion tissues, at the start of each growing season, no cambial breakage or tearing was evident. Differences in springtime cambial activity were not correlated with initiation or penetration of suberin zones. It should be noted that the 13-month collection just described was too small for accurate determination of percentage values for suberin initiation and development or for formation of xylem wound areas.

External symptoms of incompatibility became visible on some grafts during the second year. Scion needle drop and chlorosis at the start of the second year was followed by graft failure within the following 2 months. Twenty-three percent of all grafts living after 220 to 230 days died between the 13th and 14th month. Anatomical examination revealed that suberin zones had penetrated from cortex to cambium in all dead grafts. Death of connecting bark tissues within union zones occurred between ages of 220-230 days and 13-14 months. Suberized areas presented a relatively impermeable barrier to water and nutrient movement between stock and scion cells. Scion needle drop and chlorosis resulted after scion and stock tissues became separated by suberin zones. Even xylem ray cells became necrotic and suberized. This probably eliminated all lateral water movement between xylem tracheids and living bark tissues.

Deepest suberin penetration within a graft occurred in union areas that contained the most vertically disoriented tissues. Lower rates of cambial activity were thought to result in deeper and more extensive suberin development. Number of cambial unions within a graft did not influence initiation of suberin zones but did affect chance of future graft survival. Mortality at the 13- to 14-month collection date was greatest in grafts with fewest cambial unions. A greater number of union areas increased probability that at least one area would not develop suberin zones into the cambium. Grafts with some unpenetrated cambial area would survive for at least another year. Initiation of suberin zones was not affected by physical structure of the union, but collections made in the first and second years showed suberin zone penetration to be altered by union structure.

A pattern of suberin zone initiation and development, similar to that found in grafts of the first year, was recorded at 15, 17, and 19 months. Suberin zones were generally retricted to the cortex during active growth periods (15-month collection), and then suberin zones progressed inwards during period of slow cambial activity (17- and 19-month collections). Percentage of grafts with phloem or cambial penetration in the second year was less than was recorded for the 220- to 230-day collections. The probable cause of lower second-year values was death of most severe incompatible combinations during the 13th and 14th months. Although suberin penetration depth was generally less than at 220 to 230 days, percentage of grafts which had initiated suberin zones was very similar between the 2 years. Eighty-six and 85 percent of compatible and incompatible clone grafts, respectively, initiated suberin zones in October of the second year (19-month collection). Those values closely matched the October collection values of the first year (220- to 230-day collection), when 83 and 86 percent of the compatible and incompatible clones, respectively, initiated suberin zones (Table 1).

A second characteristic internal symptom of Douglas fir graft incompatibility was first noted in the 15-month collection. This symptom will be called a xylem wound area (Fig. 1). Xylem wound areas, as seen in transverse view, developed at the start of the second growing season where stock and scion cells merged. The areas were composed of irregularly shaped tracheids that were disoriented vertically; lignified callus cells that had dark-stained cell contents; and necrotic areas of crushed, suberized, cambial and phloem tissue. Wound callus cells were formed only for a short time after regrafting occurred, and then irregular, disoriented tracheids developed. More normal tracheids were differentiated later in the growing season from derivatives of the xylem wound cells. Vertical xylem disorientation became less, and cross-section tracheid diameters returned to nearly normal size and shape. At the end of the growing season, some grafts developed normal tracheids, but other grafts continued to produce disoriented tracheids.

Xylem wound areas were formed in grafts of both compatible and incompatible clones. They occurred only in grafts of 15-, 17-, and 19-month collections that also contained suberin zones, but not all suberized grafts developed xylem wound areas (Table 1). Size of xylem areas was positively correlated with size of suberin zones located in bark opposite them. Both incompatibility symptoms varied in size within union areas of individual grafts. It is concluded that xylem wound areas were formed as a result of prior suberin zone penetration of the cambial zone. Autoplastic grafts did not develop suberin zones; thus, no xylem wound areas were found.

Comparison of cell types located in xylem wound areas with cell types and tissue organization developed after first grafting indicated that regrafting of stock and scion tissues had occurred at the start of the second season. As growth started the following spring, suberin zones and cell necrosis had either caused cambial death or severely disrupted cambial continuity. When spring growth began, a continuous cambial zone no longer existed between stock and scion. Mitotic activity of stock and scion cells near suberized and necrotic cambial areas resulted in formation of extensive callus areas. If grafts were to survive, a continuous bridge of living cells had to fill the gap between stock and scion. Grafts that succeeded in breaking through suberin zones later differentiated new cambiums across bridge areas. Newly organized cambium formed irregular and vertically disoriented tracheids. Cell types in regraft areas were different from those formed immediately before or after regrafting and provided excellent visual evidence of severe scion-stock incompatibility in Douglas fir. Thus, regrafting resulted in formation of xylem wound areas. This symptom will be of diagnostic value for estimating incompatibility of new clonal selections for future orchards.

Examinations of 2- to 4-year-old seed orchard grafts, which were dead or dying of incompatibility when collected, revealed that xylem wound areas developed in all xylem union areas at the start of the second year's growth (Fig. 1). No graft formed xylem wound areas one year and then reverted to normal the following years. Also, no graft union that was normal the first few years developed xylem wound areas in later years. If a stock-scion combination was incompatible enough to cause xylem wounding, it began the process at the start of the second year. Xylem wound area was found in all union zones where cambium-to-cambium contact existed between stock and scion. The grafts had previously survived by regrafting each year until the time came when regrafting failed and the graft finally died. After regrafting failed, incompatibility symptoms in older seed orchard grafts were seen externally as scion overgrowths, and still later, as chlorosis and needle drop. Grafts only 2 to 3 years old normally died without developing scion overgrowths.

A summary of the graft mortality and union anatomy data revealed that 26 and 63 percent of compatible and incompatible and scion clones, respectively, showed symptoms of incompatibility severe enough to cause death or regrafting at the start of the second year. Regrafting will ultimately fail and then graft death will occur. It should be remembered that only worst incompatible and most compatible clones were examined in this study. A collection of grafts from nonselected clones might have an incompatibility value between 26 and 63 percent.

Symptoms of Douglas fir graft incompatibility resemble but are slightly different from symptoms reported by pomologists. Repeated regrafting is an old story to apple workers, so this symptom is not specific for Douglas fir. Major characteristic separating Douglas fir incompatibility from other plants was area of suberin initiation. Pomological literature reported that suberin zones begin in phloem or cambium. This study has shown that suberin zones in Douglas fir are always initiated at some point in the cortex. The zone is never formed first in phloem or cambial areas but reaches those tissues only after inward penetration from its cortical point of origin.

Cause(s) of incompatibility in Douglas fir are uncertain. However, it is evident that a simple growth rate difference between stock and scion is not the cause, that different periods of growth initiation had no effect on stock-scion compatibility, and that physical act of union formation did not cause incompatibility. The results of this study suggest that inverse correlation exists between rate of suberin penetration and amount of cambial activity. A biochemical antagonism, or possibly an antigen-antibody reaction, might exist between stock and scion tissues. Also, the possibility of viral infections cannot be overlooked.

Summary

Two internal symptoms of incompatibility were found during the first 2 years—(1) initiation and penetration of suberin zones in bark areas of the unions and (2) initiation and development of xylem wound areas in xylem areas of unions. The suberin symptom was first seen in the cortex of an 84-day-old graft. Xylem wound areas became visible when the grafts were 15 months old. The suberin symptom became increasingly evident as age increased during the first year. Incompatible clones differed from compatible clones anatomically only in depth of suberin penetration. No similar symptoms were ever found in any autoplastic graft.

During the first year, necrotic phloem and cambial cells developed near suberized tissues. Incompatible grafts, which did not die before or soon after start of the second growing season, regrafted. Xylem wound areas developed only where deep suberin zone penetration occurred. Potential incompatibility losses were 26 percent for compatible clones and 63 percent for incompatible clones.

Cause(s) of graft incompatibility in Douglas fir are still not known. Growth rate, grafting technique, and spring

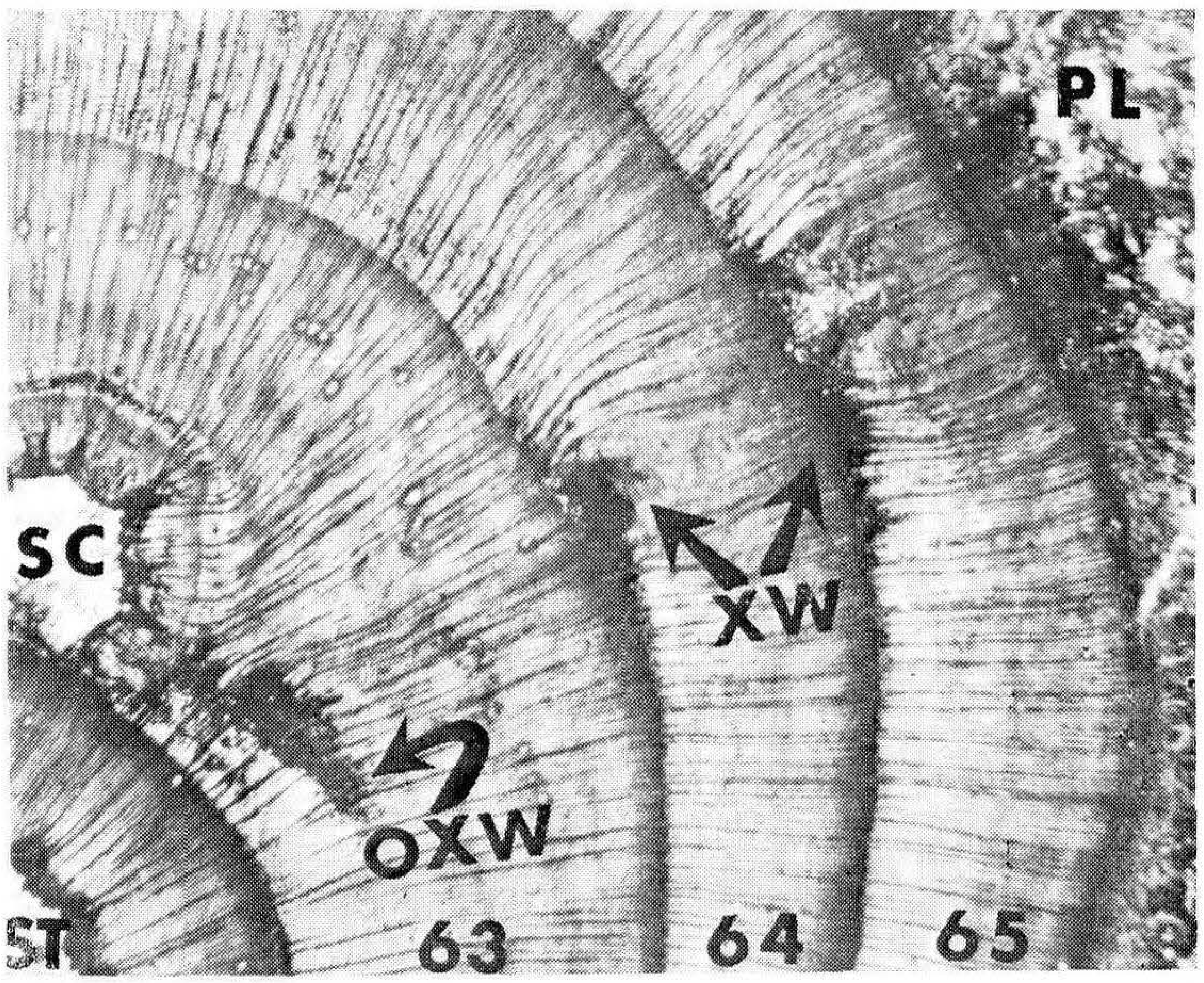

Figure 1. Three-year-old graft union containing two xylem wound areas formed at the start of the second and third year's annual growth. Transverse view. 40X. (Xylem wound areas, XW; original graft xylem wound cells, OXW; scion, SC; stock, ST; phloem, PL.)

phenology have been ruled out as causes. Viral infections or biochemical antagonisms caused through stock-scion interaction might be causes of symptom initiation.

MODERATOR DOUGLASS: The next speaker is Ralph Jack, who is the owner of the Silver Falls Nursery and Christmas Tree Farm, Silverton, Oregon, which is in the Cascade Foothills, east of Salem. Mr. Jack has specialized in growing some 200 varieties of trees and shrubs for the wholesale market; these include Christmas trees, Christmas tree planting stocks, specimen trees, ornamentals and bonzais. Ralph Jack:

FIELD PRODUCTION OF CONIFERS

RALPH A. JACK
Silver Falls Nursery and Christmas Tree Farm
Silverton, Oregon

Our nursery and tree farm has as objectives: (1) raising seedlings and transplants for our use in growing Christmas trees, which we wholesale and (2) producing container stock for wholesale to nurseries, as well as for our own mail-order retail business.

We are located at Silverton Hills near Silverton, Oregon, in the Cascade foothills at an elevation of 1500 feet. We are 15 airline miles east of Salem, Oregon. Our soil is Olympic clay loam and is of a medium texture. Locally it is called "shot" soil.

We gather some conifer seeds for our own use, such as noble fir, western and mountain hemlock, *Abies magnifica* and *Abies concolor*. Noble fir is collected in the Cascades at 3500-4000 feet elevation. *Abies concolor* and *Abies magnifica* are collected in the Sierra Nevada mountains of California at about 7000 and 8000 feet elevation, respectively. We buy most of our seeds.

Seed is stratified in one of two ways; (1) with damp peat in plastic bags—50% seeds and 50% peat with moisture squeezed out—or (2) soaked overnight, drained and placed in plastic bags. For both methods we keep the seed in cold storage at 34° to 41° F. from five to eight weeks. We try to plant them just as soon as sprouts appear.

Seed bed preparation includes plowing with a rotary plow which breaks the soil into particles about ⅛ inch size. Vapam has been used in the past for soil sterilization. Beds are 34 inches wide, and are cultivated and raked. Seeds are broadcast by hand, then covered with ¼ to ⅜ inches of fine soil. This is either done by hand or by a trailer following a tractor. Sifted soil is shoveled onto a 4′ x 4′ plywood piece with a long handle. One man rides the trailer and shakes the board to drop the soil off evenly onto the seeds.

Seed beds are enclosed by wooden frames 3′ x 12′, made of 1 x 4 lumber. Hardware cloth (½″ x ½″ mesh) is nailed phenology have been ruled out as causes. Viral infections or biochemical antagonisms caused through stock-scion interaction might be causes of symptom initiation.

MODERATOR DOUGLASS: The next speaker is Ralph Jack, who is the owner of the Silver Falls Nursery and Christmas Tree Farm, Silverton, Oregon, which is in the Cascade Foothills, east of Salem. Mr. Jack has specialized in growing some 200 varieties of trees and shrubs for the wholesale market; these include Christmas trees, Christmas tree planting stocks, specimen trees, ornamentals and bonzais. Ralph Jack:

FIELD PRODUCTION OF CONIFERS

RALPH A. JACK
Silver Falls Nursery and Christmas Tree Farm
Silverton, Oregon

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Seed beds are enclosed by wooden frames 3′ x 12′, made of 1 x 4 lumber. Hardware cloth (½″ x ½″ mesh) is nailed on top. This protects the seeds from birds and field mice. Ground squirrels and sometimes field mice will burrow under the screens. For them we place a small aluminum container of poisoned barley or wheat in every fourth frame. Our nursery is bordered on three sides by timberland so our "varmint" problem is greater than it is in more settled communities. Seed beds are sprinkled by irrigation lines once or twice daily. We try to grow 25 seedlings per square foot. As conifer seeds range from 400 to 240,000 seeds per pound, our plantings are only roughly at the rate we desire. Extremely small seeds are either mixed with sand for planting or are scattered, then spread by a very light raking. Fifty percent shade is required for seedlings of most spruces. For them we use lath nailed over the screens above the hardware cloth. We had been advised that lath alone on the frames would frighten the birds away but we found the lath was merely a good landing field for the birds who hop right down through into the seed beds.

Almost all of our seedlings are transplanted. They are dug, root-pruned and wrapped in crinkly waterproof paper or one-mil plastic with the roots covered with damp peat or shingle tow. Our tree planter is a "Root Spread". It has a double plow which opens a furrow several inches deep and about four inches wide. We can place the roots and keep the trees straight. Rubber tired packing wheels tamp them. If the soil is at just the right dampness nothing further is required. On days when the soil is not good for planting I have a man follow, straighten any seedlings that are leaning and tamp each one by stepping near it. We use this planter for seedlings 7 to 24 inches tall, planted 8 to 16 inches apart. We also use it for planting Christmas trees. For smaller seedlings we use a two-seater berry-type planter. Seedlings are placed between two fiber disks which rotate and release them right side up in the row which the machine has opened. Metal wheels tamp them. We plant from 3 to 12 inches apart. Many seedlings are hand-transplanted. We use either planting boards, trenching tools, or hoe and trowel. We have tried 3-foot planting boards crosswize or 12-foot boards lengthwise of the row. We find the shorter ones are better as two planters can work, one from each side without being on the transplant bed. We had a tool made for trenching. A piece of flat 1/8" steel, 7" x 20", has a light piece of one-inch angle iron welded across the long edge. This provides a wide edge upon which to step. A 27" handle of 1/2" pipe has 12 inches of 1/2-inch pipe welded across the handle for hand grips. One can open prepared soil by inserting this into the soil then wriggling it back and forth. Trees are placed in the opening. Opening the next trench tamps those previously planted. At certain soil moisture levels the soil sticks to the trencher. This is a nuisance and slows work. Our planters prefer to use the hoe and trowel method. Prepared soil is opened with a narrow or pointed hoe. One worker opens the trench across the row. One women at each side of the row places and covers the trees.

Field plantings of conifers for Christmas trees are made with a tree planter, planting 4 x 4 feet for true firs. We grow red fir, *Abies magnifica;* Shasta fir, *Abies magnifica* var. *shastensis;* white fir, *Abies concolor;* and noble fir, *Abies procera.* True firs command top prices, require no pruning unless injured, have excellent taper, good color and are good for stump culture. In our soil, with one heavy irrigation in late June, the trees grow about the right amount (about 12 inches) per year. True firs have even whorls of four to seven segments. This gives the trees an excellent shape. Fertilizer is used only about very two years. Two ounces of ammonium sulphate per tree is sprinkled near the drip line. It must be kept off the foliage as it will burn the needles. Nitrogen helps needle length and improves color. Trees that were culls one season became premium trees the next after ammonium sulphate was applied. We apply the fertilizer just prior to the June irrigation. Alternate years we spot fertilize only those trees that appear to need it, either because of slow growth or yellowish color.

True firs lend themselves to "stump culture". Our policy is that if a tree is good all the way down we cut it near ground level. If one or more whorls are irregular we cut just above them. This leaves a whorl or more of limbs to keep the roots alive. Limbs will either turn up and form a tree, or central shoots will form which will make an excellent tree. We prefer to use the central shoot. When limbs turn up for a year or two the new tree will tend to be flat. A central shoot will produce a symmetrical tree. *Abies concolor* limbs will produce a nice tree without waiting for a center shoot. I have found that to get good central shoots the stump should be cut within one inch of the whorl that is being left. We allow two or three central shoots to grow until they are about one foot tall. We select the best one and prune off the others. These we prune about two inches long so they will form more central shoots. We have five-foot stump culture trees nearly ready to harvest, with another shoot a foot tall growing to form the third tree from the stump.

Where we live deer are in our fields every night. Of 40,000 trees we lose about six per year where bucks rub the velvet off their horns. Perhaps they ruin a few others but we see little evidence of it. Jack rabbits like to bite off *Abies concolor* transplants which are about twelve inches tall. We dispose of some of the rabbits, but found the best remedy is to plant more trees.

All true firs seem to be subject to frost damage under certain conditions. Perhaps some seasons the buds come out too early. After all, our true firs are displaced 600 miles and 6000 to 7000 feet in elevation from their native habitat.

True firs are tough enough to start new tops after frost or rabbit damage. We select the best top and prune off the others. Of those we grow, *Abies concolor* trees seems to be most affected by frost damage but they recover readily.

MODERATOR DOUGLASS: We have one more presentation in this session. John Walters is the Director of the University of British Columbia Research Forest, Haney, B. C. John, we understand you have developed an ingenious gun for literally "shooting" planting stock into the ground. It will be our pleasure to have you explain this to us. John Walters:

CONTAINER PLANTING IN FORESTRY

JOHN WALTERS
Research Forest, University of British Columbia
Haney, British Columbia

Forest tree planting began about 400 years ago. Since that time the methods of tree planting have changed only slightly while the principles have changed not at all. Although 1½ billion seedlings are planted each year in North America we rely still on the same techniques which were developed for much smaller quantities of planting stock at a time when labour costs were insignificant. Forestry in the Pacific Northwest currently relies on manual methods to plant two-year-old bare root Douglas fir seedlings. About 500 trees per man-day are planted with this technique, currently in wide use in the Pacific Northwest.

Today, we are faced with the problem of accomplishing a monotonous, tedious job with a labour force which is rapidly diminishing in terms of quantity and quality. In some regions an attempt has been made to mechanize this operation by borrowing techniques from agricultural practice and by modifying agricultural equipment such as the broccoli planter. These tractor-drawn implements do not operate well on sandy and rocky soils, nor do they do a good job of planting on rolling terrain. Moreover, much of the terrain of the Pacific Northwest is inaccessible to this type of furrow-making planter. Besides the steep slopes broken by granitic outcrops, the areas are littered with large volumes of heavy logging debris.

However, regardless of the topographic conditions of the planting site, present day reliance on bare-root seedlings limits the development and introduction of new planting methods. Bare-root seedlings, having dimensions and succulence which vary from seedling to seedling, have obliged all modern tree-planting machines to rely heavily on manual aids both during the insertion of seedlings into the furrows and also, subsequent to planting, follow-up operations to improve the job done by the machine. Moreover, critical requirements of seedling physiology must be protected during the planting operation. The accommodation of these requirements imposes stringent demands upon the planting process and it is safe to say that bare-root planting requires more accommodation than any other method, whether machine or manual.

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From the biological point of view the best method is the one which provides for the least disturbance of the root system. This requires that the seedling be moved from nursery to planting site with its roots still in the soil in which it germinated. In horticultural practice this has been accomplished best by ball-root planting, and, increasingly, by container planting. The overriding advantages of container planting are: firstly, that it requires least accommodation in terms of protecting seedling condition and, secondly that it permits the fixing or stabilizing of seedling dimensions so that seedlings can be metered mechanically throughout nursery, transportation, and planting processes. In the face of these crucial advantages it is incredible that container planting in forestry was almost completely ignored until after the Second World War. The reason for this neglect is not clear but recently forestry has made several attempts to catch up. Paper bags treated with asphalt have been tested in Europe. Containers made of tin, concrete, galvanized iron pipe, palm leaves, banana bast, sunflower stems, bamboo, and wood veneer have been used extensively, specially in the tropics. Polyethylene bags are used in the semi-arid areas of Africa and in Taiwan. By far the most popular is the peat pot common to horticulture. This year the Swedish government and industry are spending nearly 1 million dollars in an attempt to develop a mechanical planting system using peat pots. The main disadvantage to this type of container is associated with its lack of rigidity and its rapid deterioration, resulting in high labour costs. Synthetic rooting media are also being tested. One of these is a polyurethane foam, containing nutrients, developed by Dow Chemical Co. which is being tested at U. B. C. Research Forest.

Increasingly, forestry is turning to plastic tubes of various kinds. In Alberta, government and industry have cooperated to test several types made of vacuum-formed polyethylene or extruded polyethylene; 18 million polyethylene tubes were planted in Ontario last year and the program in 1967 calls for 37 million. In all of these containers, the growing medium, usually soil, or sand and peat, is poured in and the seed inserted using various semi-mechanical aids. The crucial disadvantage of this type of semi-flexible container is, however, that its composition and design limit its suitability for total mechanization in any of the nursery, transportation. and planting processes.

In an attempt at the University of British Columbia to develop a new planting method which could be totally mechanized, old principles were joined to new techniques and this method has been under development and test in B. C. since 1950. The devices described here are called the planting gun and bullet (Figures 1 and 2).

Although the objective of the project was to mechanize planting, the conditions under which reforestation are carried out in much of the Pacific Northwest dictate that the machinery must be manually transported over the planting sites. This fact strictly limits the weight and method of operation of machinery. The planting gun[1] weighing seventeen pounds, is sufficiently light and convenient to be portable over logging debris on steep and rocky slopes. It also became evident early in this project that mechanical metering of large numbers of seedlings under rugged field conditions required that the dimensions of the seedlings should be constant and that this could be accomplished, within narrow tolerances, only by

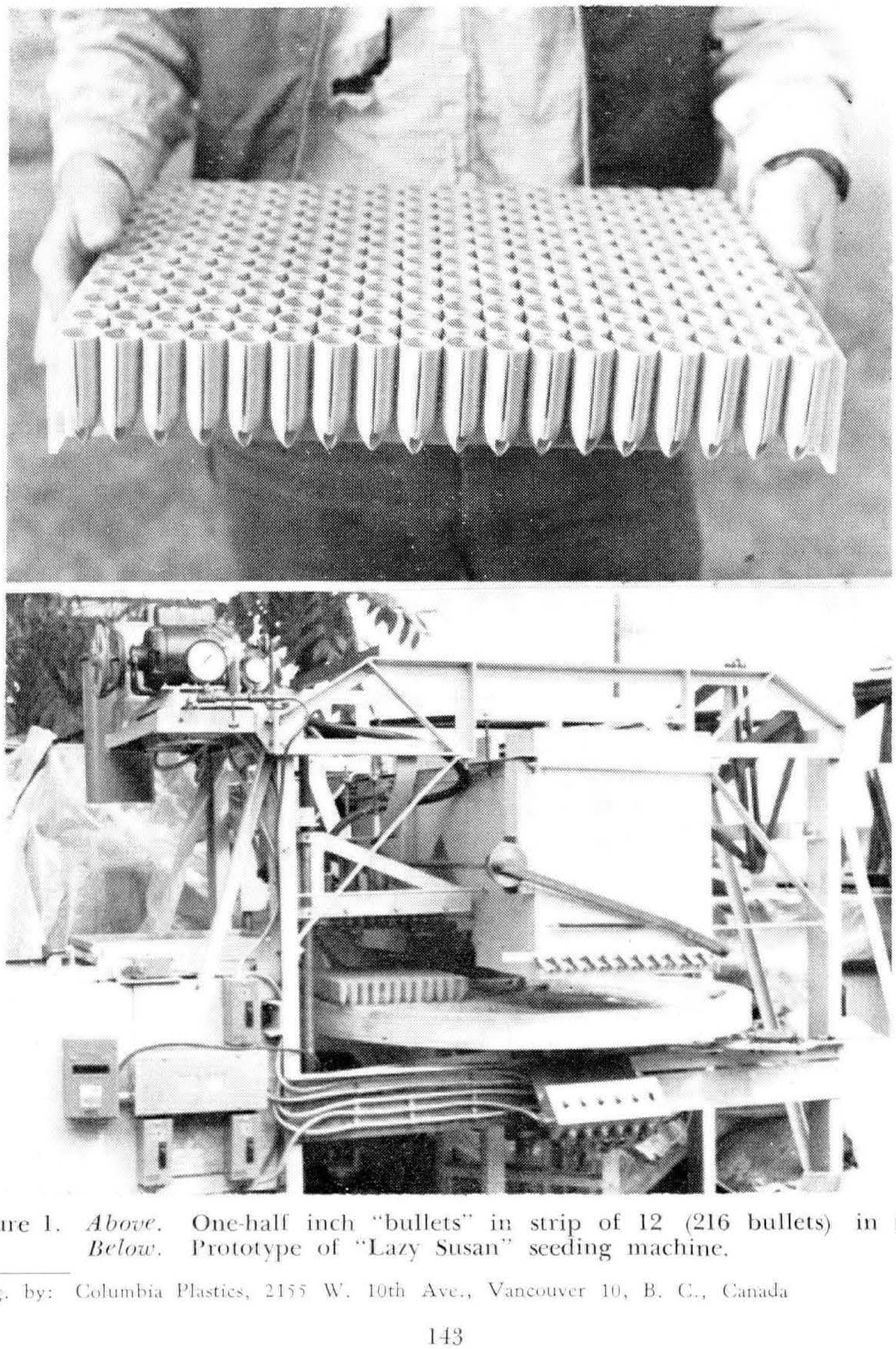

Figure 1. *Above.* One-half inch "bullets" in strip of 12 (216 bullets) in tray.
Below. Prototype of "Lazy Susan" seeding machine.

[1]Mfg. by: Columbia Plastics, 2155 W. 10th Ave., Vancouver 10, B. C., Canada

growing seedlings in containers of fixed dimensions. For this reason a rigid container was designed which could be pro-

Figure 2. Planting "gun". *Above.* Single-shot gun in use. *Below.* 24-shot planting gun.

duced from a relatively inexpensive material. Styrene plastic was chosen to fill the latter requirement and the needs of mass production met by injection molding. The bullets[1] are 2½ in., 3½ in., 4½ in., and 5½ in. in length, are ⅞ in. in outside diameter, and have walls 1/16 in. in thickness. The wall of each bullet is weakened by a slit which is 1/16 in. wide and which extends longitudinally from the rim to a hole near the point of each bullet. The hole is ¼ in. wide and ½ in. long, and is offset from the point to permit passage of the roots while preserving the essential profile and strength of the bullet. A longitudinal groove, 1/32 in. deep, and diametrically opposing the slit further weakens the bullet and acts as a fulcrum for the unfolding bullet as root growth widens the slit. The bullets are molded in strips of twelves and received from the factory in disposable plastic racks.

Bullets are filled with University of California Soil Mix C (Fertilizer I) and seeded mechanically. The machine weighs 1,000 pounds. A ¾ HP compressor actuates a turntable which completes one revolution per minute in four equal stages controlled by a solenoid. The compressor also operates soil-metering grids on diametrically opposed soil hoppers, a tracked seed-pan, a seeder, and a soil-tamper. The machine is adjustable to accommodate bullets ranging in length from 2½ in. to 5½ in. Plastic trays containing 18 strips of bullets, are placed below the main soil hopper which fills the 216 bullets simultaneously with soil mix. A quarter turn of the table carries the tray to the second position where the soil is mechanically tamped. The transfer of the tray to the tampers clears the first position for the insertion of a second tray of bullets. Another quarter-turn carries the first tray to a second hopper which refills the tamped bullets. Finally, in the fourth position, the wheeled seed pan rolls under, and lifts up to, 216 vacuum-operated nozzles each of which picks up one seed. When the seed-pan rolls back, the nozzles are lowered to meet the incoming tray of bullets. The operation is synchronized to release the vacuum when the nozzles are submerged ¼ in. below the rim of the bullets. The tray, filled with soil mix and seed returns to the first position where it is removed and placed in the lath shed. Completed in one minute each revolution of the turntable fills 864 bullets.

Trays of seeded bullets are placed in troughs and sub-irrigated. When ready for planting, seedlings in the plastic trays are transported to the planting site and transferred to the pack-boards of the planting gun operators.

The planting gun is a tubular device, which inserts the bullet-shaped plant-pots, each containing a tree seedling, into the ground when a downward force is applied manually to the gun handle. When the downward force is discontinued, a coil spring extends the gun to actuate blades which cut one bullet from the strip of bullets in the magazine. The bullet then drops to the muzzle of the gun where it is held ready for planting. Tests carried out since 1957 at the University of British Columbia Research Forest prove that the bullets are shattered by root growth after three or four growing seasons, depending on site quality and rate of growth.

Some of the containers described here were introduced with the sole purpose of improving survival and subsequent growth. This worthy objective is no longer adequate and must be supplemented by mechanical aids. It is already apparent that for biological and mechanical reasons each phase of a container program has important implications for other phases. Because of this, revolutionary techniques of sowing, growing, transporting, and planting will be developed in the very near future. It seems certain that many of these techniques will have applications in agriculture and horticulture as well as forestry and that each of these three sciences will benefit by learning and borrowing from the others.

VICE-PRESIDENT TICKNOR: The moderator for our second session this morning, which is on "Chemicals and Plant Growth", is Dr. J. W. Neill. Dr. Neill is in the faculty of the Division of Plant Science, University of British Columbia, Vancouver. Dr. Neill:

MODERATOR NEILL: I am most happy to be here and to give you my own word of welcome to British Columbia. The subject matter for this session is a very fundamental and important one to all of us — "Chemicals and Plant Growth." Our first speaker is Dr. Dennis Lavender, from the Forest Research Laboratory, Oregon State University, Corvallis. Dr. Lavender has spent some 20 years in forest research in the Pacific Northwest. He is going to discuss the role of growth regulators in the physiology of Douglas fir seedlings. Dr. Lavender:

THE ROLE OF GROWTH REGULATORY SUBSTANCES IN THE PHYSIOLOGY OF DOUGLAS FIR (*Pseudotsuga menziesii* [Mirb.] Franco) SEEDLINGS

DENIS P. LAVENDER AND JOE B. ZAERR
Forest Research Laboratory, School of Forestry
Oregon State University
Corvallis, Oregon

Douglas fir, in common with most conifers, is characterized by extremely slow seedling growth and by very heterogenous populations. Obviously it does not recommend itself as an experimental organism to physiologists studying basic processes in plant growth. It is not surprising, then, that there are little data describing chemical growth regulation of this species nor that the great majority of the existing information is derived from highly empirical trials. Unfortunately, while then drops to the muzzle of the gun where it is held ready for planting. Tests carried out since 1957 at the University of British Columbia Research Forest prove that the bullets are shattered by root growth after three or four growing seasons, depending on site quality and rate of growth.

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The first part of this paper will be concerned with the aforementioned trials; the second, with problems we have encountered in our attempts to measure endogenous growth regulators; and the last, with current studies designed to define the role such endogenous regulators play in the physiology of Douglas fir seedlings.

Table 1 is a compilation of the chemicals reported which have been employed in studies of growth regulation of Douglas fir. It does not include, however, such synthetic plant growth regulators as the phenoxy group which have been used primarily as silvicides.

The term "growth retardants" is defined by Cathey (5) as "chemicals that slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effects". Optimum applications of these materials will result in reduced plant size but not reduced vigor or development.

The first such chemical, B-995, is a member of a new class of growth retardants which are somewhat similar to maleic hydrazide (5). It has been shown to retard growth of apples, pears, cherries, and other plants (3). In our laboratory, one-month-old Douglas fir seedlings were sprayed to the drip point six times at bi-weekly intervals with aqueous concentrations up to a maximum of 4,000 ppm. When the four-month-old seedlings were harvested, no treatment effect upon dry weight was found and only the highest concentrations re-

Table 1. Growth Regulatory Chemicals Applied to Douglas Fir Seedlings

B-995 (N-dimethyl amino succinamic acid)
CCC ([2-chloroethyl] trimethylammonium chloride)
Phosfon D (tributyl-2, 4-dichlorobenzyl phosphonium chloride)
maleic hydrazide (diethanolamine salt of 6-hydroxy-3(2H pyridazinone)
naringenin (4′, 5, 7-trihydroxyflavanone)
abscisin II (dormin) (3-methyl-5-[2′, 6′, 6′-trimethyl-1′ hydroxy-4′-keto'cyclo-hexa-2′-enyl] *cis-trans*-2,4-pentadienoic acid)
SD 8339 (6-[benzylamino]-9-[2-tetrahydropyranyl]-9H-purine)
gibberellic acid
indoleacetic acid
alpha-naphthaleneacetic acid
indolebutyric acid
kinetin (6-furfurylaminopurine)
MDB (2-methoxy-3, 6-dichlorobenzoic acid)
TPP (2,4,5-trichlorophenoxypropionic acid)

duced stem elongation (32). Further, Pharis *et al* (27) report no significant effect of an 8,000 ppm soil drench applied twice weekly for two months upon the growth of two-year-old Douglas fir seedlings.

The second compound, a quarternary ammonium compound abbreviated CCC, is an analogue of choline. It has been shown to retard the growth of the majority of plants tested (5). Lang and co-workers have concluded that the mode of action of CCC is inhibition of the biosynthesis of gibberellins which are required for growth processes (16, 25). Workers at the Earhart Plant Research Laboratory report that CCC applied as a 5,900 ppm soil drench twice weekly for two months had no significant effects upon the growth of two-year-old Douglas fir seedlings (27). Similarly we have found that this chemical is not effective in retarding the growth of Douglas fir seedlings when employed as a soil drench at concentrations up to 0.02% of soil weight of the active material. However, seedlings sprayed at bi-weekly intervals with concentrations up to 2,500 ppm active ingredient developed marked chlorosis and greatly shortened crowns. Plants treated with 2,500 ppm were very bushy and weighed less than one third of the control seedlings at the end of the four month study (32).

A second quarternary compound, phosfon-D, has been reported to reduce internode growth and to produce dark green leaves for a number of test plants (5). In common with the previous two retardants, this chemical has been most effective when applied to dicotyledons. Several trials with Douglas fir seedlings have demonstrated either no, or erratic, height growth control, but increasing levels of the chemical in the soil—up to a maximum of five grams of active material per quart of soil—resulted in increasing chlorosis of the seedling foliage (22, 27, 38).

In contrast to the above compounds, Cathey (5) describes maleic hydrazide as a "growth inhibitor", a class of compounds which may suppress growth completely in treated plants. Maleic hydrazide suppresses apical dominance and frequently results in plants with greatly shortened internodes and dark green foliage (5). One-year-old Douglas fir seedlings in nurseries in England were sprayed with 0.05, 0.1, and 0.2% aqueous solutions of maleic hydrazide during the period of bud swell in the spring (15). The purpose of such treatment was to control seedling size and late season flushing, but no significant response in seedling growth was noted. In contrast, seedlings sprayed with maleic hydrazide in late summer in the Nisqually Forest Nursery failed to form terminal buds and subsequently died during the winter[1].

The next two compounds, naringenin and abscisin II (dormin) have been shown to be associated with the biochemistry of dormancy of certain perennial plants. Hendershott and

[1]Personal communication from Dr J W Duffield, December, 1962.

Walker (18) and Phillips (28) have shown that naringenin is present in extracts from dormant peach flower buds and apparently plays a role in maintaining dormancy in this species. It is one of the flavenoids reported to occur naturally in the flowers, but not in other tissues of Douglas fir (21). However, there is no evidence that the dormant buds of Douglas fir were examined for this chemical. Two-month-old Douglas fir seedlings were sprayed to drip point at our laboratory with aqueous solutions of naringenin from 5 to 625 ppm at six bi-weekly intervals. The seedlings were maintained under an 18-hour photoperiod and a 25°-15° C. thermoperiod. A similar second trial employed 1% naringenin in lanolin applied to seedling epicotyls. No effect of the treatment on height growth or on initiation of dormancy was noted in either experiment.

Abscisin II (dormin) has been found in birch and sycamore, cotton, and a wide range of other higher plants (9, 10, 11, 13). Wareing and co-workers have shown this substance to be associated with growth inhibition or dormancy in both birch and sycamore (13, 33). In our laboratory, two-month-old Douglas fir seedlings were sprayed to drip point one, two or three times at bi-weekly intervals with concentrations of from 0 to 25 ppm. The seedlings were maintained under an 18-hour photoperiod and a 25°-20° C. thermo period for three months after treatment. No treatment effects upon seedling crown length, total dry weight, or initiation of dormancy were found at the conclusion of the study. No effects of the application of this chemical in lanolin at concentrations of 0.1 or 0.01% upon seedling growth were noted in a parallel trial. The data may reflect the low concentrations of active material employed, although one part of abscisin per billion has been reported to cause detectible inhibition of *Lemna minor* growth (26). However, without definitive data upon the absorption and translocation of this material by Douglas fir seedlings, it is impossible to determine if the lack of response was caused by the inactivity of abscisin in Douglas fir or the failure of the plant to absorb or translocate the material to an active site.

The remaining compounds in Table 1 are generally considered to be growth promoters and are termed "cytokinins", "gibberellins" or "auxins".

Cytokinins have held a fascination for plant physiologists ever since their discovery a few years ago. One of their disappointing properties, however, was that they do not seem to be translocated in the plant. If applied to a leaf, they tend to remain in that leaf. Dr. J. van Overbeek, at the Shell Development Laboratory, Modesto, California, attempted to formulate a cytokinin which would be translocated in plants. The result was SD 8339, the code number for 6-benzylamino-9-(tetrahydropyranyl)-9H-purine. This compound did appear to be translocated in plants and appeared to be a plant growth regulator. When applied to grapes, it increased fruit set and increased the size of the berries (36).

Two-month-old Douglas fir seedlings were treated with concentrations of SD 8339 as both aqueous foliar sprays and in lanolin paste, according to the schedule presented in Table 2.

Table 2. Treatment Schedule for SD 8339

Aqueous spray (to drip point)

(1) Control — 3% "Tween 20" and 6% ETOH.
(2) 500 ppm SD 8339 in above solution.
(3) 1000 ppm SD 8339 in above solution.
(4) 5000 ppm SD 8339 in above solution.

Solutions applied: (a) once; (b) three times (at bi-weekly intervals) or (c) 5 times (at weekly intervals).

Lanolin (applied to either stem tip or cotyledons)

(1) Control — pure lanolin.
(2) 0.1% SD 8339 in lanolin.
(3) 0.5% SD 8339 in lanolin.
(4) 1.0% SD 8339 in lanolin.

Lanolin paste applied: (a) once; (b) three times (at bi-weekly intervals); Control: Untreated, intact seedlings. All treatments tested on 10 Douglas fir, two-month-old seedlings.

Figure 1 illustrates the range of effect of the treatments. The first two lanolin treatments produced little change in the seedling growth and are represented by the seedlings in pots 1, 2, and 3 while the high concentration is represented by pots 5-6 (control seedlings are also represented by seedling in pot 1). In contrast the increasing concentrations of aqueous sprays resulted in the increasing effect upon seedling growth shown by the plants in pots 4 to 6 until the highest concentration resulted in dying or dead seedlings (pots 7 and 8).

A member of the second major class of plant growth promoting chemicals, gibberellic acid, has been shown to be an effective growth promoter for a wide range of plants, but, in general, the greatest response has appeared in herbaceous angiosperms (24). Gymnosperms have generally shown little or no response to applications of this compound (29). Ching and Ching (7) reported that Douglas fir pollen demonstrated greater pollen tube growth and more rapid cytological development on a nutrient agar with up to 1000 ppm of the potassium salt of gibberellic acid than did pollen germinated on a control medium. Richardson (30, 31) has shown that low (5-10 ppm) concentrations of gibberellic acid can stimulate the germination of non-stratified Douglas fir seed as well as increase the growth of radicles of newly germinated seeds.

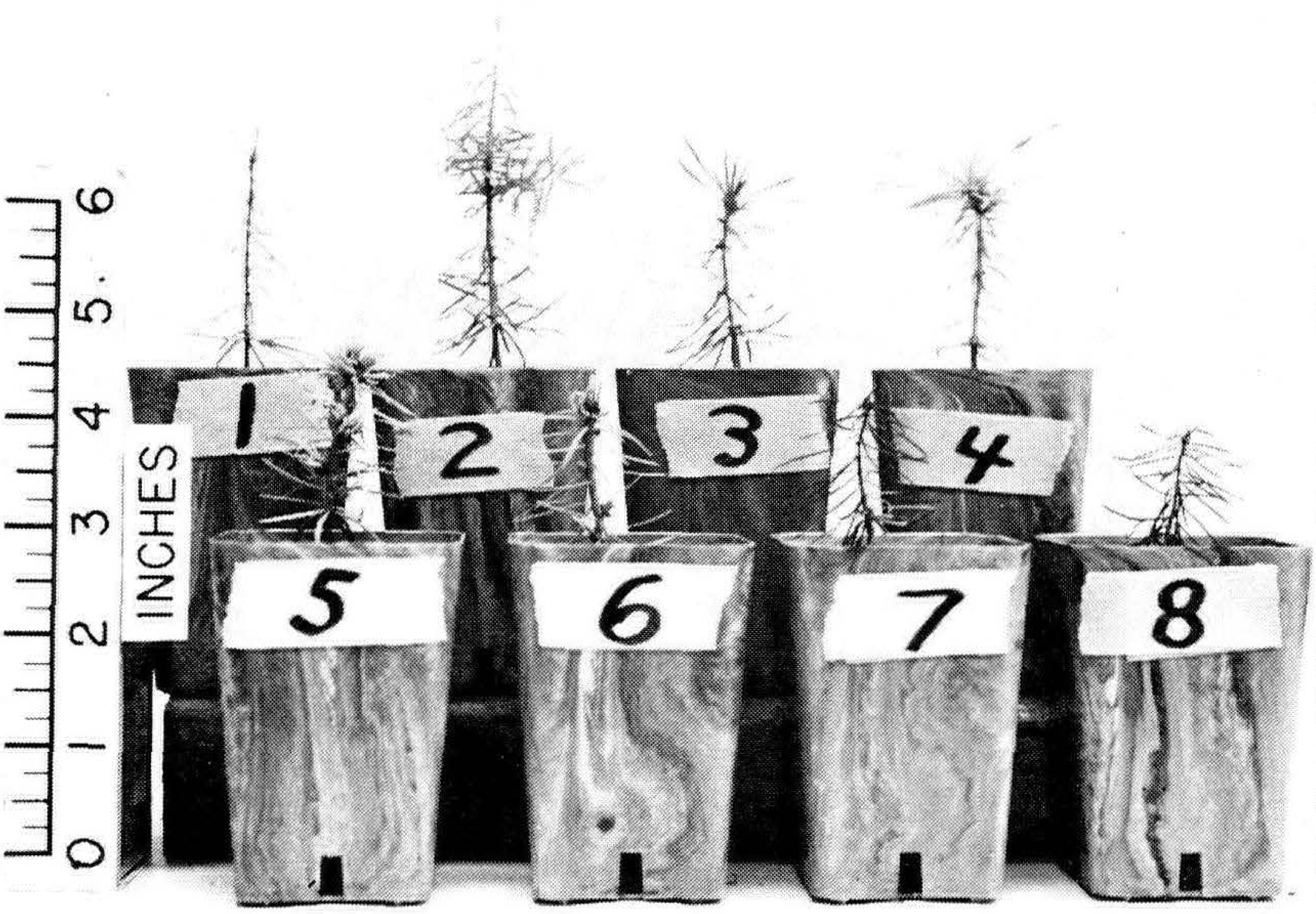

Figure 1. Effects of SD 8339 upon the growth of Douglas fir seedlings. Seedling 1, control; seedlings 7 and 8 treated with 5000 ppm aqueous spray. Note proliferation of lateral buds near apices of seedlings 3 to 6.

However, attempts to modify the growth of older seedlings, under greenhouse and under field conditions, have not only failed to produce a positive response (8, 19, 29, 35) but, in one trial (29) actually killed the seedlings. It should be noted that all these studies reported the use of gibberellic acid. It may be that one of the other more recently isolated gibberellin compounds will be found to be effective on Douglas fir (27).

Indoleacetic acid, the major native indole auxin in plants, was first reported by Went (37). This compound is thought to be universally present in higher plants, but the only recorded data on its occurrence in Douglas fir are the inconclusive chromatographic studies of Dinus (12). Experience with other coniferous species convinces us, however, that the negative data reported by Young (39) were very probably a result of the experimental procedures and not by a complete lack of diffusible indoleacetic acid in the test seedlings. Evidence that growth regulators might hasten the onset of dormancy of Douglas fir seedlings[1] prompted trials with indoleacetic acid at our Corvallis nursery. No effects upon seedling phenology were noted after treatment with aqueous sprays of 125 ppm indoleacetic acid in May, June, July, August. However, trials in a controlled environment chamber demon-

[1]Personal communication from Dr. J. W. Duffield, 1962.

strated that one-month-old Douglas fir seedlings produced twisted, rigid shoots when sprayed with indoleacetic acid solutions at 200-300 ppm. Shoot elongation and shoot dry weight were generally reduced by this treatment (32). Lavender and Hermann (23) reported that 100 micrograms of indoleacetic acid applied in lanolin paste to decapitated seedling apices significantly increased production of xylem elements.

Although naphthaleneacetic acid is not a natural plant hormone (4), it has been shown to produce many of the growth responses engendered by indoleacetic acid but is, in general, somewhat less effective (4). Dr. J. W. Duffield found that aqueous sprays of NAA at 125 to 250 ppm applied in August produced early dormancy in Douglas fir seedlings.[1] He also reported that similar spray treatments appeared to increase root regeneration of Douglas fir seedlings lifted in November and December (2). Heitmuller (17) notes that Douglas fir cuttings soaked for 24 hours in a 0.0005% (5 ppm) solution of the potassium salt of naphthaleneacetic acid rooted vigorously, while a six-hour period of soaking in 0.002% (20 ppm) naphthaleneacetic acid plus 0.002% (20 ppm) indoleacetic acid yielded slightly less favorable results.

The final compounds shown in Table 1 have been employed (indolebutyric acid both singly and in combination with naphthaleneacetic acid) in rooting trials of Douglas fir cuttings at Oregon State University's North Marion Experiment Station. Unfortunately, Dr. Ticknor reports only erratic success with indolebutyric acid and virtually none with the remaining compounds.[2]

The above discussion demonstrates that Douglas-fir is much less responsive than many angiospermous plants to the major classes of plant growth regulating compounds. This may reflect a more primitive physiology which would be consistent with the generally accepted theory of the relative primitive development of conifers in general and *Pinacease* in particular, vis-a-vis the angiosperms. This primitive physiology is also reflected by the nature of the pigments in Douglas-fir flowers. These flavanoid substances are much less complex than the pigments of angiosperms.

We are concerned with the detection of growth regulators in Douglas fir. In the past, portions of grass seedlings have been used for the assay of growth regulators, the most well-known assay being the *Avena* coleoptile curvature test. The popularity of the various *Avena* bioassays and similar bioassay systems is probably a result of the historical development of the study of hormones and the relative speed and ease with which these bioassays can be conducted compared with alternative methods. For meaningful results applicable to the intact plant, however, the bioassay tissue should be of the same species as the tissue from which the extract is made. Thus,

[1]Personal communication from Dr J W Duffield, 1962

[2]Personal communication from Dr Robert L Ticknor, August, 1967.

Douglas fir tissue is desirable as a sensing element for growth regulators extracted from Douglas fir tissue.

It would be preferable to use the entire plant in a bioassay, not just one portion of it. The intact plant would be more likely to contain all of the cofactors necessary for the manifestation of a naturally-occurring plant growth regulator. Furthermore, since our ultimate goal is to identify growth regulators which might be used to control the growth of Douglas fir, the intact plant is most likely to tell us what we want to know. If that approach fails, the next-best procedure would be to use portions of Douglas fir plants, preferably tissue such as a meristem, which would be likely to respond to growth regulators.

We have tried both these approaches in our attempt to develop a bioassay. To date we have not found a usable system. With indoleacetic acid as a standard of sensitivity, we cannot elicit a response from intact seedlings with less than about 10 micrograms of indoleacetic acid per plant. That response, which is a bending, is too variable to be useful. Flemion (14) grew excised Douglas fir embryos on filter paper to determine their germinative capacity. We tried to detect indoleacetic acid with excised embryos using her technique but got no response at all. Our attempts at adapting Allen's (1) pine hypocotyl test to Douglas fir have met with serious problems of bacterial contamination so we have not been able to evaluate that method satisfactorily. The hypocotyl section test seems to hold the most promise at this time.

Bioassays using Douglas fir tissue are not easy to conduct; seed must be stratified and germinated, germinants must be grown to the desired size, and the bioassay itself may take several days or even a week to conduct. Considerable planning is required to have plants ready for a bioassay when they are needed. In addition, a large inherent variability must be accepted. The advantages of a bioassay using Douglas fir outweigh these disadvantages, however. We plan to continue our search for a usable bioassay with Douglas fir tissue.

In his review, "Dormancy in Woody Plants", Samish (34) suggests that the dormant period of perennials is not a homogenous phenomenon, but rather a series of distinctly different physiological states. He terms these periods as "quiescence", "preliminary rest", "mid-rest", and "after-rest". Each state is defined by the growth response produced by an environment favorable to growth. The growth which may be expected during quiescence, preliminary rest, or after-rest is much more vigorous than that which occurs during mid-rest.

Interest in the natural and potential artificial regulation of dormancy in Douglas fir was stimulated at Oregon State University by evidence that seedlings disturbed during routine nursery harvest procedures in the period from late September until early December were much less able to withstand stress than were plants harvested from December to March (20). One tenable hypothesis for these data is that physical disturbance during the "mid-rest" phase of dormancy results in a severe delay in the normal sequence of concentrations of growth regulators.

The first of a series of experiments expected to establish the validity of the above hypothesis was designed to define the seedling tissues which are the sites of growth regulator synthesis during the dormancy period. Data from this study indicated that: (a) seedling buds are the major site of synthesis of growth regulatory material; (b) the growth stimulatory substance (or substances) produced by active buds are not translocated to dormant buds; (c) lateral meristem growth is stimulated by materials exported by acropetal active buds; and (d) root growth is independent of shoot activity (23).

The second series of experiments was conducted to ascertain whether application of growth regulatory materials to decapitated seedling apices could change the regulatory system for the plant as a whole. These materials, (indoleacetic acid and gibberellic acid) did not affect the activity of the roots or buds nor did they stimulate lateral meristems in stems with respect to controls, except in the period of transition from mid-rest to after-rest. The effect of indoleacetic acid in this period of transition provides a clue to the manner in which the growth-regulatory system may work. In the fall, buds may contain such an accumulation of inhibitors that meristems cannot be activated even with the application of exogenous growth promotors. At the end of mid-rest, the biological activity of the inhibitors seems to diminish but synthesis of intrinsic auxin is not sufficient to stimulate the growth of lateral meristems as much as does the application of exogenous indoleacetic acid. It is during this period, also, that the effect of long photoperiods in stimulating bud activity first begins to lessen, and that the foliage appears to export materials which may stimulate buds (23). In after-rest, concentrations of inhibitors in the buds are very probably sharply reduced and the production of auxin increased to a level where addition of exogenous auxin fails to stimulate meristematic activity (20).

The third year's experiment was designed to measure the effects of girdling, defoliation, and debudding of seedlings, together with applications of indoleacetic acid and gibberellic acid (19). Data obtained from this study indicate that: (a) the activity of seedling root systems, although apparently independent of measurable shoot growth is, in fact absolutely dependent upon materials exported from the shoot; (b lateral meristems of seedlings which were defoliated produced no new xylem elements until the growth of acropetal buds had produced fully expanded foliage (this is in contrast to growth of lateral meristems in intact seedlings which was stimulated by the swelling of acropetal buds) ; and (c) gibberellic acid may stimulate proliferation of cortical tissue, but, unlike indoleacetic acid, does not stimulate production of xylem elements.

Future experiments will be designed to isolate and identify the substances exported from buds and foliage, to determine their levels during the different phases of the dormant period, and to elucidate the effects of nursery practice upon the endogenous rhythm in the levels of growth regulating materials in Douglas fir seedlings.

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MODERATOR NEILL: We now have Dr. Fenton Larson from the Department of Horticulture, Washington State University at Pullman. He will speak on the subject of chemical defoliation of deciduous woody plants. Dr. Larson:

FIVE YEARS' RESULTS WITH PRE-STORAGE CHEMICAL DEFOLIATION OF DECIDUOUS NURSERY STOCK[1]

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The use of chemicals to defoliate nursery stock dates back to at least 1940, when Milbrath, *et al.*, (7), advocated the use of ethylene gas for defoliating roses in storage, a method that apparently works well but which has disadvantages.

The need for early defoliation in the nursery to allow earlier digging of stock has undoubtedly existed for years in many areas. Hand-stripping is a common, but very expensive method of leaf removal. Other non-chemical methods (sweating in pits, use of animals, etc.) have been used but all have serious limitations.

Chemically-induced defoliation prior to digging and storage is potentially the most promising method of leaf removal, but an entirely satisfactory chemical treatment for a wide variety of plants has not been found. A number of chemicals have been tried (3,4 6,8,9,10,11) by various workers, but only a few have been useful and none has received commercial acceptance. A naturally occurring growth regulator, such as Abscisin II (1), seems potentially to be the ultimate answer, but present information indicates that it, too, lacks the features of an effective nursery stock defoliant (2) in spite of considerable speculative publicity to the contrary.

An effective defoliant for deciduous woody nursery stock should cause 50% or more leaf fall in 2-3 weeks and any remaining leaves should be loose enough to drop during digging and handling prior to storage. Little or no bud or bark damage can be tolerated, and the plant must grow normally following transplanting.

During the past five years, with the cooperation of several members of the Washington State Nursery Association, a number of chemicals and chemical combinations have been tested for nursery stock defoliation in central Washington. Various commercial defoliants (developed primarily for field crops) and miscellaneous chemicals were tried. The results of these tests are reported here.

MATERIALS AND METHODS

Sprays were applied at commercial nurseries in central Washington using a portable power sprayer operating at approximately 150 psi. Sprays were applied to runoff, using rates based on the manufacturer's suggestions when available. At weekly intervals following treatment, until the plants were dug and stored by the nurseryman, the percentage defoliation was visually determined. Following winter storage, the plants

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were replanted for observation in commercial plantings or at Pullman in test plots. In all years, except 1966, single plots of 5 plants or more were treated for each cultivar. During 1966, duplicate plots of 3 or more plants were used.

In 1962, treatments were started September 28 and repeated 3 times at weekly intervals on previously untreated plants. In 1963, treatments were applied on October 17 and 24. In 1964, applications were made on October 15 and 22 at low concentrations on the same plants and compared with single higher doses. In the years following 1964, only one application per plot was made, but treatments were applied twice, a week apart, on previously untreated plots. In 1965, sprays were applied on October 8 and 15, and in 1966 on October 13 and 20.

Throughout the text, concentrations are expressed in percentages of the formulation or chemical as received and not active ingredients or absolute amounts. Percentages are calculated on volume for liquids and weight for dry materials.

RESULTS AND DISCUSSION

1962:

During 1962, 10 chemicals were used on 13 cultivars. The results from only two chemicals and the last two treatment dates are given in Table 1. These chemicals were DEF (S, S, S-tributyl phosphorotrithioate) and Folex (tributylphosphorotrithioite), both commercial defoliants and very similar in composition. Other chemicals used, which were unsatisfactory at the rates used and under the conditions of this trial, are listed in Table 2. The two earliest spraying dates (September 28 and October 5) resulted in excessive damage with all chemicals.

One Washington nursery used DEF at about 1% on a moderate scale with success for one or two years prior to 1962. Two nurseries used this material extensively in 1962 and both reported some unfavorable results. As noted in Table 1, a 1% concentration may be too high under some conditions with some plants.

Some chemicals listed in Table 2 might be satisfactory if used at lower rates, but with the exception of Glytac EC plus oil, all caused extensive damage.

1963:

In 1963, 7 chemicals were used on 10 cultivars. Those that produced the best results are listed in Table 3. UC 20299 was the poorest of these chemicals. Damage with most chemicals was minor compared to the previous year. Potassium iodide (KI) and aminotriazole were generally unsatisfactory because of excessive damage, and Cadox was generally ineffective at the rates used (Table 2). In spite of the injury with KI, a favorable response encouraged further work.

Table 1. Percent defoliation induced by chemicals applied in the nursery to several deciduous woody plants (1962).[1]

Plant	Treatment date (Oct)	Chemical and concentration DEF[2] 0.75%	DEF[2] 1.00%	DEF[2] 1.25%	Folex[2] 0.75%	Folex[2] 1.00%	Folex[2] 1.25%
'Edwards'	12	100 (4)[3]	100 (4)	100 (4)	100 (4)	100 (4)	100 (4)
plum	19	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)
'Early Italian'	12	—	—	—	—	—	—
prune	19	95 (3)	95 (3)	95 (3)	100 (3)	100 (3)	100 (3)
'Perfection'	12	100 (3)	100 (3)[4]	100 (2)[4]	100 (2)	100 (2)[4]	100 (2)[4]
apricot	19	100 (2)	100 (2)[4]	100 (2)[4]	100 (2)	100 (2)[4]	100 (2)[4]
'Bartlett'	12	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)[4]
pear	19	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)	100 (3)[4]
'Anjou'	12	—	—	—	—	—	—
pear	19	100 (3)	100 (3)[4]	100 (3)[4]	100 (3)	100 (3)[4]	100 (3)[4]
'Winesap'	12	100 (4)	100 (4)[4]	100 (3)[4]	100 (4)	100 (4)[4]	100 (3)
apple	19	100 (3)	100 (3)[4]	100 (3)[4]	100 (3)	100 (3)[4]	100 (3)[4]
'Rome Beauty'	12	—	—	—	—	—	—
apple	19	80 (3)	80 (3)	80 (3)[4]	50 (3)	50 (3)	50 (3)[4]
'Anthony Waterer'	12	—	—	—	—	—	—
spiraea	19	20 (3)	20 (3)	20 (3)	20 (3)	30 (3)[4]	40 (3)[4]
Weigela rosea	12	—	—	—	—	—	—
	19	20 (3)	30 (3)	30 (3)	20 (3)	30 (3)	30 (3)
French crab	12	—	—	—	—	—	—
sldg	19	60 (3)	60 (3)	60 (3)	80 (3)	80 (3)	80 (3)
French pear	12	—	—	—	—	—	—
sldg.	19	50 (3)	60 (3)	75 (3)	75 (3)	75 (3)	75 (3)
Pyrus calleryana	12	—	—	—	—	—	—
sldg.	19	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)	0 (3)
Prunus mahaleb	12	—	—	—	—	—	—
sldg.	19	75 (3)	75 (3)	75 (3)	70 (3)	80 (3)	100 (2)

[1]Defoliation of controls was nil on November 9, four weeks following the first application except for 'Perfection' apricot which had lost 20% of its leaves
[2]Concentration calculated on the percentage of formulation used, not active ingredient (6#/gal.) Dupont spreader-sticker used in addition at 1 pt/100 gal spray material
[3]Numbers in parentheses are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[4]Concentration excessive under conditions of this trial, usually judged because of poor growth after replanting rather than damage prior to storage

Table 2. Miscellaneous chemicals used in defoliation trials but considered generally unsatisfactory at the indicated rates and under the conditions of these trials on deciduous woody nursery stock

CHEMICAL	CONCENTRATION[1]		
1962			
Endothal (3,6 endohexahydrothalate)	1.0%	1.5%	2.0%
TD 273 Harvest Aide	1.0	1.5	2.0
Endothal-TD 288 Harvest Aide	1.0	1.5	2.0
Ansar 138 (cacodylic acid)	0.12	0.24	0.36
Diquat (1:1 ethylene-2:2 dipyridylium dichloride)	1.125	0.25	0.50
Paraquat (1:1-dimethyl-4,4' dipryidylium dichloride)	0.125	0.25	0.50
Glytac EC (plus 10% Volck supreme oil)	0.125	0.25	0.375
Hydrogen cyanamid	0.60	1.20	1.80
1963			
Cadox (cadmium oxyquinolate)	0.12	0.24	0.36
Aminotriazole (3-amino-1,2,4-triazole)	0.12	0.24	0.36
Potassium iodide (KI)	0.60	1.20	1.80

[1]Concentration calculated on the percentage of the formulation used, not active ingredient

Table 3. Percent defoliation induced by chemicals applied in the nursery on two dates (October 17 and 24) to several deciduous wood plants. (1963)

Plant		'Red King' apple		'Bartlett pear		'Stewart Bartlett pear		'Daroga Red' peach		'Laroda' plum	
Treat Date (Oct)		17	24	17	24	17	24	17	24	17	24
Chemical	*Conc. (%)* [1]										
DEF	0.75	0 (4) [2]	0 (3) [3]	0 (4)	5 (3)	50 (4)	30 (3)	100 (3)	———	90 (4)	20 (3)
	1.00	0 (4) [2]	0 (3)	0 (4)	5 (3)	50 (4) [2]	50 (3) [2]	100 (3) [2]	———	90 (4) [2]	20 (3) [2]
	1.50	0 (4) [2]	0 (3)	0 (4)	5 (3)	50 (4) [2]	75 (3) [2]	100 (3) [2]	———	90 (4) [2]	20 (3) [2]
Nacconol	1.00	0 (4)	0 (3)	10 (4) [2]	40 (3)	90 (4) [2]	100 (3)	50 (3)	75 (2)	10 (4)	20 (3)
NR[4] (plus	2 00	0 (4) [2]	0 (3) [2]	10 (4) [2]	40 (3)	90 (4) [2]	100 (3) [2]	50 (3)	95 (2)	10 (4)	20 (3)
3% Volck	3.00	0 (4) [2]	0 (3) [2]	10 (4) [2]	40 (3) [2]	80 (4) [2]	100 (3) [2]	75 (3)	95 (2)	10 (4)	20 (3)
Supreme oil)											
Hydrogen	0.12	0 (4)	0 (3)	5 (4) [2]	20 (3)	50 (4) [2]	100 (3) [2]	70 (3)	90 (2)	20 (4)	10 (3)
cyanamid	0.48	0 (4)	0 (3)	5 (4) [2]	20 (3)	50 (4) [2]	80 (3) [2]	70 (3)	75 (2)	20 (4)	25 (3)
	0.72	0 (4)	0 (3)	5 (4) [2]	20 (3) [2]	75 (4) [2]	100 (3) [2]	80 (3)	95 (2)	20 (4)	40 (3)
UC 20299	0.12	75 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	25 (4)	25 (3)	80 (3)	95 (2)	10 (4)	20 (3)
	0.36	10 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	5 (4) [2]	25 (3) [2]	90 (3)	60 (2)	10 (4)	20 (3)
	0.60	30 (4) [2]	0 (3)	0 (4) [2]	20 (3) [2]	5 (4) [2]	50 (3) [2]	90 (3)	60 (2)	10 (4)	20 (3)
NONE	———	0 (4)		5 (4)		50 (4)		35 (3)		10 (4)	

[1]Concentration calculated on a formulation basis, not active ingredient X-77 also used at 1 pint/100 gal
[2]Concentration excessive under conditions of this trial, usually judged because of poor growth following replanting rather than damage prior to storage
[3]Figures in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[4]An alkylarylsulfonate.

Table 3 (continued)

Plant		French crab sldg		Bartlett pear		P mahaleb sldg		Eva Rathke weigela		Spiraea billiardii	
DEF	0 75	20 (4)	10 (3)	90 (4)	85 (3)	60 (5)	60 (4)	95 (5) [2]	40 (4) [2]	40 (5)	30 (4)
	1 00	20 (4) [2]	25 (3)	100 (4) [2]	95 (3)	70 (5)	50 (4)	95 (5) [2]	90 (4) [2]	40 (5)	30 (4)
	1 50	50 (4) [2]	50 (3)	100 (4) [2]	95 (3)	40 (5)	40 (4)	95 (5) [2]	90 (4) [2]	40 (5) [2]	30 (4) [2]
Nacconol NR[4] (plus 3% Volck Supreme oil)	1 00	0 (4) [2]	0 (3)	60 (4) [2]	25 (3)	100 (5)	90 (4)	50 (5) [2]	15 (3)	90 (5)	95 (4)
	2 00	0 (4) [2]	0 (3)	70 (4) [2]	25 (3)	100 (5) [2]	50 (4)	50 (5) [2]	15 (3)	60 (5)	95 (4)
	3 00	0 (4) [2]	0 (3) [2]	70 (4) [2]	80 (3)	90 (4) [2]	90 (4)	50 (5) [2]	15 (3)	90 (5) [2]	100 (3) [2]
Hydrogen cyanamid	0 12	0 (4)	0 (3)	40 (4)	25 (3)	90 (4)	80 (4)	50 (5)	30 (4)	30 (5)	20 (4)
	0 48	0 (4)	10 (3)	40 (4)	25 (3)	75 (5)	80 (4)	50 (5)	30 (4)	60 (5)	20 (4)
	0 72	0 (4)	25 (3)	95 (4)	90 (3)	95 (5)	95 (4)	50 (5) [2]	30 (4)	90 (5)	60 (4)
UC 20299	0 12	20 (4)	0 (3)	50 (4)	75 (3)	30 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	100 (5)	100 (4)
	0 36	20 (4)	0 (3)	50 (4) [2]	60 (3)	50 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	25 (5)	50 (4)
	0 60	20 (4)	0 (3)	100 (4) [2]	40 (3)	40 (5) [2]	20 (4)	20 (5) [2]	10 (4) [2]	25 (5)	50 (4)
NONE	——	0 (4)		25 (4)		10 (5)		5 (5)		0 (5)	

1964:

In 1964, 7 chemicals—or combinations of chemicals—were applied on October 15 and 22 on 11 cultivars, and single and double applications (on the same plants) were compared (Table 4). Damage was almost nil, occurring only on weigela, 'Rome' apple, and *P. mahaleb* seedlings. The damage to 'Rome' apple was not apparent until after storage and replanting. The most satisfactory chemical treatments were KI in combination with Nacconol NR (an alkylarylsulfonate) or with DEF. These combinations frequently resulted in faster defoliation than when these chemicals were used separately. Repeat applications of low and medium rates were usually more satisfactory than single low, medium, or high rates. The time required for complete defoliation (where achieved) under undisturbed conditions varied from 1 to 6 weeks. The figures with 'Yellospur', 'Hi-Early', 'Rome' apples and 'Italian' prune are low because of early digging (2 and 3 weeks after treatment). An additional week in the field at the stage they were dug would usually increase defoliation considerably.

1965:

In 1965, 15 chemicals or chemical combinations were used on 14 cultivars applied on October 8 and 15. Damage was more severe than the previous year, especially with the earlier application date. However, both dates were earlier than in 1964; this undoubtedly accounts for a good portion of the damage. The 5 years' data presented here indicate that plants become more resistant to damage and easier to defoliate as dormancy approaches, and that more damage occurs from treatments made prior to October 15, even though growth and conditions varied considerably from year to year.

The most satisfactory materials were KI, KI + alanine, Bromodine (a bromine-iodine complex) and DEF. Other materials were not as effective and/or caused more damage. *Pyrus calleryana*, French crab, and 'Bartlett' pear seedlings were not completely defoliated without damage by any treatment. Some cultivars were more subject to damage than others, especially 'Bartlett' pear. The time required for complete defoliation with undisturbed conditions varied from 2 to 5 weeks, depending on the plant.

Table 4. Percent defoliation induced by chemicals as a result of single and double[1] spray applications (October 15 and 22) applied in the nursery to several deciduous woody plants. (1964).

Plant		'Yellospur' apple		'Hi-Early apple		'Rome apple		'Italian prune		'Bartlett' pear		'Montmorency' cherry	
Treat Date (Oct)		15	22	15	22	15	22	15	22	15	22	15	22
Chemical	Conc. (%)												
KI	0 15	5 (3)[2]	15 (2)	40 (3)	40 (2)	5 (3)	5 (2)	80 (3)	95 (2)	100 (4)	100 (5)	100 (5)	100 (4)
	0.3	25 (3)	42 (2)	40 (3)	40 (2)	5 (3)	5 (2)	95 (3)	100 (2)	100 (5)	100 (3)	100 (3)	100 (2)
	0.6	20 (3)	30 (2)	30 (3)	0 (2)	10 (3)	0 (2)	95 (3)	65 (2)	100 (4)	100 (4)	100 (3)	100 (3)
KI +	0.15	40 (3)	65 (2)	85 (3)	90 (2)	0 (3)	0 (2)[3]	85 (3)	95 (2)	100 (4)	100 (3)	100 (3)	100 (1)
DEF (0.25%)	0 3	25 (3)	50 (2)	95 (3)	100 (2)	0 (3)	0 (2)[3]	95 (3)	100 (2)	100 (4)	100 (3)	100 (3)	100 (2)
	0 6	65 (3)	95 (2)	40 (3)	0 (2)	0 (3)	0 (2)[3]	100 (3)	60 (3)	100 (3)	100 (3)	100 (3)	100 (2)
KI +	0 15	25 (3)	100 (2)	15 (3)	90 (2)	0 (3)	0 (2)[3]	95 (3)	100 (2)	100 (5)	100 (4)	100 (5)	100 (4)
NAC NR	0 3	30 (3)	100 (2)	35 (3)	50 (2)	0 (3)	0 (2)[3]	100 (3)	100 (2)	100 (4)	100 (3)	100 (4)	100 (2)
(0 5%)	0 6	0 (3)	25 (2)	20 (3)	0 (2)	0 (3)	0 (2)	100 (3)	65 (2)	100 (4)	100 (4)	100 (3)	100 (2)
KI +	0 15	15 (3)	10 (2)	70 (3)	80 (2)	5 (3)	5 (2)	20 (3)	50 (2)	100 (4)	100 (3)	100 (3)	100 (1)
W Sulfur	0 3	0 (3)	25 (2)	80 (2)	85 (2)	5 (3)	5 (2)	90 (3)	90 (2)	100 (5)	100 (3)	100 (5)	100 (3)
(0.5%)	0.6	0 (3)	30 (2)	40 (3)	0 (2)	5 (3)	0 (2)	100 (3)	15 (2)	100 (4)	100 (4)	100 (3)	100 (2)
DEF	0.25	10 (3)	10 (2)	10 (3)	10 (2)	5 (3)	5 (2)	15 (3)	70 (2)	100 (5)	100 (4)	100 (6)	100 (3)
	0.50	15 (3)	25 (2)	10 (3)	10 (2)	5 (3)	5 (2)	70 (3)	80 (2)	100 (6)	100 (4)	100 (4)	100 (3)
	1.00	0 (3)	0 (2)	10 (3)	10 (2)	5 (3)	0 (2)	90 (3)	50 (2)	100 (6)	100 (4)	100 (5)	100 (4)
NAC NR	0 50	5 (3)	30 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	80 (2)	100 (6)	100 (5)	100 (5)	100 (4)
	1 00	40 (3)	40 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	90 (2)	100 (5)	100 (4)	100 (5)	100 (4)
	2.00	40 (3)	0 (2)	10 (3)	10 (2)	0 (3)	0 (2)	85 (3)	15 (2)	100 (5)	100 (4)	100 (5)	100 (4)
Defolate	0 22	25 (3)	25 (2)	40 (3)	40 (2)	0 (3)	0 (2)	25 (3)	70 (2)	100 (5)	100 (3)	100 (4)	100 (3)
	0 24	25 (3)	50 (2)	40 (3)	40 (2)	0 (3)	0 (2)	30 (3)	60 (2)	95 (5)	100 (4)	100 (4)	100 (3)
	0 48	45 (3)	0 (2)	30 (3)	0 (2)	0 (3)	0 (2)	70 (3)	20 (2)	100 (5)	100 (4)	100 (3)	100 (3)
NONE	———	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)	15 (3)	15 (2)	100 (6)	100 (5)	100 (6)	100 (5)

[1]The figures for October 15 were all a result of single applications while the low and medium figures for October 22 were a result of treatment of the same plants on both dates with the same concentration

[2]Numbers in parenthesis are the weeks required for the indicated percentage defoliation preceeding the parenthesis Plants usually dug by that time

[3]Four to six inches damage on some branch tips, obvious only after replanting and commencement of growth

[4]Terminals damaged at storage time

Table 4 (continued)

		'Ev[1] Rathke weigela		Spiraea billiardii		P mahaleb sldg		'Bartlett pear sldg		French crab sldg	
		15	22	15	22	15	22	15	22	15	22
KI	0 15	10 (6)	70 (5)	60 (6)	100 (4)	100 (5)	100 (2)	90 (5)	100 (4)	5 (5)	5 (4)
	0 3	60 (6)	85 (5) [4]	95 (4)	100 (2)	90 (5)	100 (4)	20 (5)	40 (4)	5 (5)	10 (4)
	0 6	15 (6)	90 (5)	70 (6)	60 (5)	100 (5)	100 (5)	60 (5)	40 (4)	20 (5)	50 (4)
KI + DEF (0 25%)	0 15	40 (6)	50 (5) [4]	100 (6)	100 (2)	20 (6)	95 (5)	70 (5)	———	10 (5)	———
	0 3	35 (6)	80 (5) [4]	100 (6)	100 (3)	25 (6)	100 (4)	60 (5)	———	50 (5)	———
	0 6	20 (6)	70 (5)	80 (6)	95 (5)	100 (5)	100 (4)	100 (5)	———	85 (5)	———
KI + NAC NR (0 5%)	0.15	15 (6) [4]	90 (5)	80 (6)	100 (5)	100 (5)	100 (4)	80 (5)	90 (4)	5 (5)	10 (4)
	0 3	70 (6) [4]	70 (5) [4]	90 (6)	100 (4)	100 (5)	100 (4)	80 (5)	70 (4)	20 (5)	30 (4)
	0 6	30 (6)	75 (5) [4]	95 (6)	95 (5)	100 (5) [4]	100 (4)	80 (5)	35 (4)	40 (5)	30 (4)
KI + W Sulfur (0 5%)	0 15	5 (6)	60 (5)	50 (6)	100 (5)	25 (6)	25 (4)	25 (5)	20 (4)	30 (5)	40 (4)
	0 3	15 (6)	90 (5)	100 (5)	100 (4)	80 (6)	100 (5)	20 (5)	50 (4)	20 (5)	60 (4)
	0 6	10 (6)	80 (5)	70 (6)	75 (5)	100 (5)	100 (5)	40 (5)	65 (4)	40 (5)	25 (4)
DEF	0 25	5 (6)	25 (5)	50 (6)	50 (5)	100 (6)	100 (5)	15 (5)	15 (4)	0 (5)	5 (4)
	0 50	25 (6)	65 (5)	40 (6)	90 (5)	30 (6)	25 (5)	20 (5)	30 (4)	15 (5)	5 (4)
	1 00	5 (6)	30 (5)	40 (6)	40 (5)	20 (6)	25 (5)	50 (5)	20 (4)	20 (5)	5 (4)
NAC NR	0 50	25 (5)	5 (4)	70 (6)	90 (5)	45 (6)	80 (5)	10 (5)	15 (4)	5 (5)	5 (4)
	1 00	25 (6)	10 (5)	70 (6)	100 (5)	20 (6)	30 (5)	20 (5)	20 (4)	10 (5)	10 (4)
	2 00	30 (6)	5 (4)	70 (6)	60 (5)	90 (6)	40 (5)	20 (5)	20 (4)	10 (5)	5 (4)
Defolate	0 12	5 (6)	5 (5)	30 (6)	95 (5)	25 (6)	20 (5)	40 (5)	15 (4)	15 (5)	20 (4)
	0 24	15 (6)	10 (5)	60 (6)	90 (5)	10 (6)	10 (5)	15 (5)	60 (4)	50 (5)	35 (4)
	0 48	10 (6)	5 (5)	30 (6)	25 (5)	75 (6)	10 (5)	85 (5)	60 (4)	75 (5)	35 (4)
NONE	———	5 (6)	5 (5)	20 (6)	20 (5)	30 (6)	30 (5)	5 (5)	5 (4)	5 (5)	5 (4)

Table 5. Percent defoliation induced by chemicals applied in the nursery to several deciduous woody plants (1965).

Chemical	Conc (%)	Barkley Red Rome' apple		'Red Rome' apple		'Jonathan' apple		Idared' apple		'Winesap' apple	
Plant											
Treat date (Oct)		8	15	8	15	8	15	8	15	8	15
Potassium	0.2	90 (4)[2]	0 (3)	—	50 (3)	100 (4)	50 (3)	10 (5)	15 (4)	100 (4)	100 (3)
iodide (KI)	0.3	95 (4)[4]	35 (3)	—	40 (3)	100 (4)[4]	90 (3)	100 (5)[4]	80 (4)	100 (4)	100 (3)[4]
KI (0.3%)	1.5	———	35 (3)	—	60 (3)	———	100 (3)	100 (5)	80 (4)	———	100 (3)
+ b-alanine	2.0	———	60 (3)	—	60 (3)	———	100 (3)	80 (5)[4]	90 (4)	———	100 (3)[4]
KI (0.3%) +	0.5	100 (3)[4]	5 (3)	—	60 (3)	100 (4)[4]	70 (3)	90 (5)	20 (4)[4]	100 (3)	100 (3)
hexamethyl-	1.0	100 (4)[4]	5 (3)[4]	—	70 (3)	30 (4)[4]	85 (3)	10 (5)	50 (4)[4]	100 (4)[4]	100 (3)
entetramine											
(HMTA)											
KI (0.3%) +	1.0	35 (4)	5 (3)	—	20 (3)	75 (4)	50 (3)	40 (5)	20 (4)	100 (4)	100 (3)
Formaldehyde	1.5	25 (4)	5 (3)	—	35 (3)	70 (4)	40 (3)[4]	50 (5)[4]	60 (4)	100 (4)	100 (3)
b-alanine	2.0	———	5 (3)	—	60 (3)	———	30 (3)	10 (5)	15 (4)	———	80 (3)
HMTA	1.0	0 (4)[4]	5 (3)	—	10 (3)	30 (4)[4]	5 (3)[4]	5 (5)[4]	10 (4)	5 (4)[4]	70 (3)[4]
Formaldehyde	1.5	10 (4)	5 (3)	—	35 (3)	30 (4)[4]	40 (3)	50 (5)	50 (4)	20 (4)[4]	60 (3)[4]
Bromodine	2.0	80 (4)	55 (3)	—	80 (3)	50 (4)	95 (3)	65 (5)[4]	70 (4)	85 (4)	90 (3)
	3.0	100 (4)	85 (3)	—	60 (3)	100 (4)	100 (3)	100 (5)[4]	100 (4)	100 (4)[4]	95 (3)[4]
DEF	0.75	100 (4)[4]	100 (3)	—	100 (3)	100 (4)	100 (3)	100 (4)	35 (4)	100 (4)[4]	100 (3)
	1.0	100 (4)[4]	100 (3)	—	100 (3)	100 (3)	100 (3)[4]	100 (5)[4]	85 (4)[4]	100 (3)	100 (3)
Shedaleaf	0.36	65 (4)	70 (3)	—	95 (3)	100 (4)[4]	100 (3)[4]	50 (5)	60 (4)	80 (4)[4]	100 (3)
	0.48	90 (4)[4]	85 (3)[4]	—	100 (3)	100 (4)[4]	100 (3)[4]	50 (5)[4]	75 (4)[4]	90 (4)[4]	100 (3)
Defolate	0.24	60 (4)	45 (3)	—	75 (3)	70 (4)[4]	80 (3)	20 (5)	20 (4)	70 (4)	95 (3)
	0.36	75 (4)	45 (3)	—	100 (3)	100 (4)	85 (3)	35 (5)	60 (4)	90 (4)	100 (3)
Union 76-1	5.0	5 (4)	35 (3)	—	100 (3)	10 (4)	70 (3)	35 (5)	55 (4)	5 (4)[4]	50 (3)
	10.0	40 (4)	60 (3)	—	85 (3)	100 (4)	95 (3)	10 (5)[4]	85 (4)[4,3]	10 (4)	75 (3)[4]
Union 76-2	5.0	25 (4)[4]	50 (3)	—	75 (3)	50 (4)	90 (3)	5 (5)[4]	20 (4)	25 (4)	50 (3)
	10.0	40 (4)[4]	50 (3)	—	90 (3)	90 (4)	90 (3)	25 (5)[4]	70 (4)[3]	25 (4)	70 (3)
Union 76-3	5.0	70 (4)[4]	50 (3)	—	65 (3)	90 (4)	80 (3)	60 (5)	60 (4)	5 (4)	55 (3)
	10.0	85 (4)[4]	85 (3)	—	85 (3)	95 (4)[4]	95 (3)	60 (5)[4]	90 (4)[3]	65 (4)	90 (3)
Chipman	0.75	———	70 (3)	—	85 (3)	———	60 (3)[4]	15 (5)	55 (4)	———	100 (3)
2929	1.50	———	90 (3)	—	65 (3)	———	100 (3)[4]	35 (5)[4]	85 (4)	———	100 (3)
NONE	———	0 (4)		0 (3)		5 (4)		0 (5)		5 (4)	

[1]Concentration calculated on the percentage of formulation X-77 used in addition at 1 pint/100 gal
[2]Numbers in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time
[3]Some terminals damaged at storage time
[4]Growth not comparable to control after replanting

Table 5. (Continued)

Chemical	Conc. (%)	'Sunglo' apricot		'Italian' prune		'Montmorency' cherry		'Bartlett' pear		'Bartlett' pear sldg	
Plant Treat date (Oct.)		8	15	8	15	8	15	8	15	8	15
Potassium	0.2	85 (5)	75 (4)	100 (3)[4]	100 (3)	—	100 (3)	100 (5)[4]	95 (4)	10 (5)	15 (4)
iodide (KI)	0.3	85 (5)	75 (4)	100 (3)[4]	100 (3)	—	100 (3)	100 (5)[4]	100 (4)	35 (5)	25 (4)
KI (0.3%)	1.5	85 (5)	95 (4)	—	100 (3)	—	100 (3)	100 (3)	100 (3)	—	30 (4)
+ b-alanine	2.0	85 (5)	100 (4)	—	100 (3)	—	100 (3)	100 (3)[4]	100 (3)	—	40 (4)
KI (0.3%) +	0.5	50 (5)	70 (4)	100 (3)	100 (4)	—	100 (3)	100 (5)[4]	95 (4)[4]	70 (5)[4]	30 (4)
HMTA	1.0	50 (5)[4]	55 (4)	80 (5)	100 (4)	—	100 (3)	40 (5)	95 (4)[4]	75 (5)	40 (4)
KI (0.3%) +	1.0	80 (5)[34]	85 (4)[4]	100 (5)[4]	100 (4)	—	100 (3)	100 (5)[4]	100 (4)	65 (5)	15 (4)
Formaldehyde	1.5	25 (5)[34]	90 (4)[4]	100 (5)[4]	80 (4)[4]	—	100 (3)	100 (5)[4]	100 (4)[4]	100 (4)[4]	50 (4)[4]
b-alanine	2.0	65 (5)	90 (4)	100 (4)	90 (4)	—	60 (3)	100 (5)	60 (4)	—	5 (4)
HMTA	1.0	100 (5)[4]	60 (4)	80 (5)	95 (4)	—	50 (3)	20 (5)[4]	40 (4)	5 (5)	5 (4)[4]
Formaldehyde	1.5	70 (5)[4]	80 (4)[4]	80 (5)	90 (4)[4]	—	30 (3)	100 (5)[4]	90 (4)[4]	80 (4)[4]	50 (4)[4]
Bromodine	2.0	70 (5)	100 (4)	100 (3)	100 (4)	—	100 (3)	100 (3)	100 (3)	50 (5)	40 (4)
	3.0	60 (5)[4]	100 (4)	100 (3)	100 (3)	—	100 (3)	100 (3)[4]	100 (3)[4]	70 (5)[4]	95 (4)
DEF	0.75	95 (5)	90 (4)	70 (5)	100 (4)	—	100 (3)	100 (5)[4]	100 (4)	25 (5)	35 (4)
	1.0	95 (5)	90 (4)	70 (5)	100 (4)	—	100 (3)	100 (5)[4]	100 (4)[4]	50 (5)	65 (4)
Shedaleaf	0.36	95 (5)	70 (4)	70 (5)	100 (4)	—	95 (3)	70 (5)[4]	80 (3)[4]	80 (5)	15 (4)
	0.48	95 (5)	80 (4)	70 (5)	100 (4)	—	100 (3)	60 (5)[4]	90 (4)[4]	90 (5)	80 (4)
Defolate	0.24	95 (5)	80 (4)	70 (5)	100 (4)	—	90 (3)	70 (5)[4]	80 (4)[4]	10 (5)	70 (4)
	0.36	95 (5)	85 (4)	70 (5)	100 (4)	—	100 (3)	75 (5)[4]	100 (4)[4]	50 (5)	90 (4)
Union 76-1	5.0	25 (5)[34]	60 (4)	100 (5)	100 (4)	—	10 (3)	30 (5)[4]	90 (4)[4]	0 (5)[4]	15 (4)
	10.0	50 (5)[34]	70 (4)	100 (5)	70 (4)	—	15 (3)	30 (5)[4]	90 (4)[4]	20 (5)[4]	50 (4)[4]
Union 76-2	5.0	40 (5)	65 (4)	100 (5)	70 (4)	—	15 (3)	25 (5)[4]	70 (4)[4]	20 (5)[4]	20 (4)[4]
	10.0	45 (5)	70 (4)	100 (5)	70 (4)	—	15 (3)	25 (5)[4]	75 (4)	25 (5)[4]	40 (4)
Union 76-3	5.0	90 (5)	90 (4)	95 (5)	80 (4)	—	5 (3)	30 (5)[4]	65 (4)	70 (5)	30 (4)
	10.0	90 (5)[4]	95 (4)	100 (5)	95 (4)	—	5 (3)	90 (5)	80 (4)	90 (5)	50 (4)
Chipman 2929	0.75	95 (5)[34]	100 (4)	100 (5)	100 (4)	—	75 (3)	95 (5)[4]	90 (4)[4]	10 (5)	5 (4)
	1.50	95 (5)[34]	100 (4)	90 (5)[4]	100 (4)	—	50 (3)	100 (5)[4]	90 (4)	10 (5)	10 (4)
NONE	—	60 (5)		20 (3)		5 (3)		35 (5)		0 (5)	

Table 5. (Continued)

Plant		P mahaleb sldg		French crab sldg		P calleryana sldg		Spiraea billiardii	
Treat date (Oct)		8	15	8	15	8	15	8	15
Chemical	Conc. (%)								
Potassium	0 2	—	95 (3)	5 (5)	5 (4)	20 (5)	20 (4)	—	90 (3)
iodide (KI)	0 3	—	100 (3)	5 (5)	10 (4)	30 (5)	10 (4)	—	90 (3)
KI (0 3%)	1 5	—	100 (3)	—	5 (4)	—	20 (4)	—	100 (2)
+ b-alanine	2 0	—	100 (3)	—	20 (3)	—	20 (3)	—	100 (2)
KI (0 3%) +	0 5	—	90 (3)	10 (5) [4]	0 (4)	10 (5)	30 (4)	—	95 (3)
HMTA	1.0	—	90 (3)	5 (5) [4]	5 (4)	20 (5)	10 (4)	—	100 (3)
KI (0.3%) +	1.0	—	40 (3)	5 (5) [4]	5 (4)	15 (5)	10 (4)	—	35 (3)
formaldehyde	1 5	—	50 (3) [4]	5 (5)	5 (4) [4]	20 (5)	20 (4)	—	15 (3)
b-alanine	2 0	—	5 (3)	—	0 (4)	—	15 (4)	—	100 (2)
HMTA	1 0	—	20 (3)	0 (5)	0 (4)	0 (5)	5 (4)	—	10 (3)
Formaldehyde	1.5	—	35 (3)	0 (5)	5 (4)	25 (5)	25 (4)	—	10 (3)
Bromodine	2.0	—	85 (3)	5 (5)	0 (4)	20 (5)	15 (4)	—	45 (3)
	3 0	—	50 (3)	25 (5) [4]	60 (4)	20 (5)	65 (4)	—	70 (3)
DEF	0 75	—	35 (3)	30 (5) [4]	5 (4)	15 (5)	25 (4)	—	60 (3)
	1 0	—	55 (3)	50 (5)	30 (4)	25 (5)	30 (4)	—	70 (3)
Shedaleaf	0 36	—	75 (3)	0 (5)	25 (4)	10 (5)	5 (4)	—	25 (3)
	0 48	—	85 (3)	40 (5)	20 (4) [4]	10 (5)	5 (4)	—	40 (3)
Defolate	0 24	—	75 (3)	5 (5) [4]	5 (4)	5 (5)	10 (4)	—	30 (3)
	0.36	—	70 (3)	5 (5)	5 (4)	5 (5)	15 (4)	—	40 (3)
Union 76-1	5 0	—	5 (3)	0 (5)	0 (4)	10 (5)	20 (4)	—	25 (3)
	10 0	—	50 (3)	0 (5)	0 (4)	30 (5)	35 (4)	—	20 (3)
Union 76-2	5 0	—	5 (3)	0 (5)	0 (4)	20 (5)	10 (4)	—	20 (3)
	10.0	—	30 (3)	0 (5)	0 (4)	15 (5)	20 (4)	—	20 (3)
Union 76-3	5 0	—	25 (3)	0 (5)	0 (4)	15 (5)	30 (4)	—	35 (3)
	10 0	—	70 (3)	0 (5)	0 (4)	25 (5)	45 (4)	—	50 (3)
Chipman 2929	0 75	—	55 (3)	0 (5)	0 (4)	20 (5)	35 (4)	—	35 (3)
	1.50	—	20 (3)	0 (5)	25 (4)	40 (5)	25 (4)	—	30 (3)
NONE	—	10 (3)		0 (5)		0 (5)		(5 (3)	

1966:

In 1966, 7 chemicals, or chemical combinations, were used on 12 cultivars. Bromodine, KI, and KI plus Bromodine were the most satisfactory. The addition of alanine to KI did not help as much as the previous year.

Almost no injury was apparent at storage time, but many plots failed to grow properly after replanting, notably those of 'Chinook' cherry and 'Bartlett' pear. It is of interest to note that plants which were replanted in commercial plantings ('Red Winesap', 'Golden Delicious', and 'Hi-Early' Delicious apples), rather than in test plots, grew normally. This would indicate that handling, planting, and subsequent care may have been more conducive to good growth under commercial conditions and that defoliated plants may be more subject to adverse conditions than non-defoliated plants. This had been suspected in previous years, but had not been nearly as apparent. However, the evidence is far from conclusive, since comparable plants were not observed under both conditions. Plants in the test plots were not headed back as in commercial plantings and less growth stimulation would be expected. Moisture may have been less adequate in test plots because of somewhat shallower plantings. Another factor contributing to the difference observed may have been the physical condition of the stock at the time of treatment, although these plants had set terminal buds when treated. It is not known whether hand-stripped plants would respond in a similar way or if the chemicals were entirely responsible. It is possible that hand-stripped plants might respond similarily if defoliated too early.

Pyrus calleryana, French crab, and Bartlett pear seedlings showed little response to the defoliants by the time they were dug. An additional week would have helped considerably except with *P. calleryana*, which did not respond satisfactorily to any treatment during the course of the experiments.

Interesting data was collected, although not presented here, to show that it would not be necessary to wait for complete defoliation in the field prior to digging. It was noted that plots showing as little as 10% defoliation at digging time could be 100% defoliated after digging, bundling, loading, and transporting to the storage. Thus, it would only be necessary to wait for partial defoliation, if the remainder of leaves was loose, prior to digging.

Table 6 Percent defoliation[1] induced by chemicals applied (October 13 and 20) in the nursery to several deciduous wood plants (1966)

Plant		'Bartlett' pear		Italian prune		'Chinook' cherry		'Red Rome' apple		'Red Winesap' apple		'Golden Delicious' apple	
		13	20	13	20	13	20	13	20	13	20	13	20
Chemical	Conc (%)[2]												
Potassium iodide (KI)	0 1	100 (5)[3]	100 (4)	100 (5)[5]	100 (3)	100 (5)[5]	100 (3)[5]	0 (5)	0 (4)	50 (4)	10 (3)	10 (4)	0 (3)
	0 15	100 (5)	100 (4)	100 (5)[5]	100 (3)	100 (4)[5]	100 (3)[5]	0 (5)[5]	0 (4)	50 (4)	10 (3)	10 (4)	0 (3)
	0 20	100 (5)[5]	100 (4)[5]	100 (4)[5]	100 (3)	100 (4)[5]	100 (3)[5]	30 (5)	0 (4)[5]	60 (4)	10 (3)	10 (4)	0 (3)
	0 30	100 (4)[5]	100 (4)[5]	100 (4)[5]	100 (3)[4]	100 (3)[5]	100 (3)[5]	70 (5)	0 (4)	60 (4)	10 (3)	10 (4)	0 (3)
KI (0 2%) + b-alanine	1 5	100 (5)[5]	100 (4)[5]	100 (4)[5]	100 (3)	100 (4)[5]	100 (3)[5]	35 (5)	0 (4)	60 (4)	10 (3)	10 (4)	0 (3)
	2 0	100 (4)	100 (4)	100 (4)	100 (3)	100 (3)[5]	100 (3)[5]	35 (5)	0 (4)	60 (4)	10 (3)	25 (4)	0 (3)
KI (0 3%) + b-alanine	1 5	100 (4)	100 (3)	100 (4)[5]	100 (3)	100 (3)[5]	100 (3)[5]	30 (5)[5]	0 (4)	65 (4)	10 (3)	20 (4)	0 (3)
	2 0	100 (4)[5]	100 (3)[5]	100 (4)[5]	100 (3)	100 (3)[5]	100 (3)[5]	30 (5)[5]	30 (4)	75 (4)	10 (3)	20 (4)	0 (3)
b-alanine	1 5	90 (5)	85 (4)	90 (5)	90 (4)	75 (5)[5]	35 (4)[5]	5 (5)	5 (4)	25 (4)	10 (3)	5 (4)	0 (3)
	2 0	100 (5)	85 (4)	90 (5)	90 (4)	75 (5)[5]	35 (4)[5]	5 (5)	5 (4)	25 (4)	10 (3)	5 (4)	0 (3)
Shedaleaf	0 36	100 (5)	100 (4)[5]	100 (5)	95 (4)	100 (4)[5]	100 (3)[5]	75 (4)	60 (4)	80 (4)	30 (3)	85 (4)	20 (3)
	0 48	100 (5)[5]	100 (4)[5]	100 (5)[5]	100 (4)	100 (3)[5]	100 (3)[5]	80 (4)	60 (4)	75 (4)	25 (3)	85 (4)	25 (3)
Bromodine	1 0	100 (4)[5]	100 (4)[5]	100 (5)[5]	100 (3)	100 (4)[5]	100 (3)[5]	40 (5)	0 (4)	95 (4)	15 (3)	55 (4)	0 (3)
	2 0	100 (4)	100 (3)[5]	100 (4)[5]	100 (3)	100 (4)[5]	100 (3)[5]	80 (5)	70 (4)	100 (4)	40 (3)	90 (4)	0 (3)
	3 0	100 (3)[5]	100 (3)[5]	100 (4)[5]	100 (3)	100 (4)[5]	100 (3)[5]	100 (4)[5]	90 (4)[5]	100 (4)	40 (3)	100 (4)	0 (3)
Bromodine (1%) + KI	0 1	100 (3)[5]	100 (3)[5]	100 (4)[5]	100 (3)	100 (4)[5]	100 (3)	70 (5)	0 (4)	95 (4)	5 (3)	40 (4)	0 (3)
	0 15	100 (3)	100 (3)[5]	100 (4)	100 (3)[5]	100 (4)[5]	100 (3)[5]	70 (5)	0 (4)	95 (4)	10 (3)	50 (4)	0 (3)
	0 20	100 (3)[5]	100 (3)[5]	100 (4)	100 (3)	100 (3)[5]	100 (3)[5]	95 (5)	70 (4)[5]	95 (4)	40 (3)	75 (4)	0 (3)
NONE	———	5 (5)		95 (5)		50 (5)		5 (5)		0 (4)		0 (4)	

[1]Figures based on duplicate plots of 3 or more plants each
[2]Concentration calculated on the percentage of formulation used, not active ingredient X-77 used in addition at 1 pint/100 gal
[3]Numbers in parenthesis are the weeks required for the indicated percentage defoliation Plants usually dug by that time.
[4]Terminals damaged at storage time.
[5]Growth after planting not comparable to control

Table 6. (continued)

Plant		'Hi-Early' apple		Japanese greenleaf barberry		P. mahaleb sldg		French crab sldg		'Bartlett' pear sldg		P. calleryana sldg	
Potassium iodide (KI)	0.1	30 (4)	15 (3)	80 (5)	50 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0.15	40 (4)	15 (3)	80 (5)	50 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0.20	60 (4)	40 (3)	90 (5)	70 (4) [5]	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0.30	65 (4)	50 (3)	95 (4)	80 (4) [5]	100 (4)	100 (3)	0 (3)	0 (2)	15 (3)	0 (2)	0 (3)	0 (2)
KI (0.2%) + b-alanine	1.5	50 (4)	30 (3)	95 (5)	80 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
	2.0	80 (4)	20 (3)	100 (5)	80 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
KI (0.3%) + b-alanine	1.5	80 (4)	15 (3)	100 (4)	100 (4)	100 (5)	100 (4)	0 (3)	0 (2) [5]	0 (3)	0 (2)	0 (3)	20 (2)
	2.0	85 (4)	20 (3)	100 (3)	100 (4)	100 (5) [5]	100 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	20 (2)
b-alanine	1.5	15 (4)	10 (3)	65 (5)	65 (4)	35 (5) [5]	55 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2) [5]	0 (3)	0 (2)
	2.0	40 (4)	10 (3)	35 (5)	65 (4)	35 (5)	55 (4) [5]	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2) [5]
Shedaleaf	0.36	95 (4)	10 (3)	50 (5)	50 (4) [4]	100 (5) [5]	100 (4)	0 (3)	30 (2)	50 (3)	15 (2)	0 (3)	0 (2)
	0.48	100 (4)	10 (3)	50 (5) [5]	50 (4) [45]	100 (5) [5]	80 (4) [4]	0 (3)	30 (2)	50 (3)	35 (2) [5]	0 (3)	0 (2)
Bromodine	1.0	90 (4)	10 (3)	100 (4) [5]	100 (4) [5]	85 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	2.0	90 (4)	10 (3)	85 (5) [5]	85 (4) [5]	100 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	3.0	95 (4)	15 (3)	50 (5) [5]	80 (4) [45]	75 (5) [5]	100 (4) [4]	50 (3)	0 (2)	65 (3)	0 (2)	45 (3)	0 (2)
Bromodine (1%) + KI	0.1	100 (4)	10 (3)	100 (3)	100 (4)	100 (5)	100 (4)	0 (3)	0 (2)	0 (3)	0 (2)	0 (3)	0 (2)
	0.15	100 (4)	10 (3)	100 (3) [5]	100 (4)	100 (5) [5]	100 (4)	0 (3)	0 (2)	0 (3) [5]	0 (2)	0 (3) [5]	0 (2)
	0.20	100 (4)	10 (3)	100 (3) [5]	100 (4)	100 (5) [5]	100 (4) [5]	25 (3)	0 (2)	0 (3)	0 (2)	0 (3) [5]	0 (2)
NONE	——	0 (4)		50 (5)		5 (5)		0 (3)		0 (3)		0 (3)	

SUMMARY AND CONCLUSIONS

Of the 30 chemicals or chemical combinations used during the 5-year period of this study, DEF (0.25 - 0.75%), Bromodine (1.0 - 2.0%), KI (0.1 - 0.2%), Nacconol NR (0.5 - 1.0%), and KI (0.1%) in combination with Bromodine (1.0%), alanine (1.5 - 2.0%), Nacconol NR (0.5%) or DEF (0.25%) were most successful. These chemicals were all used on a number of plants during at least two years of the study.

The 33 cultivars used varied considerably in their response to defoliants. No satisfactory treatment was found for weigela or for *P. calleryana* seedlings. 'Rome' apples were very difficult to defoliate without injury, probably because they tend to grow late in the season. Apple and pear seedlings (other than *P. calleryana*) varied considerably in ease of defoliation. In general, all plants became more resistant to damage and easier to defoliate as dormancy approached, because growth ceases, tissues harden, and the natural abscission processes begin. Evidence was obtained to show that it would not generally be necessary to wait for complete defoliation prior to digging, but only for adequate loosening of leaves. Subsequent digging and handling prior to storage caused the loss of remaining leaves.

It was evident that two defoliant applications approximately a week apart at low rates would often cause faster defoliation with less injury than a single application of a higher rate. Satisfactory results might be obtained by using a very low rate applied approximately 4 to 5 weeks prior to digging followed by a second application one to two weeks later.

Many factors appeared to influence the response to defoliants, i.e. plant vigor, stage of plant growth, nutrients, moisture, temperature, growing season, location, and individual plant characteristics. It is, therefore, doubtful that a given chemical can be found, except one which is naturally occurring, which will be satisfactory for a large number of plants. If such a chemical can be found, the proper rates will probably vary and the response will be influenced by the above factors. The chemicals mentioned above as being most satisfactory can undoubtedly be safely used on a number of plants, but they cannot be used without regard to the influencing factors just mentioned. Not only is this important, but inadequate care following transplanting may cause undue loss of defoliated plants.

More trials must be made. Undoubtedly, additional promising chemicals will be found. Programs currently underway which are searching for fruit looseners may yield chemicals of value for stimulating leaf abscission (5). More needs to be known of the plant characteristics which influence the penetration and response to defoliants in order to make it possible to defoliate difficult types. Other approaches to defoliation, such as the use of electrical current or a combination of defoliants and growth regulators might have promise.

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FRIDAY AFTERNOON SESSION

September 8, 1967

VICE-PRESIDENT TICKNOR: Our second session this afternoon is on the subject of "Rhododendron Propagation". We have a most capable moderator whom you all know — Bill Curtis, of Wil-Chris Acres, Sherwood, Oregon. Bill, will you get the program underway again.

MODERATOR CURTIS: Our first speaker is Mrs. Jean Whalley. When the rest of us fail to get something really tough rooted, we go to Mrs. Whalley and she roots it for us and does a real good job. It is my pleasure to introduce Mrs. Whalley to those of you who have not met her before. Mrs. Whalley:

ROOTING RHODODENDRONS IN PLASTIC BANDS

JEAN WHALLEY
J. B. Whalley Nursery
Troutdale, Oregon

We have always used electric bottom heat; many years ago we used lead cables — then the so-called "Roberson" cables — next General Electric, and we have now, for the past several years, used the type of electric cables which builders put in floors or walls of houses (which are about half the price of our former cables). By the way, I learned about using the building cables at one of our Propagators' meetings. We keep our bottom heat set at about 72° or 73° F and have automatic thermostats to control the temperature. We have laid ½" mesh hardware cloth over the cables as a protection and to keep them from getting out of place, although they are pegged down with wire loops at the ends of the beds. The cables are about 2" to 2½" apart in the beds.

Our first operation is to lay down the bands, which are made of 2¾" plastic. The beds where we root our rhododendrons are all ground beds, so we lay down the bands in straight rows, anywhere from 17 to 28 bands across- depending on the width of the beds, which average between 4 and 6 feet. We have sponge rubber kneeling pads, which may be laid across the top of the bands in order to reach across the beds.

After the bands are laid down we fumigate the entire house, including the bands, which we often are able to use for several seasons. We fumigate with formaldehyde (1 part formaldehyde to 15 parts water) applied with a Syphonex on a hose. We leave the house closed for 24 hours or more, then air it well for several days, or until there is no odor.

At this time we fill the bands with heaped up piles of peatmoss, which has been thoroughly watered, then smooth it over with a board until the rooting medium is even with the tops of the bands. After this we punch it down with a wooden punch which just fits into each band. We then put on more peatmoss, level it off and this time do not tamp it down but just water it well. This makes the moss compact enough to hold the cuttings in place. The peatmoss we prefer is called "Greenhouse Grind" and is medium coarse. We use straight peatmoss, with nothing else mixed with it. We have rooted rhododendrons with Hormodin #3 plus the same quantity of Captan mixed with it (also Jiffy Grow, usually 1 to 10 in strength). We have also used Hormodin #3 with half Captan and 1% indolebutyric acid added; we find this and the Jiffy Grow solution to give about the same results.

After the cuttings are made up and dipped in the hormone we stick them in the bands in the same manner in which we filled the bands, i.e. kneel on the paths or bands where necessary.

We use intermittent mist over the beds, from Flora Mist brass nozzles, 4 feet apart, on ½" plastic pipe. There is one line over the narrow beds and two over the wider beds. We have Intermatic clocks, which we have set to mist from 30 to 45 seconds every half hour. They may be adjusted to mist every 15 minutes if we wish. Each bed has a clock and there is a master clock, if we wish to use it.

After the rhododendrons are well-rooted, but before the roots have grown down into the cables, we take them up and put them in flats, 30 to a flat, leaving them in the beds but with the heat turned down to about 50° F — just high enough to help prevent frost if it should turn very cold. We try to keep the plants cool for six weeks or so, then hope the weather will turn warm, otherwise we may have to turn on our boilers to force out the top growth. During this time we fertilize about every 2 weeks with a water soluble fertilizer, 25-10-10 at half strength, or 1 lb. to a gallon of water through the Syphonex. As new growth develops we try to keep the shoots pinched to induce branching.

We are very unorthodox in that we find that cuttings made in October under our conditions give the best results, although we do stick them as early as July if our customers request it. We do quite a bit of "custom propagating" of rhododendrons as well as rooting our own cuttings.

The advantages of rooting directly in the bands are:

Saving on labor costs — less handling.

Roots are not disturbed, as in transplanting.

The disadvantages are:

More space taken up to start with, thus more electricity used.

If cuttings do not root well, space is wasted.

Last year we rooted between 100,000 and 110,000 cuttings and our overall rooting percentage was 75 to 80%. We had several varieties which did not root well last year— (both our own cuttings and the same varieties from others) which reduced our percentage, but many lots rooted about 100%. This year we are not rooting the difficult varieties in bands but will transplant them after they are rooted.

MODERATOR CURTIS: The next rhododendron grower-propagator on the program is Mr. Ranville Hart. Mr. Hart lives in Mt. Vernon, Washington. Mr. Hart.

THE PROPAGATION OF RHODODENDRONS

RANVILLE HART
Mount Vernon, Washington

I propagate my rhododendrons in a 100 by 25 ft. glasshouse which is equipped with hot water heat. The pipes are located in the air beneath the benches. The temperature is kept at 75°F in the pot zone by thermostatic control. There is no top heat. One 42″ two-speed fan provides forced air ventilation.

The benches are made of concrete slabs with a six inch sides. They are skirted with polyethylene. Monarch spray nozzles with a 5-ft. coverage set four feet apart adequately provide controlled mist. They are controlled by a clock with a 10 second every 5 minute cycle but are shut off nights and rainy days. Every few days I "spot water" to cover the dry areas.

I use square peat pots set on ½″ of sand — 3″ for standard varieties and 2¼″ for dwarfs — firmly filled with a medium of 50% coarse sand and 50% peat by volume. These pots are well-watered after they are set and the heat is turned on before I begin taking cuttings.

I make my cuttings during the first part of November. I have tried taking cuttings earlier but have had best success with the early November ones. The cuttings are three inches long and have a heavy double wound. I quick-dip them in Jiffy Grow — one part per ten parts water — as I stick them in the bench. This is done as quickly as possible to prevent loss of moisture. I water them in immediately.

The cuttings are well-rooted by the first of May and are ready to be set out. I don't move them until I transplant them into the lathhouse. I had 95% rooting this past year using fifty varieties.

For greenhouse sanitation I have had success by leaving the benches open in summer and using Captan dust to control fungi if any appears during the winter.

I grow the plants in the lathhouse one year, then at least two years in the field, before sale. The year-old liners are planted in beds in sandy loam soil, sprayed with Casoron immediately, then mulched with two inches of alder sawdust.

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MODERATOR CURTIS: In the Portland area there are a great many rhododendrons grown and the next man to speak, I would say, came by his work honestly. His father was one of the early experts in growing rhododendrons from cuttings. In fact, I think he was one of the first men to root rhododendron cuttings. So Ted had real good early training, and he is following in his father's footsteps and is doing the same good job his father did. It is a great pleasure to introduce Ted Van Veen.

SELECTING RHODODENDRON CUTTINGS

TED VAN VEEN
Van Veen Nursery
Portland, Oregon

Today the nurseryman is greatly aware of the economic importance of increasing his production and reducing his costs in order to maintain a reasonable profit margin. As a commercial grower, our nursery is ever mindful of this premise as a necessity for survival. Proper selection of cuttings can be a decisive profit maker. I come with no profound message, no new scientific discoveries, or great panacea to all rhododendron problems. The selection of cuttings still is more of an art than a science. But scientific research has been, and will continue to be, a tremendous guide for all of us. Through this discussion, I hope to share with you the methods we use in our nursery for taking cuttings. Whether you agree or disagree with these procedures is not important. Of more significance, it is an opportunity for you to add to your storehouse of information, correlate these experiences with your own, and possibly enable you to reach some new conclusions which will help the profit picture of your own operation.

Consideration must be given to the objectives of the propagator. As a large producer of rhododendrons exclusively, our aims could be quite different from someone else's. Our situation becomes complex because we carry a wide selection of varieties for varying purposes. However, in general, our goal for the major commercial varieties is to produce quality rooted cuttings quickly — cuttings which will result in healthy, multi-branched plants in the spring. And of great importance is a substantial, well-attached root ball — so necessary for the eventual survival of the plant.

Well established stock plants are essential for quality rhododendron production. Optimum rooting in the shortest time cannot be attained by field stripping production plants because of different treatments. The high nitrogen content in field plants, being pushed along for best possible growth and bud set, is not conducive to fast and high rooting percentages. And, of course, in spite of the fact that they root more easily, juvenile cuttings from small plants cannot be successfully used because they will not result in top quality stock.

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Many of the stock plants in our nursery are 25 to 30 years old. Incidentally, they do not seem to have lost any of their vigor or their ability to produce a good percentage of quality plants. This mother stock is in full sun with a permanent overhead water system. In order to attain faster, better growth, all stock plant flower buds are removed just as they begin to swell prior to blooming. As a preventive maintenance measure the entire nursery is sprayed for root weevil once each year. The stock plants are carefully watched for any sign of infestation by aphids which could reduce the strength of newly-breaking shoots.

Toward the end of June the first cuttings are taken. Depending upon the weather conditions of the season, and based on rooting history records, the selection of varieties for cutting continues on through July and possible into the early part of August. A smaller second crop, so to speak, is started about the middle of September.

Since our primary goal is to produce a salable plant as quickly as possible, the larger caliber cutting wood is selected. Much of this wood will have flower buds in early formation, but this is of no concern. Flowering shoots normally have a number of axillary vegetative buds which will break into well-branched plants with the first flush of growth in the spring. This procedure is tempered somewhat for the few difficult-to-root varieties. However, these normally are not our large volume, commercial items.

Short cuttings are avoided because they result in inconsistent quality in the finished plants. The stem should be long enough so that the foliage of the prepared cutting does not touch the rooting medium. Longer stems also allow for better aeration and consequent reduction of potential rot. Cuttings with second growth in early development should not be taken. If this growth is retained in the cutting bench, quite often it will rot. Cuttings that do survive, produce only stunted and weak growth — a poor base for a quality plant. If this second growth is removed it will frequently encourage further undesirable shoots in the cutting bench. Burned and scarred foliage is another inducement for rot.

I would like to add a brief note about preparation of cuttings because it ties in with the type of cuttings we select. Stems are left a little longer than normal for rhododendron propagation because we prefer to retain a few more leaves. For greater rooting potential, the top foliage is trimmed very lightly, but a little more extensive shearing is done on the lower leaves. All flower buds are removed at the time the cutting is prepared in order to reduce potential rot and to prevent competition later with the new root system.

Our percentage of rooting is usually 85% to 90%. This percentage would be much better if we would propagate only easy-to-root varieties, tried no experiments, and did not discard all cuttings not rooted by the end of March. While this percentage is not particularly good, we feel that the over-all quality of the finished plants is of much more importance, that the first year field survival will be better, and customer satisfaction will be greater. It would not be difficult to improve our rooting ratio by using inferior cuttings. However, we prefer the higher profit record to the higher rooting record.

MODERATOR CURTIS: Our next speaker is from Marion, Oregon, which is right close to Salem. He is doing an exceptionally fine job with azaleas and rhododendrons. Most of his material, I think, is sold by mail order. He has a number of new varieties. Here is Mr. Robert Comerford, who will speak to us on Exbury azaleas.

EXBURY AZALEA PROPAGATION

ROBERT COMERFORD
Comerfords
Marion, Oregon

I joined this organization to learn but after six years as a member here I am up front, and 10 minutes is a long time with nothing new to say. I shall have to take a review approach. But, the more I worked on this topic the more I felt it was needed.

I now have a specialized mail-order business selling rhododendrons and azaleas directly to the home owner at retail. Rhododendrons root well in the fall and winter and Exbury azaleas root well in spring and summer, so I can keep my benches full the year around. I have no sure-fire rooting method that has worked well three years in a row.

I have tried almost every new idea in deciduous azalea propagation through the years. I try to grow about 80 different deciduous azaleas, of which some 60 are named Exbury azaleas. A few are rather easy to propagate but, as usual, most of the best yellows, reds, and some pinks are "bearcats" to propagate.

Using a glass-house, I have tried everything from a plastic tent, plastic tent plus mist, mist only, outside mist, heating cables, no cables, coarse sand, fine sand, fine sand and peat, fine sand and peat plus Sponge Rok, sand and Sponge Rok, etc. Then Hormodin #1 and #2, Cutstart ½X-X-XX-XXX, Jiffy Grow #2, and none at all. I have used liquid fertilizer injections into the mist lines. I have tried lights during rooting. I have waited stubbornly for nine months to see if the cuttings would root in spite of me.

I have yet to root the deciduous azaleas in a commercially acceptable percentage by any method three years in a row. In other words I dare not stick my head out in the wholesale arena. I consider no one method the best as yet. I have tried the winter forcing — then rooting — technique mentioned percentage is not particularly good, we feel that the over-all quality of the finished plants is of much more importance, that the first year field survival will be better, and customer satisfaction will be greater. It would not be difficult to improve our rooting ratio by using inferior cuttings. However, we prefer the higher profit record to the higher rooting record.

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With summer propagation a "Fail-Safe" mist system is needed. This summer my main fuse box went out for about ½ hour and I got tip burn on everything. However, I seem to have about 50% rooting so far this year. A competitor friend says his percentage is quite high this year. He uses rows of modified Nearing frames. He also took his cuttings very late in June. Our season was extremely abnormal this spring — very late. Last year I took cuttings April 7th but this year I took them May 10th and later.

Withholding fertilizers from stock plants seems to help but I can't see maintaining a large planting of half-starved stock plants as a sound commercial venture. If I had to do this I feel I should go back to layering. In the current issue of The Plant Propagator, Vol. 12, No. 4, the article on "Root Propagation of Native Azaleas", by Fred Galle makes one get excited. Of course one has to lift the plants, etc. but 100% rooting is quoted, with 70% as sure-fire. I am sure this is possible but the exact way to do it on a large scale must still be worked out.

I feel one of the main problem of propagation is the broad geographic origin of the plants used for today's azalea hybrids. Here is a brief history. About 1730, two American azalea species were introduced into England — the swamp honeysuckle — *Rhododendron viscosum,* and the pinxterbloom — *R. nudiflorum* followed in 1800 by the flame azaleas — *R. calendulaceum* and the oconee — *R. speciosum.* This quartet of American species was then combined with the East Europe plant of the Pontic apalas — *R. luteum* (syn, *R. flavum*). This group formed the Ghent azaleas introduced in 1825. Apparently, about this same time, similar species were used by others, but thought to be included are the Chinese form of *R. molle* and our native sweet *R. arborescens.* About 1850, Waterer of Knaphill Nursery, England, began breeding, using forms of the Chinese *R. molle* and *R. calendulaceum* with the Ghent Hybrids and later with the North American, *R. arborescens* and our West Coast native *R. occidentale.* We now have a total of eight species, plus hybrids, in the development of the Knaphills and a race of azaleas with untold possibilities genetically — and the need of an IBM computer to determine the parentage. This is where Lionel de Rothschild started. His estate was called Exbury, hence the name given to his group of azalea hybrids. His breeding program lasted about 40 years. He could afford and did get the better forms, made hundreds of crosses, and raised thousands of seedlings. So, at this point, we now have Azaleas with much larger flowers (some in trusses or clusters), hardiness, fragrance and an extended blooming season. It is very dynamic group but extremely difficult to propagate. Everytime I get over-confident and think I have the answer, I all flat n my face.

In conclusion, here is what I think works best for me:

1. Take cuttings as early in the year as possible — April if you can — and so soft they are almost limp. Take them very early in the morning and quit by 10 A.M. Water the stock plants the day before.
2. Dip the cuttings in Jiffy Grow #2, diluted 20 to 1. Do not wound but water in well.
3. For a rooting medium use ⅔ coarse sand and ⅓ Sponge Rok, medium grade.
4. Use a plastic tent about 3 ft. above the bench, primarily as a "Fail-Safe" system in case the mist goes off.
5. Mist lines: Use your own judgement as to mist interval. The leaves are coarse and hairy and with this type of leaf there is likely to be more leaching through the leaves.
6. I put heating cables down but don't use them until the nights become cool.
7. At about 10 weeks I give a foliar spray of Jiffy Grow #2 at 25:1 dilution.
8. If the cuttings are very slow to root, inject liquid fertilizer into the mist lines for a day. I use Liquinox 10-10-5 because of it's detergent type action for wetting the coarse leaves.
9. When you think you can't wait any longer, transplant the cuttings to a cool house for the winter then move the plants out to full sun the following spring.

I now stick 10,000 cuttings a year and have had 70% rooting as my best effort. I believe that someday these will be rooted by the hundreds of thousands. It has been said that the rhododendron is the King of shrubs. The Exbury azaleas then are the aristocracy.

MODERATOR CURTIS: The next topic on the program concerns factors influencing rooting of rhododendron cuttings. Mr. Johnson, our next speaker, has a B. S. degree from Colorado State University. In 1964 he spent a year in Copenhagen, Denmark, and then returned to Oregon State University in 1965. Mr. Johnson.

LEAF AND APICAL BUD REMOVAL AS A MEANS OF STUDYING THE INFLUENCE OF FLOWERING ON ROOTING IN RHODODENDRON

C. R. JOHNSON AND A. N. ROBERTS
Department of Horticulture
Oregon State University, Corvallis, Oregon

Both internal and external factors are important in adventitious root formation. We are interested in the endogenous physiological factors, particularly the influence of flower initiation on rooting. Although flowers are viewed mortremely difficult to propagate. Everytime I get over-confident and think I have the answer, I all flat n my face.

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Both internal and external factors are important in adventitious root formation. We are interested in the endogenous physiological factors, particularly the influence of flower initiation on rooting. Although flowers are viewed morphologically as shoots with metamorphosized leaves, their structure and function are quite different from leaves (11). The stimulus responsible for flower induction is unknown. Flowering, as well as rooting, is probably brought about by a constellation of chemical reactions.

It is generally considered that shoots with terminal leaf buds root better than those with flower buds (4). Kemp (5) suggested that flower buds inhibited rooting in the *Rhododendron* shoot. De Boer increased the rooting of flowering rhododendron shoots by removing flower buds (2), as did O'Rourke with *Vaccinium* (7). Turezkaya, as reviewed by Selim (9), found that rooting in cuttings of *Perilla* and *Soja* decreased with flower initiation, and disappeared completely during anthesis. She concluded that the flowers and fruits mobilized plant auxins leaving none for root initiation. Recent evidence (6) supports this conclusion, showing an acropetal transport of IAA after flower initiation. Adams (1) noted that flower initiation in *Rhododendron* 'Roseum Elegans' began when the shoot and largest leaf were half expanded. He found the enlarged leaves resulting from flower initiation did not have the rooting-potential of smaller leaves from non-flowering shoots.

We are using growth analysis, following leaf and flower bud removal, to study the flowering-rooting phenomenon. Roberts (8) by mechanical leaf removal on plum, and Fulford (3) using defoliating sprays on apple found complete defoliation prior to flower initiation caused terminal buds to produce new vegetative growth. The buds produced flowers when shoots were defoliated after initiation, serving to index time of flower initiation in relation to shoot development. The rhododendron bud has been found incapable of vegetative reversion after 90 - 100 mm of shoot extension. Certain leaves on the shoot are more important in flower initiation than others. Early removal of these should hinder flowering and thereby enhance rooting. This technique could also be helpful in studying the importance of leaf position in rooting. For example, leaf removal in a certain position could enhance the rooting in another.

Flower bud removal is a direct means of studying the flowering-rooting relationship. This method of study has proved satisfactory in research on cultivar 'Pink Pearl' this past year. Lateral buds in the second or third leaf axils subtending the terminal flower bud were removed and dissected at different stages of shoot elongation. Previous studies have shown that shoots arising from this position usually terminate in flower buds. Their flowering nature was substantiated by the heavy flowering of remaining shoots. The mature flower bud usually contained 18 bud scales and about 16 flowers. Expanding shoots were found to produce 18 scales when 36 mm long, so it seemed reasonable to expect that apical bud removal before this time would eliminate the flowering stimulus. Apical buds were removed from such expanding shoots at 6 stages of elongation:

Stage	Shoot Length
1	20 - 28 mm
2	29 - 34 mm
3	35 - 45 mm
4	46 - 55 mm
5	56 - 65 mm
6	66 - 115 mm

Leaf-petiole cuttings were taken the last of August for evaluating the rooting capacity of the shoots. The rooting response was determined on the basis of actual root-ball diameter and the rooting-potential was calculated as root-ball diameter per 10 cm^2 leaf area.

In general, larger leaves were found to be associated with flower initiation, but apical bud removal before flower initiation reduced leaf size. However, the terminal 3 - 4 leaves were nearly always equal in size regardless of bud removal treatment. Thomas (10) found that expanding leaves in *Chenopodium amaranticolor* were stimulated most during flower initiation. The middle leaves were expanding during flower initiation but the terminal leaves were not, thus leaf expansion in relation to flower initiation helps explain the differences in leaf size.

Larger leaves produced slightly greater root-ball diameters than smaller ones but the smaller leaves had greater rooting-potential. Apical bud removal before flower initiation increased rooting response. In most cases rooting was increased by apical bud removal at all stages of shoot elongation. This increase is attributed to the elimination of the competitive sink established by developing flower buds, which attract materials essential in rooting.

Summary. Flower initiation is known to decrease the rooting of *Rhododendron* cuttings. Leaf and flower bud removal were used for studying the flowering-rooting relationship. Leaf removal was useful in determining time of flower initiation and studying leaf position influence. Apical bud removal before, during, and after flower initiation was a more satisfactory means of studying the flowering-rooting relationship. Bud removal before initiation reduced leaf area and increased rooting-potential. Later removal did not affect leaf area but did slightly enhance rooting. It appears that bud removal at the right time eliminates a sink which competes for factors essential in rooting.

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VICE-PRESIDENT TICKNOR: For the last session of the 1967 meeting, Dr. Howard Brown, Head of the Ornamental Horticulture Department, California Polytechnic College at San Luis Obispo, will be our moderator. We will have a session now on varieties and teaching. Howard, will you get the program underway?

MODERATOR BROWN: Our first speaker for this panel has been in the field of plant propagation and plant growing for many years. In fact he was telling me last night he taught his first class in plant propagation 46 years ago. He taught at Rutgers and received his doctorate from Columbia University. He came to Washington and was engaged in cranberry farming before he went into the nursery business. He now operates Clarke Nursery at Long Beach, Washington, and is a specialist in rhododendron production. His topic today is naming and registering plants. It is my pleasure to present Dr. J. H. Clarke:

NAMING AND REGISTERING PLANTS

J. HAROLD CLARKE
Clarke Nursery
Long Beach, Washington

The naming of plants is not strictly a part of propagation but is closely allied with it. All plants we work with have names, or numbers, or identification tags of some kind.

Some of our members are plant breeders and perhaps they have the greatest responsibility in this matter of naming — responsibility to themselves and their own good name, and to the public at large.

Many of our members are engaged in research. Every good plantsman knows that different kinds of plants, and dif-

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VICE-PRESIDENT TICKNOR: For the last session of the 1967 meeting, Dr. Howard Brown, Head of the Ornamental Horticulture Department, California Polytechnic College at San Luis Obispo, will be our moderator. We will have a session now on varieties and teaching. Howard, will you get the program underway?

MODERATOR BROWN: Our first speaker for this panel has been in the field of plant propagation and plant growing for many years. In fact he was telling me last night he taught his first class in plant propagation 46 years ago. He taught at Rutgers and received his doctorate from Columbia University. He came to Washington and was engaged in cranberry farming before he went into the nursery business. He now operates Clarke Nursery at Long Beach, Washington, and is a specialist in rhododendron production. His topic today is naming and registering plants. It is my pleasure to present Dr. J. H. Clarke:

NAMING AND REGISTERING PLANTS

J. HAROLD CLARKE
Clarke Nursery
Long Beach, Washington

The naming of plants is not strictly a part of propagation but is closely allied with it. All plants we work with have names, or numbers, or identification tags of some kind.

Some of our members are plant breeders and perhaps they have the greatest responsibility in this matter of naming — responsibility to themselves and their own good name, and to the public at large.

Many of our members are engaged in research. Every good plantsman knows that different kinds of plants, and different clones of the same kind of plant, differ greatly in their cultural requirements, their response to pest control methods, and their response to different methods of propagation.

Our retail nurserymen members know that different varieties have widely different values and so he, as well as other horticulturists, has a vested interest in clear, concise, easily remembered non-duplicated names. We all want to know what we are working with.

Botanical names. The botanists, since the time of Linnaeus, have had a systematic scheme of naming the various kinds of plants as they appear in the wild. For a number of years they have had a Code of Botanical Nomenclature, internationally recognized, and reasonably well followed. For some ornamentals, both woody and herbaceous, the botanical name suffices, although all too often it is obscured and confused by local common names which follow no code or system.

My own interest has been with woody plants and the strawberry, gladiolus, iris, and others which are usually propagated asexually. My remarks from here on will deal primarily with woody plants, and illustrations will be from the genus *Rhododendron* which includes azaleas. For several years I have served as Registrar of names for the American Rhododendron Society, and so have followed, with some interest, developments in the field of naming plants.

What's in a name? First and most important it is a method of identification, nearly always necessary, although at certain stages a number would do as well. However, names may also be descriptive; they may, by their aptness, add value to the variety, or they may serve as a memorial to some individual or place.

Clonal names long used. Names for certain clones of woody plants, notably fruit trees, were in use as far back as we have written records in those particular fields. The widespread use of clonal names seems to have developed with modern agriculture, getting a significant start some 100 to 200 years ago. As would be expected, such usage was somewhat disorganized; names were likely to be changed at will, used over again, or given to other clones already named. There was a tendency, with certain plant groups, to ape the botanists and show off their erudition by giving Latinized names to horticultural varieties.

During the last 100 years there has been a slow, voluntary, development of reason and restraint in the naming of plants. The use of vernacular (English in Canada and the U. S. A.) names, instead of Latin, became more universal as did the disapproval of renaming, the giving of names already in use, and the questionable practice of using names superlatively laudatory such as 'World's Best'.

Although the Botanical Code is strictly technical, and gives little attention to horticultural varieties, it did set people to thinking that something should be done with horticultural names. As a matter of fact, certain botanists and horticulturists had started making such proposals over 100 years ago. It was not until 1952 that a rather complete "International Code of Nomenclature for Horticultural Plants" was actually agreed upon, printed, and widely distributed. The Royal Horticultural Society of London printed the Code in a pamphlet which outlines its historical development in some detail. A later edition was published in 1961 and doubtless there will be further amendments and printings. It is not the purpose of this paper to give the details of the various sections of the Code, a copy of which may be obtained from the American Horticultural Society, Washington, D. C. The American Association of Nurserymen has published a useful leaflet, based primarily on the Code, entitled "How to Name a New Plant".

No specific legal requirements. In the U. S. A. there are no legal requirements directly governing the naming of a plant. The breeder may use any name he wishes, subject only to the laws governing libel and liability; renaming an existing variety might cause financial loss and redress might be sought in the courts.

Names may be protected by copywright. Plant patents are given to a plant entity, based on a description, and not to a name. The Code of Nomenclature does not change the legal aspects of naming plants. It usually does offer help in checking and evaluating names, and there is usually the reward of publication and the attendant publicity.

Who? Who should name a plant? This seems a simple question, and it usually is. However, in the rhododendron field we have had varieties resulting from a cross made by one man, seedling raised by another, bloomed by a third party, and the plant then sold to a fourth for introduction. Mutual agreement would be desirable, but anyone who owns an unnamed plant has a right to name it. When more than one person owns stock of a single unnamed clone there should be agreement, but if not, the first name published, with a description, in a reputable horticultural publication, is considered under the Code as being the valid name. Whether this would stand up in court in case of a suit for damages would, I presume, have to be decided by the court, on the basis of all the evidence.

When? When to name a plant is something to be considered. If the breeder is working solely for his own enjoyment and his varieties are not to be sold or distributed it doesn't make much difference if he gives a name to every seedling he raises. Most breeders probably have some hope of producing a variety worthy of being sold, or some friend who receives a plant as a gift may feel it is worthy of distribution. So *every* plant breeder really should be conservative, name only the best, and choose his names carefully.

I like to see selections numbered, or given some code designation, until trials over at least 3 or 4 blooming seasons indicate the plant is better than previously existing plants of the same general season and description. Many plants are named too soon, a good name is used up, and the variety may eventually prove not worthy of propagation. On the other hand some clones get into the trade while still under a number, and some purchaser may take it upon himself to give it a name, which may make the breeder very unhappy.

Breeders sometimes use "pet" names to identify their selections before they are introduced. Too often a plant may be given to some friend, and he lets a nurseryman have it under the pet name, which may very well be a poor one, even a duplicate of one being used for some other clone in the trade. Of the names which are sent to me for registration by plant breeders, presumably well thought out names, about one fourth have been used before for rhododendrons and hence are not valid names.

How? How to name a plant is probably the question I am supposed to answer. To comply with the Code the following are the main items of procedure: Select a name which you think is unused and a good one, make out a description of the plant and flower and send it to the official registering agency for the particular kind of plant. For rhodendrons the Registrar is Dr. Harold Fletcher of the Royal Botanic Gardens Edinburgh, Scotland. I serve as Registrar for the American Rhododendron Society and send all such names and descriptions to Dr. Fletcher for approval before publishing them in the A. R. S. Bulletin. If your name is turned down, try another. The name and description, to be valid, should be published and if it goes to Dr. Fletcher directly, or through me, and is accepted, it will be published.

Follow the Code, some of the most important points being:

Do not use a name previously used for a clone in the same genus, or one so similar as to be confusing.

Do not rename a variety already given another name. The first name published has priority.

The name must be in English (for the U. S. A. or Canada), not Latin.

The name should not be too long, two words is usually long enough. 'The Honorable Jean Marie de Montague' would not be accepted now.

Avoid the use of Mr., Mrs., Dr., A, or The as part of the name.

Avoid names of countries, of states, and preferably of prominent political figures.

Do not use names of living people without their consent.

Avoid names which exaggerate.

Avoid initials if possible.

Variety names are not affected by source, as hybrid, or selected clone of a species, bud sport or chimera.

Imported varieties. Imported varieties should be handled under their original names if they are suitable. If not, they may be translated into English, or transliterated from a non-Roman to a Roman alphabet. In certain cases, with permission of the originator, a new "commercial" synoym may be registered and used.

Group varieties. Unfortunately, the practice started in England, some 40 or 50 years ago, of giving a group, or grex, name to all the offspring of certain crosses, at first crosses between species, and later to back-crosses, and even further. Subsequent crosses, between the same species, were supposed to be given the same grex name. Many of our well known rhododendrons, such as 'May Day', 'Elizabeth', and many others are groups, not clones. In some cases clones within the group have been named, as 'Loderi King George', 'Loderi Venus', and many others. The International Rhododendron Register, and publications of the American Rhododendron Society indicate, in so far as possible, which varieties are clones and which are groups. The practice of naming group varieties is now frowned upon both here and in the British Isles, but some breeders are still doing it.

Other items in the code. The International Code suggests that names of horticultural varieties be printed in Roman letters with the words capitalized, and included in single quotation marks, and that species names be printed in italics and not capitalized. We try to do that in the A. R. S. publications.

The Code suggests, instead of horticultural variety, the word "cultivar", which I do not like and seldom use. "Horticultural variety" is a good term, used long before the word cultivar was coined, and is still used almost exclusively in the fruit growing and vegetable growing industries.

The code also suggests the parents of a hybrid be given in alphabetical order, accompanied by the signs indicating male or female. This is very confusing and I do like it because breeders and geneticists for many years have written the female parent first and there was no good reason for changing it. Few typewriters have the symbols for male and female. In A. R. S. publications, the female parent is always written first.

The actual choosing of a name is a highly personal thing and the breeder may, and often does, let his imagination run wild. I would suggest that it be short, euphonius, distinctive, and one which will appeal to the public. It may be descriptive, as 'Snow Lady', 'Pink Pearl,' 'Blue Jay'. It may commemorate a location as 'Olympic Lady', 'Bulstrode Park', or a person as 'John Wister', 'Aunt Martha', or an event as 'Armistice Day'. Other names may be chosen for a variety of reasons, as 'Jock', 'Unique', or 'Little Gem'.

A good name may have a great deal to do with the commercial success of a variety. I have often heard it said that the name 'Pink Pearl' has been an important factor in the continued popularity of that variety.

Registration. At the time the Code was adopted, provision was made for setting up a system of registration. Over 20 institutions and organizations have been designated as Registration Authorities, some in the U.S.A., some in Great Britain, and some in continental Europe. Check-lists, including all known names have been published for most important groups of ornamental plants. Breeders should contact the Registrar for their particular plant interest and work with him.

MODERATOR BROWN: Thank you, Dr. Clarke. Our next speaker has been chairman of the Ornamental Horticulture Dept. at California Polytechnic College, Pomona, since 1946. He is going to speak on the topic of facilities for teaching plant propagation. It is my pleasure to present Oliver (Jolly) Batcheller:

FACILITIES NECESSARY FOR TEACHING PROPAGATION

O. A. BATCHELLER
Ornamental Horticulture Department
California State Polytechnic College
Pomona, California

I feel highly flattered that the program committee felt I was able to come up with a magic formula for "Facilities Necessary for Teaching Propagation" at the high school and junior college level.

It is pleasing to many of us to see this new interest in the horticultural field at this level. Not only is *horticulture* an ancient and honorable profession, but *home gardening* is the number one hobby in the United States. Nearly all individuals at one time or another will be concerned with the gardens around their homes.

Propagation is the heart of any horticultural program, but as the various phases of propagation involve nearly all of a horticultural unit, I am broadening my presentation to include the overall layout of an Ornamental Horticultural Unit. This will include the following: an enclosed area for the unit and for growing plants, the greenhouse and headhouse combination, the classroom and a shade or lathhouse area. I will limit my presentation to the facilities that should be planned for a new school ground, rather than attempt to suggest how an existing school ground should be made over. Unfortunately, I have not had the opportunity to visit any of the new horticultural programs here in the Northwest, and will have to base my remarks on the programs that I have observed in Southern California.

I would like to say at the outset that unless there is an intelligent, well-trained, enthusiastic teacher for the program, the name 'Pink Pearl' has been an important factor in the continued popularity of that variety.

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I would like to say at the outset that unless there is an intelligent, well-trained, enthusiastic teacher for the program, all the facilities in the world will not make the program a success.

The first and most important facility is to have an area of ground set aside particularly for horticulture. This should be good agricultural soil and should be well-drained with necessary walks and roads. It should be fenced off from the rest of the school area so that only authorized persons will be able to enter. Most schools that I am familiar with have this as a part of the school grounds itself, although in a few instances this has been a separate piece of ground some distance from the main school grounds. An acre of ground is normal, although I have seen some larger, and a few smaller. I will discuss the arrangement and use of this area later.

The second most important facility is the greenhouse and headhouse combination. Certainly here in the Northwest, with the long periods of inclement weather, these two structures must be considered as one unit. The greenhouse should be a minimum of 20 feet wide by 40 feet long. It should be equipped with wide doors, wide cement walks that are crowned and finished with a broom finish rather than smooth troweled. The unit should be equipped with automatic controls for both heat and ventilation, and if the summer months have extreme heat conditions, I would recommend "pad and fan" cooling. I would recommend that the heating system be of the hot water type. Hot air types may be satisfactory for very mild climates, but for prolonged cold periods they do not provide as satisfactory results. Some school units are heated by steam, but for a small greenhouse such as this, the high upkeep of the steam unit, plus the danger of live steam with students, make the use of steam questionable.

Cedar or redwood should be used in the construction, and although these woods are rot-resisting, it usually is desirable to treat them with preservative or paint before construction as well as after the greenhouse is completed. The widths of the benches should be such that the plants and materials can be easily reached, and the height of the benches should be about 29 inches. Great strides have been made in the manufacture of plastics as a substitute for glass, and I would recommend the use of the clear or translucent solid material. I would not recommend the use of the flexible polyethylene sheeting, as it is short-lived and has little resistance to wind.

A part of one bench should be equipped with an automatic mist propagation system. I would recommend that this be a timed interval control with a cycle of 12-15 minutes, the misting period should be a minimum of 15 seconds. The system should be connected to a day and night clock with adjustments for the hours of operation. The heads or nozzles should be spring loaded so that water is passed only with positive pressure. The system should have proper screens that may be easily cleaned, and the system should be of plastic pipe beyond the solenoid control. This will materially reduce stoppage of the nozzles and make for better operation. If heat cannot be trapped beneath the bench for proper temperature, an electric heating cable may be used with a sand bed covering.

Drainage is of great importance in the greenhouse, and if the soil is slow in taking up the excess water, additional drainage must be provided. It generally helps to have the area under the benches covered with coarse gravel.

Corrosion in the greenhouse is a big problem, and all fixtures must be of a material or grade that will withstand high humidity, temperature changes, and the presence of chemicals. Although there is nothing particularly difficult about the construction of a greenhouse, most institutions contract for their building. Care must be taken that the heating unit is adequate to maintain the proper temperatures despite the weather conditions. Even though night classes are not contemplated, I would suggest that proper lighting be provided for the greenhouse and that weather-proof outlets be provided at intervals in the structure. The use of the structure for adult education or for "Open House Displays" are a possibility for which you must provide.

Nearly as important as the greenhouse is the headhouse. This is the area in which most of the work will be done, and for this reason it should be conveniently arranged, well-lighted with windows and supplementary electrical lights, and be properly heated. I would suggest that the building be at least 20 feet by 60 feet, that it have a cement slab floor. It should either connect directly to the greenhouse or it should connect to the greenhouse by means of a glass-covered passageway. One door should be large enough so that truck deliveries of soils, materials and supplies can be handled. The benches should be metal covered, and one portion of the building must be partitioned off to provide for proper locked storage of tools, equipment and extra supplies. The space under the benches provides for adequate storage for some soil and soil additives and for pots and containers most frequently used. A few shallow cupboards over one bench will be found very handy for small items frequently used. There should be one large sink with easily cleaned traps, and there should be at least two hose connections for moistening soil and watering plants. A portable blackboard will be found most convenient. Safety regulations will normally require that gasoline-powered equipment be stored outside of the building.

The use of cold frames or hotbeds do provide additional propagation area and are not expensive to construct. If the school has a shop class in carpentry, these can make a very desirable project. Such frames will materially increase the propagation area and for certain materials they will be most satisfactory. They also allows overflow space for students with special projects.

If at all possible, I would suggest that a separate classroom be constructed within the Ornamental Horticultural area. This is the plan that has been adopted by the Los Angeles City School System and has proven to be most desirable. First, it gives a permanent home to the program and allows for the permanent display of horticultural information without distracting other classes. Many of the Los Angeles schools have special collections of books and reading materials in an open-type library that are readily available to the students. These buildings are all equipped with washroom and toilet facilities and, in addition, have an office for the instructors. I do not feel it is necessary to discuss further the features of the classroom other than to mention that a raised lecture table with sink and running water is most desirable.

The lath or shade house should be 30 feet by 30 feet, and for the Northwest I am sure that a wooden structure would be most satisfactory. In Southern California, where we are not bothered by sleet or snow, we find the use of Saran plastic makes the most satisfactory shade and permits much easier construction. I would suggest that the lathhouse be equipped with an overhead watering system—Rainbird or the like — to take care of summer watering. Some schools that I know even have the system set up on a time clock so that most of the summer watering is taken care of automatically.

One further word about the ground in the enclosed area. In addition to the walks and road, it should be provided with adequate water faucets, so spaced that all areas may be easily reached with one section of hose. Most of the area should be divided into plots which will be used by the individual students for growing their plants and the balance should be planted with materials useful for instruction. The choice of this material would have to be made on the basis of what is most beneficial for the instructional program in the area. It would be impossible for any school on such a small plot of ground to grow all of the plant material necessary for instruction. For this reason I suggest that the instructor work closely with the grounds maintenance department so that full use of the plants grown on the institutional grounds can be made. This type of cooperation can and has been used in many cases. The students use the grounds for their laboratory and in turn, the students often grow material that will reduce the operation budget.

It should be mentioned here that plant materials grown by the department become a very acceptable means of communicating with the administration and other departments. Flowers and corsages for special functions and plants for the offices do a lot in creating good will. The quality of the materials grown should be such that surpluses should find ready market with the local nurseries, either as sales or exchange for needed materials.

MODERATOR BROWN: I think at this time we could entertain questions. Perhaps we should start with this last panel. Does anyone have a question? Yes, Brian Gage.

BRIAN GAGE: Dr. Clarke, if you want to take the name, 'Pearl', that is now applied to a rhododendron, could you use that same name for a rose?

DR. CLARKE: No objection to that. In fact, one of the best places to find rhododendron names is to look over the list of iris names.

RALPH JACK: Another question for Dr. Clarke. One of the large southern nurseries has an R within a circle, for some plant name like 'Scotch and Soda'. Now if we buy such plants from them and propagate it by cuttings do we still use that name with a little R in it, as 'Scotch and Soda', or do we have to pay them something, or what is the deal?

MODERATOR BROWN: The question here is on the use of copyrighted names — a registered trademark name. Dr. Clarke, would you answer this?

DR. CLARKE: I think the best example of this is the 'Golden Delicious'. I understand that name is registered and copyrighted, while 'Yellow Delicious' can be used most anywhere.

RALPH MOORE: The use of 'Sunkist' as the name of a rose can be done by getting the permission of the Sunkist Citrus Growers.

MODERATOR BROWN: I have one that I want to call attention to; that is, this morning one of our speakers wondered why Four Winds Growers would go to the trouble of using rubber bands from a stationery store to wrap their citrus grafts when he wrapped his grafts with regular budding rubbers. Don, would you or Fred answer that?

DON DILLON: As far as I know the rubber bands work well. They don't have to be held flat. They can be turned over and I haven't really checked the price but we think the rubber band is a pretty cheap item.

VOICE: This is a question on the program as a whole. I wonder if it would be feasible at all to arrange for a Verifax or some other copying machine so that if there was a particular five-page speech we wanted we could copy it for 2 bits a page, or so. We could crank one out and take copies with us — or would the editors object to this?

MODERATOR BROWN: How about that Hudson? Would there be a possibility of having a copy machine, so we could take this information home and use it while we are still thinking about it, instead of waiting until the Proceedings come out?

HUDSON HARTMANN: This is a decision that would have to be made by the International Board of Directors. If the decision was to invest in or rent such a copier and make copies right here and now, I am sure it would be possible to do so.

RALPH PINKUS: We had a trade show in Dallas last January and the Xerox people loaned us a machine and gave us all of the paper we could use and invited everyone to bring their papers to copy. Everybody could have copies of all the papers to take with them. They loaned it to us free and we ran off 900 sheets.

MODERATOR BROWN: A good suggestion. A complimentary gesture from the Xerox Co. Perhaps we could have our Fresno program chairman next year contact some of these outfits and see if they would be interested. Certainly they do go all out for advertising their product.

DON DILLON: I am wondering if Mr. Walters is here, and if he can tell us where the plastic "planting bullets" he spoke of this morning are available?

MODERATOR BROWN: Bill Curtis, could you make a comment concerning the plastic "bullets"?

BILL CURTIS: I talked with Mr. Walters and he gave me the name of the concern here that manufactures the "bullets". I called them on the phone and they are going to bring us a sample of the plastic bullets before the evening is over.

MODERATOR BROWN: Thank you Bill. This is very quick service.

BRIAN GAGE: I would like to ask a question on plant names. We often see a single "i" or a double "i" at the end of a person's name, used as part of a plant name. Is it correct to use one "i" or two "i's"?

DR. CLARKE: Well, that is for a latin ending and it shouldn't be used for cultivar names. For a species name it has been our practice to follow what is in the RHS Rhododendron Handbook and, in most cases, they use two "i's". This is really from the botanists; whatever they give us I am willing to use. But I wouldn't eliminate one "i" just because I can't see the reason for it. That is the name that has been given to the species and you should use it although it may not always be pronounced.

MODERATOR BROWN: I believe our new manual in California on nomenclature has used the two "i's" for all names.

MR. WILSON: We have a problem in late or early spring with green algae. It builds up to about $\frac{1}{4}$ inch deep in our flats. Has anyone had this problem and how do you get rid of it?

MODERATOR BROWN: I will entertain an answer from any of you. A problem in the spring with green algae developing to quite a depth over flats — flats of cuttings under mist, probably.

BILL CURTIS: There are two materials you can use. One is "Purispray" or "Puratized Agriculture Spray". You use one tablespoon of either to a gallon of water. The only thing I have used it on is mugho pine; it didn't hurt them but it killed a growth of liverworts. Another material which is common in the trade is "Knoxmoss". It is a powder. I have also used this on mugho pine. It is used at two ounces per gallon; we put on both of these materials with a knapsack sprayer. We drenched them even in full sun and it did not hurt the plants at all. It is best, though, to try such sprays at first only on a few plants rather than kill the whole crop.

MODERATOR BROWN: I would like to say that green algae or moss is sometimes a problem along concrete walks, where it does present real hazards for somebody slipping and falling. A very good material for removing it is Sani-Flush, and then spraying afterwards with copper naphthenate, which will prevent it from coming back.

DUANE SHERWOOD: There are some of the Puratized types agricultural sprays that have not been released for edible crops; there have been serious illnesses in humans where this has been used.

BRUCE BRIGGS: In the winter we ran tests with "Purispray" on azaleas in the lathhouse and our results, where it didn't give plant injury, was poor. This was in a lathhouse and in a plastic house. I am curious about "Knoxmoss"; is that an iron product?

VOICE: Yes.

BRUCE BRIGGS: Well, we ran tests with such iron products and they give control if you can get a level which will not also give plant injury. It will kill moss and other algae, but you also get injury if you use too much.

CHARLES PFEIFER: The azalea growers in the Seattle area use copper sulfate. It is metered into the water every time they irrigate. I will have to find out what the concentration is, but every time they water they use copper sulfate. This keeps the moss off the stems but there will still be some on the pots, but at least the moss is not on the stem of the azalea plants.

RALPH MOORE: Two years ago we had quite a serious problem in a new plastic house during the winter with moss and algae on plants. The material was grown in a sand-peat mix for growing miniature roses; the difficulty stemmed from the fact that the house was probably a little too tight; we also get a great deal of winter fog in central California and the outside air was saturated. The fan pulled this cold moist air in from the outside to give us a high level of moisture. A lot of algae and moss built up on these flats of roses, producing other molds and rots. One day I got the idea to tilt each flat along an edge so as to let it set on the edge of the next flat. That is the way we have been doing in this particular house ever since; this lets excess moisture out one end and we haven't had any trouble since.

MODERATOR BROWN: This sounds like a very simple solution. Just tilting the flat, and getting rid of the excess water, eliminates the growth of the algae.

BERNARD DOUGLAS: Dr. Kelley menioned that high nitrogen content of tissues of broad-leaved evergreens cuttings inhibited rooting; I wonder if that situation would apply to the coniferous species in rooting.

MODERATOR BROWN: I would say — yes, the carbohydrate/nitrogen relationship is as important too with conifers, particularly in milder climates, as it is with the broad-leaf evergreen materials. Here again, when we say a low concentration of nitrogen, we don't mean absolutely nothing. A low to moderate concentration of nitrogen and a relatively high concentration of carbohydrates would probably give the best rooting.

DUANE SHERWOOD: Some of the blueberries are very difficult to root; they often root best in straight sawdust. Perhaps this carbohydrate/nitrogen balance may be increased by lowering the nitrogen level in the cutting due to the competitive action of the sawdust for the nitrogen.

FRED REAL: We didn't know we were doing this but when we rooted our citrus rootstock cuttings in straight sawdust we got so many roots we couldn't take the cuttings apart. That is why we gave it up and started the rooting in vermiculite.

VOICE: Was this fresh sawdust or old sawdust?

FRED REAL: Either. It was redwood sawdust.

VOICE: I would like to make a comment on Douglas fir sawdust. If you get old material you may have some real serious problems. Don't use black Douglas fir sawdust. Fresh sawdust is far better.

VICE-PRESIDENT TICKNOR: Before we close, be sure to turn in your critique sheets or mail them to the Secretary-Treasurer. We thank you very much for being a good audience and we thank all those who have participated in the program this year. Thank you.

the mailing. The breakown was 100 from Commercial members and 64 from Non-commercial and Juniors. In the returns we had 46 papers offered for the meeting; 36 kind people offered to be moderators; and 6 offered to have some type of an exhibit. This is a response that is very heart warming — and almost unbelievable. As a consequence we have represented at this meeting, 24 states, 3 Canadians and one paper from England. The 46 participants at this meeting include 24 Non-Commercial, 19 Commercial and 3 Junior and 1 guest. Because of the afore-mentioned data, the program was 98% completed by April 30, 1967. My deep and heartfelt thanks to everyone who made my responsibility for this meeting a joy.

Now to get our 17th annual meeting underway, it is with a great deal of pleasure that I introduce the first moderator of our program this year. There is no-one better qualified to moderate a Seedage Symposium than Hugh Steavenson, Forrest Keeling Nursery, Elsberry, Missouri. Hugh is a Past - President of the Eastern Region and of the International Plant Propagators' Society. In 1953 I attended my first I.P.P.S. meeting as Hugh's guest — no other gentleman in the nursery community has given so much to me in guidance, understanding and compassion than your first moderator of our 17th meeting — I present to you my mentor and dear friend — Hugh Steavenson!

MODERATOR STEAVENSON: As Ralph knows I am here substituting for that eminent gentleman and friend of ours, Dr. F. L. O'Rourke, Department of Horticulture, Colorado State University. Unfortunately, Steve is unable to be here today and Ralph has asked me to read his paper.

SEED PROPAGATION REVIEW

F. L. STEVE O'ROURKE
Department of Horticulture
Colorado State University

Plant propagation from seed is an ancient art. It had its beginnings when primitive man first established permanent sites and relinquished a nomadic existence. Throughout the ages seed propagation has developed with mankind and in the modern world is basic to man's need for food and clothing.

In our time plant propagators are interested in seed propagation for several primary reasons:

1. Many homozygous seed strains (pure lines) of various species of both woody and herbaceous plants come "true from seed", that is, the seedlings are relatively uniform and resemble their parents in practically all characters.

2. Plants from heterozygous parents are quite variable, nonuniform, and seldom resemble their parents. However, certain individual plants may show superior or desired characteristics.

Thus selections may be made and the chosen plant may thereafter be propagated vegetatively as a clone.
3. Combinations between two pure lines may produce seedlings of exceptional quality. An example is "hybrid corn".
4. Rootstocks needed as stocks for grafting and budding are obtained to a large degree from seed.
5. Seed, which is relatively light in weight and resistant to injury during shipment, is a means of securing new or desired plants from far-off places.

Propagation by seed has been a matter of concern to members of the International Plant Propagators Society since its organization in 1951. The sixteen volumes of the Proceedings, 1951 to 1966, contain 27 articles on seeds and seedage. Some of these papers are broadly basic and comprehensive, some quite narrowly specific, while others treat of practical measures to insure economic stands of seedlings. All of the articles, however, have contributed to a broader knowledge and fuller understanding of seed problems and how to overcome them. Any enthusiastic prospective plant propagator may, by reading these articles, obtain a knowledgeable background of the factors involved and learn how practical plant propagators effectively and economically produce plants from seed.

The physiology and basic underlying causes of germination problems have been adequately discussed in the Proceedings by Barton 1956 and 1958, Bergh 1960, Heit 1964, Kester 1960, and Reisch 1962. The problems and solutions affecting seeds of specific plants have been reported by Barton 1958, Fennichia 1966, Fordham 1960, Galle 1953, Kern 1952, Mitiska 1954, Morey 1960, Nordine 1952, Stuke 1960, and Warner 1954. Nursery operations and practical propagation procedures with seeds of conifers and deciduous woody plants have been thoroughly explained by Fordham 1962, Holmason 1963, Pinney 1957, 1962, 1964, Schneider 1960, Steavenson 1959, 1960, Stoutemyer 1960, Strong 1951, and Vuyk 1956, 1961.

Heit, 1966-67, a in a series of articles in the American Nurseryman, has emphasized the wide variation in germination and subsequent seedling performance among seeds from various geographical races (ecotypes) within the established range of a species. Scots pine is a notable example. Thus the response from one lot of seeds may be quite unlike another lot from the same species. Each lot should be specifically tested under laboratory conditions before planting in order that the propagators may know how thickly to sow to achieve the desired density in the seed bed.

The most perplexing problem affecting practical plant propagators in the temperate zone is "delayed germination" which may be caused by "internal dormancy" (rest period), a hard seed coat, an underdeveloped embryo, biochemical inhibitory substance within the seed, or the need of certain temperature, moisture, or light conditions to initiate the germiniation process.

Delayed dormancy of seed is a survival factor which has been developed under natural conditions of the environment. If seeds which normally ripen in the fall would germinate immediately the resulting seedlings would be killed by cold. Thus the seeds of many of these species are internally dormant when the fruit is ripe and must be "after-ripened" by "stratification" in a cool moist environment for a period of one to four months depending upon the particular seed strain involved. Under natural conditions internal dormancy keeps the seed from germinating during the late fall and early winter and the winter cold or external dormancy prevents it from germinating until the warm moist days of spring have arrived.

The seeds of some plants are "double dormant". These are often termed "two-year seeds" because a cold period (first winter) is needed to stimulate the radical (root) to emerge, a warm period (first summer) to allow root growth, another cold period (second winter) to "after-ripen" or stimulate the epicotyl (stem) into growth, and a subsequent warm period (second summer) for the shoot to emerge above ground and develop the new plant. Each species or even individual seed strains within the species follow somewhat different patterns as indicated by the papers presented in past volumes of the Proceedings.

When the plant propagator knows the particular conditions under which each seed lot may best be after-ripened he may "stratify" the seeds by mixing them with two or three times their volume of moist, but *not wet,* sand, peat, sawdust or other moisture-holding material. Polyethylene bags are usually used for containers. These may be placed in storage, usually from 32°F to 50°F (optimum 41°F) for a period ranging from 30 to 120 days depending upon the particular requirement of the species or seed strain. The moisture content of the medium should be checked at intervals. If too dry, the seeds will not after-ripen, if too wet, molds will kill the seeds.

Hard seed coats impermeable to water and air, occur in many species, notably with legumes. Under natural conditions in the soil the seed coats break down gradually due to bacterial and microbial action and thus may germinate over a period of years. This again is an instance of a survival factor for the species as some years may be more favorable for germination and plant growth than other years.

Immediate germination of these hard-coated seeds may usually be secured by "scarification", the term applied to the partial breakdown of the seed coat by either chemical or mechanical means. Immersion in concentrated sulfuric acid for periods ranging from 5 minutes to over an hour, depending upon the type of seed, is a common practice to insure prompt germination. Mechanical methods of scarification range all the way from nicking the seed with a file or rubbing on sandpaper, to large concrete mixer types of machines equipped with erosive surfaces.

The thickness and relative resistance of the seed coat to erosion determines the time and degree of force to be exerted. Embryos may be injured if either the chemical or mechanical processes of scarification are carried on for too long a period.

The temperature and moisture requirements most favorable for the development of embryos which are immature at the time of seed ripening varies with the species but apparently proceeds well at temperature from 40°F to 50°F. The time period also varies with the species but usually requires a year of more. Thus seeds of hollies may be termed "double dormant" from an entirely different cause than that of other two-year seeds.

Some seeds are "light sensitive". These must have light in some degree to initiate germination, but the intensity and the duration of the light varies widely among the species involved. Other seeds germinate well only in total darkness.

Seeds of other species may remain dormant due to a combination of factors. Thus a seed may have a hard seed coat, a need for after-ripening, and perhaps an immature embryo as well. The propagator therefore must resort to several treatments in proper sequence to obtain maximum germination.

"Secondary dormancy" is another disturbing condition which often confronts the propagator. Even after all the after-ripening requirements of a seed have been satisfied and the germinative process has started, a sudden lack of moisture, oxygen, or even light may cause it to return to a state of deep dormancy. This secondary dormancy can only be broken by another series of after-ripening treatments which means that another year must pass until the seed is again ready to germinate.

Apparently all the factors of internal dormancy and other influences that affect germination are controlled by the genetic structure of the plants which produce the seed. Different geographical races or even different individual trees, within the same species, may produce seeds with different pregermination requirements. Each seed source must be investigated so that the propagator may determine the optimum treatments for the particular lot of seed.

After the pregermination requirements have been satisfied a favorable combination of optimum temperature for the species, adequate moisture, and a goodly supply of air should provide the conditions for satisfactory germination and subsequent seedling growth. The optimum temperature will vary with the species. Most warm area plants germinate better at a relatively high temperature, more northern plants at a cooler one. Some plants germinate best in total darkness, others in varying degrees of light intensity. Both water and oxygen are needed in adequate quantities, so the seeding medium should be both retentive of moisture and highly aerated.

When seeds are sown in the greenhouse or cold frame, coarsely shredded sphagnum moss will provide the best medium for the seeds of most woody plants as all the factors for germination and growth can be definitely controlled. Seedlings may be held in "living storage" in sphagnum moss for long periods without harm. In addition the anti-biotic qualities of sphagnum moss will prevent infection by fungus diseases.

Sterile substances such as vermiculite, arcillite, or perlite have value as media for seeds which germinate rather quickly and are transplanted soon thereafter. The seed may be treated with a fungicide before sowing as a precaution against diseases which may be carried in or on the seed coat.

Soil should not be used indoors but is necessary for large lots of seeds out of doors. A good soil for sowing seed should be light in texture, well drained, well aerated, and contain a fair degree of organic matter to prevent rapid loss of moisture. Treatment with steam or chemicals to control weeds, nematodes, insects, and diseases is important before the seed is sown.

Since seeds vary so widely in their pregermination and germination requirements, the need for accurate observation and research with each particular species or seed strain is evident. Every plant propagator can assist in this endeavor. Accurate records of every operation and environmental factor should be kept and reported thereafter in the Proceedings or quarterly journal of the International Plant Propagators Society. Thus, bit by bit, the information will accrue so that the plant propagator of future years may be the recipient of more definite and detailed instructions for each type of seed than is available at present.

MODERATOR STEAVENSON: Before we have any discussion we will hear our next paper presented by another old friend of the Society, Mr. Al Fordham of the Arnold Arboretum.

HASTENING GERMINATION OF SOME WOODY PLANT SEEDS WITH IMPERMEABLE SEED COATS

ALFRED J. FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

Germination of many seeds is hindered only by seed coats that retard the admission of water. If these impervious coats are not modified by pretreatment, germination can be erratic and sometimes extended over many years. Three hundred seeds of *Gymnocladus dioicus*, the Kentucky coffee tree, were placed in a tray of water in April 1963 and since that time have been kept at room temperature. Each week the seeds were examined, those which had germinated were removed, and the results recorded. In the first 10 days, 13 seeds imbibed water and the produced radicles. These, no doubt, had fissures in their seed coats at the outset. Twenty-one months later, in January 1965, three more imbibed water and germinated. The following table shows how many more have done so since that time:

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Year	Number germinated
1963	13
1964	0
1965	4
1966	4
1967	5
Total	26 germinated since 1963

In four years and seven months about 8% of the seeds imbibed water and germinated. Large seeds such as those of Kentucky coffee tree can be perforated by holding them between the fingers and stroking them several times along the edge of a three-cornered file placed on a bench. Complete germination can then be expected in about a week.

In December 1963, 1000 seeds of *Gleditsia triacanthos,* the honey locust, were submerged in water under similar conditions to record germination. The following table shows how many have done so since that time:

Year	Number germinated
1963	20
1964	16
1965	8
1966	19
1967	22
Total	85 germinated since 1963

In four years about 8% of the seeds have germinated. A complete stand of seedlings appeared in about ten days after the seeds were steeped in concentrated sulfuric acid for 2½ hours. Comparative tests, shown in the following table, proved this to be an optimum treatment:

Treatment	% Germination
Control, sown without pretreatment	5
Steeped in hot water (190°F.)	29
Steeped in sulfuric acid for 1½ hours	62
Steeped in sulfuric acid for 2½ hours	98

As it now appears, the tests with Kentucky coffee tree and honey locust can go on indefinitely, possibly for decades.

Many legumes and some other seeds that are inhibited only by water-tight protective seed coats are relatively easy to prepare for germination. Abrasion, perforation, or modification of the seed coat with hot water or sulfuric acid is usually all that is necessary. When such seeds reach full development on the plant, the coats, which will provide protection for the contents, undergo changes in structure. They diminish in size and weight and develop hard, water-impermeable seed coats.

Seeds of *Laburnum watereri*, the Waterer laburnum, were collected on July 21, 1965. At this time the pods were soft and the seed coat only a thin green membrane. To test whether or not a barrier to germination existed at this stage, the seeds were divided into two lots and processed immediately. Seeds of Lot #1 were sown without pretreatment while the coats of those in Lot #2 were punctured with a needle. In five days, each lot germinated uniformly. There was no appreciable difference in percentage, for at this stage the seed coats were water-permeable. Dry seeds of *L. watereri*, however, are an entirely different matter. In a series of trials, dry seeds required a two hour steep in concentrated sulfuric acid to obtain the optimum germination.

Laburnum alpinum, Scotch Laburnum, seeds were collected in October 1963 and kept in dry storage until June 1965. The seeds were divided into four lots. An accounting 23 days later showed the following results:

Treatment	% Germination
Control sown without treatment	0
Hot water treatment	18
Sulfuric acid for one hour	29
Sulfuric acid for two hours	68

Although the highest percentage of germination was 68 only one sound seed remained ungerminated, thereby indicating that the balance was not viable.

Cytisus supinus seeds were provided treatment as follows:

Treatment	% Germination
Control sown without pretreatment	1
Hot water	4
One hour of acid	64

Germination of *Cercis siliquastrum* (Judas tree) seeds was hindered by impermeable seed coats plus internal conditions. Lot #1 was treated with hot water and sown, while Lot #2 was provided with hot water treatment followed with 3 months of cold stratification at 40 degrees. Lot #2 germinated uniformly in 22 days while Lot #1 produced only one seedling in four months. Seeds of *Cercis canadensis* (Eastern redbud), *C. chinensis* (Chinese redbud), *C. griffithii,* and *C. occidentalis* (Californian redbud) behave in a similar manner, requiring a cold treatment after the seed coat has been modified.

Germination of seeds of *Hovenia dulcis*, the Japanese Raisin tree, is inhibited only by extremely hard, water-impervious seed coats. Lot #1 was sown without pretreatment while Lot #2 was provided with a two hour sulfuric acid treatment. Lot

#2 germinated uniformly in 16 days, while the untreated lot produced only two seedlings in two months and six seedlings after a lapse of nine months.

Concentrated sulphuric acid treatment

Some seeds with coats not responsive to hot water treatment can quickly be germinated after a more drastic measure — immersion in concentrated sulphuric acid, (H_2SO_4). This highly corrosive substance, when employed for this purpose, accomplishes in hours, or portions thereof, a process that could require months or years if the seed coats were not treated.

Sulfuric acid treatment, when dealing with small amounts of seeds, consists of placing the dry seeds in a glass container and carefully pouring acid over them until they are covered. Sulfuric acid is a viscous substance of high surface tension which acts superficially on seed coats without penetration. In fact when trials were carried out on an unfamiliar subject suspected of having an impermeable seed-coat, periods of acid treatment as long as one and one-half hours have been given seeds which later proved to be water permeable. Despite such mistreatment, however, the seeds were not destroyed but germinated when sown. The acid did not have the ability to penetrate the seed coat, although water did.

As acid treatment progresses gummy by-products of corrosion will fuse the seeds into a cohered mass which must be separated from time to time to insure that all seeds are acted upon uniformly. Cautious prodding and careful stirring with a glass rod will accomplish this. The length of treatment varies greatly, depending upon the subject, the objective being to corrode away sufficient seed coat to permit the entry of water without exposing the interior to destruction by the acid. Observations can be made during treatment by removing a few seeds, rinsing them and examining the seed coat to see how much of it has been eaten away. When treating large batches it is advisable to run a few trial lots to determine proper timing before processing the main bulk. An important point which must be considered when using sulfuric acid is the effect of temperature. Higher temperatures accelerate the rate of action while lower ones retard it. Acid treatments at the Arnold Arboretum are usually performed in the winter when room temperature is maintained at approximately 70° F.

On completion of the treatment, seeds are placed in a sieve and washed thoroughly in running water for several minutes to remove all the acid. Now they are ready for the next step, which involves either immediate sowing or cold stratification. We do not employ a neutralizer after the use of acid and have never noticed detrimental effects for not having done so.

Precautions when handling sulfuric acid

Precautions to be taken when handling sulfuric acid cannot be over emphasized. It need not be feared, but should be handled with the greatest respect, for it becomes safe to use only when adequate precautions are observed. Each year millions of tons of this highly essential industrial chemical are transported about the country in tank-cars and tank-trucks. It is used extensively by chemists, industrial workers and students and with care others can do the same.

In our treatments, small though they are, the workman performing the task dons protective equipment consisting of glasses, neoprene gloves and an apron. The work is done adjacent to running water and nearby is a shower that could be reached in a few seconds if its use became necessary, for, despite precautions, accidents are always possible. To minimize the chance of breakage, our supply of acid, in a glass container, is imbedded in a five gallon can of perlite stored in an out-of-the-way location.

When treatments have been completed, the acid which has been used is poured into a glass bottle. In a few days extraneous substances caused by corrosion settle to the bottom and the clear acid is then poured off for re-use.

MODERATOR STEAVENSON: Thank you very much, Al, for a very fine presentation which was a fine complement to Steve O'Rourke's paper. Now we will open the floor for discussion.

VINCE BAILEY: I would like to ask Al if he recommends the use of sulfuric acid on *Tilia*.

AL FORDHAM: We have not had any experimental work with *Tilia*. However, I believe the Woody Plant Seed Manual does recommend the use of sulfuric acid for *Tilia*.

VINCE BAILEY: Is that after the removal of the fleshy seed coat or before removal?

AL FORDHAM: I beleive the procedure is to first remove the fleshy outer coat and then treat the inner seed coat.

HANS HESS: Has Al used sulfuric acid treatments on *Cercis canadenis* and on *Gymnocladus?*

AL FORDHAM: Yes, I have. With *Cercis canadenis* after treating the seed coat with the sulfuric acid it is necessary to give the seeds a period of cold stratification. The length of the cold treatment varies with the seed source. We also use a hot-water treatment to break the seed coat dormancy of *Cercis canadenis*. We pour hot water at about 190° over the seeds and they are left to cool overnight. The following day the seeds are placed in cold storage. The *Gymnocladus* seed needs a rather long period of sulfuric acid treatment. Actually we have not had personal experience with sulfuric acid on *Gymnocladus* seed. We have so few seed that we just scarify the coats with a file. If you use acid, it would probably take at least 2½ hours exposure.

RALPH SHUGERT: I would like to make a brief comment on the hot-water treatment. We have used the hot-water treatment for *Robinia* seed and at one of the meetings I gave our procedure to a member. He followed the procedure that I had given him and he lost the entire lot of seed. The thing that I am trying to bring out here is that it is very important, particularly in the case of *Robinia,* to know where the seed has come from. We expose our seed to three hot-water treatments — one at 140°, the second at 160° and the last at 170°F. This works very well on the seed brought in from Europe but, if you try this on domestic seed; you will lose all of it. The word of caution here is to try the treatment out on a small lot of seed before you treat the entire lot.

AL FORDHAM: Our treatment is a little bit different from yours. Rather than heating up the seeds to a temperature of 140, 160 or 170 degrees, we start out with water at about 190° and pour it over the seeds and then allow it to cool.

RALPH SHUGERT: That's right. I do the opposite as far as treatment in concerned. I put the seeds in water and then bring the temperature up to the 140, 160 or 170 degrees F level.

RALPH SYNNESTVEDT: Al, do you use the acid treatment for *Crataegus Crus-galli?*

AL FORDHAM: Yes, we generally do. The thickness of the seed coat varies enormously. There are many species of *Crataegus* and in some cases the seed coat may be as much as 3/16 of an inch thick. With this type of seed it may require as much as 7 or 8 hours of sulfuric acid treatment.

JIM WELLS: Why do you use a hot-water treatment? When I brought in a lot of *Acer palmatum* seed I found that just soaking them in cold water was sufficient. If the seeds were planted dry even though the soil was moist, germination was very poor. However, giving them a cold-water soak stimulated good germination.

AL FORDHAM: I think we are talking about two different things here. The hot-water treatment which I described is used to modify the seed coat which was impermeable to water.

JIM WELLS: Does the hot water cook the coat?

AL FORDHAM: No, the hot water modifies the seed coat so that moisture will be able to penetrate. Cold water is not effective in modifying the seed coat.

JOHN ZELENKA: Al, what are your recommendations for handling European Mountain Ash seed?

AL FORDHAM: European Mountain Ash just requires three months of cold stratification, if the seeds are fresh.

AL FERGUSON: Have you tried any detergents with your hot-water treatment,

AL FORDHAM: Yes, a few years ago we used wetting agents such as Tween 20 and they were of no help at all. With some other types of seeds which do not have impermeable seed coats such as grass seeds, it is sometimes possible to speed up the rate of germination a few days with wetting agents.

CASE HOOGENDOORN: Do you ever try to hold the seeds in hot water at a given temperature for a given period of time and then allow them to cool off?

AL FORDHAM: No, we do not do that. Just pour the hot water over the seed and allow it to cool. A prolonged period of high temperature could be harmful to the seeds.

MARTIN VAN HOF: Have you tried the scarification treatment with the sulfuric acid on *Myrica pennsylvanica*, the Bayberry.

AL FORDHAM: There are two problems with this seed. One is the waxy coat. The second is a cold stratification requirement. The wax is removed just by putting the seeds in lukewarm water and then the seed is given a three-month period of cold stratification. After that the germination should be very good.

JOERG LEISS: What is the concentration of the sulfuric acid which you use?

AL FORDHAM: I don't recall the specific gravity, but we use concentrated sulfuric acid. I believe it runs about 93%.

JIM WELLS: I would like to direct this question to Hugh Steavenson. I have read that if the seed bed is maintained at a moisture level 95% of field capacity that the seed germinaion will be very good. Have you had any experience along these lines?

MODERATOR STEAVENSON: It is essential during the germination process of most tree and shrub seeds to have an adequate to high level of moisture availability at the seed level. It is also essential to have a well aerated medium. The high moisture level can be obtained in a couple of ways. Some nurseries are well set up with irrigation systems and can give frequent light applications of water which keeps the soil moisture high. The alternative is to use a mulch. However, with the mulch system there are some seeds with which it does not work. For example we have not been successful with White Birch. Perhaps there is a light factor involved.

AL FORDHAM: I have heard about this light factor with Birch but in our experience it has not been a problem and we have tested seed from many, many sources. However, I should point out that this is done with small lots under greenhouse conditions.

JIM WELLS: My point about soil moisture goes back to some work done a number of years ago by Dr. Thornthwaithe who ran the Department of Climatology at Seabrook Farms. He developed a unit called an evapotransporometer. It is a device which enables you to determine exactly how much water has been lost both by evaporation and tranpiration. By using the evapotransporometer he was able to determine exactly when the soil moisture level had dropped to the 95% level of field capacity. I have a paper in my files done by a field testing station in Canada dealing with the raising of pine and spruce seedlings in which Dr. Thornthwaithe's evapotransporometer and formulas were used. They showed very clearly that if you precisely determine the moisure level and maintained it at hte 95% level, the size of the seedlings in one year was equal to the normal size at the end of two years. You were able to gain a full year's growth by controlling water.

PETE VERMEULEN: I would like to ask what effect does a mulch on a seed bed have upon the soil temperature?

MODERATOR STEAVENSON: Although the color of the mulch may effect its ability to absorb or reflect heat, in most cases the mulch is an insulating blanket so that the soil temperature may be held back in the springtime. With us, this is a real good thing because otherwise we have seeds which germinate too early and then are caught by a late frost.

CASE HOOGENDOORN: What do you use for a mulch?

MODERATOR STEAVENSON: We use sawdust.

ROBERT FARMER JR.: I would like to make a comment in regard to temperature. There is a growing body of knowledge that shows that southern seed sources require a much shorter period of cold stratification than do northern seed sources. This is true for most species although I believe the White Pine is an exception. The temperature required at germination is influenced by the amount of cold stratfication that the seeds have been exposed to. After a short period of stratification most tree species require a high temperature but the longer the cold stratification period they are exposed to, the lower the temperature they will be successfully germinated. The optimum temperature then for germination depends upon the geographical location of your seed source and the amount of cold stratification that has been used.

MODERATOR STEAVENSON: Our next paper for this morning's session will be given by Mr. Richard Bedger from Musser Forests, Inc. and he will speak on "Conifers and Hardwoods from Seed".

CONIFERS AND HARDWOODS FROM SEEDS

RICHARD C. BEDGER
Musser Forests, Inc.
Indiana, Pennsylvania

Mr. Steavenson, Society Members, and guests. It is a pleasure to discuss with you this morning the propagation of plants from seeds. I feel that the key to this whole phase of propagation is one word "seed". We can have the most beautifully prepared beds, the most fertile soil, and sufficient water, but if the germination capacity of the seed is low or if it is sterile, the beds will be poor or fail.

In our operations at Musser Forests, we store large amounts of seed in sealed jugs in refrigerated storage. In any year that nature produces a good crop, we purchase a two or three year supply of seed. Not only is the seed cheaper but the viability in a good crop year is normally greater.

As each shipment of seed is received from the supplier, it is put in the jugs for storage. A sample of approximately 1,000 equal to the normal size at the end of two years. You were able to gain a full year's growth by controlling water.

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MODERATOR STEAVENSON: Although the color of the mulch may effect its ability to absorb or reflect heat, in most cases the mulch is an insulating blanket so that the soil temperature may be held back in the springtime. With us, this is a real good thing because otherwise we have seeds which germinate too early and then are caught by a late frost.

CASE HOOGENDOORN: What do you use for a mulch?

MODERATOR STEAVENSON: We use sawdust.

ROBERT FARMER JR.: I would like to make a comment in regard to temperature. There is a growing body of knowledge that shows that southern seed sources require a much shorter period of cold stratification than do northern seed sources. This is true for most species although I believe the White Pine is an exception. The temperature required at germination is influenced by the amount of cold stratfication that the seeds have been exposed to. After a short period of stratification most tree species require a high temperature but the longer the cold stratification period they are exposed to, the lower the temperature they will be successfully germinated. The optimum temperature then for germination depends upon the geographical location of your seed source and the amount of cold stratification that has been used.

MODERATOR STEAVENSON: Our next paper for this morning's session will be given by Mr. Richard Bedger from Musser Forests, Inc. and he will speak on "Conifers and Hardwoods from Seed".

CONIFERS AND HARDWOODS FROM SEEDS

RICHARD C. BEDGER
Musser Forests, Inc.
Indiana, Pennsylvania

Mr. Steavenson, Society Members, and guests. It is a pleasure to discuss with you this morning the propagation of plants from seeds. I feel that the key to this whole phase of propagation is one word "seed". We can have the most beautifully prepared beds, the most fertile soil, and sufficient water, but if the germination capacity of the seed is low or if it is sterile, the beds will be poor or fail.

In our operations at Musser Forests, we store large amounts of seed in sealed jugs in refrigerated storage. In any year that nature produces a good crop, we purchase a two or three year supply of seed. Not only is the seed cheaper but the viability in a good crop year is normally greater.

As each shipment of seed is received from the supplier, it is put in the jugs for storage. A sample of approximately 1,000 seeds is kept out for testing. We test most conifers we grow except for hemlock and white pine. These species require special pre-chilling. Mr. Claude Heit at the New York Agricultural Experiment Station, Geneva, New York, does an excellent job of testing all seeds, therefore, we get Mr. Heit to test these difficult species for us. The tester we use in testing our seed is a cereal grain tester and is not the most efficient. With most of the species we test such as pines and spruces and some of the hardwoods, it does an excellent job and serves our purpose. Most of the spruces, by putting them on moist blotting paper in the tester at 70° fahrenheit from ten to fifteen days, we can tell within a reasonably good accuracy what percent of the seeds will germinate in the seed beds.

In the past ten years, we have started growing more hardwoods from seed. These hardwood seeds, in a lot of cases, are gathered locally and planted immediately. In some cases, they are cleaned and planted. The seeds with a fleshy pulp covering such as white flowering dogwood and barberry must be cleaned before seeding. The reason these seeds must be cleaned is that the pulp covering over the seed coats retards the breakdown of the seed coat. In nature, the birds and animals do this for us by digesting the seed pulp leaving the clean seed exposed to the weather so that it can break down the seed coat and allow the seed to germinate.

At the present time, we are seeding about 30 species of conifers and over 40 species of hardwoods. The most limiting factor many times in our production is seed. As the economy improves, it appears that fewer people are willing to gather seed.

The next important factor after the seed is the soil and soil preparation. Some of our seed beds have been in the production of seedlings for up to 30 years. Other areas, as we expand, are farm land, woodland, or pine plantations that have been cleared. Each of these three areas must be handled differently. The old land which has been in seed beds for many years after the seedlings have been removed in the spring, is plowed deep and put into cover crop for the summer. Sometimes we can get in early enough to get a crop of oats and plow it down by the middle of June. Also we can still get in a crop of buckwheat or Sudan grass. This gives us two crops of green manure to improve the fertility of the soil before it goes back into the beds the following fall.

On new farm land which has been in farm crops or hay, we like to plow for up to two years before we put them into seed beds. Normally putting in crops such as rye, oats, buckwheat, or corn, never letting these crops mature but plowing them down as green manure to improve the soil and its texture. Newly cleared land such as forest land, pine plantations, or old Christmas tree ground are bull-dozed with a root rake to remove all foreign material and then plowed and cover cropped the same as the other land before being put into seed beds.

After the soil fertility has been achieved, we like to sample the soil the summer before the beds are prepared. Normally the pH in our area is on the low side and also we are normally low in phosphate and potassium. If the pH is around 5 or less we normally apply two tons of lime per acre to bring the pH up to approximately 6 or 6.5. We believe that at this level the nutrients are more available to the plants and we get a better growth than at the lower pH levels. The final phase of our soil program is a cover crop planted about the first of June which is normally Sudan grass. It is plowed down the end of July and left to rot for a month before the beds are prepared. However in the last two years, the new hybrid Sudan grasses have given us trouble because of the stems being so large that they will not rot down sufficiently to insure a good soil preparation by the first of September. We start to prepare our beds the first of September so that we can have beds ready to transplant by the 15th of September. Our bed preparation starts after the soil has been disced and harrowed. Then the soil is rotovated normally with a Howard Rotavator to prepare the soil for the throwing of the beds. The centerline of each bed is staked and the beds are mounded by a Gravely Tractor with a rotary plow. We normally do not use a bed former because in our preparation all beds are kept at a very uniform width with a uniform path. After the beds have been thrown up, in the past eight years we have used Vapam as a soil fumigant with varying degrees of results. Vapam is injected into the soil with a JP Enterprise Soil Injector. After the Vapam is injected, it is followed with a water seal of the soil. We use tank type sprayers and usually two to three applications of water is sprayed onto the surface of the soil to form a crust which holds the gas in the soil and allows it to do its job.

I feel that efficiency of the treatment is determined greatly by the weather. If the soil is too moist or too dry, or the weather is too cold or too warm, this greatly affects our treatment. In the past season of 1967, our treatment has varied considerably as to the time it was applied and the weather conditions changing. The earlier treatment which was done in early September when the soil moisture was lower and the temperature higher appears to be much more satisfactory than the treatment applied later when the soil moisture was much higher and the weather a little cooler. The later treatment was applied on some days when the weather was just beginning to change. Soon after the treatment was applied there was a heavy rainfall that night causing the gas to be forced down into the soil and therefore the surface of the beds have already begun to show weeds and grasses. This, I feel, is due to excess moisture pushing fumigating material into the soil not allowing it to come up to the surface and perform its job. At the present time, all seed beds and transplant beds required for a full year are prepared in the fall. This allows us more time in the spring to get our nursery work done and also our shipping and packing.

As the beds are needed, we break them down with the rotavator for seeding or transplanting. The beds are laid out 54″ on the surface with a 32″ wide path. All of our tractors, trailors, and equipment, are set with the wheels on a 84″ center. This allows the wheels to straddle all the beds and also it will straddle our field rows of ornamental plants which are lined out on approximately 40″ to 44″ centers. After the seed beds are prepared, I like to fertilize all conifer seed beds with 15 pounds of 10-6-4 slow release type fertilizer per 400 square feet of seed bed before seeding. All hardwood beds are seeded without fertilizer. Hardwoods normally are much larger seeds and have a bigger food supply on which to get started. After the hardwoods are up a few inches which is usually the first of June, I like to give them a top dressing of about 15 pounds of slow release fertilizer per 400 square feet of bed. In our seeding, we like to see as much as possible done in the fall because we have more time and also germination in the spring is usually earlier and produces a slightly larger seedling than the spring seed. The spring seeding is not done until the first of June which makes the spring seeds germinate up to a month later. By the end of the first and second years, a considerable difference can still be noticed. The fall seeding has just been completed. Many of the large seeds must be put on the beds by hand. The conifiers are all broadcast on the seed bed to a width of four feet. This seeding is done with a 4′ Gandy Spreader with the axle extended to 7 feet.

After the seed is sown, it is rolled into the surface of the bed. After rolling, we cover the seed with sand 1/8″ to 1/4″ thick. The sand is applied to the beds with a special sanding machine designed by Syntron Corporation which is a local magnetic vibrator company. The sander is pulled by a tractor and is powered by an electric generator. It vibrates the sand onto the bed at the desired thickness. After the sanding, the seed bed is mulched with salt hay. Salt hay is harvested in salt water swamps along the coasts of Jersey and Delaware. After the bed is mulched with salt hay, it is then covered with shades. All of our shades are made with spruce lath and hemlock rails that are 10 feet long and 4 feet wide. These shades are made without legs. We use a 24″ wooden stake driven into the ground with a 54″ cross piece over top of two stakes to hold the shades off the seed beds. Fall seed beds remain covered in this manner until early spring when the shades are raised just before the seed germinates. As the seed starts to germinate, salt hay is removed, if possible on a cloudy moist day. The removal of the salt hay is a critical phase because excessive drying of the seed at the time of germination may result in poor beds.

The hardwoods and a few of the conifers such as the *Juniperus virginiana, Taxus cuspidata capatada,* and the *Cedrus* *atlantica* are handled differently. These seeds are rolled into the soil with a good layer of sawdust, then they are covered with shades. Some of the larger seeds such as chestnuts, black walnuts, etc. are covered with a thick coat of sawdust and also with salt hay to insure that the seed is well covered and protected from winter. We have found in the past that if the chestnuts, for instance, are not planted sufficiently deep in the soil, a poor germination results the following spring. These beds are then covered with shades and the shades remain on the bed until the plants start to grow and the tips of the new growth come up and are touching the lath on the shades. On the coniferous species and on a few of the hardwoods such as the birches, the shades are raised. On all other hardwoods, when the plants are two to three inches tall, the shades are removed and the plants are left unshaded for the balance of the season. To insure proper germination, it is sometimes also necessary to irrigate the seed beds. At the time the seed is starting to germinate or perhaps even before germination occurs, it is necessary to irrigate. For the seed to properly germinate, we must have sufficient moisture in the soil and mulch.

Seeding is only a part of the total operation. Fall seeding normally takes place the last two weeks in October and the beginning of November. Spring seeding is normally done the end of May. By the middle of June all the seedlings are up and ready to be cared for from three to four years. Bringing the seedlings through the first summer and first winter is the most critical period. All conifers are shaded the first growing season. Some of the spruces and firs are shaded through the first and second growing season. In our area some hot, dry weather occurs in June, July, and August, which makes shading necessary. Also during this period irrigation is often very necessary to insure the seedlings proper growth.

About the middle of August when the nights start to get cooler and days not quite as warm, we begin to pull the shades off the beds to harden the plants for the winter. Normally we pull the pines first, leaving the spruce and hemlocks until later in the fall. After the shades are removed, the girls give the beds a good weeding before the cold weather sets in. About the first of November mulching of the first year beds can begin. All one year conifer beds are mulched with salt hay to prevent frost heaving and winter burn. The mulch remains on the beds until early in the spring when the danger of heavy freezes which would cause heaving is passed. The mulch is then removed and stored for use the following year.

The largest single cost and the largest single problem in the growing of the seedlings is control of weeds. The treatment of the beds with Vapam is a great help but it does not eliminate hand weeding. I have done work with pre-emergence type weed control on one, two, and three year seedlings with varying degrees of result. Simazine appears to do the best job in most cases whenever the plants show any tolerance. Most one year pines are tolerant and can be treated with granular Simazine in September and held throughout most of the second year with very little weeding. Other chemicals used have been: Dyamid, Enide, and Casaron. All these chemicals are useful in species not tolerant to Simazine, especially in the control of some grasses and a few weeds. With the cost of labor continually going up, we have found that it is necessary to resort to some of these chemical controls in order to survive in the cost-profit relationship of modern business. We also transplant a sizable quantity of coniferous seedlings. Most of the transplanting is done at the age of two years and occasionally at the end of the third year. A considerable amount of transplanting is done in the fall of the year when more labor is available. However, fall transplanting requires more mulching and special attention to pull them through the first winter. We still feel that it is a definite advantage to transplant in the fall since our other work in the spring often holds off transplanting until late in the season. We have been very successful in the fall transplanting of Colorado blue spruce, Norway spruce, white spruce, balsam fir, Frazer fir, and Scotch pine. Most of the transplanting in the spring does not get started until late in May when the trees are removed from refrigerated storage. The trees are lifted early in the season, perhaps as early as the beginning of April and put into the refrigators to hold them until we can have sufficient labor and the soil in working condition so that a reasonably good job of transplanting can be done. After the trees are moved from the refrigerators, we like to soak them overnight in water and transplant them the following day. This gives them a chance to acclimate themselves to the warmer weather outside the refrigerator. We have had some good results with this and it extends our normal planting season until the first week of June. With this operation, however, constant irrigation is necessary sometimes even in the middle of the day to insure that the trees do not dry out from the hot sun which we experience at this time of the year.

I have not mentioned anything about lifting, packing, and shipping of trees. As propagators, we forget this phase of the operation and I feel that it is very important to the consumer to receive the plants in the best possible condition. We should continually strive to improve our shipping and packing methods as well as finding new methods of handling the plants so that the consumer receives them as fresh as when they came from the seed beds.

MODERATOR STEAVENSON: It is always a great pleasure to introduce our next speaker, Mr. Peter Vermeulen. I know of no one who approaches things in a more scholarly and thorough-going manner than our recent past president. Pete is going to discuss "Seedling Propagation of Some Broadleaf Evergreens and Deciduous Azaleas".

SEDDLING PROPAGATION OF SOME BROADLEAF EVERGREENS AND DECIDUOUS AZALEAS

J. PETER VERMEULEN
John Vermeulen & Son Inc.
Neshanic Station, New Jersey

INTRODUCTION

I must emphasize the word "some" in my subject title because our recent seeding experience has been limited itemwise in broadleaved evergreens to *Enkianthus campanulata palibini, Kalmia latifolia, Leucothoe catesbaei, Oxydendron arborem. Pieris floribunda, Pieris japonica,* and Rhododendron species and hybrids and such deciduous Azaleas as *calendulacea,* Exbury, Knaphill, Slocock Hybrids, Mollis Hybrids, *Mucronulatum, flavum, poukhanense, schlippenbachi,* Ghent Hybrids and *Kaempferi.* Since the methods used have been constantly successful for the past several years this paper will therefore generally center on methods rather than the science of growing broadleaf evergreens from seed. I hope that it will be of some benefit to you today as well as to subsequent readers. Interestingly it will treat practically the same broadleaf evergreen items as did the paper of Zophar Warner presented to this Society at Cleveland in 1954. (1)

WHAT TO GROW

Many of the species are considered to "come true" from seed produced from a parent that has been pollinated with pollen from the same species. In many instances the characteristics of the resulting progeny are remarkably identical. However in many instances there will result progeny with widely different characteristics though generally they can still be considered of the same species. These differences may be in leaf size or form, rate of growth, plant habit or shape, flower form or color, hardiness, disease resistance, etc. In a few instances selected "strains" have been inbred by being crossed repeatedly and over the years, with culls or rogues removed from the line, there has resulted a "strain" with acceptable fixed characteristics. These are called "line-hybrids'. Progeny resulting from the crossing of two species are called cross-breeds. I have mentioned that frequent variations occur. These when selected and propagated for perpetuation by asexual or other than sexual means are referred to as horticultural cultivars or varieties. Progeny produced from seed of these cultivars most generally yield plants unlike the parent and most often more like the original species from which the parent cultivar was selected. When two different species are crossed and produce seed the progeny are called "hybrids". Here again we find that progeny or seedlings produced from seed of a hybrid will not be identical to the parent. All of this may lead one to believe that seedlings resulting from cross-breeds or hybrid crosses are worthless. This is far from the truth for most of the cultivars in use today originated in this manner. The great caution that must be exercised is to discard the inferior and keep only the equal or superior. Of equal importance, the parent cultivar name should *not* be applied to any of the seedlings produced from it. In other words, and I think it safe to say this, no cultivar will produce seedlings identical to it. Therefore unless the cultivar is reproduced by other than sexual means, the cultivar or variety name can not be attached to it.

SEED COLLECTION AND STORAGE

Producing seedlings starts with the collection of the seed itself. We maintain many stock plants from which seeds are collected. We also purchase seed from reliable collectors and accept seed from those who are interested in having seedlings produced from seed which they themselves have collected. Collection begins in the Northeast U. S. generally in September-October after the first fall frost. The seed pods then have turned from green to brown and have just about started to crack open. Timing is important since a lot of valuable seed can be lost if the pods open too widely before collection. The pods are picked carefully and placed in clean separate containers and labeled as to name, location and date. Cleaning is a tedious job. When distance or time are factors in the collection phase, we sometimes collect pods that are still green or have not cracked open sufficiently for easy extraction of the seeds. These green pods are placed in shallow cartons or flats and placed in the greenhouse. Care must be taken that no direct moisture falls on the pods. We have pipe framed greenhouses and so can place the cartons or flats up high where they will get plenty of light, heat and no direct moisture. This is generally sufficient to get the pods to open up. On rare occasions we place the pods outside on sunny days when the temperature is below freezing and in a position sheltered from wind. This often helps crack the pods but sometimes they have to be gently crushed to extract the seeds. Leach states seed may be collected in August, oven dried for 3 days at 100° F, extracted and sown immediately, with good germination. (2)

The actual cleaning is done with small sifters or screens. We have 6 of these each with different mesh screens. The seeds are run through these sifters starting first with the widest mesh and then successively down the line. The number of siftings depends on the size of the seed and the amount of dust present. When the seeds have been thoroughly cleaned they are placed in clearly identified screw top glass tubes or jars with caps screwed on tightly and stored in a refrigerator. Generally best germination occurs with current years crop but we have been successful with seeds up to 2 or sometimes 3 years old.

MEDIA FOR GERMINATION

All of our broadleaf evergreens and deciduous Azaleas are sown in flats. We used to follow a rather exacting procedure in preparing our seed flats. We were aware that seeds sown in sphagnum germinate very well but we determined subsequent growth would be restricted unless nutrients were later added. A fair percentage of our flats are sold throughout the summer and fall and even into winter when customers find they have some spare greenhouse space that they want to utilize profitably. The combination germinating-growing medium we used permitted us to sell or transplant a strong healthy growing seedling without any subsequent fertilization rather than one that has germinated and then marks time until transplanting. The first step in preparation was a layer of coarse peat on the bottom of the flat. This was leveled and lightly tamped and a tablespoon of Agrinite sprinkled evenly over the entire flat. Next came a layer of growing medium which for us is or is supposed to be ⅓ Birdsboro silt loam which has been treated with Methyl Bromide at the rate of 2 lbs. per 100 sq. ft. (approximately 50 cu. ft.), ⅓ granulated sphagnum peatmoss and ⅓ fine horticultural grade Perlite. However we most often wind up with more peat and perlite than soil, perhaps 20/40/40 rates in the order previously given. Various combinations, even pure peat and/or pure leaf mold can be used. The flat was filled to about full and the medium settled, especially around the edges, and then leveled to about ¼ inch from the top. Over this was screened through a ¼ inch mesh screen more growing medium to a depth of about ½ inch. This was leveled and then firmed in by pressing it down with a broad flat stick. When finished the medium was just below the rim of the flat on the edges and mounted up about ¼ inch toward the center. The next step was to screen a thin layer of dry German peatmoss over the medium. Using a 12 x 12 mesh screen the dust was first removed and discarded. The remaining peat was then gently forced through the screen by rubbing. This formed a very nice spongy surface to accept the seeds.

That was how we used to do it. What a lot of work! Our medium now is simply pure Wisconsin milled sphagnum moss which in the trade is called 'Nodampoff'. It comes in 8 lb., 2 bushel sacks. A sack fills about 7 of our shallow flats for a price per flat of approximately 50c, labor and flat price excluded. Our flats are still 12 x 19 but only half as deep (1¾") as a standard flat. This saves 50% on medium cost and we find it completely satisfactory.

The moss it moistened with water to the point where if squeezed hard in the hand it should drip only slightly. It is then very firmly packed into the flat taking great care that there are no air pockets of 'soft spots'. A stick the width of the flat and about 2-3 inches wide is used to press the moss in. The fingers are used around the outer edges of the flat. Care is taken to see that moss level at the center of the flat is higher than around the edges, sort of gently mounded. The first two years that we used milled sphagnum in shallow flats we used Peters soluble liquid fertilizer 20-20-20 and had to irrigate rather frequently. This year in our second sowing the flats purchased were inadvertently deeper by about ¼ in. We found the seedlings grew twice as large without any fertilization whatsoever and required less frequent irrigation. We are wondering if and how the extra ¼″made the difference.

SOWING THE SEED

Some weeks prior to anticipated sowing date we run germination tests. This is very important since it dictates the thickness of subsequent sowing. We strive to produce in a 12 by 19 inch flat approximately 300 to 500 seedlings. The number is determineded by the ultimate size the seedlings will obtain prior to the first transplanting. The larger leaved sorts are generally limited to 300 to 400 and the smaller leaved sorts to 400 to 500. Some exceptionally fine seeds are difficult to manage even though we premix these small seeds with extremely fine particles of sand. This acts as a carrier or in other words dilutes the amount of seeds in the sowers hand or vibrator if you use one. We do not. Dad is the sowing expert and does a remarkable job in getting just the right amount of seed in a flat using the index and middle finger of his hand. The seed is caused to a run down the little valley formed by the two fingers by a sweeping shaking motion of the hand. Several passes over the flat are used in preference to trying to get an almost impossible even sowing with one attempt. Even so sometimes with the tiny seed sorts we'll wind up with as many as 600 or 700 seedlings in a flat. The seeds are gently pressed into the surface using a broad flat dry stick, again the width of the flat and 2-3″ wide. At this time the flats are watered with Morsodren (¼ tsp. per gal.). We use a small watering can with a fine rose and go over the flat at least two or three times to assure a thorough soaking. Seed can also be sown in outdoor frames in late spring but since one has very little control over the seed's environment during germination we do not follow this practice. The time to sow will depend largely upon your own schedule. We prefer to start transplanting about the first of April so that the transplanted seedlings can be grown outdoors through the summer and be of sufficient size and vigor that they will be able to remain outdoors the next winter with protection. I will explain that a bit later. We therefore start first sowings in mid-December filling up the space available. A second sowing is made in March generally for summer and fall sale.

GERMINATION AND CARE

The finished flats are placed in deep benches in the greenhouse and covered with glass sash or clear polyethylene. The poly is about 5″ above the surface of the flat. The greenhouse is covered with 6 mil polyethylene and 52% polypropylene shading. The shading is removed in January or February. We try to maintain 70 degree day and 60 degree night temperatures in the house while temperatures in the germination bench run about 75 to 80 degrees. When we used sashes these were lifted each morning to remove condensation which might cause drip spots. If the house temperature was too low this was delayed to later in the day. This we called dripping the sashes. Now with polyethylene cover we do the same except that the sections of poly are lifted instead of the sashes. The poly is fastened to the bench side at the rear. In the front it is allowed to hang over and weighted with 1″ x 2″ wooden strips. Each section is 10′ long and overlaps at the edges. The strips can be hung on the greenhouse rafters when desired to permit easy access and working in the bench and also to ventilate. At this time the flats are checked and watered if necessary using a Fogg-It nozzle on the end of the hose. Germination occurs in about two to four weeks depending on the subject. Now comes a critical period when the germinated seedlings are given a little more air each day. This continues until it is determined that the poly can be left up all day, however it is generally put down again at night for the next few days especially on real cold nights when house temperatures can not be maintained. After a number of days of this treatment the flats are removed from the case, the poly removed and, using wooden stringers over the benches, the flats are placed on top of the benches where they will be subject to more air circulation and more light. We continue using the Fogg-It nozzle for watering.

Greenhouse ventilation is accomplished using the fan and perforated poly tube system. The system is operated every day if possible to effect a complete change of air. This reduces the chance for occurance of *Botrytis* Leaf Blight. When blight spots are noticed we dust them lightly with Fermate using a small hand duster. As a precaution the entire house is lightly dusted occasionally. The whole process from sowing to transplanting takes from three to four months although some sorts could be transplanted earlier if necessary. Broadleaf evergreens in general are responsive to photo period treatments and we have treated some of the very slow growing seedlings like *Kalmia latifolia, R. keiskei, R. racemosum, R. smirnowi,* etc., to hasten growth so that they could be transplanted along with the others.

TRANSPLANTING

Transplanting starts usually in late April or early May. We try to get it all done in a matter of 4 to 6 weeks if possible. The earlier the better even though some of the tiny seedlings are hard to handle. Women and girls are exceptionally adept at handling the transplanting and have the patience required for the job. At the time of pricking off the seedlings are graded and planted in the same sized flats (12″ x 19″) but 3″ deep. The smaller ones can be spaced 70 to a flat, the larger ones 40. We find potting fits our program much better however and so the graded seedlings are potted into 2¼″ Jiffy pots and also placed in flats, 40 per flat. (Medium used is that discussed earlier.) The finished flats are placed in a heated mist house where they receive intermittent mist as required. Temperatures remain about the same — about 70/60.

SUBSEQUENT CARE

After about two to three weeks they will have sufficient root attachment. After all danger of frost is past they are removed to Saran or poly propylene, the latter preferred, covered houses with about 50% shade where they are grown on until sold or are again transplanted. Prior to first fall frost these houses are covered with 6 mil white polyethelene which stays on until the last spring frost. These houses are simple but practical. Our first five were inverted 'V' or some say 'A' frame although we do not have the cross member. The bars are nailed to railroad ties laid on the ground and spiked together at the ends. This is classified as a temporary structure which is quite important in the urban areas where growers are confronted with strict building codes. They can be made any length. We chose 99′ to accommodate the commercially available 100′ lengths of poly. However new tapes and adhesives or a generous overlap make any length desired practical as so dramatically pointed out by Dick Vanderbilt last year in Newport. (3) A 13′ width is working well for us. We now use ¾″ EMT or thin wall conduit, with 2 10′ lengths formed into a bow and fastened at the top. The material cost is slightly more than wood, considerably less than pipe and a lot easier to erect.

Irrigation is accomplished with 10 Buckner Midget Rotary Sprinklers #1124-1 suspended from an overhead main. The water dispersion and rate of application are almost perfect. We fertilize with Peters Soluble 21-7-7 and 20-20-20 intermittently using a GEWA proportioner and a hose. Fertilization can be accomplished through the irrigation or by dry broadcasting. Seedlings are ready for bedding or canning in one year. If put in larger pots or spaced more widely in flats they could stay 2 years in the poly houses, then transplanted, even directly to the field.

I won't go into the growing on phase as this would exceed my time limit and my topic assignment which is "propagation". I believe I have said more than Zo did in 1954. That in itself is an accomplishment. I hope it has been said as well and is as meaningful.

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MODERATOR STEAVENSON: Our final discussion for this morning's session will be presented by Mr. Loy Shreve, who is a guest of the Society. Mr. Shreve is from Manhattan, Kansas, and will discuss "Some Effects of Gibberellic Acid on Year-Old Pecan Seedlings".

SOME EFFECTS OF GIBBERELLIC ACID ON YEAR-OLD PECAN SEEDLINGS[1]

BY LOY W. SHREVE AND RONALD W. CAMPBELL[2]

Pecan seedlings may require several growing seasons to reach a size suitable to graft or bud. Reducing that time would reduce production costs. Also, pecan growers who propagate their own trees could have producing trees sooner.

Gibberellic acid applications increased the height of one-year seedling yellow poplar, sweet gum, cherrybark oak, willow oak, and southern red oak (Nelson, 1957). GA_3 increased stem elongation of newly germinated pecan seedlings grown under greenhouse conditions (Martin and Wiggins, 1961). GA_3 treated black walnut, willow oak, and loblolly pine seedlings were 40% taller and twice as thick as untreated seedlings (U.S.D.A., 1958).

This study attempted to determine: 1. if field applications of GA_3 increased pecan seedling growth for budding and grafting earlier than untreated pecan seedlings; 2. if time of application affected response; and 3. response of pecan seedlings to repeated GA_3 treatments.

MATERIALS AND METHODS

Stratified northern hardy pecan seed was planted in a sandy loam soil at the Ashland Horticultural Farm near Manhattan, Kansas, in April, 1965. Seeds were planted six inches apart in three rows spaced four feet apart.
Seedlings were weeded and irrigated as needed. Twenty-four plots each containing nine seedling pecan trees were used. Ten unsprayed control seedlings separated sprayed plots. Five seedlings in each of the 24 plots were sprayed June 20, 1966, with an aqueous solution of 5,000 ppm GA_3. Each sprayed tree in each treated plot was separated from the other treated trees by an unsprayed guard tree.

Sixty trees in twelve untreated plots, laid out as described above, were sprayed July 20. Sixty trees sprayed June 20, received a second application of GA_3 at 5,000 ppm July 20.

Spray applications were made with a hand operated compressed air sprayer. Three drops of a surfacant, Tween 20, was added to each 135 ml. of spray. The pH of the spray solution was 3.2. Plants were sprayed to run off. Excessive dam-

[1]Contribution No 418, Department of Horticulture and Forestry, Kansas Agricultural Experiment Station, Manhattan, Kansas

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age from spray drift was prevented by covering seedlings with a polyethylene bag and inserting the spray nozzle into the bag.

A side dressing of 20-10-5 fertilizer at 350 pounds per acre was applied August 20, 1966, to all seedlings in uniform eight-inch bands on each side of the row just before irrigating.

Twenty trees selected at random from groups treated once in June and in July and others sprayed twice were dug and prepared in early December and prepared for study, as were 118 unsprayed control trees. Measurements recorded included stem and root length, collar and stem diameter four inches above the collar. All samples were cut to approximately half inch pieces and oven dried ten days at 70°C. Data then collected included dry weights of stems, roots and entire plants. The ratio of dry weights of stem: root was calculated. Analysis of variance was calculated for each value obtained, and effects of treatments were compared by the Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Table 1 shows response in growth of pecan seedlings to spray applications of GA_3 at 5,000 ppm. Comparisons can be made among trees sprayed in June or in July and those sprayed both months.

Seedlings sprayed with GA_3 in July had longer stems, greater stem diameters and heavier stems than controls. However, average dry weights of roots and root length were less than for control trees. The stem: root ratio was greater for sprayed trees than for controls while the average collar diameters and total dry weights did not differ significantly.

The same pattern was repeated essentially for trees receiving two sprays except that differences were greater, as shown by significance at the 1% level and a much greater stem: root ratio.

Cumulative effects of the two GA_3 sprays gave significantly longer stems, greater stem dry weights, and lighter roots than trees sprayed only once in June or July (Table 11). Also, trees sprayed twice had significantly larger stem diameters than June sprayed trees and significantly greater stem: root ratios than seedlings sprayed only once in June or July.

The only significant difference between trees sprayed only in June or only in July was in stem: root ratio, which was larger for July sprayed trees.

Date-of-spraying differences probably resulted from the amount of GA_3 that penetrated into leaves of trees treated later. Both temperature (Van Overbeek, 1956) and surface area treated (Sargent, 1965) apparently affect the penetration into leaves. Average high temperature June 15 to 25 was just above 85°F. Average high temperature July 15 to 25 was nearly 94°F. Those two factors may also account for differences in response between trees sprayed twice and those sprayed once in June or July.

Table I Some effects on growth of year-old pecan seedling trees from aqueous sprays of GA_3 at 5,000 ppm in 1966

		Mean Measurements, inches				Mean Weights, grams			
Date treated		Stem length	Root length	Collar diameter	Stem diam 4 in above collar	dry wt Stem	dry wt Root	dry wt Total	Ratio dry wt stem root
6/20/66	a.	17.930	18.952	.388	.333	11.894	25.868	37.761	.544
		**	ns	ns	ns	*	*	ns	**
	b.	11.180	21.280	.441	.295	8.450	36.342	44.788	.238
7/20/66	a.	21.515	20.280	.437	.388	14.927	15.245	30.172	1.058
		**	*	ns	**	**	**	ns	**
		9.700	24.674	.415	.268	5.891	33.011	38.953	.182
6/20/66	a.	27.833	21.718	.442	.411	22.947	11.276	34.223	1.983
and		**	ns	ns	**	**	**	ns	**
7/20/66	b.	11.180	21.280	.441	.295	8.450	36.342	44.788	.238

(a) treated seedlings
(b) control seedlings

* significant at 5%
** significant at 1%

ns non-significant at 5%

Table 2 Effects of spray applications of 5,000 ppm GA_3 on growth and development of year-old pecan seedlings.

	Mean measurements, inches				Mean weights, grams			
Date treated	Stem length	Root length	Collar diameter	Stem diam 4 in above collar	Stem dry wt	Root dry wt	Total dry wt	Ratio dry wt stem root
6/20/66	17.930a	18.952a	.388a	.333a	11.894a	25.868a	37.761a	.544
7/20/66	21.515a	20.280a	.437a	.388ab	14.927a	15.245a	30.172a	1.058
6/20/66 and 7/20/66	27.833b	21.718a	.442a	.411b	22.947b	11.276b	34.223a	1.983

Values with the same letter are not significantly different at 5%
Values with unlike or no letters differ significantly at 5%

This study generally confirms findings of Martin and Wiggins (1961) with one exception. They reported only limited growth of pecan seedlings over 51 days of growth regardless of concentration used or number of spray applications. We found repeated application of GA_3 increased stem growth of year old pecan seedlings. They found that increasing soaking time of pecan seeds with GA_3 from 12 to 192 hours reduced root dry weight and total dry weight and total dry weight of seedlings germinated.

Seedlings sprayed in June were larger than untreated trees when both groups were sprayed in July. The greater surface area of seedlings treated in June allowed them to receive more spray solution and therefore a higher concentration of GA_3 which apparently increased stem length and dry stem: dry root ratio over trees sprayed only in July.

Mango seedling stocks sprayed a second and third time with GA_3 responded with stem elongation within a month after each treatment and had longer stems and larger stem diameters than trees treated once (Thomas et al., 1963). Three applications of GA_3 to black walnut seedlings caused them to produce several seasons' growth in one year (Marth and Mitchell, 1961). Repeated spraying of roses with GA_3 increased stem length over one treatment (Mastaterz, 1965). Supplemental spraying belladonna with GA_3 doubled stem height and reduced root dry weight. However, stem dry weight was not affected (Kuskova, 1965).

Increased stem: root ratio from greater concentrations of GA_3 probably results from increased stem growth at the expense of root development. Halevy et al. (1964) found that the effect of GA_3 on translocation of assimulates is to increase the mobilization of stored materials and to enhance redistribution toward stem tips. Nanda and Purohit (1965) have reported that increased growth in *Salmalia malabarica* caused by gibberellin treatment probably results from mobilizing stored food so it becomes readily available for growth extension.

SUMMARY

Field application of GA_3 at 5,000 ppm in July or in June and July to year-old pecan seedlings significantly increased stem diameter. Stem diameters were less on the seedlings sprayed in June only. However, the diameter increase was enough in both cases to improve suitability of seedlings for budding and grafting.

Time of treatment is a factor in seedling response to GA_3. Seedlings treated in July had a significantly higher dry stem: dry root ratio than those treated in June.

A second application of 5,000 ppm GA_3 in July to seedlings previously treated in June gave significant increases over other treatments in stem length, dry stem: dry root ratio, and stem dry weight. Root dry weight was significantly less than

root dry weight of June sprayed seedlings and those sprayed in July only. Stem diameter was significantly larger than for trees treated only in June but not significantly different from stem diameters of trees treated only in July.

In this study, GA_3 reduced root length of seedlings when sprayed in July only. Additional research is needed to determine the ideal combinations of time, treatments, and concentrations of GA_3 to optimize benefits to growers. Also, other gibberellins (Van Overbeek, 1966) may hold promise in such research.

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MODERATOR STEAVENSON: We will now have time for questions dealing with the previous three papers.

BEN DAVIS, II: What type of gibberellin did you use? Who makes it and where can it be obtained?

LOY SHREVE: I used GA_3 and it was supplied by Merck Company. It was a 90% preparation. The "3" refers to the type of GA that I used. There are some twelve or thirteen different types of gibberellic acid.

CHARLES SCHEER: I would like to ask Mr. Bedger how much water was placed on top of the Vapam and what was the rate that you used?

RICHARD BEDGER: We applied Vapam at approximately sixty gallons per acre. The water seal was formed by making three passes of the sprayer which puts on about a quarter of an inch of water or until you form a type of crust on the soil.

RICHARD JAYNES: I would like to ask Pete Vermeulen if he ever stratifies *Kalmia latifolia* seed and what does he consider to be a normal percent germination?

PETE VERMEULEN: No, we do not stratify *Kalmia latifolia* seed. I don't really have an answer for the percent of germination. We use a given volume of seed per flat and we do not really have an actual count of the number of seeds in that volume. The volume used is based on past experience.

JOHN VERMEULEN: It is very difficult to count the seeds. You may get as high as 500 to 1000 seedlings from 1/16 of a teaspoonful of seed.

MARTIN USREY: I would like to ask Mr. Bedger if he has made any comparisons between Vapam and methyl bromide for soil sterilization?

RICHARD BEDGER: It's not that we prefer the Vapam because actually I would prefer to use methyl bromide. Unfortunately, when you treat some twenty acres of seed beds and particularly the way we prepare our seed beds, the methyl bromide just is not feasible to use.

MODERATOR STEAVENSON: I would like to ask Mr. Bedger if he is using the Vapam primarily for weed control, or is he also using it for the control of nematodes and insects?

RICHARD BEDGER: All of the soil fumigants give us better plant growth. This is particularly true of our rooted cuttings of azaleas, rhododendrons, and *Ilex* species. We do get some weed control, it's not 100%, but it does give us quite a bit of help in the early spring. We get pretty good control until May. I feel the fumigant helps control the nematodes and some of the other soil organisms.

ARIE RADDER: We use Mylone and find it is easier to apply than Vapam.

JOHN KNAPP: I'd like to ask Mr. Bedger what type of jars does he use for seed storage?

RICHARD BEDGER: We use five gallon jugs; the same type as is used on water coolers. The jugs are filled with seed and then we drive in a cork. We do not wax in the cork as is done by some of the state nurseries. We have stored Red Pine up to ten years in this type of a jug. The temperature in our refrigerator where the seed is stored runs about 34° to 36°F. Bruce Briggs at Washington State Research Center did some work on the time of transplanting rhododendron and azalea seedlings. He found that just as soon as you could obtain the true leaves that this was the best time for transplanting; there was no shock or setback. He transplanted seedlings every two weeks for several months. He found that those seedlings which were left in the seed flat for six weeks, as compared to seedlings which were transplanted as soon as the first true leaves appeared, were only about one third as large as the early transplanted seedlings.

THURSDAY AFTERNOON SESSION

November 30, 1967

The afternoon session convened at 1:30 p.m. and was concerned with the propagation of specific plant materials. Dr. H. B. Tukey, Jr. served as moderator.

MODERATOR TUKEY: The first speaker on the program this afternoon is Andy Klapis of the Kansas City School Department, Kansas City, Missouri.

SEVEN YEARS WITH VIBURNUMS FROM SOFTWOODS

ANDREW T. KLAPIS JR.
Kansas City School District
Kansas City, Mo.

In a brief tour around my postage stamp backyard last week, I counted seven different varieties of viburnum. All these plants have been there for at least five years through temperatures ranging from 15° below zero to 110° above; and all are thriving and healthy. Because of their hardiness and versatility, viburnums are held in high esteem in our rigorous plains country. When I go East or South, my mouth waters and I'm envious of the beautiful broadleaf material which the nurseryman can grow and market with impunity. However, all of us can grow many of the viburnums, and experiences which we have had in propagating these plants both at Raytown Nursery and at the School Gardens of the Kansas City Missouri School District is the tale I wish to tell.

From the accompanying table you can see that initially the number and variety of the cuttings stuck was very limited. In 1958 plant propagation was a brand new field to me, and Ben Asjes gave me a list of material he wanted propagated, and off I went gungho with high hopes and "rots o' ruck". Well you know what happened. We used perlite for the rooting medium and Rootone as the hormone. We got a fair strike for such a haphazard operation, but luck played a very important role.

As we went along through 1959, 1960 and 1961, you'll notice the varieties and numbers change very little. Since our needs in a small landscape nursery were modest, the number of cuttings stuck was low. In 1962 and for several ensuing years, we widened the number of varieties considerably, although the number of cuttings of a given variety stayed relatively static. Due to the low number of cuttings per variety, this material may be of limited use to the big producer. However, some of the information concerning rooting mediums and overwintering may be of some use.

The system used for making viburnum cuttings was intermittent mist with a 12 minute tork repeating timer which was regulated for frequency according to weather conditions. The mist house was outdoors, ten feet wide and 30 feet long, paved with gravel and tiled to ensure good drainage. This area is enclosed on four sides by wooden frame six feet high and covered with clear 4 mil polyethylene film. The top is open but in the past two years has been covered with saran screen which gives about 1/3 shade. The cuttings were stuck in tomato lug boxes filled with rooting medium to a depth of 6 inches. Rooting hormones used varied from Rootone to Jiffy-Gro.

The business of rooting mediums seemed to have a good deal of bearing on the survival of the cuttings after they had rooted. In 1958 when the rooting medium was perlite, we potted off the rooted cuttings and plunged them in sand in cold frames outdoors. During the ensuing fall and winter, 90% of them died. Some of this was freeze damage, but by far the largest part of the mortality couldn't be explained. This we wrote off to experience; but we didn't learn much, so in 1959 we repeated our operation with largely the same results. In talking with other nursery men in the area, I somehow got the idea of trying some different rooting media.

In 1962 we tried a mixture of peat and sand, peat and perlite and a third medium of long fibered sphagnum moss. Out of this bit of experimentation with viburnums we drew the conclusion that the long fibered sphagnum moss had very definitely proved to be the best medium in our hands. The root systems were larger and were distributed all up and down the stem of the cutting. Even though the moss tended to stay very wet under the mist, the cuttings stayed in good shape.

About this time something else occurred which led us to another discovery. Several flats of rooted viburnum cuttings in sphagnum moss had been placed under a bench in our cool greenhouse until I could get around to potting them off. This was around September 15 and of course, we got busy and when the flats were discovered, it was March. The flats had gotten some water through the winter but I don't believe any of it was on purpose. Now why do you suppose that those rooted cuttings survived almost 100% and came through without fungus problems or any other problems for that matter? This is what we wanted to know and tried to find out. Apparently the light watering which they received when the herbaceous plants on the bench above them were watered was enough to keep them in good condition throughout the winter. Also the anti-fungus entity which is apparently present in sphagnum moss kept them in good shape. To finish up this story; we potted them off, put them out in cold frames (this was about March 25) and they broke dormancy in the normal way and kept right on going.

Needless to say, we used long fibered sphagnum moss as the rooting medium for viburnum during the next season. We weren't convinced about the overwintering procedure, so we split the viburnum cuttings putting half under the greenhouse bench in flats and potting off the other half—but leaving them in the cool greenhouse to overwinter in pots. Results: the group left in the original flats were potted off in late March with 95% breaking dormancy and growing. Those potted off in the fall and overwintered in the cool greenhouse only had about a 15% survival. One other conclusion we drew from this trial by error procedure was that the flats of rooted viburnum cuttings taken from the mist house must be kept dry. The winter before when the flats had stayed under the bench forgotten and neglected showed better results than when we checked the flats each day and decided they hadn't had quite enough water. The conclusion which we drew from this was that these flats of rooted viburnum cuttings should be run dry almost to the point of dessication when they are overwintered in a cool greenhouse.

In the years since 1962 we have followed this procedure pretty much at Raytown Nursery and at the Gardens of the School District of Kansas City, Missouri for viburnum cuttings:

TIME OF YEAR TAKEN—July and August

SIZE OF CUTTINGS—Varies from 2½ to 5 inches

TYPE SYSTEM—Intermittent mist, enclosed with polyethelene and ⅓ shade on top. Mist heads are on 3 foot centers and pipes are 3 feet apart.

MEDIUM—Tomato lug flats are filled to 6″ depth with long-fibered sphagnum moss.

HORMONE—Indole Butyric Acid (Hormodin #3, IBA 20 mg/gm of talc, Jiffy-Gro, or Chloromone). Cuttings of most varieties were wounded.

OVERWINTERING—Flats are taken from mist and placed under bench in a cool greenhouse (55-60 degrees). These should be placed so they get some direct sun for part of the day.

WATERING—As lightly as possible during winter months, just enough to prevent dessication of the cuttings.

POTTING—In late March or early April.

One of the continuing problems with this method of overwintering viburnum cuttings is the onset of fungus or bacterial disease if the flats are kept too wet. To combat this in the past two years we have been using a drench combining Dexon and Terachlor*. So far this product has done a good job of prophylaxis.

*Root & Crown Rot Control — Patterson Chemical Co. K.C., Mo.

Active ingredients	
P-Dimethylaminobenzenediazo sodium sulfonate	5.0%
pentachloronitrobenzene (PCNB)	69.0%
Inert Ingredients	26.0%
	100.0%

Over a seven year period from 1959 through 1966 we have worked with viburnum softwood cuttings. Several conclusions were reached concerning the success of propagating these plants in our hands:

1. Indole Butyric acid in several concentrations was an adequate hormone.
2. A specific rooting medium—long fibered sphagnum moss—gave significantly better rooting, qualitatively and quantitatively.
3. Overwintering rooted cuttings in cold greenhouse in the original flats is necessary to assure survival of rooted cuttings.

VIBURNUMS FROM SOFTWOOD CUTTINGS
A SEVEN YEAR RESUME

Plant	Number Of Cuttings Stuck	Date Stuck	Hormone Used	Medium	Cuttings* Rooted
		1958			
Viburnum burkwoodi	120	6-27-58	Rootone	Perlite	84
Viburnum carlesi	100	6-27-58	Rootone	Perlite	69
		1959			
Viburnum burkwoodi	270	7-11-59	Rootone	Perlite	186
Viburnum carlesi	120	7-11-59	Rootone	Perlite	87
Viburnum juddi	60	7-11-59	Rootone	Perlite	28
		1960			
Viburnum burkwoodi	215	7-5-60	Hormodin #3	Peatmoss	195
Viburnum carlesi	150	7-5-60	Hormodin #3	Peatmoss	93
Viburnum rhytidophyllum	70	7-5-60	Hormodin #3	Peatmoss	58
		1961			
Viburnum burkwoodi	100	7-1-61	Hormodin #2	Perlite	72
Viburnum juddi	90	7-7-61	Hormodin #2	Perlite	46
Viburnum rhytidophyllum	60	7-7-61	Hormodin #2	Perlite	47
		1962			
Viburnum burkwoodi	125	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	100
Viburnum carlesi	100	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	100
Viburnum dentatum	100	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	100
Viburnum juddi	100	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	72
Viburnum lantana	200	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	134

(*Continued on next page*)

*All the totals in the last column labeled "cutting's rooted" indicate the number of cuttings potted off from flats. Prior to 1962 this was done in the fall with poor overwintering results and a high percentage of plants failed to break dormancy. After 1962 we potted off the cuttings in late March and early April and the plants broke dormancy and started growing normally.

VIBURNUMS FROM SOFTWOOD CUTTINGS
A SEVEN YEAR RESUME (continued)

Plant	Number Of Cuttings Stuck	Date Stuck	Hormone Used	Medium	Cuttings* Rooted
Viburnum lentago	50	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	27
Viburnum rhytidophylloides	200	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	167
Viburnum rhytidophyllum	110	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	96
Viburnum willowwood	100	7-13-62	Chloromone 1:1 Dilution	Long Fibered Sphagnum Moss	77
		1963			
Viburnum carlesi	310	7-16-63	IBA 12 MG/GM	Sphagnum Moss	277
Viburnum rhytidophylloides	77	8-22-62	IBA 12 MG/GM	Sphagnum Moss	69
Viburnum rhytidophylloides	170	9-10-63	Hormodin #3	Sphagnum Moss	157
Viburnum setigerum	64	6-15-63	IBA 12 MG/GM	Sphagnum Moss	58
		1964			
Viburnum dentatum	56	7-15-64	IBA 12 MG/GM	Sphagnum Moss	42
Viburnum setigerum	115	7-15-64	IBA 12 MG/GM	Sphagnum Moss	101
Viburnum rhytidophylloides	102	7-15-64	IBA 12 MG/GM	Sphagnum Moss	77
		1965			
Viburnum dentatum	115	8-19-65	IBA 20 MG/GM	Sphagnum Moss	111
Viburnum lentago	65	8-6-65	IBA 20 MG/GM	Sphagnum Moss	49
Viburnum rhytidocarpum	90	7-9-65	IBA 20 MG/GM	Sphagnum Moss	69
Viburnum sargenti	55	8-19-65	IBA 20 MG/GM	Sphagnum Moss	51
Viburnum setigerum	97	8-19-65	IBA 20 MG/GM	Sphagnum Moss	83
Viburnum tomentosum	110	8-5-65	Jiffy Gro 10:1 Dilution	Sphagnum Moss	81
Viburnum willowwood	52	7-8-65	IBA 20 MG/GM	Sphagnum Moss	46
		1966			
Viburnum carlesi	57	8-19-66	Jiffy Gro 10:1 Dilution	Sphaghum Moss	15
Viburnum dentatum	152	8-16-66	Jiffy Gro 10:1 Dilution	Sphagnum Moss	125
Viburnum rhytidophyllum	55	8-11-66	Jiffy Gro 10:1 Dilution	Sphagnum Moss	25
Vibuurnum rhytidophylloides	60	8-16-66	Jiffy Gro 10:1 Dilution	Sphagnum Moss	16
Viburnum setigerum	76	8-15-66	Jiffy Gro 10:1 Dilution	Sphagnum Moss	47
Viburnum willowwood	70	8-16-66	Jiffy Gro 10:1 Dilution	Sphagnum Moss	31
		1967			
Viburnum carlesi	390	7-20-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum dentatum	394	7-19-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum lantana	170	7-18-67	Jiffy Gro 10:1 Dilution	Sphagnum Moss	—

(*Continued on next page*)

*All the totals in the column labeled "cutting s rooted" indicate the number of cuttings potted off from flats. Prior to 1962 this was done in the fall with poor overwintering results and a high percentage of plants failed to break dormancy. After 1962 we potted off the cuttings in late March and early April and the plants broke dormancy and started growing normally.

VIBURNUMS FROM SOFTWOOD CUTTINGS
A SEVEN YEAR RESUME (continued)

Plant	Number Of Cuttings Stuck	Date Stuck	Hormone Used	Medium	Cuttings* Rooted
Viburnum lantana	147	6-21-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum lentago	100	7-17-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum prunifolium	140	7-17-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum rhytidophylloides	65	8-16-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum sieboldi	92	7-24-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum setigerum	124	7-28-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum tomentosum	352	7-19-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—

MODERATOR TUKEY: It is always a real pleasure to introduce one of the patriarchs of our Society and I have that pleasure right now. Mr. John Vermeulen will speak on the "Propagation of *Franklinia alatamaha* from Softwoods".

PROPAGATION OF FRANKLINIA ALATAMAHA FROM SOFTWOODS

JOHN VERMEULEN
John Vermeulen & Son, Inc.
Neshanic Station, New Jersey

It is fairly simple to grow *Franklinia alatamaha* from softwood. We take the cuttings in our area about the middle of July just before the new growth starts to get woody. We prefer the cuttings from older plants as these are more firm in texture. We therefore have a row of stock plants about 20 years old. They get a severe trimming every 3 years which makes for nice sturdy cuttings. We make our cuttings about 5 to 6 inches in length and take off all but 5 or 6 leaves which are cut in half.

The cuttings are stuck directly in 3″ peatpots in a rooting media consisting of 53 parts peatmoss, 17½ parts #1 Perlite, 17½ parts styrofoam, 9 parts fine sand, 3 parts soil, firmly packed. We put 28 pots in a regular greenhouse flat. The flat is placed outdoors in a mist frame which is covered with cloth giving about 20% shade. This cloth is placed at an angle about 4′ above the frame.

Intermittent mist is applied from about one hour after sunrise until about sunset. I cannot give you an exact timing for the mist as it depends mainly on weather conditions, but we use short periods at short intervals as this will keep the foliage cool.

VIBURNUMS FROM SOFTWOOD CUTTINGS
A SEVEN YEAR RESUME (continued)

Plant	Number Of Cuttings Stuck	Date Stuck	Hormone Used	Medium	Cuttings* Rooted
Viburnum lantana	147	6-21-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum lentago	100	7-17-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum prunifolium	140	7-17-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum rhytidophylloides	65	8-16-67	Jiffy Gro 10:1 Dilution	Milled Sphagnum	—
Viburnum seiboldi	92	7-24-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum setigerum	124	7-28-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—
Viburnum tomentosum	352	7-19-67	Jiffy Gro 10:1 Dilution	50% Peat 50% Perlite	—

MODERATOR TUKEY: It is always a real pleasure to introduce one of the patriarchs of our Society and I have that pleasure right now. Mr. John Vermeulen will speak on the "Propagation of *Franklinia alatamaha* from Softwoods".

PROPAGATION OF FRANKLINIA ALATAMAHA FROM SOFTWOODS

JOHN VERMEULEN
John Vermeulen & Son, Inc.
Neshanic Station, New Jersey

It is fairly simple to grow *Franklinia alatamaha* from softwood. We take the cuttings in our area about the middle of July just before the new growth starts to get woody. We prefer the cuttings from older plants as these are more firm in texture. We therefore have a row of stock plants about 20 years old. They get a severe trimming every 3 years which makes for nice sturdy cuttings. We make our cuttings about 5 to 6 inches in length and take off all but 5 or 6 leaves which are cut in half.

The cuttings are stuck directly in 3″ peatpots in a rooting media consisting of 53 parts peatmoss, 17½ parts #1 Perlite, 17½ parts styrofoam, 9 parts fine sand, 3 parts soil, firmly packed. We put 28 pots in a regular greenhouse flat. The flat is placed outdoors in a mist frame which is covered with cloth giving about 20% shade. This cloth is placed at an angle about 4′ above the frame.

Intermittent mist is applied from about one hour after sunrise until about sunset. I cannot give you an exact timing for the mist as it depends mainly on weather conditions, but we use short periods at short intervals as this will keep the foliage cool.

Complete rooting should take from 3 to 4 weeks, then misting is reduced. This is a must as the roots rot easily. After about 7 to 8 weeks the plants are just kept under shade. To overwinter in our area the plants are placed in a heated pit frame covered with opaque plastic. The white plastic keeps a more even temperature than clear plastic. Night temperature is kept at about 38 degrees.

MODERATOR TUKEY: Our third paper for this afternoon's session will be presented by Mr. Larry Carville of the Rhode Island Nurseries, in Newport, Rhode Island. He will speak on the "Propagation of Exbury Azaleas from Softwoods".

PROPAGATION OF KNAPHILL AZALEAS FROM SOFTWOODS

LARRY CARVILLE
Rhode Island Nurseries
Newport, Rhode Island

Without question, the most notable addition to the deciduous azaleas for colder climates during the last decade has been the introduction of the Knaphill Azaleas from England. This group of azaleas fills the needs of both the connoisseur and the grower in that these plants are vigorous in growth habit, offer exceptional color during the blooming season, and are dependably hardy in the northeast.

I propose to limit this paper in content since the material I am presenting results from experience and observations gained in growing Knaphill azaleas in the greater Hartford, Conn. area over an eight-year period. I do not propose to disagree with or dispute authorities in the horticultural field who have had vastly more extensive experience than I but rather submit to you for your consideration my personal experiences.

For the purpose of simplification I will refer to this group of deciduous azaleas as the Knaphill azaleas, but please realize that I include the Exbury azaleas as well. Perhaps I might touch briefly on their history so that we may share a common base of understanding. The Knaphill azaleas are predominately North American in specific origin in that six of the species involved in their breeding are native to this country, namely: *R. viscosum, R. nudiflorum, R. calendulaceum, R. speciosum, R. arborescens,* and *R. occidentale.* Although the Knaphill azaleas first began to appear in this country around 1950, their origin dates back as far as 1860 when Anthony Waterer began crossing the Ghent azaleas with the Chinese molle and the flame azaleas, *R. calendulaceum.* To these crosses were added additional hybrids, the Albican (*occidentale molle*) and the sweet azalea (*arborescens*). The Knaphill strain originated at Waterer's Knaphill Nursery but was further developed by Goldsworth Nursery; at Ilam Estate, Christchurch, New Zealand; and beginning in 1922 at Exbury by Lionel de Rothschild. This extensive and interrelated breeding therefore gives rise to four

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During the period that we have been growng the Knaphill hybrids, we have found them as a group to be completely winter hardy as well as tolerant of extremely dry summers. Although Lee (1) in his book on azaleas makes some rather definite zonal recommendations for growing these azaleas, I feel that they may be grown as far north as a line extending between Buffalo-Albany (N. Y.), Pittsfield-North Adams (Mass.), Concord (N. H.) to Augusta (Maine). There are of course exceptions both above and below this line, but generally speaking I would defend this as an arbitrary northern limit. More difficulty is encountered with these plants as we move south since they do not tolerate the extreme summer heat of the southern states. I would agree with Lee that probably Atlanta, Georgia, is the most southerly point at which they may be grown successfully.

Under normal growing conditions, we begin taking softwood cuttings in early June and have taken them as late as August 28th. We found that the optimum time for us to take cuttings of the Knaphill azaleas was a period between June 10th and June 15th when cuttings are still green, semi-soft but not sticky, and before apical buds are evident. Cuttings are collected early in the day, dipped briefly in a solution of Captan-Seven?Wiltpruf (2). drained, and stored in plastic bags in a cool, shaded area until stuck. In preparing our cuttings for the bench, lower foliage is stripped, the top is pinched and a light side wound is given where necessary. Cuttings are dipped in number three Hormodin and stuck in the beds. I prefer a medium of 100% European sphagnum peat which has been thoroughly shredded, soaked and treated with Aquagro. Intermittent mist is controlled with a time-clock applying an overhead misting spray for sixty seconds every six-and-one-half minutes. This interval is less frequent on cloudy days and is gradually discontinued after six weeks when rooting is apparent. We maintain a bed temperature of 70 degrees F. and have found this to be very beneficial since without heat, bed temperatures have sometimes dropped as low as 55 degrees F. in mid-July. Extreme temperature fluctuation has a delaying and often an inhibiting effect on rooting.

Cuttings are lifted from the propagating benches after eight weeks and flatted for growing on. Growth is continued under lights in the propagating house until Sept. 15th at which time the cuttings are placed in cold sash houses for the winter. Our normal flatting mix for rooted cuttings is pure peat taken out of the benches but we have had difficulty in wintering cuttings since they seemed to dry excessively in the sash storage. After experimenting with various mixes which included soil, perl-lome, vermiculite, sand, peat moss and fertilizer, we feel that a soil-peat-perl-lome mix is most satisfactory. (1-2-1 by volume.)

A recent method which we utilized is to plant rooted cuttings directly in prepared beds in the sash houses under controlled conditions of heat and light. A minimum night termperature of 50 F. is maintained initially and these plants make continual root development. The minimum temperature is increased to 60 F. on Feb. 1st and lights are turned on Feb. 18th.

Once cuttings have wintered their first winter and begin making new growth in early April (under normal storage conditions), they have passed the most critical period in their development. We have found that our most substantial losses occur in the period from rooting to outdoor bed planting. Unless cuttings make some new growth prior to the onset of cold weather, they are valueless by spring.

Cuttings are bedded out in prepared beds during late April. Fresh peat moss is thoroughly rototilled into a sandy loam planting mix which is then fertilized with a castor pumice-cotton seed meal-triple superphosphate material (at a rate of 5 lbs. per 100 sq. ft.) Cuttings are spaced six-by-six in the beds and immediately mulched with shredded sugar cane prior to shading with snow fence. Weeds have not been a serious problem in the beds with a mulch but we have used Vapam as a soil sterilant on an experiemental basis and have excellent weed control.

We pinch the plants at time of planting to induce multiple branching. If new growth is soft, we spray with Wiltpruf and have found this treatment to be beneficial. From time of transplanting until late fall, the plants receive no additional feeding and very little cultural care other than irrigation when necessary. Growth is continuous throughout the growing season and most plants make up into a 10″-12″ grade by early fall. We remove the snow fence shade in mid-August to allow plants a gradual hardening process.

When the ground is frozen, we apply a salt hay mulch over the bedded liners and the field-grown two-year-old plants. This mulch is left on the plants until mid-March and is removed before buds begin to break. Larger plants are grown in fully exposed areas, receive no additional mulch in the late fall, and have withstood the rigors of winters in the northeast.

To discourage damage by rabbits during the winter months and early spring, we spray all plants with a solution of Arasan 42-S(3) mixed with a spreader sticker. This spray is applied in late fall and remains effective throughout the winter. Temperature should be above 40 degrees F. when application is made to insure that spray material has an opportunity to dry during the day. Since we began using this repellent several years ago, we have encountered no damage from rabbits on any of our plants.

In closing, I would like to leave with you my personal selection of the outstanding varieties as I have observed them:

red: Krakatoa	yellow: Annabella
Gibraltar	Old Gold
orange: Ginger	white: Oxydol, Toucan
pink: Cecile	bi-color: Pavane
Sylphides	Marionette

(1.) Lee, Frederick P., *The Azalea Book,* 1965.

(2.)	Cutting dip: Wiltpurf	1 part to 20 parts water 2 TB/gal Sevin 50% WP 2 TB/gal Captan 50% WP
(3.)	Arasan 42-S	1 gal to 3 gal water 1 pint sticker/4 gal.

MODERATOR TUKEY: The three papers which have just been presented are now open for discussion.

CASE HOOGENDOORN: Did you try sand for the rooting of the viburnums?

ANDREW KLAPIS: Yes, we did try sand but we did not get as successful rooting as we did when we used sphagnum moss.

CASE HOOGENDOORN: In my experience it has been best to use a bed of about 8 inches of sand and a fog system and you'll get all of the varieties of viburnums to root and to root heavily.

ANDREW KLAPIS: Our problem has been overwintering the rooted cuttings. By rooting the cuttings in flats with sphagnum moss we have been able to overcome this problem.

JOERG LEISS: I would like to ask Mr. Carville if he dips the entire cutting into the Captan-Wiltpruf mixture and does this not clog the stomates on the leaves?

LARRY CARVILLE: Joerg, what we do is to make up a solution of one part Wiltpruf to twenty parts water, two tablespoons per gallon of Sevin (a 50% wettable powder) and two tablespoons per gallon of Captan (50% wettable powder). At the time we are making our cuttings we take this pail of cutting dip with us and take two or three handfuls of cuttings and plunge them completely into the pail of dip. The cuttings are then drained in an empty pail and finally transferred to polyethylene bags. We feel that the Wiltpruf maintains the turgent condition of the cuttings from the time they are taken until they reach the propagation house. We do not feel that there is any deleterious effect of clogging the pores.

MODERATOR TUKEY: We will now move into the second part of our program and the next speaker is Mr. John DeVisser from Rochester, New York. Mr. DeVisser will speak on "Viburnums from Softwoods".

VIBURNUMS FROM SOFTWOODS

JOHN DEVISSER
Rochester, New York

It is a great pleasure for me to be here this afternoon and to talk to you on the subject of viburnums. My father has been propagating now for well over 35 years. We propagate most plants including the shade and ornamental trees, evergreens, ground covers, broadleaf evergreens and a great amount of perennials. I cannot say that propagating viburnums is as easy as throwing them on the ground but I feel they are easy to root as it is to germinate tomato seeds. *Viburnum burkwoodi* and *Viburnum carlesi* are very easy to root. We try to take our cuttings normally about the end of June when the cuttings are long enough. This is normally when the second set of foliage is formed. The cuttings are normally four to five inches long. The cuttings are brought into the greenhouse, they are cleaned and dipped into hormone. Up to the last few years we had not used any hormone at all and have had excellent results. The process is quicker with the hormone. We have been using Hormodin #3 mixed with water. The cuttings are placed in a glass greenhouse shaded with lime. The ventilators and doors of the greenhouse are kept closed during the rooting period to keep it as tight as possible. The medium used is just plain sand. We use equal parts of concrete and mason sand. The cuttings are syringed lightly about three times a day. On warm days the walks are also watered down to keep the humidity as high as possible. We have had rooting in less than four weeks, particularly when we use the hormone. Ordinarily it is about an eight weeks process. The cuttings after rooting are potted in 2½ inch clay pots. We tried jiffy pots one year but this was not good for them. The root system stayed small and it seemed as though the pots absorbed the heat from the sun and did considerable damage. We use sterilized soil and mix it with sand and peat moss and vermiculite, if it is available. The pots are placed in a warm greenhouse to stimulate active growth before winter. They are then placed in a cool greenhouse, maintained at about 50°F, in late fall and kept there throughout the winter. About the middle of March a liquid fertilizer is applied and by the middle of June when they are ready to be set out they are at a height of about nine to ten inches. The cuttings are normally taken off of three-year-old plants. By carrying the cuttings in the greenhouse over winter we have very little loss.

MODERATOR TUKEY: The next talk will be presented by Dr. Richard Stadtherr from Louisiana State University, Baton Rouge, Louisiana. His subject is "*Magnolia grandiflora* by Cuttings".

MAGNOLIA GRANDIFLORA BY CUTTINGS

R. J. STADTHERR
Louisiana State University
Baton Rouge, Louisiana

Magnolia grandiflora, the Southern Magnolia, has been propagated usually from seeds; however, since cultivars are becoming more numerous, a vegetative method of propagation is needed. Graftage can be used; however, this increases production costs considerably. Thus, propagation by cuttings was investigated.

Enright (2) reported excellent rooting, using cuttings taken in late spring or early summer. Best results were obtained using a 10-second dip in a 20,000 ppm IBA solution with cuttings wounded basally on two sides. Cuttings taken in June and kept under intermittent mist averaged 84 to 88% rooted after 63 days in the bench.

March (3) reported that the cultivar, Freeman, was propagated by using semi-hardwood cuttings taken from juvenile plants. Hormodin #3 was used and cuttings were rooted in 8 weeks under mist.

Use of juvenile trees for cuttings was also reported by Curtis (1) who used hardwood cuttings taken in November. These cuttings from young, 4 to 6 foot trees, rooted readily when they were wounded and treated with Hormodin #3 and given bottom heat of 75 to 80°F. Watering was done by hand and was heavy, especially after cuttings were stuck.

Since procedures varied greatly, an experiment was begun in 1964 to determine the best method of propagating a selected clone by Robbins Nursery, Penderlea, N. C. This clone produces a narrow-pyramidal to columnar shaped tree. The ascending branches are filled with medium-sized light green leaves above with a dark brown tomentum beneath. The leaves are somewhat elliptical with slightly undulating margins and an acute point.

Cuttings were taken from about 10 to 12 foot trees in nursery rows. Cuttings had rooted well in some years but, generally, rooting percentages were very low. Current-season vegetative shoots were collected in mid-June, 1964, put in plastic bags, sprinkled and placed in a refrigerator at 40 to 45°F. until the cuttings were prepared for treatment.

Tip cuttings using the first five nodes, and leaf-bud cuttings from the 6, 7, 8 and 9th nodes were used for the mid-June and mid-July propagation dates. All cuttings were wounded heavily with two, 1 to 1-½ inch thin, longitudinal slices on the base of each cutting. These soft to semi-hardwood cuttings were 6 to 8 inches long. The bottom leaf was removed. The controls were soaked in distilled water for 80 seconds. Treated cuttings received a dip of 10, 20, 40, or 80 seconds in a 5,000 ppm IBA solution, which contained 50% alcohol. Five cuttings were used for each replication with four replications.

Intermittent mist, averaging 2 seconds on per minute, was employed during the first week after the cuttings were stuck. Misting began a half hour before sunrise and was terminated an hour after sunset. The misting interval, after the first week and throughout the remainder of the rooting period, was about 1.3 seconds on per minute. The medium was equal parts of German peat and coarse perlite. Bottom heat between 75 to 80°F. was used. The greenhouse was air-cooled with day temperatures averaging 75°F. with night temperatures in the sixties. The greenhouse was shaded, allowing about 60% of sunlight to enter.

Practically none of the June cuttings, which were very soft, rooted. Cuttings taken in July, August, and September rooted. For the July cuttings, which were taken July 15 and removed October 22, all treated ones rooted significantly better than the controls. The means for the 10, 20, 40, and 80 second dips in the IBA solution were: 90, 100, 100, and 85 percent respectively. The control mean was 15%. Rooting percentages in the leaf-bud cuttings were unsatisfactory commercially; thus, they were not continued in subsequent tests.

For the August 18 cuttings which were rated December 14, the same procedure was followed as in July. The means were for the 10, 20, 40, and 80 second dips in IBA solution: 100, 85, 75, and 35 percent respectively. The control percentage was 15 percent.

The mean average for the IBA treated cutting in September was 20%. The control cuttings had none which rooted. Since none of the treatments gave satisfactory rooting, no further dates were used and trials in subsequent years were limited to July and August.

The experiment was continued in 1965, using three treatments: a 10 second dip in a 5,000 ppm IBA solution, a 20 second dip in a 5,000 ppm IBA solution and the controls. The same procedures were followed as in 1964, except that 10 cuttings were used per replication. Cuttings were taken from trees about 15 to 20 feet high on July 15 and August 18. Means for the July date were 78% for the 10 second dip, 93% for the 20 second treatment, and 10% for the controls. The IBA treated cuttings rooted significantly better than the controls, both in numbers and in size of the root system. Means for the August cuttings were 85, 80, and 3 percent, again indicating significantly better rooting for the 5000 IBA treatment than the controls.

Cuttings were taken in 1966, but, due to power failures which occurred just after the cuttings were stuck, reduced rooting percentages which were below commercial acceptability resulted. The experiment was continued in 1967.

The 1967 cuttings were taken from young trees grown from the 1964 cuttings. They averaged about 5 feet high. Cuttings from a second clone "B" were also included. This clone has medium-large, dark, waxy green leaves above and a heavy, rusty brown tomentum beneath. The thick, oblong leaves with an acute tip have prominent veins and smooth margins. The trees are broad-pyramidal, having dense ascending branches. Trees flower when they are young, usually in mid-July and August. Bright red fruits, heavy with seeds, follow. Growth of the trees is fast, and young trees fill out well.

Procedures were varied only slightly in 1967. Once cuttings were stuck, a Captan drench, using 3 tablespoonfuls (50WP) in 4 gallons of water, was applied biweekly. Every four weeks a 20-20-20 soluble fertilizer was applied at the rate of 1 oz./7 gal. water. Several different treatments were used. These and the rooting percentages for the two clones are given in Table 1.

In the July trials all hormone treatments gave significantly higher rooting percentages than in the controls, as well as better root systems. The most initials and greatest branching of roots were seen in the IBA treatments. Although no significant differences were noted among growth-promoting treatments and the controls in clone "B" in August; nevertheless, in most cases, roots in the control were very small with usually only one intial.

Table 1 Rooting percentages for *Magnolia grandiflora* cuttings in 1967.

Treatment	Dip	Clone "A"		Clone "B"	
		July 13[1]	Aug 16[2]	July 13[1]	Aug 16[2]
5000 ppm IBA	10 sec.	82.5	90.0	85.0	95.0
5000 ppm IBA	20 sec.	87.5	72.5	85.0	95.0
Jiffy Gro 33-1/3%	10 sec.	87.5	67.5	87.5	90.0
5000 ppm & 100 ppm Boron	20 sec.	90.0	60.0	85.0	87.5
Chloromone 33-1/3%	10 sec.	82.5	57.5	85.0	77.5
Control - water	10 sec.	27.5	45.0	45.0	80.0

[1]Cuttings removed October 4
[2]Cuttings removed Nov 2

In conclusion, with the two cultivars used in this experiment, propagation by semi-hardwood cuttings taken from mid-July to mid-August rooted satisfactorily if they were treated with 5,000 ppm IBA solution for 10 to 20 seconds. Cuttings were rooted under interrupted mist, with the mist on about 1.3 seconds out of every minute from a half-hour before sunrise to an hour after sunset. Bottom heat between 75 to 80°F was employed. The three-year mean for the mid-July cuttings dipped for 10 seconds for the 5,000 ppm IBA solution was 83.5%, while for the mid-August cuttings, 91.7%.

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2 Enright, L. J. 1958 Response of *Magnolia grandiflora* and several species of Berberis to root promoting chemical treatments Proc. Pl Prop Soc. 8:67-69
3 March, S G 1962 Excerpts from question-answer period Proc Pl Prop. Soc 12 127

MODERATOR TUKEY: Our next speaker comes from Oklahoma. Mr. Henry Walter is from the Park Department, Oklahoma City, and he will talk about "Propagation of *Hibiscus rosea-sinensis*".

PROPAGATION OF CHINESE HIBISCUS

HENRY WALTER
Park Department
Oklahoma City, Oklahoma

The Oklahoma City Park Department yearly grows about 3000 Chinese hibiscus plants which are used as annuals in its parks. Being not only concerned with the propagation and production, the behavior of the plant in the parks is also of primary importance. After testing well over 150 varieties of Chinese hibiscus, a few have been selected which are produced in the above mentioned quantities. Ease of propagation, vigorous growth, abundance of flowers, as well as all-summer performance, are the key factors used in variety selection. Over 100 varieties are still grown in the display gardens and the testing continues as new selections become available. Most of the so-called "show varieties" are produced on a two year basis; that is approximately nineteen months from a cutting to a planting sized hibiscus. We will limit our remarks to the varieties that are produced in one growing season.

Washed sharp sand is used as a rooting media. This is placed in a well drained propagating bench with thermostatically controlled bottom heat. Tests seem to indicate that a mixture of 1/3 sharp sand, 1/3 peat moss and 1/3 Perlite gives excellent results. Additional tests will be conducted with this media. Cuttings are made in September. The condition of the cutting wood determines how early in the month propagation is started. Tip cuttings are used and these are usually 6 to 8 inches long, depending on the vigor of the plant. All flower buds are removed. Usually about ⅔ of the lower leaves are stripped and the final cut is made just below a bud. Wounding by removing a one inch sliver on one side of the cutting promotes a better root system as these plants are callus rooting. The cuttings are treated with Hormodin No. 2 powder prior to insertion in the sand where they are packed tightly in place. The use of Hormodin No. 3 is often desirable on some of the more difficult to root varieties. Tests are also being conducted with Jiffy-Gro which to date are promising. It is usually necessary to cover the cuttings with paper during the day for a few days. This is especially true if the weather is extremely bright and hot. A minimum temperature of 65 de-

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Hibiscus can be successfully veneer grafted, and this method is desirable when one or two scions of a new variety are obtained. They are handled in a grafting case the same as magnolias, hollies and junipers. T-budding can also be employed, but it takes some time to develop a usable plant by this method.

The Chinese hibiscus lends itself to growing as standards and in areas where they are not killed by freeze, these make wonderful accent plants. Interesting and conversation pieces can be secured by T-budding several varieties into the top of a standard. Best results are obtained if the terminal of the standard is cut out once it has reached the desired height and the budding is done on the resulting side branches. One caution — be sure that varieties selected for budding are of about equal vigor as a strong growing variety can often dwarf the weaker growers on the same standard.

MODERATOR TUKEY: At this time we have an opportunity for questions on the propagation of hibiscus, magnolias and viburnums.

MARTIN USREY: Have you compared grafting and budding of magnolias with the rooted cuttings? We bud and graft ours in California.

RICHARD STADTHERR: No, we have not made any comparisons. We feel that the rooting of cuttings is much more economical than budding and grafting. Also, you avoid the problems of stock-scion interactions by the use of cuttings.

MARTIN USREY: We find that we have better and faster results with our plants when they are budded and grafted and when we grow them from softwood cuttings.

VOICE: I would like to ask John DeVisser about his experiences using the peat pot. We have had very good success with it.

JOHN DEVISSER: This has not been only our experience but a lot of the local people have had similar results. If you do not rip off the top of the peat pots when you plant them out in the field, the sun will heat the pots and damage the root system. Also, the roots do not seem to go through the pots and the roots just do not look healthy. The performance of the plants in peat pots was not equal to that of the plants that had been grown in clay pots.

JIM WELLS: I believe your problem with the peat pot is that you treated the peat pots the same as you treated the clay pots. You cannot do that. You have to learn how to handle the peat pots or jiffy pots in order to get good results. What works for one will not necessarily for the other.

CASE HOOGENDOORN: Does it make any difference as to where you obtain your peat pots? There are quite a number available and I question whether they all perform in the same way. We have had one batch of peat pots that after the plants were in them became covered with a white mold. What do you make of that?

PETE VERMEULEN: We have had the same experience, Case, and although it is a little frightening, we found that it did not effect the plants in anyway. Some years we have it and other years we do not. We have not had it the last few years. I would like to make a comment on Mr. DeVisser's problem with the peat pots. I do not believe that the problem is one of heat, rather I think it is evaporation. The rim of the peat pots sticking above the soil acts as a wick and all of your moistures evaporated out of the pot. If you plant the pot deeper so that the rim is below the soil level, you will not have any problem.

MODERATOR TUKEY: Our next speaker comes from Pennsylvania, The Conard Pyle Company, and will speak on a complete system for producing rhododendrons. He is Mr. Richard Vanderbilt.

SYSTEM OF PRODUCING BUDDED CONTAINER-GROWN RHODODENDRONS FROM CUTTING TO TRAILER

RICHARD VANDERBILT
The Conard-Pyle Co.
West Grove, Penna.

Stock plants are the basis of the crop. I feel that more predictable results may be obtained, if a separate block of rhododendrons distinct from the saleable crop is maintained for use as mother plants. Stock plants need a certain amount of studied neglect if the cuttings from them are to root strongly and quickly.

All of our rhododendron stock plants are grown in bushel baskets. We feed every other time we water until the first of July. We discontinue feeding stock plants from this time on.

In the middle of July stock plants will be budding up heavily. We remove the flower buds to produce another growth. Our cuttings will be either single second growths or multiple first and second growths if the cutting originated from a branch that was not cut the previous year. Cuttings are made in September, treated with a combination of IBA, Phygon and Boric Acid in talc. After twelve weeks they are lifted and potted into 1-quart Polytainers. This potting is a variance for us. Formerly, we benched the cuttings in peat moss. We found that cutting them out of the peat moss prior to canning did have a definite slowing effect on the development of the plants.

We use a potting mix of peat moss—Perlite 50-50. No limestone or superphosphate is used in the mix at this time as the cuttings seem to resent these additions. We water in Dieldrin at the rate of 4 lbs. actual material per acre plus Geigy Chelate NaFe at the rate of 2 ounces per hundred square feet after potting. The potted cuttings will receive one feeding of 20-20-20 at the rate of 4 ounces to 100 gallons of water at this time. This is enough feed until they begin active growth. The potted cuttings are kept in a greenhouse under 40 degrees night temperature, and as cool as possible during the day, for 20 days. The temperature is then raised to 65 degrees and supplemental cyclic lighting is given six minutes out of every half-hour from 8 p.m. till 4 a.m. Minimum intensity should be 20 foot candles at the darkest spot.

Another feeding of four ounces 20-20-20 to 100 gallons of water is given when soil tests indicate a nitrate level under 7 or 8 parts per million. In practice this works out to one feeding a month at this very low dosage. This is an extremely low level and safe if not used too often. It is suprisingly easy to build up an excess of nitrogen during the dark months of February, March and April. Later in the spring, soil tests frequently indicate that this feeding be increased to once every two weeks.

After the 15th of May the young liners are ready for shifting into a larger container, in the field. Farm wagons, loaded with the potting mix, are tractor pulled along the bed where the plants are to be placed. Canning is done on the wagons. The plants are placed immediately in a shaded quonset house. This is our quonset type overwintering structure and the plants will remain here the entire summer and winter. The houses have been covered with 4-mil white opaque polyethylene in which we have made 5″ - 6″ circular holes to allow the heat to escape. Over a 4 to 5 week period the number of holes are gradually increased and at the end of 5 weeks the plants are in full sun. Any variety that gets sunsick will be kept shaded.

Selection of the container and of the soil mix are very interrelated. Drainage in the soil mix within the container is just as critical as it is in bed or field culture.

The soil mix in the container behaves differently from the same mix under field conditions. It will tend to be less well-drained because of the limited depth of the container. More water stays in the lower portion of the container because it is such a limited column of soil.

We are after a mix so well-drained that there is not enough excess water available to allow the growth and development of the rhododendron root rot fungus, *Phytopthora cinnamomi.* In practice the lighter the mix and the more air in it, in relation to water, the less root rot there will be.

The soil mix we use is 50% peat and 50% coarse sand. Disease problems aside, any ratio up to and including 100% peat does a good job. The higher the peat level, however, the greater the danger of *Phytopthora.*

The canning mix is modified by the addition of:

10 lbs. Dolomitic limestone
3 lbs. Hi-Calcium limestone
10 lbs. Pulverized 0-20-0

Notice that we are applying very heavy amounts of limestone and superphosphate to the canning mix. Available phosphorous in the soil is the single most important key to early, heavy budding of rhododendrons. The limitation of available phosphorous is the chief cause for rhododendrons failing to bud.

Poor rhododendron budding in young stock or only sporadic budding, used to be almost a universal phenomenon. This is easily understood when we look at the behavior of phosphorous in soils. Phosphorous tends to be most soluble when the pH of the soil approaches 6.5 - 7. and practically insoluble at a low pH such as 3.8 - 4.5. At the lower pH the soluble phosphorous reacts with iron and aluminum. These elements become available in abundance at these low pH levels, and combine with the phosphorous to form totally unavailable iron phosphate and aluminum phosphate.

To make enough phosphorous available to produce heavy bud set is very difficult at a low pH, because of the iron and aluminum acting to lock it up.

A rhododendron growing at a pH of 6.5 - 7. normally looks quite sad. True, phosphorous is available, but iron is now totally unavailable within the plant. Result: Chlorosis and Death. Frederick Street, of England, has a couplet about this in his catalog:

"A rhododendron set in lime,
Looks like a curate doing time."

Chelated iron is the material that allows us to keep both phosphorous an iron available to the rhododendron.

While we can grow rhododendrons at a very high pH, we do not want the pH any higher than necessary to insure heavy bud set. The danger of *Phytopthora* will increase as the pH is raised. A compromise level is pH 5.5 - 5.8. The limestone rates indicated earlier will put the pH in this range if a very acid sphagnum peat moss is used—pH 4.0.

This initial application of phosphorous is further bolstered by the fertilizer ratio we use in our feeding program. We use a material with a ratio 9-45-15. It was actually formulated as a "plant starter" for seedling transplants. We start feeding with this as soon as the plants are canned. We make a stock solution of 1 lb. to 1 gallon of water. This stock solution is proportioned out at the rate of 1 gallon to 200 gallons of water. This feeding is given every other irrigation. We continue feeding at this rate until August 15th. It is then lowered to one-half this rate. The following spring we start feeding as soon as the plants need water at the higher rate mentioned. The rate is lowered again on the 15th of August of the second year to the lower level.

Dieldrin is applied again as soon as the plants have been canned. Four pounds actual material per acre.

Geigy NaFe is applied at this time. Two ounces per 100 square feet. The NaFe is applied again, at the same rate, the following spring. The Dieldrin and the NaFe are applied through our proportioners.

The type of container also determines how a given mix will behave. A metal or plastic container with holes in the bottom will not allow as much drying out or aeration as the same container made of woven wooden strips.

A mix that has roots thoroughly dispersed throughout it will keep the entire soil area at a lower and more even moisture level than the same mix with only 10% of it penetrated by roots. This means that overpotting can be a real danger because of disease build-up in the unused soil that stays wetter.

We feel that a lerio 2-gallon container is too small for two growing seasons. We have found that we get practically double the plant size if we shift the one-year 2-gallon into a 5-gallon lerio can for its second season. However, if we place the liner into a 5-gallon container the first year, we run into root rot problem. This shifting from 2's to 5's soon becomes a massive job when there are large quantities involved. We have noticed that when we use bushel baskets for growing our stock plants that *Phytopthora* is never a problem, regardless of plant size. My supposition is that this is because of the tremendous increase of air into the mix; it then follows that there must be less free water to breed and spread the disease. The basket also keeps the soil cooler than does a metal can and this also decreases the chance of *Phytopthora*.

We are going to can our rhododendron liners into a 1-quarter bushel basket. While only two gallons liquid measure, it is the equivalent of three trade gallons. This will allow us to get our desired size in two years without shifting and without the disease problem of an oversize solid container.

Pinching of the plants began in the greenhouses and is continued the entire first summer.

Second year care is feeding and watering. Budding will start in early July of the second year. 100% budding may be expected with this system.

Our spray program, which was done weekly in the greenhouse, is reduced to once every 3 weeks in the open. The choice of spray materials is vast. We use and find safe, DDT, Diazinon, Parzate and Kelthane. While there is some overlap here, we find that this combination does a fine job on mites, all leaf spot fungi and most all insects except for leaf roller. For this we use, Thiodan by itself.

We have found monthly applications of Dexon to pay their way in greatly reducing the incidence of *Phytopthora*. There seems to be some controversy about whether this material works. We feel that it is very useful as a preventative, but it is not as a cure.

Winter protection is provided by covering the quonsets, in which the plants have been growing, with 4-mil white polyethylene.

We have found a system of order filling that works smoothly for us. Our containers are pulled by customer order and placed on pallets that are on a farm wagon. A wagon holds eight 4 ft. x 4 ft. pallets. Each pallet has a 12-inch garden label placed in one can showing the trailer load number and the stop number. After loading the wagons are pulled to the loading dock, and the pallets removed by forklift. They are placed on the floor of the shed by trailer load number and stop number, as shown by the 12″ label in each pallet. These numbers are the guide and key to the whole loading operation. It is necessary to have the material for any trailer all pulled before the loading of that trailer begins. The loading on the trailer is done by a small forklift. It picks up the pallets sequentially and carries them directly into the trailer. They are checked and then stacked or decked depending on the type of load.

MODERATOR TUKEY: Thank you very much, Dick, for a very interesting paper. Our next speaker will speak on the subject of "Bench Grafting Black Walnuts". The speaker is Mr. Albert Ferguson.

BENCH GRAFTING BLACK WALNUTS

ALBERT B. FERGUSON
Linn County Nurseries
Center Point, Iowa

Some forty years ago, some members of the Northern Nut Grower's Association began to test bench grafting walnuts. When I came to Center Point, in 1935, to work for Davis Snyder, proprietor of the Linn County Nurseries, which was commonly known as Snyder Bros. Inc., Mr. Snyder was bench grafting walnuts. He was using a very similar method to the one we now use.

One year seedlings are dug in the fall and graded, taking out the small or the light grade, including trees that have a radical contortion just above the root. Also, the real large grade was generally graded off as being too large to match the better scionwood.

The root stock is stored with the roots buried in packing material, peat, sawdust or sphagnum moss or a mixture of them.

Scionwood is generally collected on warm days in February or early March. Scions of about three eighths of an inch are preferred, but five sixteenths to one half of an inch are okay.

The root stock is taken out generally in March, the tops cut off about an inch above the collar or where the roots begin. The roots are also cut off to about six inches in length.

We still use an old foot operated vise to hold the root stock. With the one inch top stub facing the operator, he cuts, using a side, or sometimes called modified cleft. The knife is inserted at an angle from near the edge of the bark into approximately the center of the stub, where the top and crown meet. The knife is held with the point forward at about forty five degrees making a deeper cut at the top than at the bottom. The scion is cut with a matching wedge, each side being approximately an inch long, one tip longer than the other. Scions four inches to five inches long are generally used. Where the nodes are rather far apart, we cut so there is a bud about one half inch below the tip.

As soon as the scion has been inserted into the understock, they are firmly tied with regular grafting tape. They are sometimes dipped in hot wax, especially the tips of the scions, but occasionally the whole scion is dipped. They are stored in an upright position in a graft box, packed in peat or peat mixture, that is quite moist, but not wet.

Mr. Snyder used to use electric cable under the graft box for two or three weeks, with temperature of about seventy five degrees, until the plants were well calloused. They need to be checked occasionally to see that the packing material is not drying out. When the buds begin to swell, the graft box is set in a cold room until planting time. As they are planted in the field, they must be desprouted as most plants will send up strong suckers beside the graft union. We like to plant deep, leaving only an inch of scion showing.

The first year in the field, they seldom make over a foot growth, but the following year often times grow from three to six feet. These plants seldom form a tap root. Most of them have a good root system. Some will have one or two lopsided roots.

As to the percentage of takes, I wish we could say we usually get a high percentage, but the fact is that it is usually quite poor, with some years near total loss. In some years, we didn't have our own seedlings, we have attempted to buy some from the trade, but have never yet been successful with these. Some years, we haven't had the best of scions and sometimes the grafts have been neglected through the callousing stage. Normally if we can get fifty percent survival, we consider we have done quite well. The late Mr. Bernath of Poughkeepsie, New York, potted all of his walnuts in clay pots in the greenhouse, grafting them after new growth started, like you would a pine or spruce.

In summary, I feel the essentials in successful bench grafting, as we do it are:

(1.) Choice one year seedlings, moderate size, stored carefully.
(2.) Thrifty scionwood of near three eighths of an inch in caliper.
(3.) Good grafting technique
(4.) Firmly wrapped.
(5.) Calloused on a quite warm bench, with adequate moisture.
(6.) Thorough desuckering.
(7.) Careful planting with only the tip of the scion showing.

Often times desuckering after new growth has started will save plants that otherwise would be lost.

We aren't entirely happy with this process. Spring grafting in the field on freshly undercut one year seedlings would probably give a much higher percentage of takes, but we simply don't have time to do it in late May. We have tried summer budding, using various techniques, but with poor takes. The varieties we graft are Meyers, Sparrow, Horton and Thomas. The Persian Walnuts are not reliably hardy with us. Their wood nearly always suffers from winter injury. Fall collected scionwood carefully stored, would probably be okay.

MODERATOR TUKEY: Our next talk comes from Oklahoma. Mr. Ben Davis is going to talk about "Pecan Grafting Outdoors".

OUTDOOR GRAFTING OF PECAN

BEN DAVIS II
Ozark Nurseries
Tahlequah, Oklahoma

There is actually nothing unusual about our method of grafting pecan trees at Ozark Nurseries. Our application of this method to our pecan propagation schedule is, however, different from the practices of most pecan growers. Budding is our primary method of pecan propagation with grafting being used as a follow up. Pecan seedlings are budded during their second summer of growth, during the month of August. The following spring all seedlings in the same block are grafted; (1) which were too small at the time of budding or; (2) on which the bud failed to take. The grafts and buds then start growth at approximately the same time. This gives us a larger percentage of trees from a given block of seedlings than we might otherwise get. This is especially desirable since all of our trees are machine dug and it would be impossible to leave the seedlings for budding the following season.

The grafting is done in the spring just as soon as the sap starts to rise in the stock. This is determined by watching the seedlings for signs of terminal bud swelling. Grafting is begun just as soon as this swelling is detected in the most advanced seedlings. Grafting must be completed before the bark starts to slip on the stock. The scion wood used is one year wood cut during the winter and kept in cold storage until grafting time. The method of grafting used is the ordinary whip and tongue graft.

Grafting is done as low on the stock as possible, but the height varies somewhat in order to match the size of the stock and scion as much as possible. Extra large seedlings are cut off with lopping shears and the graft is made on the side of the stock. On the larger seedlings it is necessary to set the scion in from the side of the stock, otherwise the cambium will not match due to the differing thicknesses of bark on the stock and scion. On seedlings on which the bud has failed, the graft is made so that the lower point of the graft will be on the opposite side of the stock from the bud scar.

The grafts are wrapped with cloth backed grafting tape which is one-half inch in width. The wrap is started at the lower point of the graft union, lapping one-half of the tape on the stock and one-half on the scion. The tape is wrapped upwards in a spiral, lapping as little as possible and taking care to keep each round absolutely as tight as possible. If the graft is properly made and wrapped, it should be possible to grasp the tip of the scion and wiggle the stock without be able to detect any movement in the joint. It is important that too much tape not be used as this multiplies the problem of girdling when the graft begins to grow. It is better to have small gaps in the tape than to lap too much. Since the tape is expensive, using too much is also a wastful addition to production costs.

After the grafts are wrapped, they are sealed with a water emulsifiable asphalt. This material is a by-product of the petroleum refining industry and is very inexpensive. The material is applied with a one inch paint brush, covering all of the tape and the tip of the scion. We discontinued using grafting wax about three years ago because the asphalt is cheaper, it is used just as it comes from the barrel and it requires no heat. When using grafting wax it is very difficult to get the laborers to keep the wax at the right temperature. They either get it boiling hot and scald the grafts or they let it get so cold that it will hardly turn loose of the brush. We noticed a definite improvement in our stands of grafts when we abandoned wax in favor of the asphalt. There is one disadvantage to the asphalt. It tends to preserve the grafting tape much better than wax so that, in some cases, the tape does not rot before it begins to girdle the graft. We overcome this difficulty by cutting through the tape on two sides of the graft with a razor blade at the time the grafts are staked.

After the grafts and buds have made about twelve inches of new growth a steel stake is placed by each one and they are tied with plastic ribbon. It is at this time that the grafting tape is cut as previously described. Periodically throughout the summer the trees are retied to the stakes as growth necessitates.

MODERATOR TUKEY: Now is the opportunity to ask these three fine speakers any questions you may have.

VOICE: Would there be any advantage to covering the entire scion with asphalt tape?

BEN DAVIS: The whole scion is not covered. The asphalt is only over the grafting tape around the graft union. I do not see any advantage in covering the entire scion with the asphalt solution. We do put a little dab on top of the scion on the cut surface to prevent it from drying out.

VOICE: I would like to ask Dick Vanderbilt how much running around of the roots does he experience in the one- and two-year containers?

DICK VANDERBILT: We have had very little because we shift the plants to larger containers. I imagine if you allow the plants to remain in the two gallon containers for more than two years, you would run into problems. With the five gallon containers it would probably take three or four years before you would have any difficulty.

ARIE RADDER: I would like to ask Dick Vanderbilt if he has taken any solubility readings?

DICK VANDERBILT: The Solu-Bridge readings are rarely over 25.

BRUCE BRIGGS: Do you use incandescent light and what type of a cycle do you use?

DICK VANDERBILT: We do use incandescent lamps. The cycle is six minutes on in every thirty minutes from eight in the evening to four in the morning.

VOICE: Are you using Dexon as a preventative or an eradicant for *Phytopthora* on rhododendron.

DICK VANDERBILT: The only eradicant for *Phytopthora* is a fire.

VOICE: In our experience it doesn't seem to be a preventative either for as I understand it, it breaks down in the presence of light within twenty-four hours.

DICK VANDERBILT: We put it on with water and water thoroughly so that the material is right down to the bottom of the can. There is not too much light there. It's true that if you put it on a dry form on top of the can, there will be no beneficial effects. It must be in solution and applied in large enough quantities so that it will be distributed right to the bottom of the can.

VOICE: Do you observe any root damage when using the higher rates?

DICK VANDERBILT: No, we have not observed any problem.

JIM WELLS: Dick, you said that you kept your rhododendron stock plants in a condition of studied neglect. Would you elaborate on this phrase and tell us what it means and what results and value you obtain from a condition of studied neglect?

DICK VANDERBILT: The only thing it means is that by the time we take our cuttings, the plant has run out of gas. If we continue to feed the plant as we would a plant which was to be sold, we would have much more trouble in rooting because of the high nitrogen level. By limiting our fertilization to a light feeding in April, the cuttings are just in the right condition by the 13th August.

JIM WELLS: Do you think you get better rooting from the gasless cuttings?

DICK VANDERBILT: There is no doubt that we do.

HANS HESS: How do the wooden baskets stand up during the time plants are growing in them and until they are ready for sale?

DICK VANDERBILT: They are dipped in a 2% solution of copper naphthenate and at the end of three years time there is absolutely no deterioration. The baskets are set on black polyethylene.

PETE VERMEULEN: Why did you use 2% copper naphthenate? I understood from some research at Ohio State that 1% was satisfactory.

DICK VANDERBILT: We dipped some wooden bands in 1% copper naphthenate and they broke down whereas if we use 2%, there was no problem of deterioration.

BRUCE BRIGGS: Are your stock plants fed a 1-1-1 ratio?

DICK VANDERBILT: No, we use the same ratio as we do for our other plants — 9-45-15.

BRUCE BRIGGS: Do you ever encounter any injury on rooting from the high phosphorus level?

DICK VANDERBILT: No, we have not run into any problem of retarded root development.

CHARLES SCHEER: Dick, have you checked the actual phosphorus levels in the containers when you use the high phosphorus fertilizer?

DICK VANDERBILT: For some reason or another the readings vary all over the block. It is usually greater than 80 parts per ten million and in some cases, in excess of 200. It doesn't seem to make too much difference as long as it is above 80 per ten million.

MODERATOR TUKEY: The first speaker on the last portion of our program today is Mr. James Law from Stark Bros. Nursery. He will speak on "Spray Programs and the Propagator".

SPRAY PROGRAMS AND THE PROPAGATOR

JAMES LAW
Stark Brothers Nursery
Louisiana, Missouri

The title of this paper may be a bit misleading. It sounds like I am going to give you a spray program to fit your propagation system. Far from it and in fact about all I want to discuss with you today is how we are approaching the problem at Stark Bro's and how some of our techniques may be of benefit to you. Like a lot of us sometimes we talk a better ball game than we actually play, so bear with us.

Let's try and get a spray program into proper perspective in our total growing philosophy. Basically, on outdoor production (and I'm purposefully avoiding discussion of microclimates such as greenhouses, mist beds and specialized propagation structures) we are working with three noncontrollable growth factors — heat, light and air. With the controllable factors we have water and nutrition.

In these two areas of water and nutrition we can manage several things to modify our control of these factors; namely, weed control, irrigation, fertilization and pest control or insect and disease control if you prefer. The point I am attempting to make is this: without the management of all these controllable factors we can't come up with the final stand, size and grade of a finished plant that we want or desire. Many of us get on a "kick" to have blocks of stock absolutely clean of weeds and yet we are content in our happiness over these weed clean blocks to overlook a disease or insect problem that is either reducing our total stand or grade. It sounds like I'm rationalizing our weedy fields. I'm not, but let's look at the whole picture.

We, and I say WE because our spray program at Stark Bro's is a cooperative effort. We approach our spray program primarily as a preventive program, not *eradicative.* We begin

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We, and I say WE because our spray program at Stark Bro's is a cooperative effort. We approach our spray program primarily as a preventive program, not *eradicative.* We begin by writing a tentative spray program in early winter by re-writing our previous season's spray program. Incidentally, this spray program is written for our five branch plants and includes spray programs for our scion orchards, vineyards and fruit variety test orchard.

Shortly after World War II upon the return of Paul Stark, Jr. to the nursery, he was instrumental in writing the spray program, which in somewhat modified form continues to this day. After the tentative program is written we have a work conference between production and research and work out final details and then issue the printed program and issue to the plant superintendents and the spray oprator involved.

As to spray records, each operator keeps a record as to crop sprayed, date, material used dosage and gallons applied, plus any remarks or notes he cares to make at that time. We do have these records for several years and use them primarily in revising our program, but also use them for estimating our material requirements when we send out bid lists for spray materials needed.

In formulating our spray program we try and keep the following general principles in mind:

(a) Recognize that timing of spray application and thorough coverage is just as important as the spray material used.

(b) The use of competent interested help is most important.

(c) Use material in our program that does not encourage the build up of other plant pests.

(d) We attempt to write spray programs with safest material possible, consistent with good control and cost.

(e) Return to the use of some of the inorganic compounds such as suphur and copper, especially the latter.

(f) We are returning to the use of some of the older insecticides, especially the miticides.

(g) Don't argue with success!

In laying out our nursery rows we leave a spray row every eight or ten nursery rows, our row spacing on this stock being forty-four inches and the spray row one hundred thirty-two inches in width. We use this space to drive through with a self-propelled sprayer built up on a truck frame with a hi-pressure pump, tank and blower mounted to the rear, with controls up next to the driver. We arrange our shade tree and scion rows on six foot row spacing and have a spray row every six rows. We spray these with the same unit as above and change the nozzle direction as needed. Except for very windy days we can spray both directions. Should it become windy we spray only one way, with the wind. We like this arrangement or two reasons. (1) — We can get good coverage, especially on trees up to ten feet tall without having to use booms. (2) — It is a rather rapid way to cover a maximum acreage in a short period of time. The main disadvantage of course is the loss of land tied up in spray rows. This is not a complete loss, however, as we do take advantage of these spray rows on both planting and digging operations.

The only Hi-row spraying we do in our nurseries is for borer control and the application of herbicides. We have several homemade units for this and we were able to purchase a standard farm unit several years ago which we are very pleased with — a John Deere model 600 Hi-clearance sprayer. We also use this unit for granular spreading and for boom broadcast spraying of herbicides.

The only other spraying that we do in the nursery is herbicide spraying in our shade tree and scion orchards. For this type of spraying we use a modified Holder tractor with *nozzles arranged in front, using spray systems off center or* off-set nozzles. We have been quite pleased with this arrangement.

For your possible help in disease and pest indentification a short list of available publications is attached. We have found the Ohio State bulletin particularly helpful to us on ornamentals and use a combination of several states on our fruit spray program.

To summarize:

(a) — Decide what you want to achieve from your program.
(b) — Indentify the problem
(c) — Formulate your spray program.
(d) — Carry through on proper timing and application.
(e) — Keep good records.

The above won't insure healthy vigorous plants of the size and grade you want but it will enable you to manage one more of the controllable factors in your production program.

Available Publications:

"The Control of Insects and plant Diseases in the Nursery"
Ohio Department of Agriculture
Division of Plant Industry
Section of Insect & Plant Disease Control
Reynoldsburg, Ohio

"Diseases of Ornamental Shrubs & Vines".
The Pennsylvania State University
Agricultural Extension Service
College of Agriculture
State College, Pennsylvania

"Pests & Diseases of Trees & Shrubs"
Wisconsin State Department of Agriculture
(Bulletin #351)
Madison, Wisconsin

"Controlling Insects & Diseases on Ornamental Trees"
Michigan State University
Cooperative Extension Service (Ex. Bulletin #269)

East Lansing, Michigan

"Insect Pests of Shade Trees & Shrubs"
Purdue University, Cooperative Extension Service
(Mimeo E-41)
Lafayette, Indiana

"Plant Pest Handbook"
Connecticut Agricultural Exp. Station
(Bulletin #600)
New Haven, Connecticut

"Illinois Trees: Their Diseases"
Illinois Natural History Survey
(Circular #46)
Natural Resources Bldg.
Urbana, Illinois

MODERATOR TUKEY: Our next subject is propagating blueberries by cuttings. Mr. Philip Fisher will be the speaker.

ROOTING BLUEBERRY SOFTWOOD CUTTINGS

PHILIP MCKAY FISHER
Blueberry Pine Farm, Inc.
Allegan, Michigan

My subject is rooting blueberry cuttings which is, of course, the cultivated high bush blueberry, *Vaccinium corymbosum*. There are not many other propagators here, if any, who want to know how to root blueberry softwood cuttings under mist, but possibly some of our experiences will have some application in other fields, with other material. The field is very specialized because if you do not have a blueberry plantation in a blueberry growing area, you do not have the material or market for blueberry plants.

Traditionally in most states blueberries are rooted from hardwood cuttings. The whips from the previous year's wood are 12 inches to 30 inches long, about the diameter of a pen or pencil, cut in 6-inch lengths and taken in March while the plants are dormant. The cuttings taken from the tip of the whip root better than those from the more mature wood at the base, and cuttings with leaf buds root better than those with flower buds. I first heard about rooting blueberry softwood cuttings at the Experiment Station in Puyallup, Washington, many years ago. Because of their cool climate, they had some success rooting them without intermittent mist.

About that time I heard about what Harvey Templeton was doing and what Jim Wells was doing at Dundee, and we got our first advice and nozzles from Jim at that time. We were advised by the Experiment Station at South Haven, Michigan, that even if we could root softwood cuttings, we could not winter them over unless we had a greenhouse. We have been

East Lansing, Michigan

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We have a crude, inexpensive set-up. I will show you a few slides which may have application for others who do not have a greenhouse. Further, I believe plants started from softwood cuttings are on the average superior to those rooted from hardwood cuttings. Another advantage is that when the South Haven Experiment Station or the U. S. Department of Agriculture at Beltsville thru their test cooperator in New Jersey releases a new variety, it can be multiplied much more rapidly because so many more laterals can be taken from a plant than can hardwood whips. The plant can grow and bear fruit at the same time you are removing softwood laterals.

The wood is usually ready somewhere near the 10th of July. We do not adhere to a date. They are heel cuttings and the laterals must have completed their primary growth and be taken just when the second growth starts. We used to get a tail that had to be cut off on a block, but by pulling them just with the right snap we get no tail but there is a ring of the old bark, or collar, at the base of the heel cutting and from which a good mass of roots start. You want a blueberry bush and not a tree and from this base it has been our experience more strong canes emerge from the base in the nursery than from hardwood cuttings.

For our propagating bed we put a layer of washed gravel on level or slightly raised ground and use one tier of concrete blocks for the sides to hold the medium which is half horticultural peat and half Perlite. We mix it on a concrete floor and keep it wet for about 2 weeks to make sure it is mixed and damp.

In the two beds you will see on the slides, we are able to stick about 8,000 cuttings in each. Our beds are about 120 feet long and 4 feet wide and the cuttings are spaced 2¼ inches by 2¼ inches.

The mist lines are about 7 inches above the bed and supported by stakes. We have found that two mist lines are better than one. We are in the country and have to rely on well for water. Our jet pump unexpectedly failed at a critical time and emergency extra shade saved most of the cuttings. This past summer the Jim Leech family's portable swimming pool with 8,000 gallons of water and a pump has been moved near the propagating beds with many hours of emergency mist available.

A small percent of the cuttings do not callous and another small percent are not rooted well enough to give them space in the nursery, plus normal casualties, but on the average 60 to 75 percent root well enough to make good plants. We are also in the Christmas tree business and use the tree planter to line the cuttings out in the nursery where they stay normally for two summers.

The cuttings must be taken off very early in the morning, as soon as you can see, and the lower half of the leaves are stripped off right in the field. The cuttings must be kept damp and stuck immediately. The bed is covered, quonset shape, with 6 inch by 6 inch concrete reinforcing wire covered with 4 mil polyethylene 6 feet wide and then covered with 46% Saran shade. If there should be a rainy, cloudy day, it is ideal, and the entire job can be done in one day instead of on several early morning segments. A crew starts sticking as soon as some cuttings are available. There is a 1/16 H.P. exhaust fan at one end of the bed. The mist is on while the cuttings are being stuck. They are flooded in as every few feet of bed is stuck and the polyethylene and shade are unrolled to cover the cuttings as sticking progresses. We have tried Hormodin #2 and #3 and found no response. The nozzles are 4 feet apart on ½ inch galvanized pipe. Each nozzle (#4 NW) delivers 4 gallons per hour if run continuously. We went thru the electronic leaf and other control devices, but now use a time clock set for 1 minute on and 5 minutes off until rooting starts and then the time off is increased. A thermostat shuts off the time clock if the temperature of the air is below 70 degrees Fahrenheit in the bed. The exhaust fan runs continuously in daylight. We have a small opening in the end of the bed opposite the exhaust fan so that the mist is carried over the bed. It is necessary to keep the leaves wet continuously when the bed temperature is over 70 derees. The mist and exhaust fan keeps the bed temperature below 80 degrees.

We remove the polyethylene when rooting is well started, but leave the shade on until fall. In preparation for winter when the cuttings are rooted and are losing their leaves, we sprinkle about one inch of sawdust right on the entire bed. After some frost and light freezing we cut pine boughs (the concrete reinforcing wire mesh is left over the beds) and cover the beds with a thick layer of boughs so that there is protection from extreme low temperatures and they are entirely dormant all winter and until the pine boughs are removed in the spring.

When the nursery ground is ready, the plants are shaken out, the last year's peat and Perlite are discarded and we are ready for the next batch. The cuttings are stuck just before the earliest varieties are ready to pick in July, so that the work load timing is favorable.

Blue Crop is a very large, popular, and satisfactory semi-early new variety that is very hard to root from a hardwood cutting but can be rooted very successfully from softwood cuttings. Some new varieties are being named and released this year. New blueberry varieties are not patented since the chief breeders are the U. S. Department of Agriculture at Beltsville and Stanley Johnston at the South Haven Experiment Station in Michigan. He bred and released all of the popular Haven series of peaches. For 25 years he has been crossing high bush and low bush blueberries to get a lower bush with excellent winter hardiness and other superior qualities. He has just named and released "Blue Haven." The crosses made at Beltsville are now all tested on the Galletta Brothers plantation at Hammonton, New Jersey. At the present time this cooperator has about 20,000 seedlings under observation, as well as about 500 acres of blueberries in production. A selection named and approved for release next spring is "Lateblue." In return for furnishing the land, cultivation and care of the seedlings and years of observation, the cooperator has, when a variety is released, the only source of plants for sale. There is also a new early variety which will probably be released next spring. A supposedly good early variety, Earliblue, released several years ago, did not live up to expectation. Because some older varieties become obsolete and new varieties are being introduced, there is a market for plants and we have found that softwood cuttings are the best method of propagation for us.

MODERATOR TUKEY: The final speaker for this afternoon will be Dr. Albert Johnson of the University of Minnesota, St. Paul, Minnesota.

VARIATION IN CLONES OF RED-OSIER DOGWOOD

MARGARET H. SMITHBERG AND ALBERT G. JOHNSON
University of Minnesota
St. Paul, Minnesota

Nurserymen have long recognized the importance of using plants well adapted to their local climatic conditions in order to produce attractive and fully hardy specimens. Presently, there is an increasing interest in the use of native plant materials. For this reason knowledge of factors relating to the geographic origin of plants used for propagating purposes is of growing concern.

In 1963 we obtained dormant cuttings of red-osier dogwood from points both in the United States and Canada. Figure one indicates the collection points of dogwood and the source of specimens in the University of Minnesota Herbarium. The resulting plants were grown in the greenhouse and then transplanted in a randomized block design into the experimental plots.

Variations both in plant form and growth rate were noted during the first growing season. The extremes in variation in form are evident when comparing a typical plant from the Minneapolis area (Figure two) with those of the same age from Alaska (Figure three) and Seattle, Washington (Figure four).

Total growth by October, 1963 was determined by measuring all stem material in excess of three centimeters. Figure five indicates total increment of all clones studied. In comparing increment with climatic parameters such as length of grow-winter hardiness and other superior qualities. He has just named and released "Blue Haven." The crosses made at Beltsville are now all tested on the Galletta Brothers plantation at Hammonton, New Jersey. At the present time this cooperator has about 20,000 seedlings under observation, as well as about 500 acres of blueberries in production. A selection named and approved for release next spring is "Lateblue." In return for furnishing the land, cultivation and care of the seedlings and years of observation, the cooperator has, when a variety is released, the only source of plants for sale. There is also a new early variety which will probably be released next spring. A supposedly good early variety, Earliblue, released several years ago, did not live up to expectation. Because some older varieties become obsolete and new varieties are being introduced, there is a market for plants and we have found that softwood cuttings are the best method of propagation for us.

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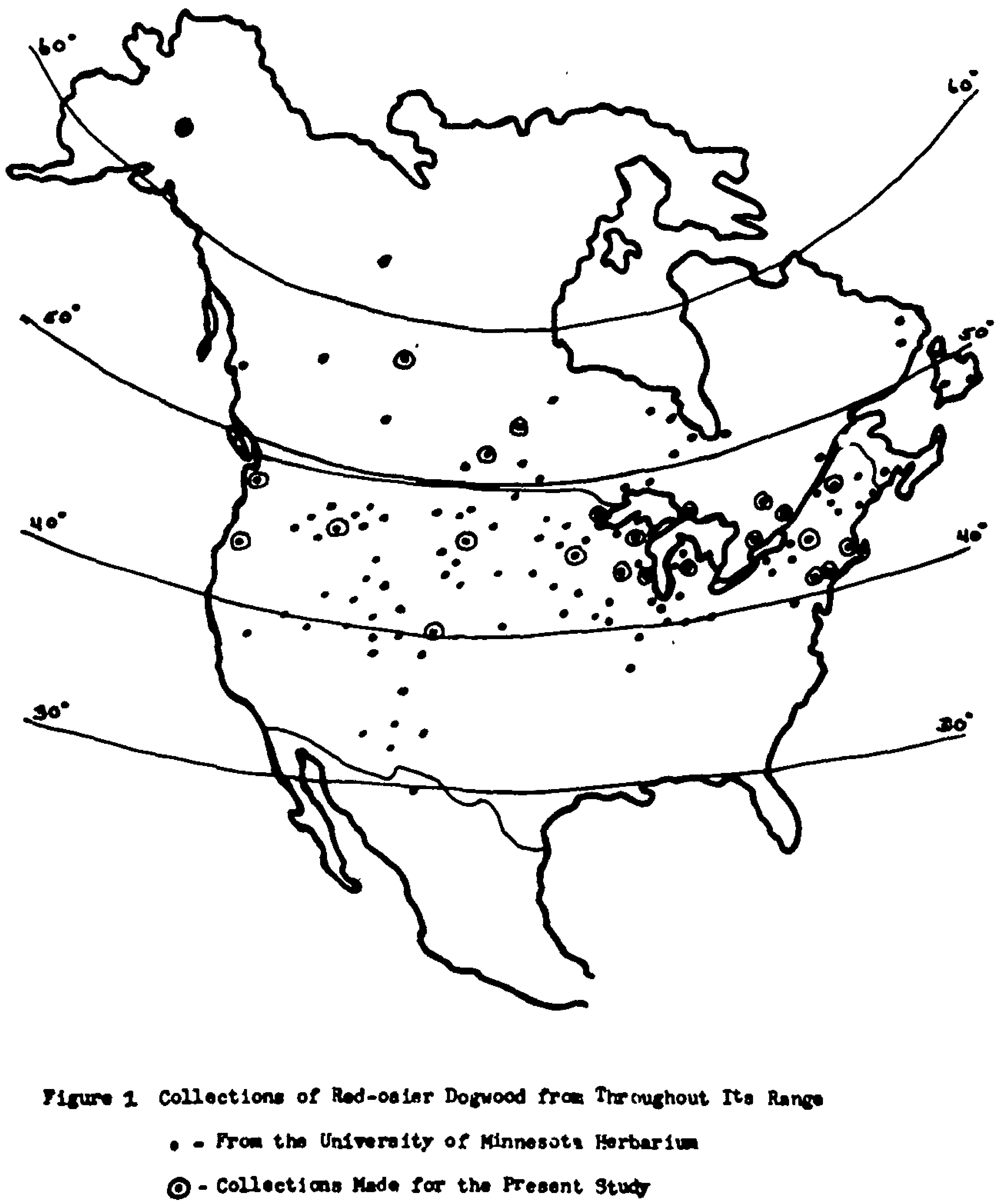


Figure 1. Collection Points of Red-osier dogwood

ing season, winter minimal temperatures and latitude it was found that closer correlation exists between increment and both growing season length and winter minima than between increment and latitude. This type of correlation was found in all other observations included in this study.

Observations were made during the late summer and fall of variations in onset of winter buds, red bark color appearance and leaf abscission. Those from northern sources produced winter buds, turned red and dropped their leaves much sooner than those from farther south. Extremes were noted in plants from Alaska, which stopped growing in early August, as compared to those from Seattle which did not stop growing until November and held their leaves all winter.

Cuttings of each clone were brought into the laboratory and slowly cooled in a freezing chamber in a series of Dewar flasks. Temperatures were slowly lowered and cuttings removed at certain temperatures. The cuttings were then placed in humid chambers where their viability was noted.

This procedure was begun in September 9 and repeated at two week intervals (except for a period in October when the freezer was inoperable) until December 4. As fall progressed the temperature range was lowered for each test run until by October 17 the lowest obtainable temperature (-90°C) was reached.

It was determined that all clones, even those from mild climates such as Seattle, Washington, became hardened to the

Figure 2. Red-osier dogwood from Twin City Area.

Figure 3. Red-osier dogwood from College, Alaska

lowest temperature the freezer could measure (-90°C), but that there were statistically significant differences in the date at which each clone became hardened. In order to provide statistically comparable data it was necessary to express the results as the date at which clones reached a given level of hardiness. Figure six thus indicates the date at which all clones of dogwood became hardy to -27 degrees centigrade. Although in the spring there was variation in dates at which summer green bark color returned there were no differences in dates of bud break. This may have been due to the fact that we had a cold April and a rapid rise in temperatures in May causing a telescoping of phenological events. We did, however, bring material in a controlled environment chamber in February and under the temperatures and photoperiods tested (see

Figure 4. Red-osier dogwood from Seattle Washington.

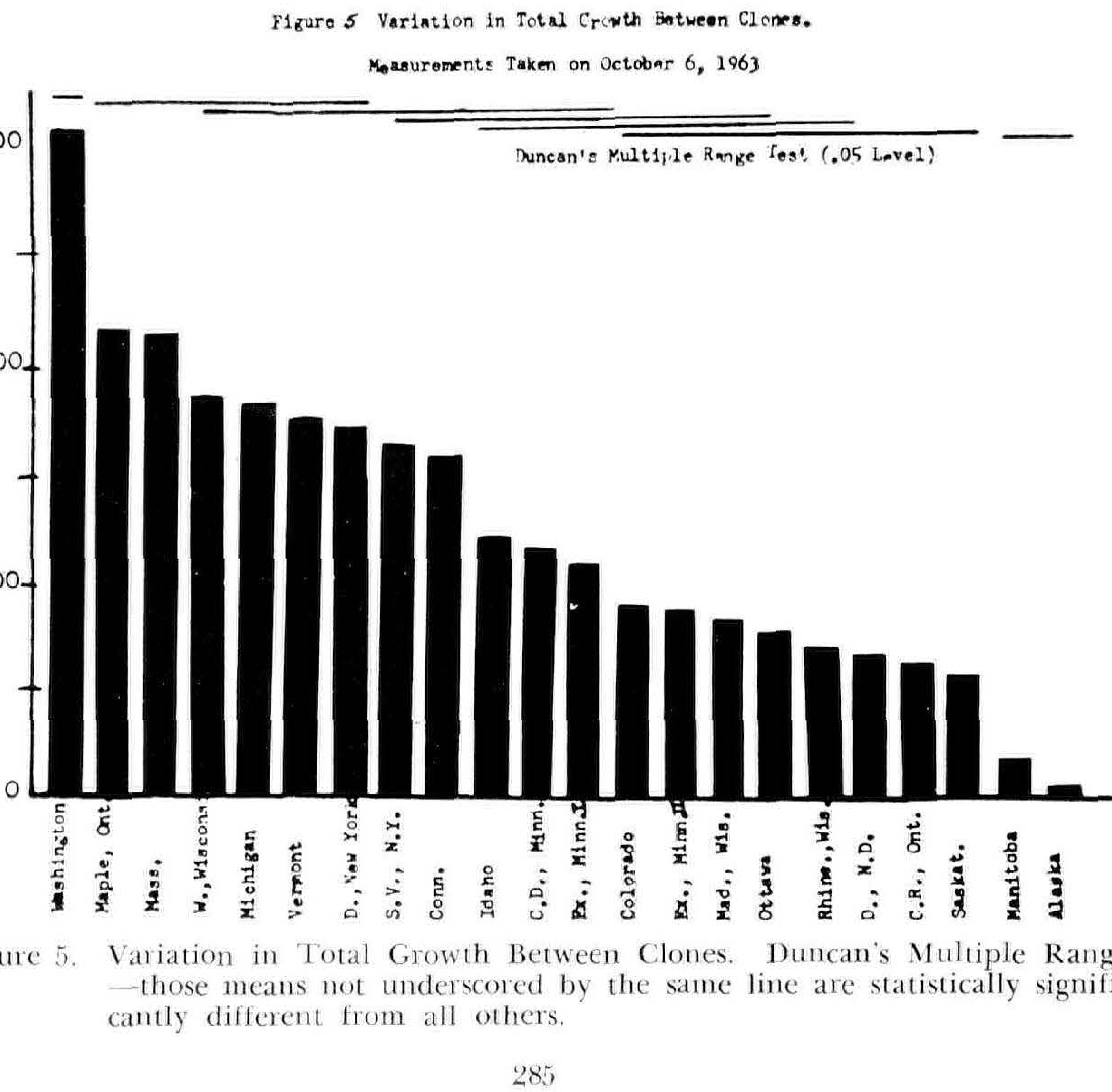


Figure 5. Variation in Total Growth Between Clones. Duncan's Multiple Range—those means not underscored by the same line are statistically significantly different from all others.

below) there was no significant difference in time to bud break.

Test 1.	70° Day	one chamber at 8 hours and one	
	55° Night	at 16 hours photoperiod	
Test 2.	55° Day	Same photoperiod as Test 1.	
	36° Night		

In summation, there are important variations in both growth and dates of phenological events in different clones of red-osier dogwood indicating the desirability of using locally adapted materials as sources of propagating stock.

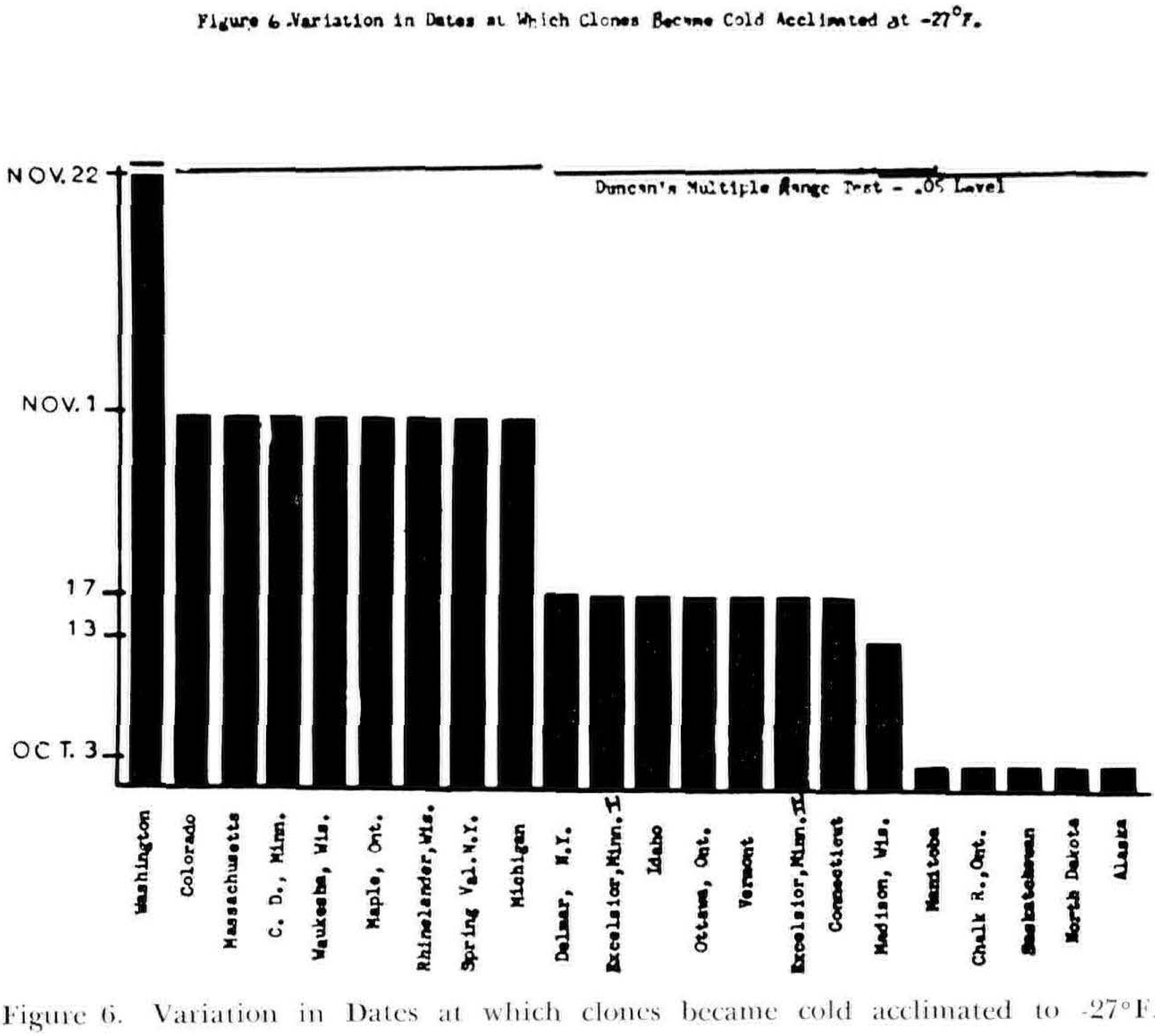


Figure 6. Variation in Dates at which clones became cold acclimated to -27°F.

MODERATOR TUKEY: Are there any questions for our previous three speakers?

JOHN ZELENKA: I would like to ask Mr. Law if they have used airplane spraying or have they had any experiments with it?

JIM LAW: No, John, none at all. We have done dusting by airplane in our plant at Oklahoma where we have extensive acreage but we have done no airplane or helicopter spraying for two years. We did have 80 acres in one block which was very wet and we did dust that because we were not able to get to it on the ground. It is difficult to use airplane spraying because we have such a range of crops and we just could not do an adequate job of spraying with one formulation for all of the crops.

VOICE: I understand there has been some airplane spraying for rabbit control. Have you heard anything about this?

JIM LAW: No, we fence everything, even material that is to be dug in the fall. It takes about 5000 feet of fence each year just to keep up with the fencing program.

RALPH SHUGERT: I'd like to make a comment in regards to rabbit control. Last year was the first time in the history of Plumfield Nursery that not a fence was put up. We had complete control of rabbit damage by spraying the blocks with Arasan and a spreader sticker. What we did was to just go around the blocks and spray into them. It was not necessary to go up and down each row. This worked for apple, pear, linden, euonymus, and other plants which are very susceptible to rabbit damage. I would like to ask Jim what you are doing for control of pear blight?

JIM LAW: We are dormant spraying; that is when growth completely stops. It is usually in November. There may be leaves on the trees and the bud scars have not completely suberized over. We spray with an 8-10 Bordeaux mixture.

BILL CURTIS: We don't have a rabbit problem but we are troubled by deer. Has anyone used a spray for deer control?

JIM LAW: We hang a small bag of blood meal on each tree. That's about the only thing that we have had any reasonable success with.

JOERG LEISS: We have had good success using Arasan at ¼ the rate that is normally used for rabbit control. It does a very good job.

FRIDAY MORNING SESSION

December 1, 1967

The Friday morning session convened at 9:00 a.m. in Ballroom A of the Admiral Semmes Hotel. Dr. Thomas F. Cannon served as moderator.

MODERATOR CANNON: I think we have a very excellent program this morning and to lead it off we have Dr. Ronald M. Girouard who will speak on the "Anatomy of Adventitious Root Formation".

ANATOMY OF ADVENTITIOUS ROOT FORMATION IN STEM CUTTINGS

RONALD M. GIROUARD
Forest Research Laboratory,
Department of Forestry and Rural Development,
Sillery, Quebec, Canada

The art of propagating plants from cuttings is old and may have started with man's initial interest in ornamental, medicinal, orchard and field plants. But as a science, a series of facts systematically arranged to explain or predict the operation of general laws, the propagation of plants from cuttings did not begin to develop until the eighteenth century (24). Probably the first paper describing the scientific approach to plant propagation was written by the French dendrologist Duhamel du Monceau in 1758 (see fig. 1 and ref. 10). My paper this morning will be an attempt to summarize what is known concerning the anatomy of adventitious root formation in stem cuttings. And when compared with the volumes written by Duhamel, my talk will simply resemble a drop in the bucket.

The rooting of stem cuttings is one of the widely used forms of asexual propagation, a fact which you all know. It involves the placing of stem pieces with one or more buds under conditions that favor the regeneration of roots. Stem cuttings we generally classify as hardwood, softwood and herbaceous depending upon the degree of lignification of the stems, the presence or absence of leaves, and the plant species involved.

Plant propagators are aware of the fact that several easy-to-root plants bear aerial roots or roots in early stages of development within the tissues of the bark. This last group has been referred to by some authors as preformed, hidden, latent and initial roots or root germs. The term morphological roots, first used by the Dutch investigator van der Lek (37), designates all of the roots present when the stems are cut from the stock plants. Figures 2 and 3 show aerial roots that have form-

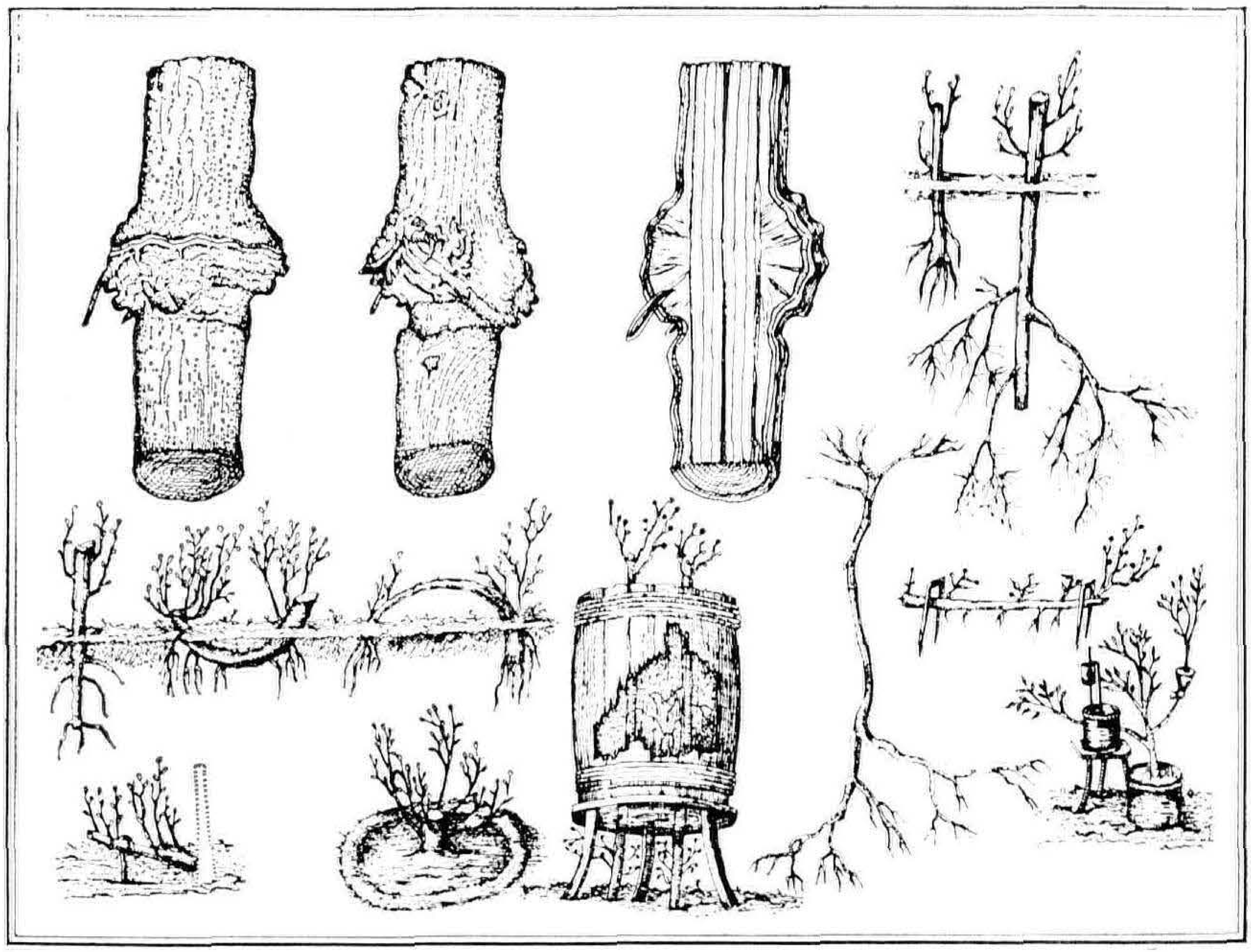


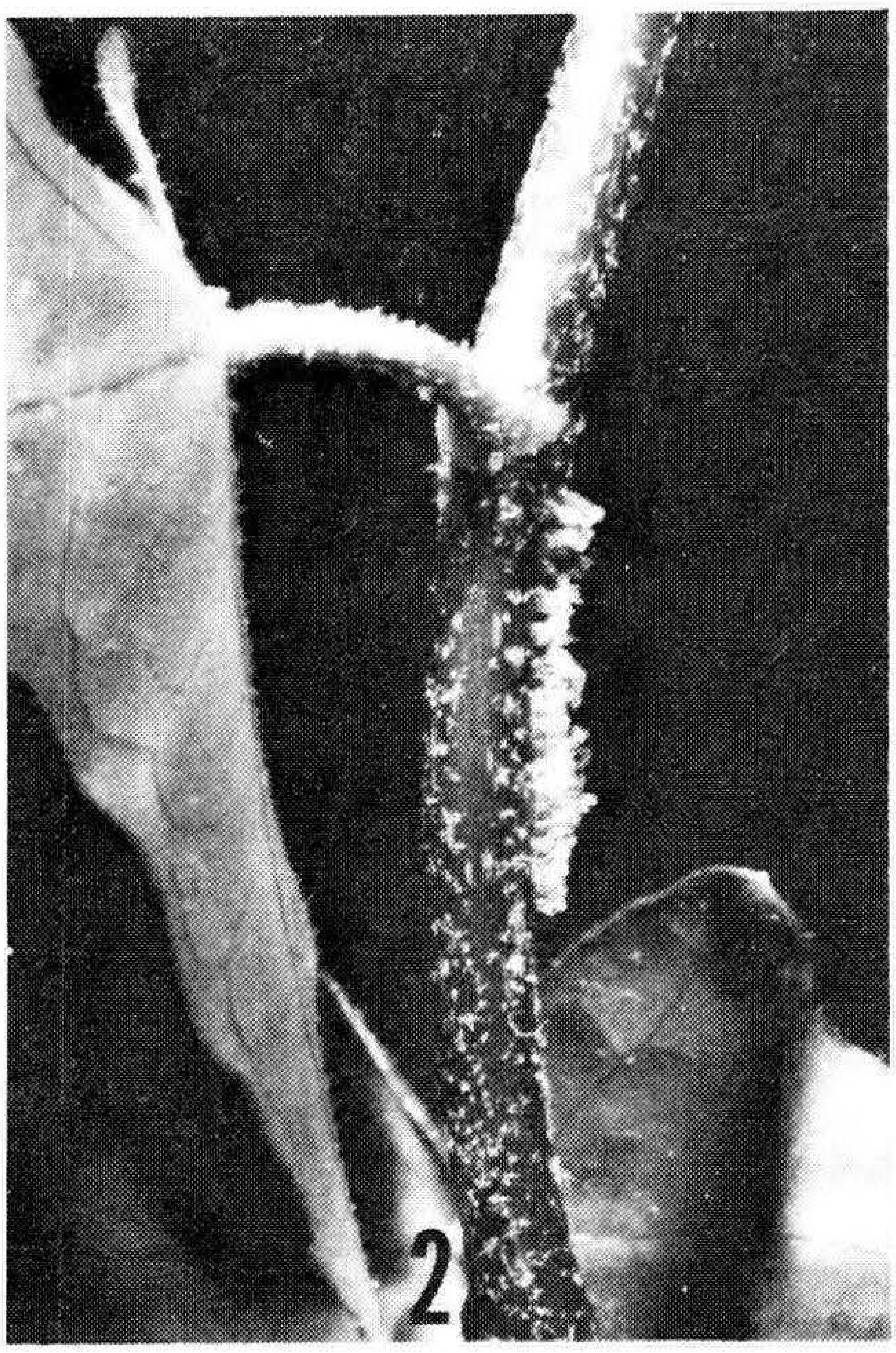
Figure 1. As early as 1758 efforts were made to study plant propagation from a scientific viewpoint. Girdling, grafting, polarity of shoots used as cuttings, and layering were a few of the subjects studied. Redrawn from H. L. Duhamel du Monceau. La physique des arbres. Guerin & Delatour, Paris. Plate XV, volume 2. 1758.

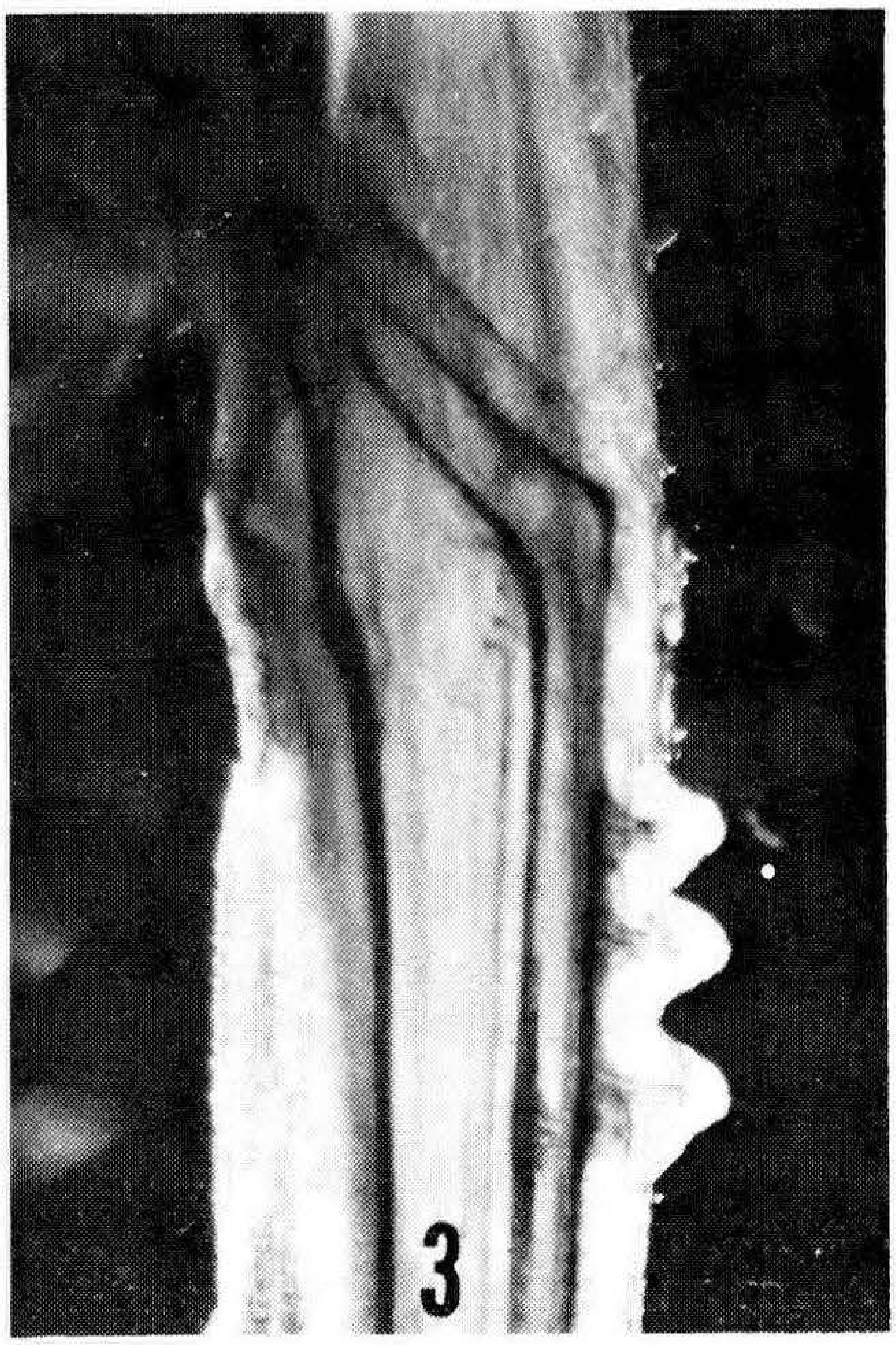
ed just below a node on stems taken from a juvenile plant of *Hedera helix*. In figure 3 the stem was stained with basic fuchsin, cleared and photographed while in methyl salicylate; the vascular bundles have retained the stain. A list of woody plants with stems bearing aerial and latent roots (morphological roots) is given in table 1.

The most common adventitious roots of stems are those that form completely after the cuttings are made; they develop near the base of stems from wounded tissues or above the cuts. It is not surprising that these structures have been named wound or wound-induced roots (18,22,37).

Since most adventitious roots arise endogenously, that is, in tissues located at some distance from the periphery of the stems, it is only appropriate that we should be familiar with some features of the internal structure of stems. First, let us consider the subdivisions of the vascular system, the vascular bundles or fascicles (traces) which function as the transport network of young shoots.

In stems of conifers and woody dicotyledons, the internodes have vascular bundles arranged in rings but separated by panels of cells high in metabolic activity. In cross-sections of stems of a number of herbaceous dicotyledons and many monocotyledons, the vascular fascicles appear scattered. Figure 4 gives us a general idea of the distribution of the bundles as found in several of the plants that we propagate. A closer look at one of the vascular bundles of a woody dicotyledon (fig. 5) reveals two smaller strands or traces: one composed of xylem





Figures 2 and 3. Aerial roots that have formed below a node on stems taken from a juvenile plant of *Hedera helix* are readily seen. In figure 3, the stem was stained with basic fuchsin, cleared and photographed while in methyl salicylate, a clearing agent. The development of vascular traces into the new roots is noted. Figure 3: from Girouard, R. M. Canad. J. Bot. *45*:1877-1881.

Table I. Woody plants with stems bearing aerial and latent roots. *

Campsis radicans
Cotoneaster dammeri (38)
Eugeissona spp. (35)
Ficus carica (11)
Hedera helix (36)
Jasminum spp. (18)
Lonicera japonica (27)
Maricaria spp. (35)
Populus Section *Aegeiros* (4)
Populus alba (25)
Populus x *canadensis* (2,3)
Populus deltoides (25)
Populus x *euramericana* (25)
Populus nigra italica (29,36,37)
Populus nigra thevestina (37)
Populus simonii (37)
Populus trichocarpa (2,3,37)
Ribes alpinum (37)
Salix alba (36)
Salix alba chermenisa (37)
Salix alba sericea (37)
Salix amygdalina (37)
Salix babylonica (37)
Salix discolor (22,37)
Salix fragilis (6,7)
Salix myrsinifolia (37)
Salix viminalis (36)
Vershaffeltia spp. (35)

* Numbers refer to references cited.

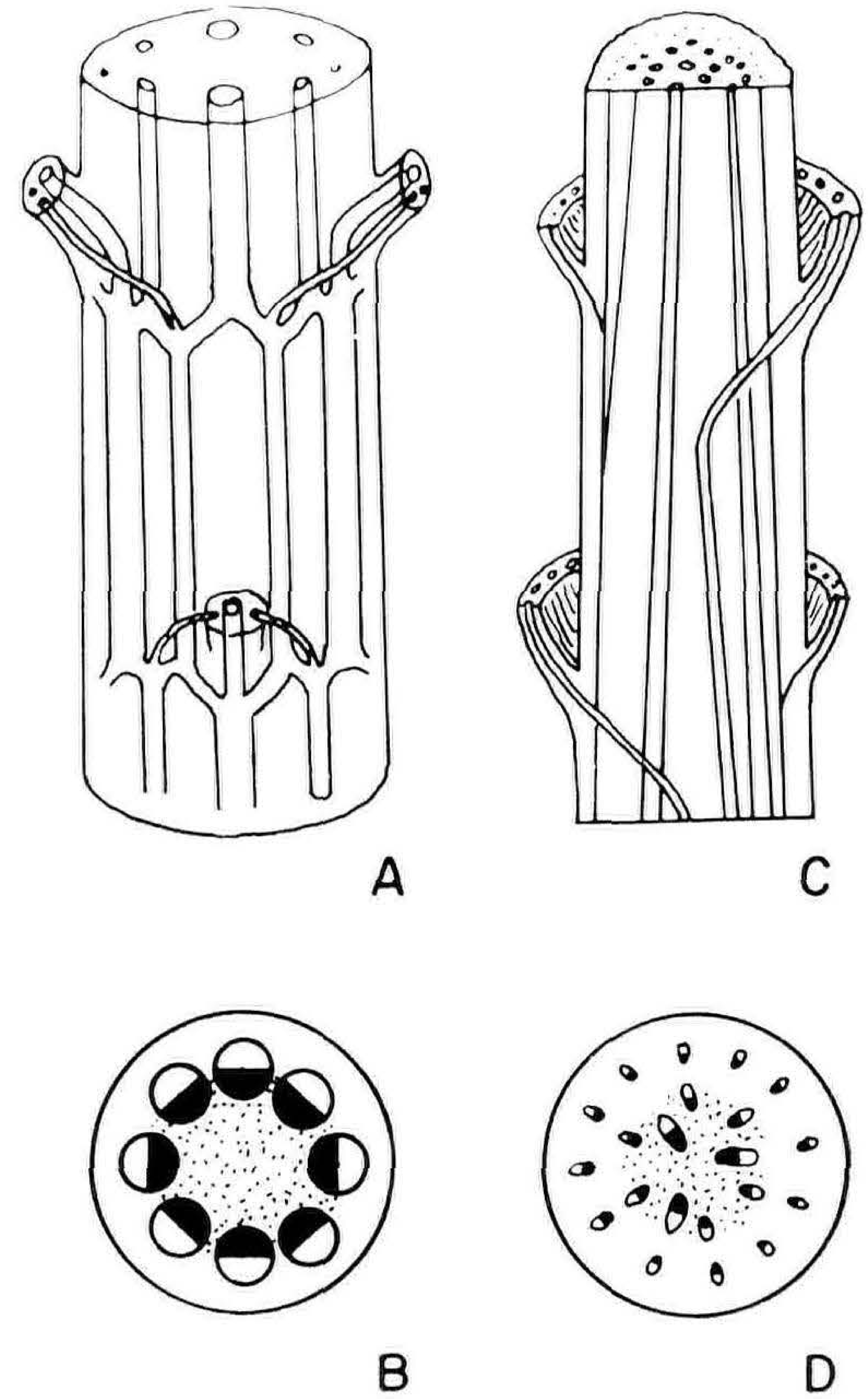


Figure 4. The vascular bundles of conifers and woody dicotyledons at the internodes are arranged in rings (A, B). In cross-sections of stems of a number of herbaceous dicotyledons and many monocotyledons the vascular fascicles are scattered (C,D). Fig. 4 A, C From: B. Huber. 1961. Grundzuge der Pflanzenanatomie. Springer-Verlag, Berlin. p. 84.

(wood) and another of phloem elements. Between the strands of xylem and phloem are cells of a lateral meristem — the fascicular cambium. At a later stage, cambial cells differentiate between the bundles to form the interfascicular cambium. It is the vascular cambium made up of the fascicular and interfascicular cambia which is responsible for the secondary growth of stems. Much of this growth is readily identified as annual growth rings in the secondary xylem. Now for a few minutes let us consider the vascular system at the nodes.

The presence of a leaf results in one or more bundles bending away from the main formation of the vascular system and in connecting the leaf to the stem (fig. 6). Bundles of this kind can be traced down through the stem to a point where they join other strands. These links between the leaf and the stem are the leaf traces. Immediately above the bending part of the traces in the stem, parenchyma cells with unspecialized properties contrast with the highly specialized cells of the vascular tissues. These groups of parenchyma cells make up the leaf gaps. Buds that form in the axils of leaves are compressed shoots or miniature branches. Nevertheless they too are linked to the main stem but by branch traces; they also have branch gaps.

I am certain that many of you like myself have wondered just where in stems the adventitious roots originate and develop, and what anatomical factors influence their development. The answer to these questions have not always been easy to obtain and they have varied considerably from one plant species to the other. I will attempt to summarize studies that have come to my attention.

It is definitely known that adventitious roots have a tendency to arise in the vicinity of differentiating tissues of the vascular bundles; the proximity of the new roots to the main axis of the stems permits a rapid vascular connection between the plant parts. In young stems of dicotyledons and gymnosperms, roots are initiated by cells located near the periphery of the vascular fascicles, often interfascicular parenchyma cells, while in relatively old stems the seats of initiation are

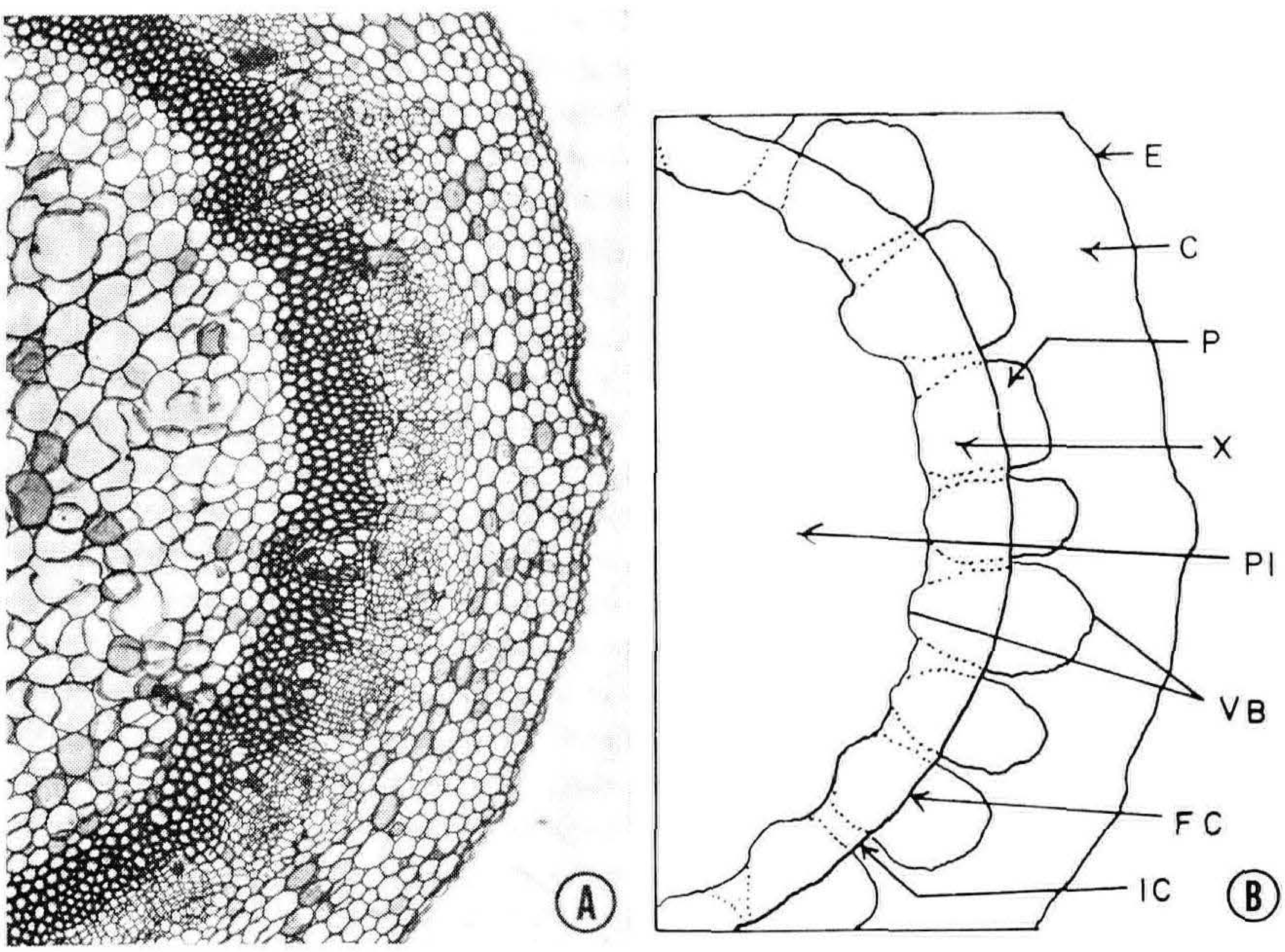


Figure 5. A close look at a cross-section of a young woody dicotyledon shows vascular bundles arranged in a ring and individual bundles composed of two strands: one of xylem (wood) and another of phloem elements. E, epidermis; C, cortex; P, phloem; X, xylem; PI, pith; VB, vascular bundle; FC, fascicular cambium; IC, interfascicular cambium. From: Girouard, R. M. 1967. Canad. J. Bot. 45:1877-1881.

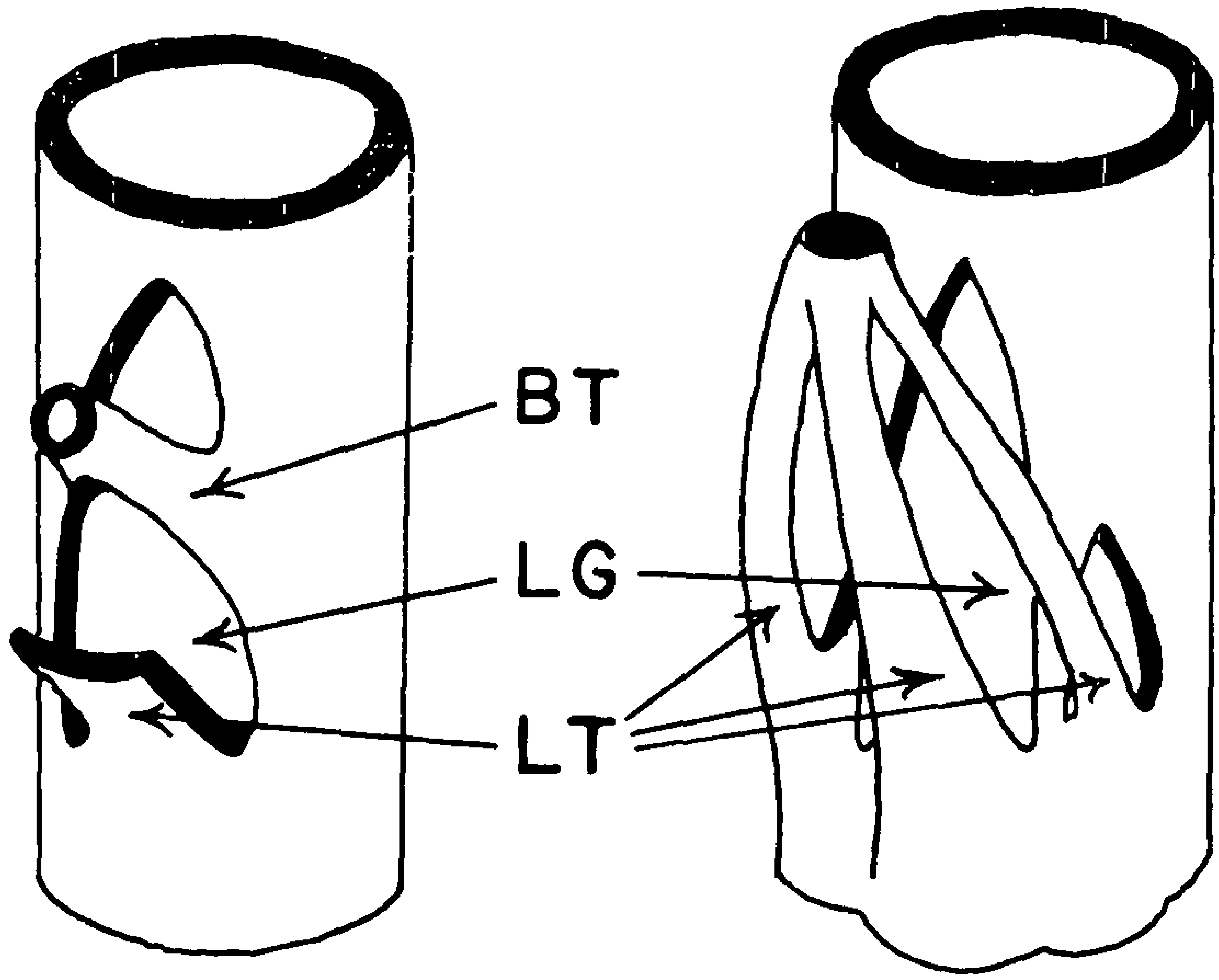


Figure 6 Leaves and buds are connected to the vascular system of stems by leaf traces and branch traces, respectively Both leaves and buds have gaps made up of parenchyma cells above their respective traces LT, leaf trace; LG, leaf gap, BT, branch trace From K Esau 1960 Anatomy of seed plants John Wiley & Sons, New York, p 209

close to the interfascicular cambium. In monocotyledons, adventitious roots arise in parenchyma cells external to the vascular tissues. In every case cells that are alive, not just walls, and that are capable of dividing are necessary for the formation of adventitious organs such as roots.

These structures can arise internally (endogenously) not only in nodal tissues adjacent to leaf and branch gaps but in internodes. They can occur externally (exogenously) in callus tissue formed at the basal end of cuttings and in hyperhydric outgrowths of lenticels. Tables 2 and 3 provide information concerning the seat of origin of morphological and wound-induced roots in several woody plants.

Up to this point I have brought to your attention the vascular system at nodes and internodes and the sites of root initiation, but one important fact remains to be mentioned. It is this: while a root may be formed within tissues of a stem, its emergence is not a sure thing. A correlation between the presence of many thick-walled cells such as fibers and sclereids (two components of sclerenchyma) and poor rooting of shoots has been reported by several investigators (1,8,9,17,23). Some workers believe that the groups of fibers act as mechanical barriers preventing the lateral emergence of roots and promoting basal emergence through callus tissue. Recently a few scientists (15,16,23) have been unable to find simple relation-

Table 2 Origin of aerial and latent roots (morphological roots) in stems of some of the woody plants listed in table 1

Plant	Reference	Site
Cotoneaster dammeri	35	Parenchyma cells of divided leaf and bud gaps.
Ficus carica	13	Leaf traces, leaf gaps and medullary rays.
Hedera helix	36	Between the bark and vascular bundles.
Lonicera japonica	27	From cells between the cambium and pericycle at both nodes and internodes.
Populus Section *Aegeiros*	4	External to the cambium but in front of primary rays.
Populus nigra italica, P. n. thevestina, P. simonii, P. trichocarpa	37	Opposite medullary rays.
Ribes alpinum	37	Opposite medullary rays.
Salix alba chermenisa, S. a. sericea, S. amygdalina, S. discolor	37	Parenchyma of leaf gaps at the nodes; medullary rays of internodes.
Salix frailis	6,7	Outside the cambium in rays associated with leaf and branch gaps.
Salix myrsinifolia	37	Parenchyma of leaf gaps at the nodes; medullary rays of internodes.

ships between density or continuity of sclerenchyma and rooting potential in woody stem cuttings. They consider differences in ease of rooting to be related to the ease with which root initials are formed, not to the restriction of developing root primordia by sclerenchyma.

To end what I have to say this morning, I will briefly describe a few illustrations to give you an idea of how wound-induced roots arise in stems of *Hedera helix*. Figure 7 A, B shows cells at the outermost end of a ray, phloem ray parenchyma, with dense cytoplasm and deeply stained nuclei. The two large cells are the product of a recent anticlinal division. Groups of fibers (F) are present external and opposite the vascular bundles (VB). In figure 8 A, B a young root initial (RI) made up of a slightly organized group of cells is seen developing between two phloem traces. Fibers (F) flank the outer portion of the vascular bundles but they do not hinder the development of the young root. In a few cases (Fig. 9 A, B), vascular rays abut at their distal end on perivascular fibers. Examples of this kind are found even in easy-to-root stems of the juvenile growth phase. The rays often stain densely as shown in this illustration. As the root initials continue to develop, cells divide and differentiate and begin to form organized tissues typical of root primordia (see fig. 10 A, B and 11). Vascular strands quickly differentiate into the actively growing primordia. Phloem elements of at least two vascular bundles and three rays take part in the formation of each root primordium. Scattered groups of fibers are unable to stop the last few stages of adventitious root formation (fig. 12). Roots with rootcaps

Table 3. Origin of wound-induced roots in stems of woody plants

Plant	Reference	Site
Abelia grandiflora	37	Callus.
Abies spp.	28	Callus.
Acanthopanax spinosa	37	Callus.
Acanthus montanus	34	Near vascular cambium.
Caragana arborescens	33	Secondary phloem; callus.
Chamaecyparis spp.	28	Vascular rays.
Clematis spp.	30	Vascular cambium.
Cryptomeria spp.	28	Vascular rays.
Cupressus spp.	28	Vascular rays.
Forsythia suspensa	33	Leaf and bud traces.
Hedera helix (juvenile)	15	Phloem ray parenchyma.
Hedera helix (mature)	16	Phloem ray parenchyma and callus.
Ilex opaca	21	Vascular cambium extended into callus; young phloem after auxin treatment.
Larix spp.	28	Bud traces.
Ligustrum vulgare	20	Outgrowths of lenticels.
Picea spp.	28	Leaf traces, callus.
Pinus spp.	28	Leaf traces, callus.
Ribes alpinum	33	Secondard xylem, cambium
Rosa 'Dorothy Perkins'	5	Secondary phloem.
Rosa dilecta 'Better Times'	31	Phloem ray parenchyma.
Rubus idaeus	32	Primary rays close to leaf traces.
Rubus occidentalis	32	From leaf and bud traces.
Sambucus nigra	20	Outgrowths of lenticels.
Sciadopitys spp.	28	Branch trees.
Tamarix aphylla	14	Outgrowths of lenticels.
Taxus cuspidata	19	Phloem ray cells and adjacent parenchyma away from basal cuts; secondary phloem near basal cuts.
Thuja spp.	28	Vascular rays.
Thujopsis spp.	28	Rays, leaf traces.
Thujopsis dolobrata	37	Callus.
Ulmus campestris	20	Outgrowths of lenticels.
Vaccinium corymbosum	23	Cambium and phloem.

present emerge above the basal cuts almost at right angle to the main axis of the stems. In cuttings made from stems of the mature growth phase roots also form from cells of the callus tissue (fig. 13 A, B).

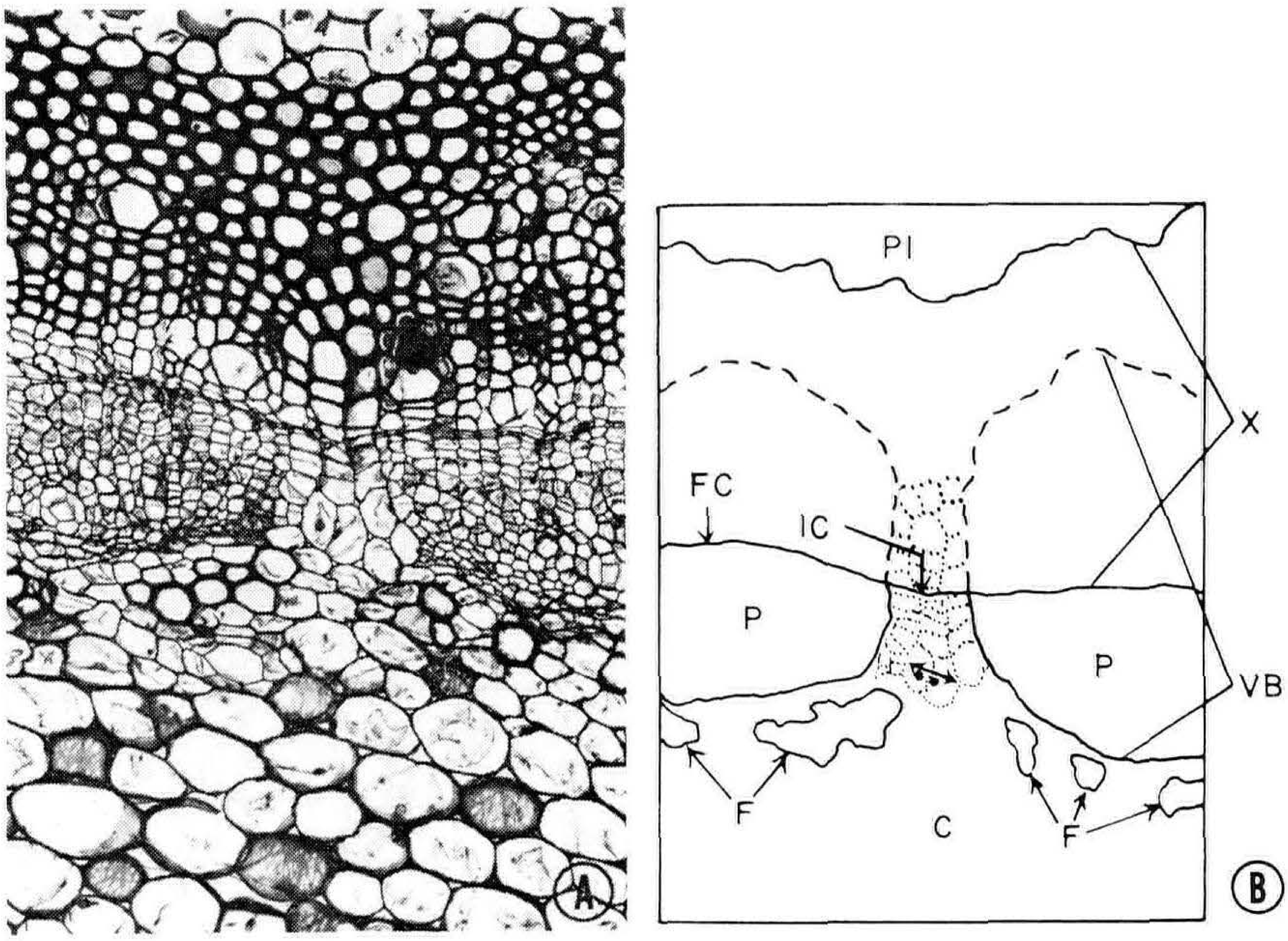
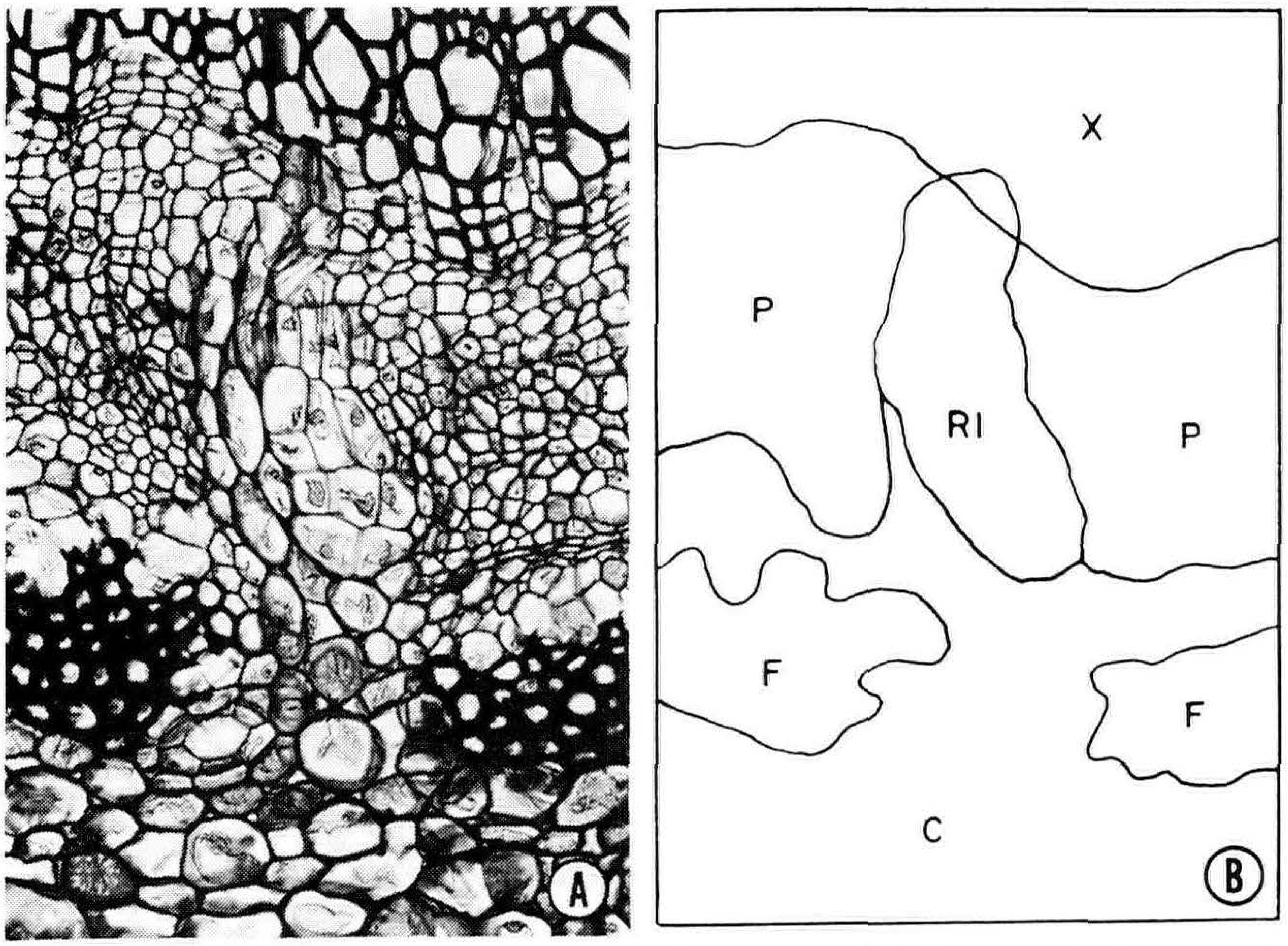


Figure 7 A, B. Two cells of phloem ray parenchyma are the product of a recent anticlinal division. These cells have dense cytoplasm and deeply stained nuclei. PI, pith; P, phloem; X, xylem; VB, vascular bundles; F, fibers; IC, interfascicular cambium; FC, fascicular cambium.



Figures 8 A, B. A young root initial made up of a slightly organized group of cells is seen developing between two phloem traces. X, xylem; P, phloem; RI, root initial; F, fibers; C, cortex.

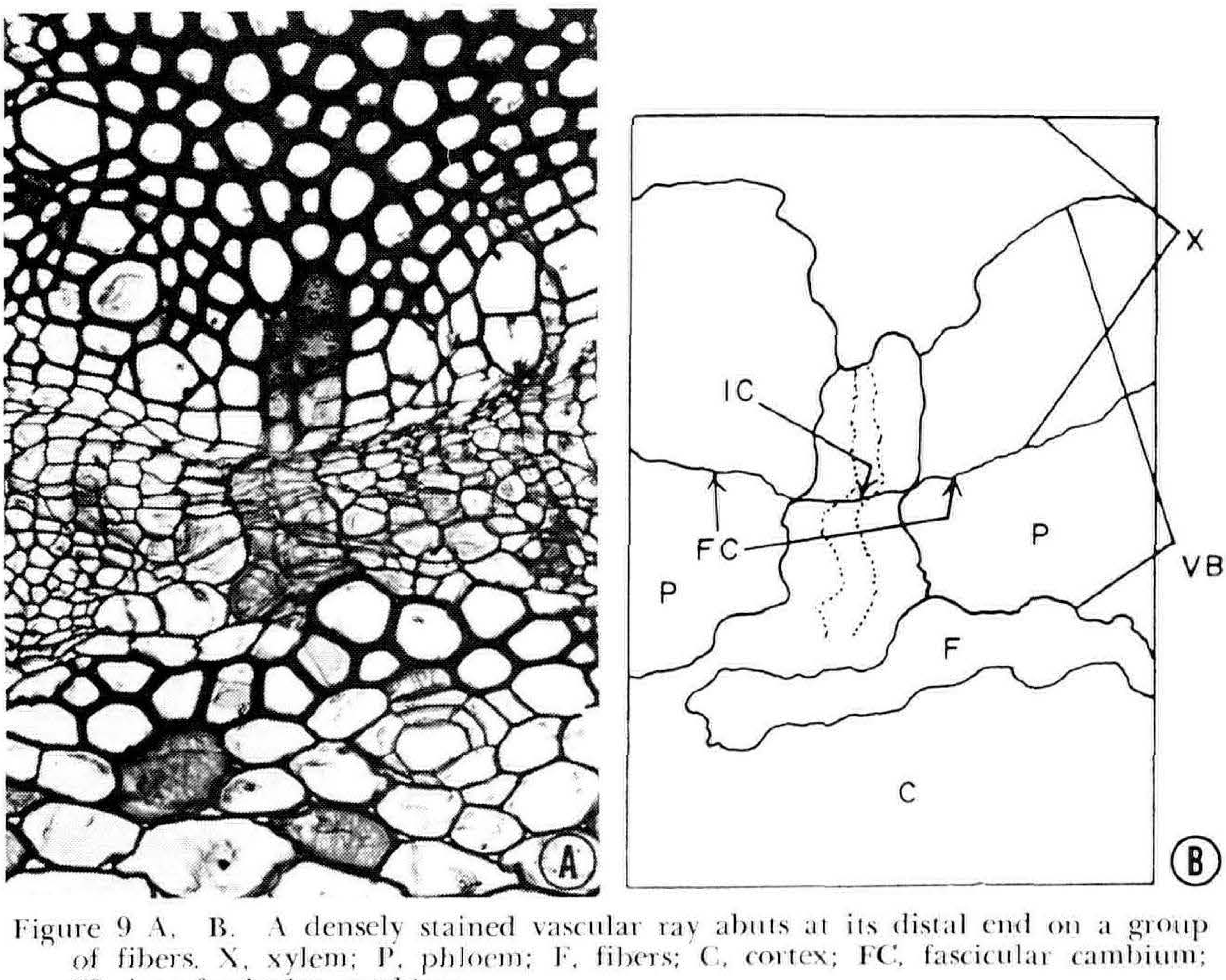


Figure 9 A, B. A densely stained vascular ray abuts at its distal end on a group of fibers. X, xylem; P, phloem; F, fibers; C, cortex; FC, fascicular cambium; IC, interfascicular cambium.

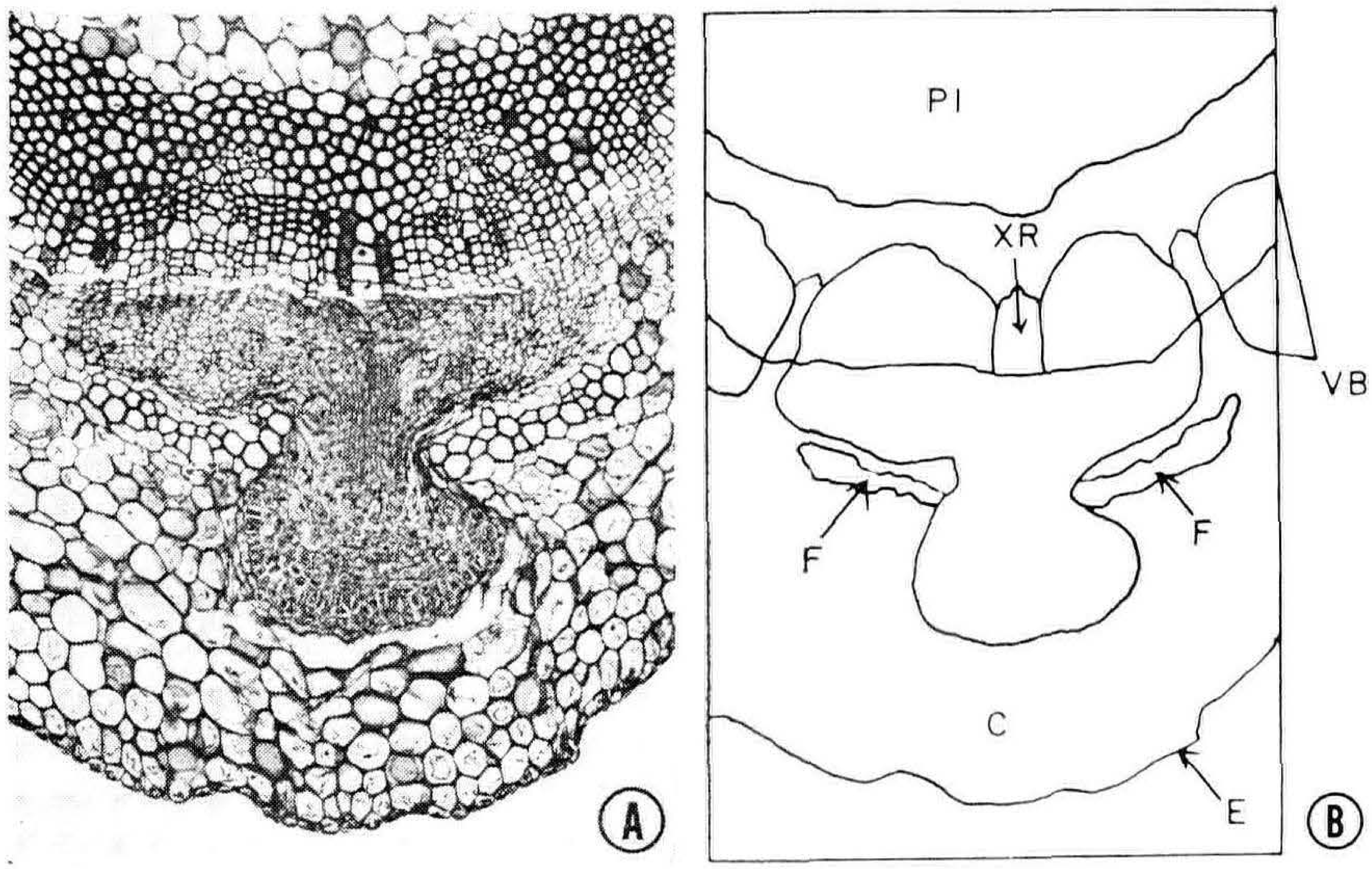
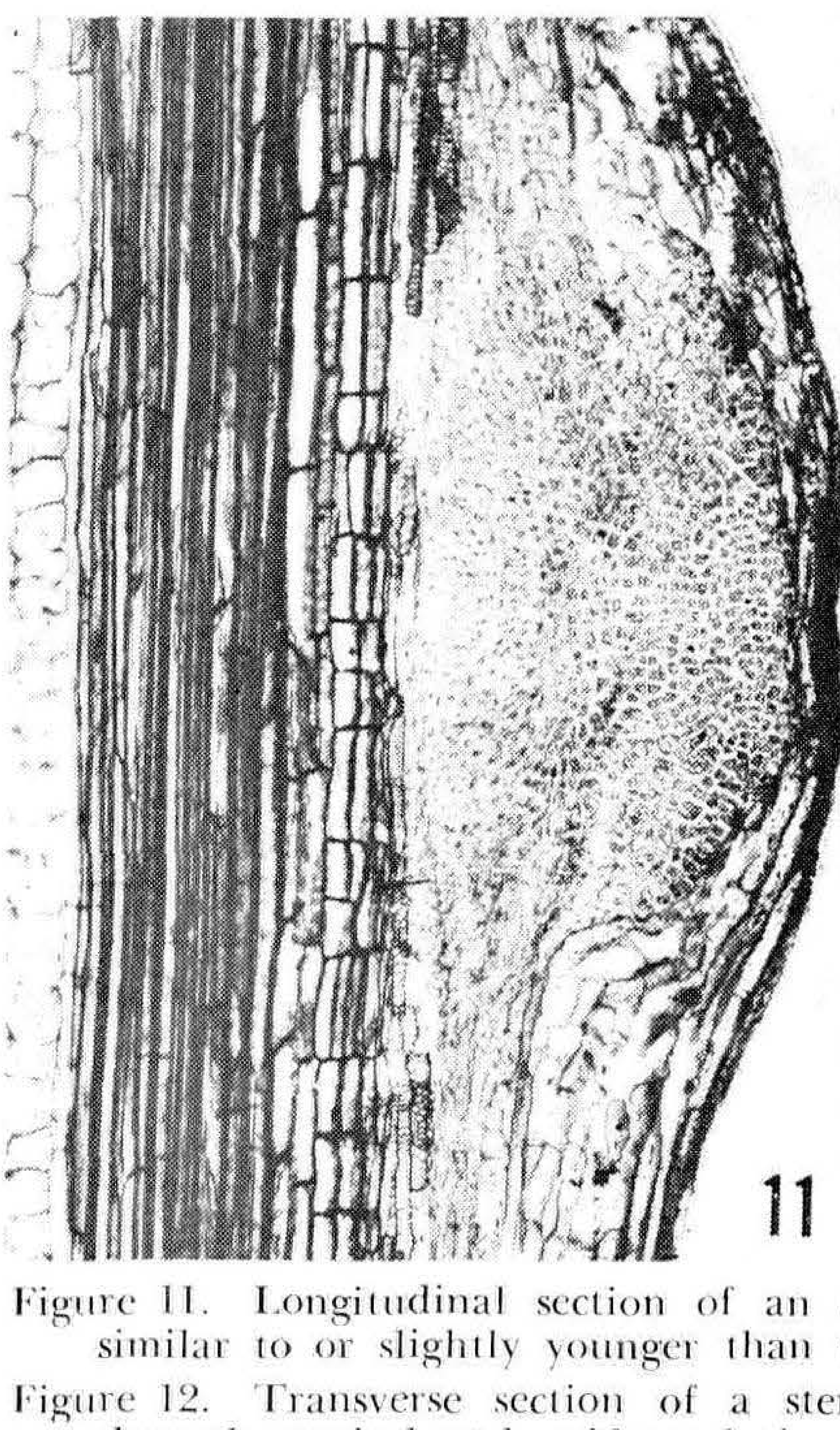


Figure 10 A, B. A young root primordium with well organized tissues. Phloem elements of at least two vascular bundles and three rays take part in the formation of a root primordium. PI, pith; XR, xylem ray; F, fibers; C, cortex. From: Girouard, R. M. 1967. Canad. J. Bot. 45:1877-1881.



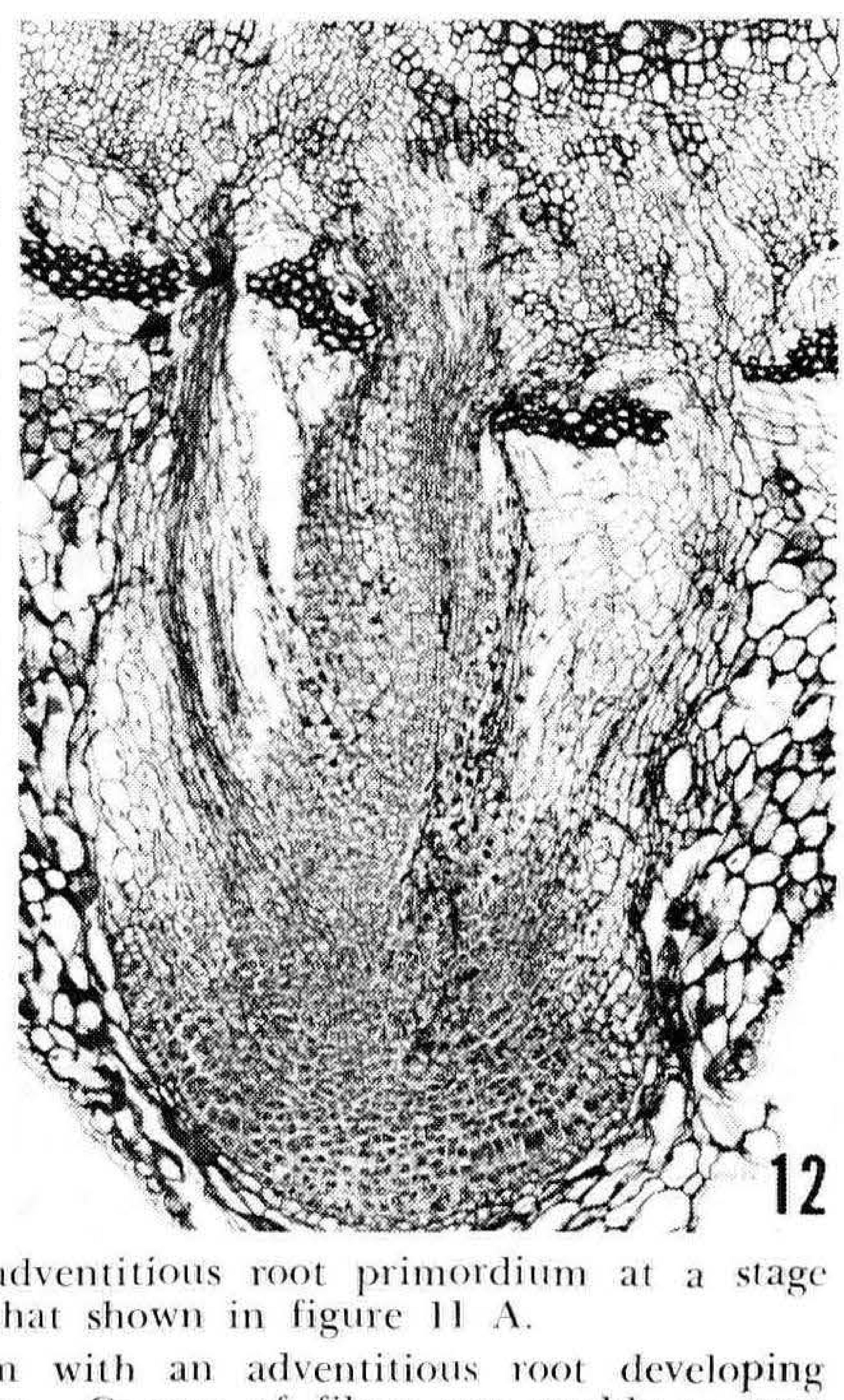


Figure 11. Longitudinal section of an adventitious root primordium at a stage similar to or slightly younger than that shown in figure 11 A.

Figure 12. Transverse section of a stem with an adventitious root developing through cortical and epidermal tissues. Groups of fibers are unable to stop the last few stages of root formation. From: Girouard, R. M. 1967. Canad. J. Bot. 45:1883-1886.

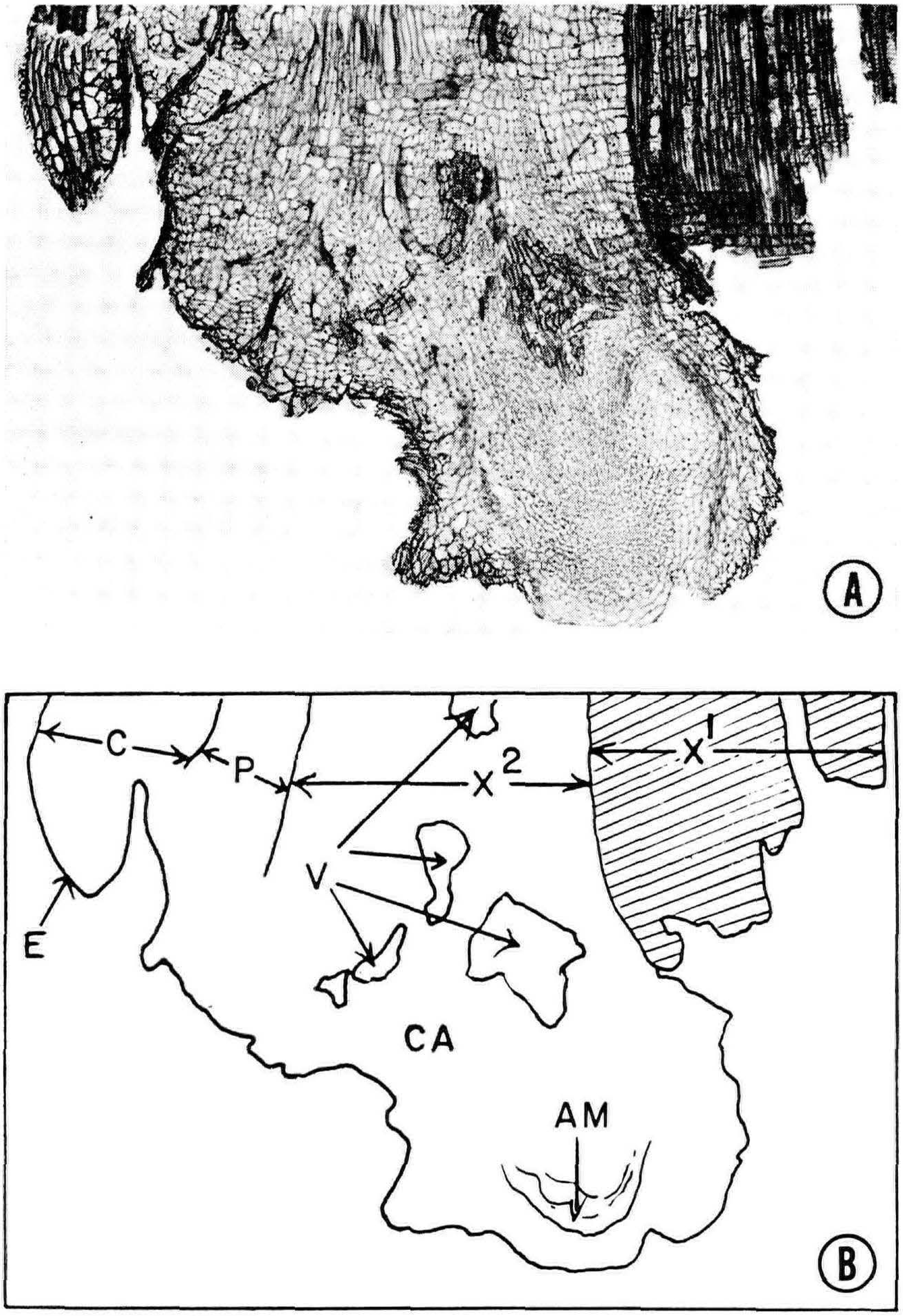


Figure 13 A, B. In stems taken from mature phase plants adventitious roots also form in callus tissue at the bascal end of cuttings. X^1, primary xylem; X^2, secondary xylem; P, phloem; C, cortex; E, epidermis; V, vessels; *CA*, *callus*; AM, apical meristem.

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MODERATOR CANNON: Our next speaker is also from Canada. Mr. Joerg Leiss will speak on outdoor grafting.

GRAFTING, OUTDOORS, DECIDUOUS AND BROADLEAF

JOERG LEISS
Sheridan Nurseries Ltd.,
Oakville, Ontario, Canada

While grafting is described as any method which permits actual cambial contact between compatible plant parts, I will refer in this paper to grafting as the placing of a scion upon an understock, this then excludes budding.

The reason for graftage is largely the same in or outdoors; mainly propagation of desirable characteristics, such as shapes and forms, unusual colouring of leaves, abundance and quality of fruiting, and the slowing or speeding of growth. Our nursery grows strictly ornamental plants and my remarks will deal with a number of trees which we propagate by graftage. Before going into details, I will briefly describe our methods:—

1. Splice grafting and its variant whip and tongue. 2. Triangling when understocks are larger than the scion. This is generally the case. We like to have a well established understock to give us the desired vigorous growth. In many cases we rather wait a year to get this more vigorous growth. 3. The last method we use is bark grafting, when the season is well enough advanced so that the bark parts easily. This method would entail the storing of scions. We cut most of our scions the day before we want to graft them.

Tying is done with raffia triple X grade. Wound covering is a tar asphalt emulsion. It can be diluted with water but once dry it will not wash off. There is enough flexibility to prevent cracking when the plant expands. Care has to be taken that enough of it is put on so the first rain does not wash it off. It cannot be used when freezing.

We start our grafting as soon as the frost begins to go out of the ground but we do not graft during frosty weather. Not only did we experience poor results, but also had quite a few nicks and cuts on the grafter's hands. Knives used are one-sided sharpened to facilitate the straight and flat cut which makes grafts so much easier to fit. They are kept razor sharp.

Team work is carried out where possible. For instance, when triangling or whip and tongue grafting; the grafter does the fitting of the scion and understock and is followed by a tier. Three or 4 grafting teams are served by a waxer. Stocks are cut level before grafting. Scions are either 3 buds or bud pairs.

In chronological order we start with *Fraxinus excelsior* varieties which are grafted at 6′ stem or above. *F. e. globosa, F. e. pendula, F. e. compacta, F. e. jaspidea* are some of the varieties we graft. Points for Fraxinus are that a bud is left on the understock at its highest point. This is called a drawing bud. Without it, grafting is not successful for Ash.

Ulmus varieties. Despite Dutch Elm disease we still grow 2 hybrid Elms for trees and intermediate stem. On this we graft: *Ulmus glabra pendula and U. glabra unbraculifera* at 6′ and 7½′ heights.

Robinia pseudoacacia is the understock we use at ground level for such varieties as *R. p. tortuosa, p. fastigiata*, its yellow form Friesen Gold. *R. hispida* and the form R. Idaho. On 6′ stems we graft *R. p. inermis* the globe and also the pink flowering forms such as *R. hispida.*

Prunus avium is used for 6 and 4′ standards of Jap. Cherries and a large number of *P. serrulata* and *P. subhirtella* forms are grown. To mention a few beside *P. serrulata* Kwanzan, *P. serrulata* Amanagawa, Fugenso, Hokusai, Kiku-Shidare, Miyako, Shogetsu and Takasago. One year heads are normally saleable. Again a drawing bud greatly helps success. *Prunus tomentosa* stems are used together with *Prunus nigra* for 4′ stems of *P. triloba* and *P. cistena.* Again heavy stocks are preferred ¾″ thick if possible. The frost is out of the ground now and we turn to the items we like to graft with a little sap flow.

Euonymus europeus 4′ and 6′ standards are used for the evergreen forms such as *E. vegetus, E. Gaiety, E. coloratus.* The only caution here is to take off leaves. Also we have also done a few *E. alatus compactus* with success.

Caragana arborescens with it's pendula form is grafted at 4 and 6′ standards. And also *C. pygmaea* at the same height and the same understock.

Malus pumila standards or the intermeidate J. Fischer is used for such species as *M. sargenti, M. Echtermeyer,* and other slow growing forms such as Dorothea. J. Fischer is an eating apple, I brought from Europe and which among others proved to be the fastest and most compatible intermediate.

Gingko biloba and its cultivars such as the Fastigiate male, "Mayfield" and "October Gold" are grafted at ground level and give acceptable takes.

Sorbus aucuparis is used at 6′ for *S. aucuparis pendula.* We have also used *S. intermedia* as understock, when we found that trees 7-8′ caliber were grafted on it. Very seldom will *S. aucuparia* as understock reach these sizes under our conditions.

We reach now the time when sap flows fairly well and to our experience we get best results to graft:

Morus alba pendula on to *M. alba tatarica* at 6′. Triangling proves to be better than any other form of grafting.

Quercus pedunculosa is used as understock for *Q. pedunculosa fastigiata* and stocks exceeding 1″ caliber are proving best. A point is not to graft too low on the stock where the bark is very thick but 4 to 5″ up from the neck. The main point is to make sure that the thick bark is not mistaken to be a good fit, but that cambium lies on cambium. *Q. petraea columnaris* is done on the same understock.

Fagus sylvatica forms *F. s. pendula, F. s. pendula purpurea, F. s. asplenifolia* tricolor, *F. s. atropunicea,* the redleaved, and the better form Spaethiana, Rohani cutleaved and purple. Fagus is our last spring item and beside grafting fairly high 6-8″ off the ground, we found 2 and 3 year old wood has given best results, provided good buds are retained. While results with Fagus are only in the 25 — 30% success range, most of our other graftings are very successful, usually in the higher 80%.

Aesculus hippocastanum is used in the summer as soon as scions are available and are inserted on the side of the stock into a T cut, well waxed, and if carried out early enough so that enough callus is formed, very successful. Waxing and defoliating is a necessity. Not only the forms of *A. hippocastanum* such as *A. h. plena, A. h. carnea, A. h. brioti,* but also *A. h. parvifolia* can be propagated and much more successful than by budding.

After care of grafted plants consists of cutting off the raffia tie after the graft has knit well and shows signs of growth. Staking of too vigorously growing grafts to prevent blowing out by high winds, and where necessary, pinching for bushier growth are carried out. The wound covering is taken off on a cool day, when it does not stick.

MODERATOR CANNON: Our next paper, "Four Years of Nut Grafting Chestnut", will be presented by Dr. Richard A. Jaynes.

FOUR YEARS OF NUT GRAFTING CHESTNUT

RICHARD A. JAYNES AND GEORGE A. MESSNER[1]

Several clones of chestnut have been selected and named because of desirable characteristics of blight resistance, form, vigor, and nut bearing. Many of these, selected primarily for orchard traits, are Chinese chestnuts, e.g. Nanking, Orrin, and Crane; others, selected largely for ornamental or forest use are complex hybrids between the Chinese, Japanese, and American chestnut, e.g. Clapper, Sleeping Giant, C9. Unfortunately large scale propagation of these or other chestnut clones has never proven feasible in the United States. Spring grafting with dormant scions has met with limited and variable success. Budding has failed, and the rooting of cuttings by many methods has invariably met with complete or nearly complete failure.

In 1963, Moore (4) described before this group a promising method he called the nurse-seed graft. The technique involved the grafting of a dormant scion into a germinated nut from which the root and shoot had been removed. Substances in the cotyledons of the nut presumably stimulated root formation from the scion near the area of contact. In 1965 one of us reported (3) the results of 450 nurse-seed grafts of chestnut using several clones and seed sources. Although roots were readily formed they did not arise from the scion, but differentiated from the seed nut near the surface of the cut petioles. Since the nut is more than a "nurse" — it contributes the root

[1]Genetics Department, The Connecticut Agricultural Experiment Station, New Haven, Connecticut, and New England Nut Tree Nursery, Wapping, Connecticut, respectively

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system — the method is more appropriately called *nut grafting*. The potential advantages of the nut grafting technique include the following; large stock plants are not needed, grafting is done indoors, timing is not critical, and the technique is relatively simple. However, more experience was needed. The following is a summary of our successes and failures with nut grafting over the past four years.

Technique

The nut graft method used (3) is summarized in Figure 1. This technique differed from Moore's in that the nuts were at an earlier stage of germination; the epicotyl and secondary roots were generally not evident.

The first year all grafts were placed in a polyethylene enclosed propagating frame in a greenhouse and, though this was used for two additional years, we have also had three years experience with enclosed outdoor frames. Grafts were set in the greenhouse frame from January through June, and in the outdoor frame from March 27 to May 30. They were placed with the union about 1½ inches deep in a mix of 5 parts sphagnum peat moss to 2 parts coarse perlite or vermiculite. It was found that the grafts grew better in the mix containing vermiculite. The medium was kept at about 70° F; the air temperature fluctuated.

Grafts started in the greenhouse frame were moved shortly after rooting, usually within 1 to 2 months, whereas in the outdoor frames they were left in place for the full growing season. In the latter beds a 2 inch layer of sandy loam under the 4- to 5-inch layer of peat-vermiculite helped sustain growth. Under the loam was hardware cloth and electric cables, which in turn rested on sand and gravel. After rooting, light applications of complete fertilizer were added every 3 or 4 weeks until mid-August.

Time is important with any propagation method; we estimate that each graft takes approximately one minute to com-

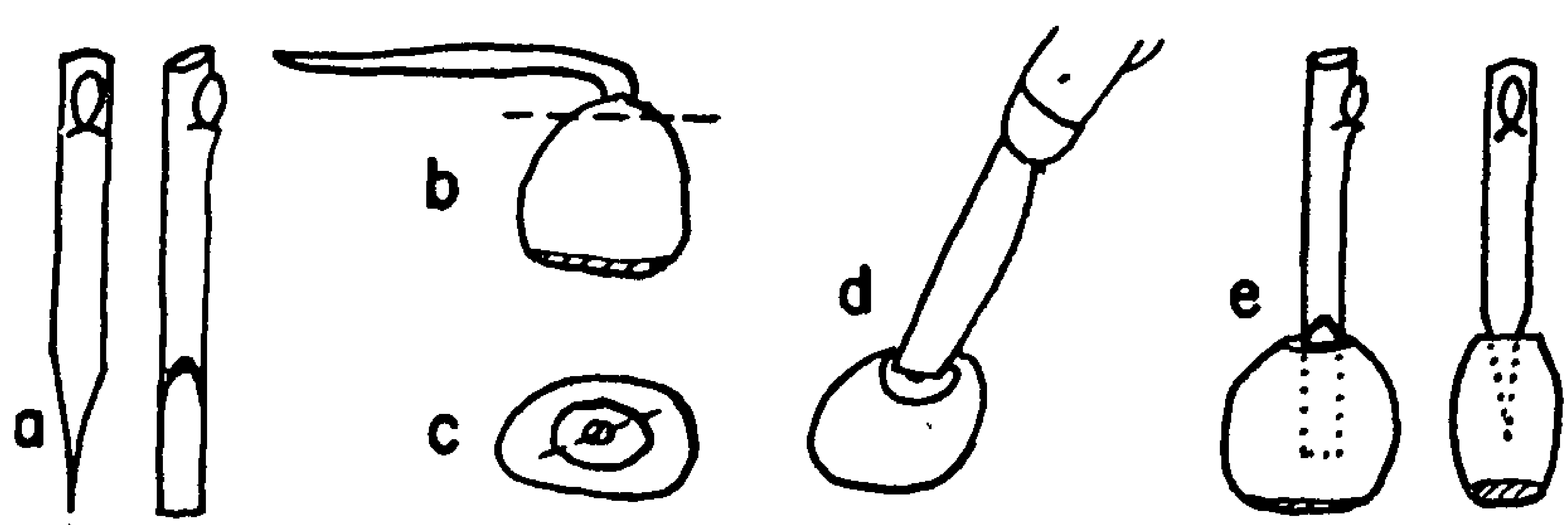

Figure 1 The nurse-seed graft A) Two views of scion prepared with wedge-shaped cut B) Germinating nut. Dashed line indicates cut that will remove root and shoot C) Shoot and root of nut removed Dashed line indicates where knife blade is inserted into nut through the petiole stubs D) Knife blade inserted in nut E) Two views of completed graft, scion inserted in nut (after Jaynes 1965)

plete. Thus, one man could graft approximately 500 nuts in a day, providing he did not have to keep track of many scion and nut sources.

Results

Over 5,600 nut grafts (Table 1) were made between 1964 and 1967 using numerous clones and nut sources. As previously reported, the time of grafting (from January to June) has little effect on success. Scions grafted in January and February broke dormancy more slowly than those grafted later. Root formation usually occurred within one month. Large nuts, about 10 grams, generally made better stocks than small nuts.

Fungicides and Growth Regulators

Prior to grafting, scions and nuts were dipped in a 0.06% w/v solution (1 tsp/gal) of 8-hydroxyquinolin sulfate to inhibit fungal contaminants. A test with this substance the first year indicated there was no harmful effect on the grafts; however, some decay of young grafts still occurred. To counteract this another fungicide was tried. A heavy suspension of thiram (Arasan 75) was sprayed around the union of 40 completed grafts before placing them in the frame. Compared to an equal number of untreated grafts, survival was reduced 22%, from 68% down to 46%. Thus the use of Arasan was discontinued.

In another test 0.8% indolebutyric acid (Hormodin Powder No. 3) was applied to the union of 20 grafts. Survival after two months was 80% as compared to 74% for 19 control grafts. A mixture of indolebutyric acid, naphthaleneacetic acid and thiram (Rootone F) was similarly tested on 2,200 grafts. Survival of the treated grafts was slightly better than the controls, 38% versus 34%. Thus it appears that the application of growth regulators might be beneficial.

Table 1 Nut graft survival

Location of frame	Year	Number of grafts	Number with roots	Percent survival
Greenhouse	1964	469	246[1]	50
Greenhouse	1965	439	211[2]	48
Greenhouse	1966	283	164[2]	58
Outside	1965	862	185[3]	22
Outside	1966	2331	859[1]	37
Outside	1967	1300	[4]	—

[1]Recorded 1-2 months after grafting

[2]Recorded 2 months after grafting

[3]Recorded 6-9 months after grafting

[4]Not tabulated, but results poor due to adverse conditions developing in frame during callus and root formation

Outdoor Frame

Three years experience using an enclosed, heated, outdoor bed demonstrates that an outdoor frame can work as well as a bed in the greenhouse (Figure 2). For instance, of 378 grafts of the Nanking clone on Nanking nuts 48 percent were rooted and alive at the end of the first growing season. At that time they were up to 40 inches high and averaged 12 to 18 inches in height.

One of the reasons for the lower average of successful grafts in the outside frames was the difficulty in maintaining adequate temperature and humidity control. The humidity needs to be high, although a saturated atmosphere may not be necessary. Grafts in an open greenhouse bench were unsuccessful as were grafts in an enclosed but unheated outdoor bed. Poor results in one frame in 1967 were attributed partly to high and near lethal temperatures which inadvertently built up in spite of two layers of shade cloth. Maintenance of proper conditions is important during rooting as well as during the hardening off period immediately after rooting. The second cause for disappointing results in 1967 was attributed to poor scion wood. As with any grafting procedure the scion and stock material must be in excellent condition.

Compatibility

In a comparison of 30 grafts each of 9 hybrids, 7 of the 9 clones unexpectedly had higher survival on Chinese nuts than on their own respective nuts—for each hybrid 15 grafts were on Chinese (Hemming) nuts and 15 were on nuts of the respective hybrid. Other comparisons also indicate that species or hybrids do not necessarily graft best on their own nuts. Among the most successful combinations, e.g. 84% survival from 31 grafts after the first growing season, were Chinese-seguin hybrids on Chinese or Chinese-hybrid nuts. Hybrid clones with seguin parentage grafted better than other scion sources regardless of the nut source. In spite of the large number of combinations tested it is not possible to recommend specific scion-nut combinations.

Translocation of Root Promoting Substance

To test the theory that the nut might transmit a root promoting substance to the scion, 70 scions consisting of two different clones were grafted with the nut on top of the scion. The graft was made as described in Figure 1, except that the wedge-shaped cut was made just above a bud on the scion, and the nut was placed on top of the scion. The nut and upper portion of the scion were wrapped in aluminum foil. The base of the scion was cut on a slight slant and placed in the medium. It was hoped that a root inducing substance might be translocated from the nut, down to the base of the scion where it would accumulate and stimulate rooting. Good union and callus formation occurred between the nut and scion, but no roots formed on the scions. The results were the same in another trial where scions were grafted into the cotyledon tissue of nuts at points other than where the petioles emerge—none of the scions formed roots.

Transplanting and Field Survival

Transplanting of rooted grafts during the growing season was generally not practical because of transplanting "shock" and limited subsequent growth. An attempt to root grafts in individual paper containers to facilitate moving them was without notable success. Grafts started in an outdoor frame could be left in place for at least one full growing season; however, their survival through the first winter has been a problem. The scions appear to be highly susceptible to winter damage, and often have loose, split bark in the spring. This problem is not unique to nut grafts, but has been reported on grafts of citrus and other nut trees (1) when the graft union is low. Presumably the scion wood from a "mature" tree does not become conditioned to the extreme temperature fluctuations near the ground as readily as "juvenile" wood. Yet there is no doubt that these nut grafts can be over-wintered, for we

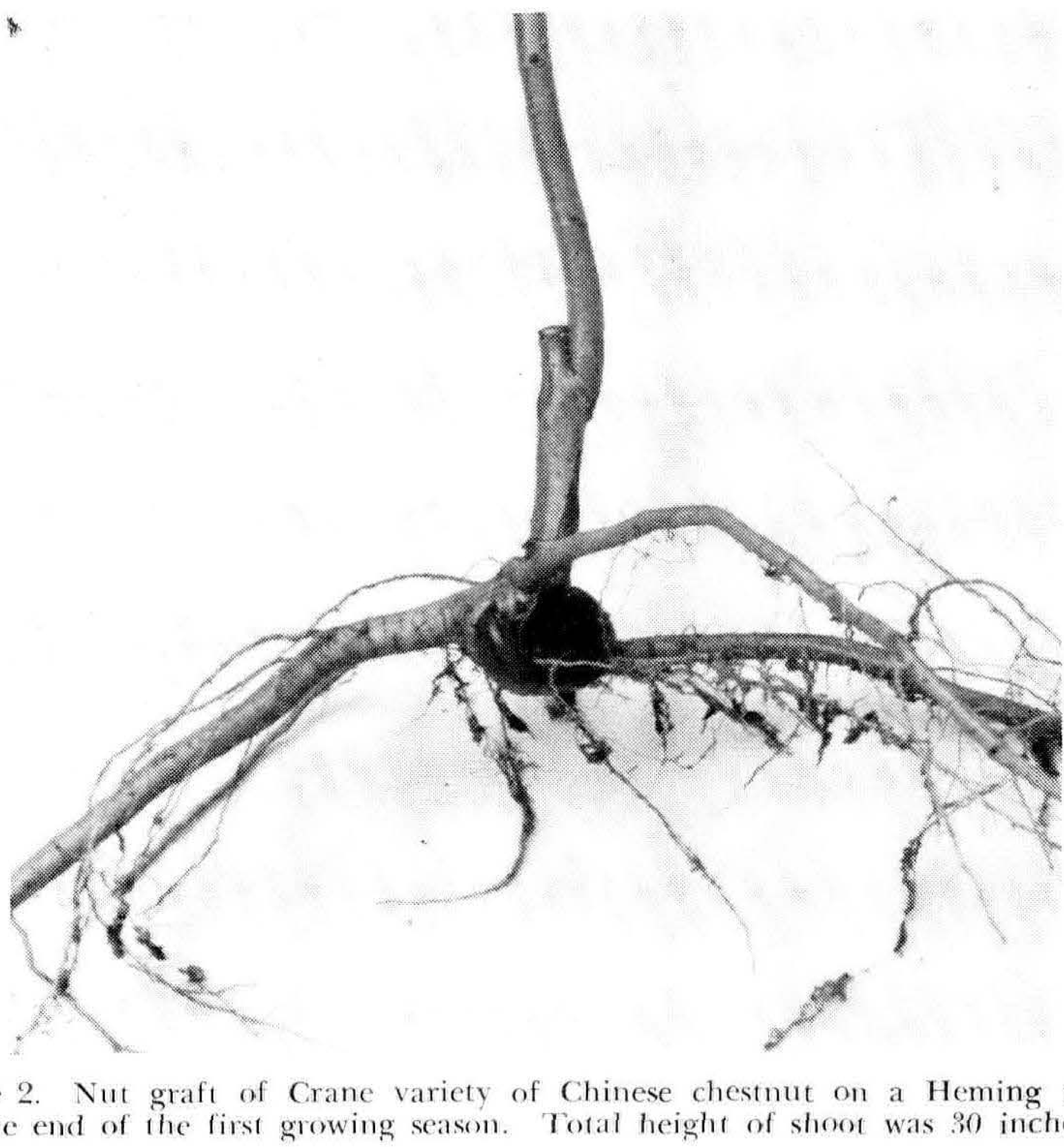

Figure 2. Nut graft of Crane variety of Chinese chestnut on a Heming nut at the end of the first growing season. Total height of shoot was 30 inches.

now have several of bearing age; but the percent surviving has been very low due to insufficient protection.

Rooting of Scions

In contrast to observations by Moore (4) and Goggans and Moore (1) no root formation on the scion proper has been observed on any of our grafts during the first growing season. Twenty-five 2-to 4-year old grafts were examined and only one of them had any roots from the scion.

Summary

Nut grafting has met with qualified success in enclosed, heated, outdoor frames. Survival of 45-80 percent has been obtained for several scion-nut combinations. A nut graft is a conventional graft made in an unconventional way. Roots arise from the stock nut, seldom from the scion. There is need for further refinement of conditions required for consistent success with the nut grafting technique. Young grafts are susceptible to winter injury and will require protection.

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MODERATOR CANNON: The program now calls for a discussion period of the three papers which you have just heard.

ROBERT FARMER: Have you tried the nut grafting on oak?

RICHARD JAYNES: We have tried the nut grafting on oak and have had very limited success. I know it can work, but I question its ultimate practicability.

JAMES WELLS: I would like to ask Mr. Girouard about the origin of a root from callus. I did not know that roots would originate in callus. We have often been told to remove a large amount of callus when it forms at the base of a cutting and I would like to know whether this is an advantage or a disadvantage?

RON GIROUARD: My experiences are limited to the adult form of the English ivy and to spruce, with which I am working now. For those two plants callus seems to be beneficial. What happens is a group of cells within a portion of the callus become meristematic. Then vascular tissues begin to grow out from the original stem and link up with the developing meristem.

DICK FILLMORE: I would like to ask Dr. Jaynes what tissues form the graft union in his nut-grafting technique?

RICHARD JAYNES: We obtain a union at both the cotyledon petioles or the extensor tissues which connect the cotyledons with the developing seedling and also directly with the cotyledonary tissue itself. The most rapid union formation and the place where the roots initiate is the cotyledon petioles or stubs which remain after the young seedling is cut away.

MARTIN VANHOF: I would like to ask Dr. Jaynes if he has planted the chestnuts and then grafted on the young seedlings during the normal growing season?

RICHARD JAYNES: Yes, we have tried that but have met with very varied degrees of success. We seem to have more success grafting and top working Chinese chestnut and in southern areas such as Georgia, and Maryland. However, in our area in Connecticut, we have not had good success. Conventional grafting has not proven feasible for any commercial nurseryman as yet.

MODERATOR CANNON: To start off the second portion of this morning's program we have Dr. Fred Lanphear who will speak on some new developments for weed control in transplant beds and field liners.

SOME NEW DEVELOPMENTS FOR WEED CONTROL IN TRANSPLANT BEDS & FIELD LINERS

F. O. LANPHEAR
Purdue University
Lafayette, Indiana

The problem of weed control in transplant beds and field liners cannot be adequately covered in a few minutes, but I would like to discuss some new concepts that are particularly relevant to the topic. Needless to say, the problem of weed control in nurseries is of great magnitude, particularly in relation to transplant beds. In fact, estimates of weed control cost have been as high as $6000/Acre/year for transplant beds where weeding was by hand. (1) Cost in field liners have ranged from $125.00 to $600.00/A/year with manual or mechanical means. It is imperative that these costs be reduced since the cost of manual labor is continuing to increase at a rapid rate. The appearance of herbicides on the scene provide some tremendous possibilities in solving this problem.

Basically, herbicides are plant poisons. Fortunately, they are selectively poisonous. This selectivity is based on a number of factors, including the ability of some plants to degrade the chemical or inactivate it in some way while others do not. One of the major factors in selectivity is the immobility in the soil once they are applied. This immobility allows the herbi-

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Basically, herbicides are plant poisons. Fortunately, they are selectively poisonous. This selectivity is based on a number of factors, including the ability of some plants to degrade the chemical or inactivate it in some way while others do not. One of the major factors in selectivity is the immobility in the soil once they are applied. This immobility allows the herbicide to prevent or kill germinating weed seedlings near the soil surface without allowing the herbicide to move into the root zone of the desired plant. However, the more shallow-rooted plants are consequently more sensitive to herbicides. Young transplanted stock and field liners fall into this category.

Traditionally researchers looked for one herbicide that would control a broad spectrum of weeds without causing injury to the desirable plants. This is asking a lot from one chemical, since usually a herbicide will be effective on a particular group of weeds, such as the grasses, while being less effective on others. To make it more effective for a broader spectrum of weeds it was sometimes necessary to recommend higher rates. Unfortunately, higher rates increased both cost and possible toxicity.

I would like to illustrate an example of this and an alternative approach to increasing the concentration or looking for another "wonder" herbicide to do the total job.

Simazine is a herbicide that has been used extensively by nurserymen with varying degrees of success. At the recommended rate of 2-3 lb/A of the active chemical, which is equivalent to 50-75 lbs of the 4% commercial formulation, simazine will control a broad spectrum of weeds, but it also is toxic to many woody ornamentals such as *Euonymus* spp., *Forsythia* spp., *Lonicera* spp., and *Liqustrum* spp. At lower rates, simazine is effective on many weeds but will not control the grasses. Consider the possibility of combining simazine at the low rate with another herbicide that would be effective on the grasses. There is such a chemical available in the form of diphenamid. Diphenamid, which is available commercially as Dymid or Enide, is a very safe herbicide on most woody ornamentals but is ineffective on many weed species other than grasses.

As shown in Table 1, simazine at 1 lb/A was relatively ineffective on grasses as was diphenamid on broadleaf weeds. However, the combination of these gave complete weed control

Table 1 The effectiveness of simazine and diphenamid alone and in combination on weed control Applied on June 4, 1964

Herbicide treatment	Rate (lb/A)	Weeds Counted June 24, 1964 Grasses	Broadleaved Weeds
		Average number of weeds per square ft	
Control	0	117.2	104.8
Simazine	4	.5	.1
Simazine	1	15.4	5.6
Diphenamid	6	.1	7.1
Simazine	1	0	0
+ Diphenamid	6		

and at the same time lowered the concentration of simazine to a non-toxic level.

The reduction in injury using this combination of the herbicides simazine and diphenamid at reduced concentrations was shown on many species normally susceptible to simazine (Table 2). This principle of combining herbicides which is being explored in other crops opens new pathways in solving weed problems in nursery plantings.

Table 2 Tolerance of selected woody and herbaceous ornamentals to the combination of simazine (1 lb/A) and diphenamid (6 lb/A)

* *Euonymus fortunei* 'Coloratus'	— No injury
Vinca minor	— No injury
* *Forsythia intermedia*	— No injury
* *Ligustrum obtusifolium* 'Regelianmum'	— No injury
Pachysandra terminalis	— No injury
Sedum acre	— No injury
* *Ajuga* 'Metallica Crispa'	— 50% killed

*Frequently injured by recommended rate of simazine

However, as shown in Table 2, the combination approach does not solve all the problems since Ajuga was severely injured with the combination.

At the same time we were investigating the use of herbicide combinations, we became interested in a technique being used in England to increase the tolerance of plants normally susceptible to a particular herbicide. The technique, which has been used successfully on strawberry plants, utilizes activated carbon (charcoal) which is applied to the roots of the plant before planting. The principle on which this is based is similar to that of the activated carbon in a filter cigarette. The finely powdered carbon adsorbs many chemicals onto the surface, thereby inactivating them. Therefore, if a herbicide should move into the root zone of the newly established rooted cutting or seedling, it will be adsorbed by the carbon, thus preventing it from being absorbed by the plant and causing injury.

The technique has been used with different sensitive species, with varying degrees of success. As shown in Table 3,

Table 3 The effectiveness of activated carbon in preventing simazine injury to *Euonymus fortunei* 'Coloratus'

Treatment	% Injured	% Dead
Control	0	4
Simazine (3 lb/A)	50	8
Simazine (3 lb/A) + Activated carbon	8	4

the simazine injury at the 3 lb/A rate was greatly reduced by the use of activated carbon. Thus, the dipping of the roots or peat pot of young plants in a 10% slurry of activated carbon provides a method of decreasing the risk factor in the use of toxic herbicides, by actually increasing the tolerance of many otherwise sensitive species to herbicides.

The last technique I would like to discuss is the possibility of applying herbicides to transplant beds in combination with mulches. Mulches are frequently used to help reduce weeds and provide more favorable growing conditions. Yet mulches seldom completely control all the weeds. By incorporating a herbicide into the mulch it may be possible to get more complete control of weeds at the same time the mulch is providing other benefits such as increased moisture retention and reduced temperature fluctuations in the root zone.

The technique has been evaluated over the past 3 to 4 years in Indiana and New York (2). The results have been better than was expected. As shown in Table 4 the incorporation of dichlobenil (Casoron) in the mulch not only provided more effective weed control than either alone, it extended the weed control into the second year. This can be partially explained by the nature of dichlobenil which is quite volatile unless incorporated into the soil, mechanically or with irrigation.

Table 4 Persistence of herbicide activity when incorporated in a mulch on weed control in transplant beds

Treatment (June, 1965)	Time of Weed Counts			
	Aug 1965	Oct. 1965	May 1966	Aug. 1966
	Average number of weeds per sq ft			
Control	31.5	5.9	7.6	7.4
2″ peat moss	1.6	1.9	15.7	5.6
Dichlobenil (4 lbs/A)	7.4	3.2	7.2	6.8
2″ peatmoss + dichlobenil (4 lbs/A)	0	0	.1	1.2

The incorporation of dichlobenil into the mulch provides the same type of volatility barrier. Another advantage of the herbicide mulch combination is the relative ease of application. By mixing the herbicide into a mulch in the proper proportions, as indicated in Table 5, a uniform and accurate application can be achieved by just controlling the depth of the mulch.

The other important consideration is the effect of this technique on plant performance. In Table 6, the increase in growth of *Spiraea vanhouttei* as measured by fresh weight is quite apparent from increasing the depth of the mulch. Similar results were obtained with *Cotoneaster acutifolia, Lonicera zabeli* and *Weigela florida*. Part of this growth response may

Table 5 Proportion of herbicide to mulch in the preparation of mulches incorporated with herbicide

Desired Depth of Mulch	Area Coverage by 1 cu ft	Amount of Casoron* per cu. ft of mulch
inches	sq. ft.	gms/cu. ft.
1	12	12.50
2	6	6.25
3	4	4.17
4	3	3.13

*Casoron expressed in gms of commercial formulation (4%)

be due to the nutritive value of the mulch which contained 2 parts shredded bark to 1 part composted sawdust, which provides a slow release of nutrients. This suggests a 3 in 1 approach: weed control plus moisture retention and temperature moderation plus fertilization all in a single handling.

Table 6 *Effect of mulch-herbicide combination on growth of Vanhoutte spirea* *

Dichlobenil (lb/A)	Depth of Mulch (in) 0	1	2	4
	Average fresh Weight/plant (gms)			
0	17	15	37	59
2	—	17	—	—
4	20	15	42	59
8	—	—	—	63

*Similar results obtained with Cranberry cotoneaster, Zabel honeysuckle, and Rose weigela

In summary the incorporation of Cásoron in an organic mulch provides a relatively easy method of application. It is only necessary to control the depth of the mulch containing the proper proportion of the herbicide for effective weed control.

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MODERATOR CANNON: The next speaker on the program is a person whom you all know, Dr. Sidney Waxman. Sid will speak on the use of fluorescent lights for propagation under semi-controlled environments.

FLUORESCENT LIGHT INTENSITY AND PROPAGATION UNDER A SEMI-CONTROLLED ENVIRONMENT

SIDNEY WAXMAN
University of Connecticut
Storrs, Connecticut

INTRODUCTION

In a previous paper presented to the Society on the rooting of blueberry cuttings, the author mentioned the possible economic benefit of rooting cuttings under fluorescent light rather than sunlight (7).

The major reason the use of fluorescent light may be more economical than sunlight is not due to the source of light, but to the types of structures that are used in conjunction with these sources of light.

In using sunlight, one is limited to the use of a glass or plastic greenhouse in which the heat losses are rather high. By the use of fluorescent light, on the other hand, almost any type of structure may be used. Ideally, of course, it would be one that is well insulated.

The advantage of using an insulated building is that its heat losses during the winter months would be far less than that of a greenhouse.

Another and equally important advantage is that within such a building, considerable control of the environment is possible. Rapid changes in temperature and humidity that occur in greenhouses do not occur in the insulated house because these conditions are not so easily influenced by changes in the weather (4,5).

Cuttings placed under a uniform environment, i. e., one that does not have wide fluctuations of light, temperature, and humidity, would, most likely, have rooting percentages that are far more consistent than would cuttings placed in greenhouses where these fluctuations occur spontaneously with each cloud that passes by the sun.

The decision as to whether the insulated propagation house is truly an improvement over the glass or plastic propagation house rests mainly on their costs of operation.

In the insulated propagation house where sunlight cannot enter, the major expense will be the cost of providing an artificial source of light, the fluorescent lamp.

The amount of light necessary to keep cuttings healthy and at the same time encourage root initiation, will determine the approximate cost of lighting.

Fortunately, many improvements in the manufacture of fluorescent lamps have taken place in the past twenty years. The life expectancy of the lamp has been increased to approximately 12,000 hours (1).

Since 1950, the 40 watt cool white fluorescent lamp has had its initial light output increased 48% (1). In addition, there have been developed fluorescent tubes capable of providing wave lengths of light reported to be particularly effective for plant growth purposes (3).

In this study an attempt was made to determine whether certain selected ornamentals would root under fluorescent light, and, if so, determine the influence of light intensity on the numbers of roots initiated.

The idea of rooting cuttings under fluorescent light in insulated buildings was reported by Stoutemyer, Close and O'Rourke in 1945 (4), Stoutemyer and Close in 1946 (5), and by Chadwick in 1949 (2). However, this system proved to be unsuccessful when attempted on a commercial scale. Perhaps, with the use of mist, and with the improved fluorescent lamps that are now avaailable, these concepts may now be carried out successfully and be competitive with greenhouse propagated cuttings.

Methods and Materials

Two propagation benches used in this experiment were placed in an unused room of an apple storage building. A bank of fluorescent lamps placed on an angle provided a range of light intensities. Each bench was partitioned with aluminum foil-backed paper to provide a total of six compartments, each having a different intensity range.

In the compartment nearest the lamps, the intensity ranged from 430 to 470 footcandles. The compartment farthest from the lamps was illuminated with only 35 to 60 footcandles (Table 1).

With the exception of the three chrysanthemum varieties, all cuttings were taken from plants that had made a flush of

Table 1 Rooting of Cuttings under Mist while Exposed to various intensities of Fluorescent Light

Per Cent Rooted

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
Berberis Chenaultii	100	100	100	100	100	100
Buxus 'Vardar Valley'	58	50	91	50	41	50
Juniperus hor. Doug.	20	88	88	20	100	100
Juniperus hor. Wiltoni	80	40	80	90	100	90
Kalmia latifolia #137	0	60	20	30	30	0
Rhod. carol. pink	60	50	90	60	50	40
Rhod. mucron.	75	70	85	85	75	90
Rhod. 'Exb. hyb.'	83	100	100	83	100	100
Ilex crenata	100	100	100	100	100	100
Pachistima Canbyi	100	100	100	100	100	100
Pachysandra term.	100	100	100	100	100	100
Mean	70.5	78.0	86.7	74.3	81.5	79.0

growth and whose stem tissue had recently become firm.

The chrysanthemum cuttings were made of tender terminal shoots in active growth. In the latter case, the tender cuttings, presumably low in stored carbohydrates, were used to determine if such cuttings would survive the low intensities used in this study.

All cuttings were rooted while under a mist system which provided two seconds of mist every 10 minutes. A temperature of 70° F., was maintained in the medium throughout the experiment. The air temperature varied from 50 to 75° F.

The light sources were eight-foot-long cool-white fluorescent lamps, in addition to several incandescent lamps which were employed to provide the longer wave lengths of light in which the cool white lamps were deficient.

All species were treated with Hormodin #3 plus Captan except for the ericaceous plants which were dipped in "Jiffy-gro" one-tenth strength.

The lights were controlled by a time-clock and were on 16 hours daily. A mixture of equal parts of peatmoss and Perlite served as the rooting medium.

Responses of the various species to the six different light intensity ranges were judged by the size of their root systems.

Roots were counted on those species whose primary roots were easily distinguishable, while those species having contiguous roots and difficult to count, were given an arbitrary category according to the overall size of the root mass.

Results

All species initiated roots with fluorescent light as the sole source of radiant energy. For the majority of the species, the percentage of cuttings rooted was similar among the ranges of light intensity employed. (Tables 1, 2, 3, 4, 5).

With few exceptions, the percentage rooting was 100% in all intensities for the Exbury Hybrid azalea, *Ilex crenata, Berberis Chenaultii, Pachistima Canbyi, Pachysandra terminalis,* and the chrysanthemum varieties: 'Grandchild,' 'Sleighride,' and 'White Keepsake' (Table 1, 4).

Table 2 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light

Average Number of Roots/Rooted Cutting

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
Berberis Chenaultii	2.4	1.8	2.2	2.0	2.2	2.8
Buxus 'Vardar Valley'	2.3	2.7	6.2	2.7	1.8	2.0
Juniperus hor. Doug.	1.0	12.6	11.6	11.5	20.0	15.4
Juniperus hor. Wiltoni	4.3	3.0	4.3	3.7	3.6	5.0
Mean	2.5	5.3	6.1	5.0	6.9	6.3

Table 3 Rooting of Cuttings Under Mist While Exposed to various Intensities of Fluorescent Light.

Degree of Rooting *

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc
Ilex crenata	1.2	2.3	2.7	2.8	2.8	3.0
Kalmia latifolia #137	0.0	2.0	3.0	1.0	2.0	0.0
Pachistima Canbyi`	1.0	2.0	3.0	3.0	3.0	3.0
Pachysandra term.	2.0	2.0	2.0	2.0	3.0	3.0
Rhod. carol. pink	1.7	1.8	2.7	1.8	2.2	2.0
Rhod. 'Exb. hyb.'	3.0	2.8	3.0	3.0	2.5	3.0
Rhod. mucron.	2.5	2.9	2.3	3.0	2.5	3.0
Mean	1.6	2.3	2.7	2.4	2.6	2.4

* 0 .... no roots
1 .... few roots
2 .... med roots
3 .... many roots

The percentage rooting of *Juniperus horizontalis* Wiltoni and *Juniperus horizontalis* Douglasi was over 80% at all intensities except for three groups in which rotting was observed at the bases of the cuttings.

The remaining species belong to the category of plants known to be difficult to root. Of these, *Rhododendron mucronulatum* rooted at percentages of 70 through 90 and exhibited no correlation between light intensity and percent rooting. Buxus 'Vardar Valley' and *Rhododendron carolinianum* 'pink' had percentages between 40 and 60 at all intensities except for 90% and 91% at the medium range of 160 to 180 foot-candles. Again, no correlation could be made between intensity and rooting percentages.

Mountain laurel, *Kalmia latifolia* #137, notoriously diffi-

Table 4 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light.

3/3/67 — 3/17/67

Per Cent Rooted

Name	35-60 fc	90-120 fc	160-180 fs	185-250 fc	325-430 fc	430-470 fc	Greenhouse Rooted
Hardy Mums:							
Chrys. "Grandchild"	90	100	100	100	100	100	100
Chrys. "Sleighride"	100	100	100	100	100	100	100
Greenhouse Mum							
Chrys. "White Keepsake"	100	100	100	100	100	100	100
Mean	96.6	100.0	100.0	100.0	100.0	100.0	100.0

cult to root, rooted in all ranges except for the lowest and highest intensities (Table 1).

Differences in the numbers of roots developed (Table 2) or degree of rooting (Table 3) that may be correlated to light intensity appeared on only four species: *Juniperus horizontalis* Douglasi, *Ilex crenata, Pachistima Canbyi,* and *Pachysandra terminalis.* Although there are indications of retarded root development under the lowest intensity ranges, the differences are small (Table 2, 3).

Chrysanthemum cuttings exhibited differences in root development according to the intensity to which they were exposed. For all three varieties, the smallest mass of roots appeared on those cuttings exposed to the 35 to 60 footcandle range. The remaining groups were similar and illustrated no definite correlation between intensity and root initiation.

Chrysanthemums rooted under the fluorescent lamps compared favorably with those rooted in sunlight in a greenhouse (Tables 4, 5).

Except for a single cutting, all cuttings of all varieties rooted within 14 days. The extent of root initiation of the hardy varieties: 'Grandchild,' and 'Sleighride' propagated under fluorescent light intensities greater than 90 foot candles, was

Table 5 Rooting of Cuttings under Mist while Exposed to various Intensities of Fluorescent Light

Degree of Rooting *

Name	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc	Greenhouse Rooted
Hardy Mums:							
Chrys. "Grandchild"	1.5	2.0	2.3	2.0	2.6	2.9	1.9
Chrys. "Sleighride"	1.6	2.5	2.8	2.3	2.6	2.9	2.4
Greenhouse Mum:							
Chrys. "White Keepsake"	1.8	1.9	2.5	2.1	2.7	2.2	2.9
Mean	1.63	2.13	2.53	2.13	2.63	2.67	2.37

* 0 .... no roots
1 .... few roots
2 .... med. roots
3 .... heavy roots

Table 6 Growth of Chrysanthemum var 'White Keepsake' subsequent to its Propagation under various Intensities of Fluorescent Light*

Average Increase of Growth in Height (mm)

Dates	35-60 fc	90-120 fc	160-180 fc	185-250 fc	325-430 fc	430-470 fc	Greenhouse Propagated
3/17/67-4/7/67	15.8	15.9	16.5	13.2	14.7	15.9	15.6
3/17/67-4/19/67	36.5	34.0	38.0	29.2	29.8	32.8	36.4

* Propagation under Fluorescent Light 3/3/67-3/17/67

equal to the cuttings propagated in sunlight in a greenhouse (Table 4).

The greenhouse variety, 'White Keepsake' did not develop as large a root system under fluorescent light as it had in sunlight (Table 5). However, the subsequent growth of this variety, after transfer to a greenhouse, was similar to those propagated in the greenhouse (Table 6).

Discussion and Summary

The intensities of fluorescent light used in this experiment, especially those in the lower ranges, are much too low to support continuous growth of most trees and shrubs.

Ordinarily, most woody species require a range of approximately 1500 to 3000 footcandles for optimum growth and survival. Although an intensity of 100 footcandles is too low for the growth of the species used in this study, it apparently is sufficient for the period of time it takes them to initiate roots. This would especially be true of the "shade-loving" species, seven of which were used in this study.

One factor that probably contributed to the high percentages of rooting was the store of reserve foods within the stems at the time they were severed.

In this study, most cuttings were taken at a particular stage of growth in which the recently developed terminal shoot had been dormant long enough to accumulate a store of carbohydrates, but not so long that the tissues had become excessive ly lignified and probably detrimental to rapid root initiation.

Root initiation of tender terminal shoots taken during the active growth stage is often more rapid than woody shoots taken during summer dormancy (6). The limited supply of stored energy in the tender chrysanthemum cuttings probably would not have been sufficient to maintain their vigor for an extended period of time while exposed to low light intensities used in this test. Rooting of the chrysanthemum occurred in less than two weeks and, as a consequence, no serious depletion of stored energy was exhibited. This was brought out by the rate of growth of plants transferred from the low fluorescent light intensities to sunlight and compared with plants propagated and grown continuously in sunlight ,Table 6).

The most striking results of this study are that there was, generally, no correlation between light intensities and root initiation among the intensities used. Cuttings that are easy to root in a greenhouse rooted easily under fluorescent light under all intensities.

The lowest range, 35 to 60 footcandles, apparently was sufficient to keep the cuttings alive while they were expending their energy in the process of developing a root system.

According to the results of this test, and to the reports of Stoutemyer, et. al. (4,5), the minimum light requirements for the propagation of many woody ornamental species are of such low order that it would be feasible to use fluorescent light for propagation on a commercial scale.

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7. ---------------- Propagation of blueberries under fluorescent light at various intensities Proceedings International Plant Propagator's Society 15 154-158 1965

MODERATOR CANNON: Our next paper is by Dr. John McGuire. Dr. McGuire is at the University of Rhode Island and will speak on the entrance of growth regulators into cuttings.

ENTRANCE OF SYNTHETIC GROWTH REGULATOR IAA-2-14C INTO CUTTINGS OF ILEX CRENATA 'CONVEXA'

JOHN J. MCGUIRE
University of Rhode Island
Kingston, Rhode Island

Since the late 1930's when synthetic growth regulators were found to be effective in promoting rooting of cuttings, a wide variety of methods have been used to introduce these materials into stem tissues. We are all familiar with talc preparations used as a dust, and aqueous solutions used either as long term dilute soaks or short duration concentrated dips. The relative efficiency of these carriers and methods was covered extensively at a meeting of this society in 1959 (5,6,9). It was concluded that concentrated basal dips were superior to other methods of application.

It has been shown that crystalline indoleacetic acid (IAA) can enter the fatty portion of the cuticle of leaves without the aid of a solvent. Crystals have been applied to stems after the stem was scraped to facilitate rapid uptake of the auxin (3,4). Auxin has been soaked into wooden pegs and the pegs have been inserted into holes drilled into the cuttings (10). In England and America, cuttings have been exposed to vacuum and then aqueous solutions of auxins have been forced into the stem when atmospheric pressure was again applied (1,11).

Contribution #1262 of the Rhode Island Agricultural Experiment Station

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Auxins have been applied to foliar portions of cuttings under normal atmospheric pressure, but in the early work results were not generally successful (2,7). More recent work at the Rhode Island Agricultural Experiment Station has shown that this method can be used successfully. This work was reported to this society last year (8).

It has been determinated by detection of radioactive auxins in cuttings that sufficient auxin for increased rooting can be absorbed through the intact foliage and terminal bud of cuttings of *Ilex crenata 'Convexa'*. A method has been devised by which the radioactive isotope is extracted with high speed centrifugation and measured by means of liquid scintillation counting. By making extractions and counts at timed intervals from segments of cuttings at known distances from the site of application, it is possible to determine how long it takes for the auxin to enter the cutting and how rapidly it moves within the cuttings.

When IAA-2-C14 was applied to five inch long cuttings of Ilex as a ten second basal dip in 40% ethanol (v/v), it was found that the isotope was carried to the uppermost inch within 24 hours. The largest portion remained in the lowest inch with progressively lesser amounts in each succeeding inch up the cutting. The least amount was found in the terminal inch. When the radio-chemical was applied as a ten second terminal dip, the largest amount of activity remained in the inch that was dip-

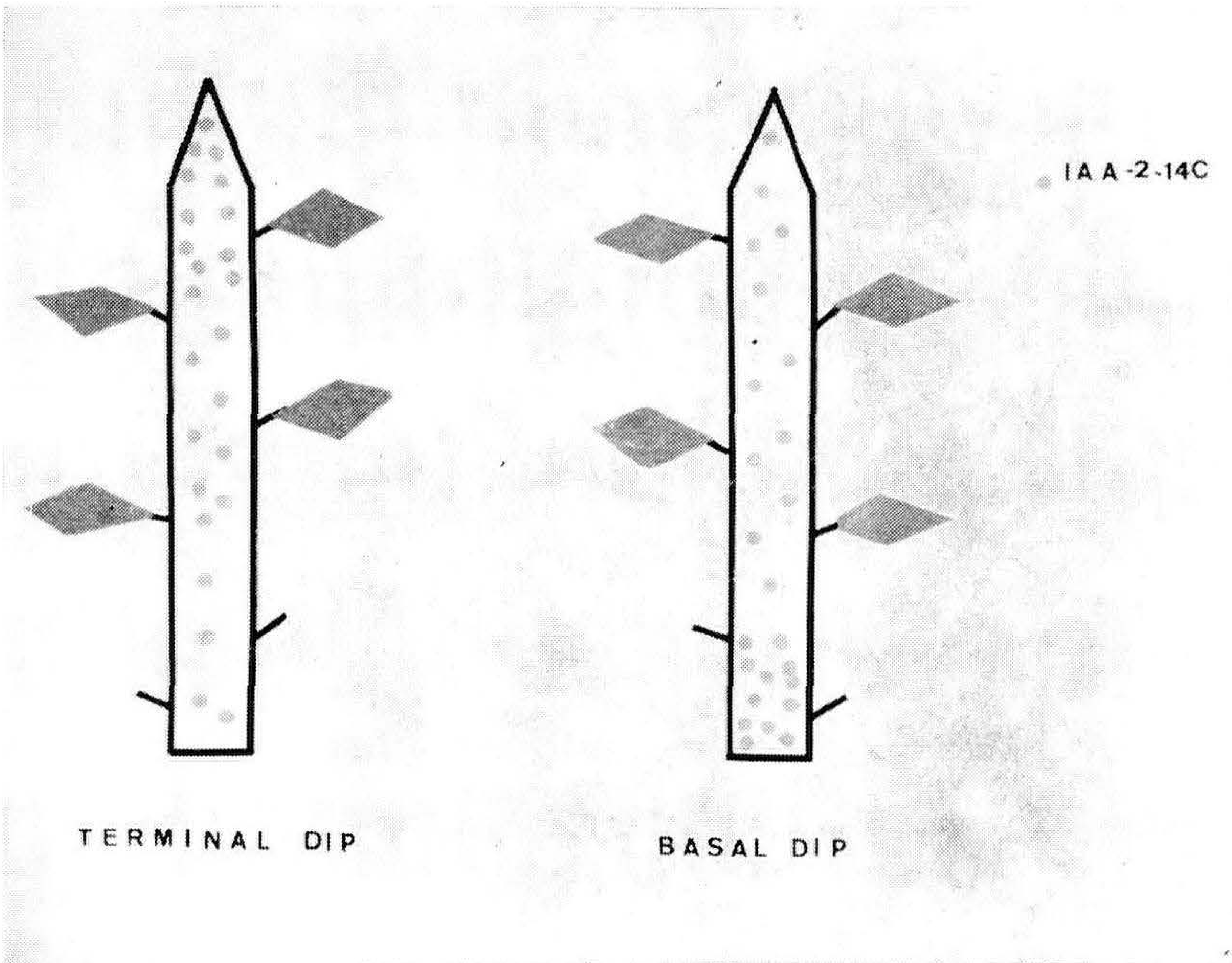

Figure 1. Comparison of auxin uptake and distribution in terminal and basal applications of IAA-2-C14 in cuttings of *Ilex crenata* 'Convexa'.

ped, and each lower inch contained progressively less activity with the exception of the lowest inch, which contained slightly more activity than the fourth segment from the tip (Figure 1).

The effect of leaf surface area on transport of IAA was studied by dipping terminal cuttings, which had the upper leaves removed, in IAA-2-C14 and comparing levels of C14 in stem segments with similar segments from cuttings that were similiarily treated but from which leaves had been removed. More of the labeled isotope was incorporated into the partially defoliated cuttings but less was transported to the basal area where rooting takes place. (Figure 2) More inhibition of terminal and lateral buds took place in the defoliated cuttings.

Since it is known that auxin moves with carbohydrates, it is not surprising that cuttings with less leaf surface do not exhibit the same degree of basipetal or downward movement of C14 as fully foliated cuttings. It was suspected that increased auxin uptake in cuttings with defoliated terminals may have occurred through freshly exposed leaf scars on the terminal inch. It was therefore postulated that the same thing could occur through leaf scars on the basal inch of stem cuttings which are normally defoliated as a commercial practice prior to treatment with auxins. The following experiment was designed to answer this question.

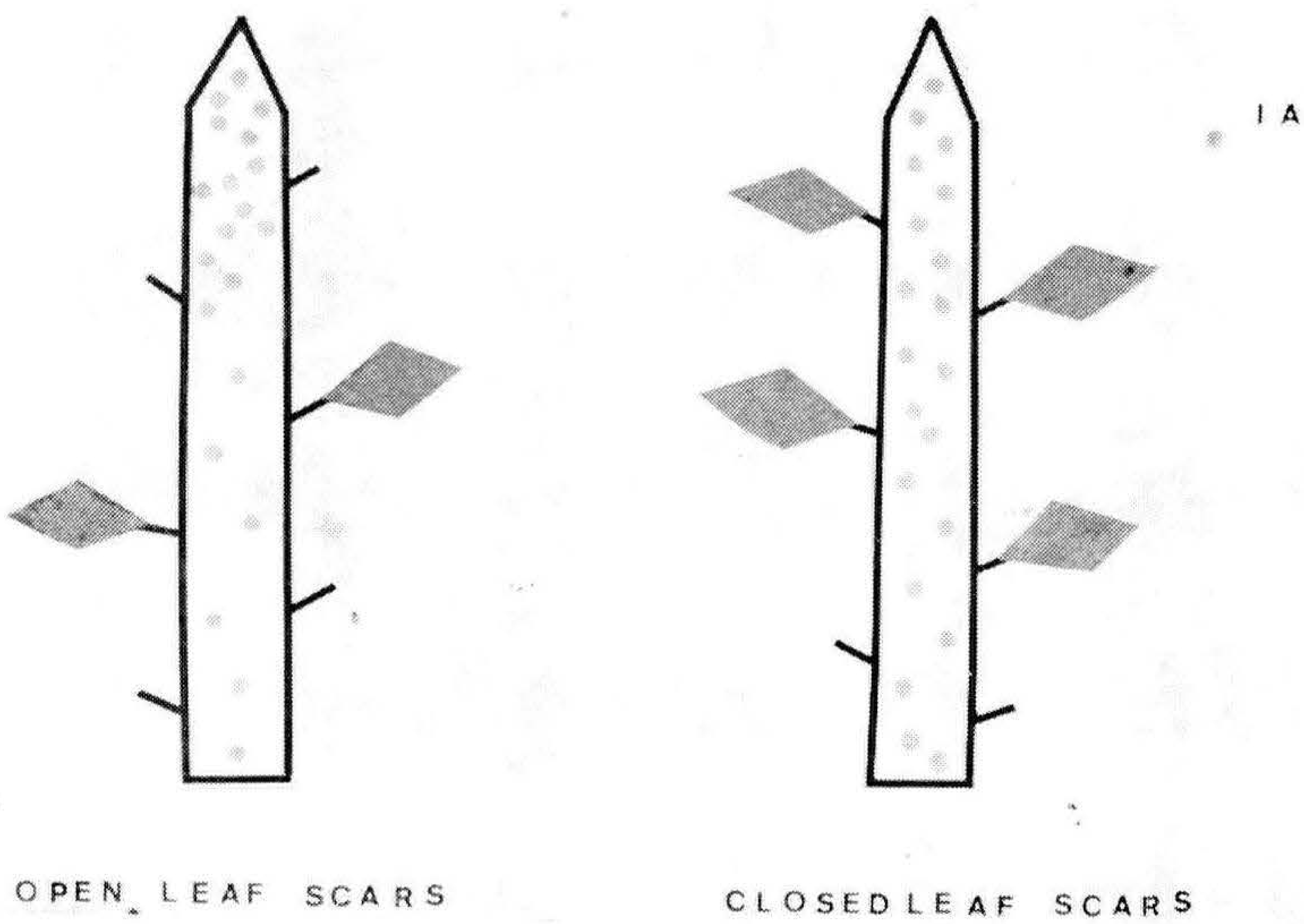

Figure 2. Effect of leaf surface area and leaf scars on auxin uptake and distribution of IAA-2-C14 in cuttings of *Ilex crenata* 'Convexa'.

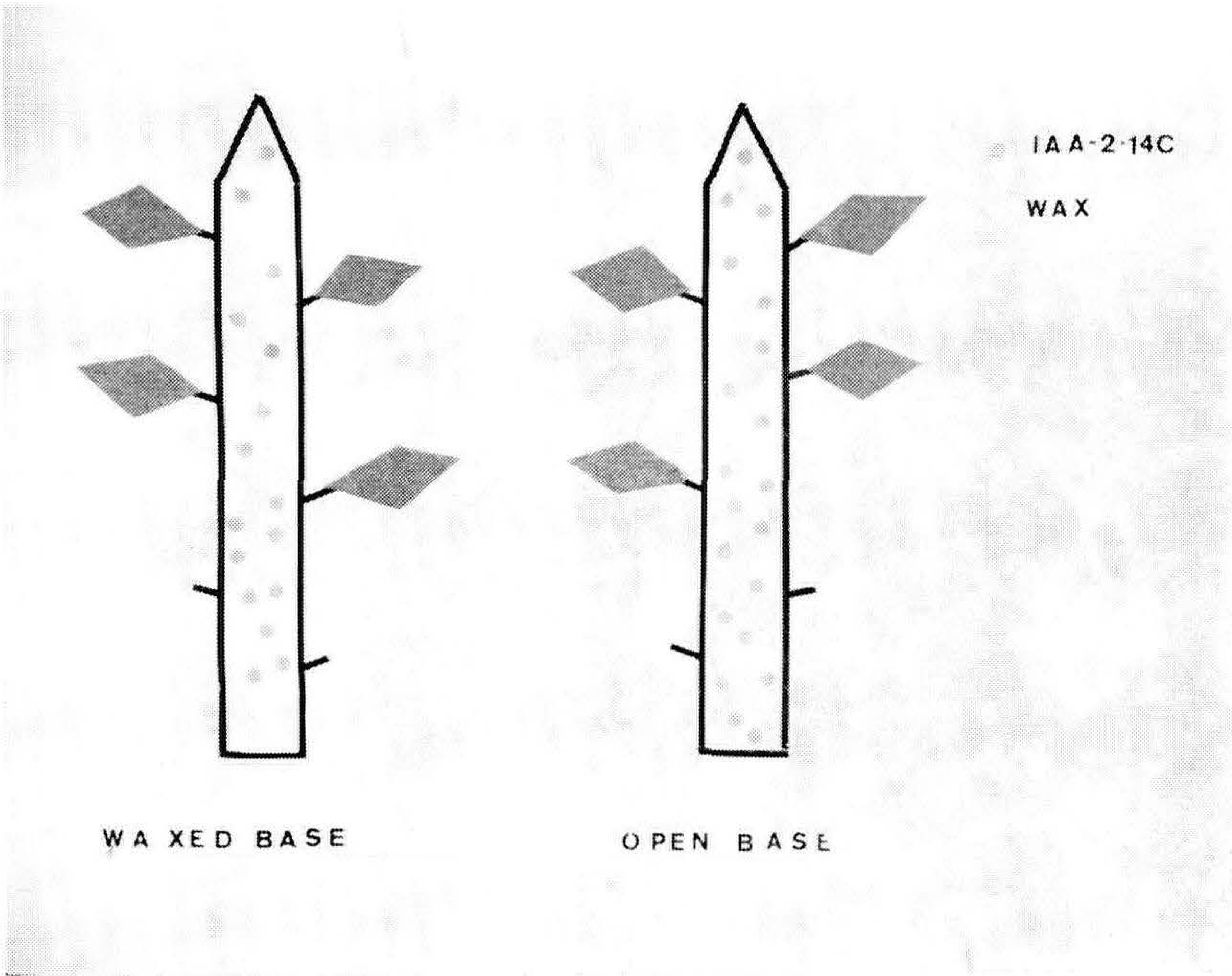

Figure 3. Effect of leaf scars on auxin uptake in basally dipped cuttings of *Ilex crenata* 'Convexa'.

Cuttings were dipped basally into the radioactive auxin (IAA-2-C14) and then they were extracted as previously described. These cuttings were compared to others which had the basal ends sealed with paraffin at the time of basal dipping so that only the outer surface of the stem and the leaf scars were exposed to the radiochemical. The study of the segments revealed that less auxin entered the cuttings with sealed ends. Cuttings with the basal end covered with wax absorbed approximately 60% as much radioactive auxin as cuttings with the basal end not waxed (Figure 3).

When rooting data were compared, it was found that there was no significant reduction in rooting when basal ends were sealed. If cuttings were dipped basally after the basal end and leaf scars were sealed with paraffin, no IAA-2-C14 entered the cuttings. It was also found that wounding the basal inch of a cutting prior to dipping in the auxin solution did not result in a significant increase in auxin uptake. If the wound was present and the cut ends and leaf scars were sealed, an amount of auxin equal to that which would have been absorbed through the ends and leaf scars was absorbed.

Terminally treated cuttings were found to be unaffected in regard to transport of IAA-2-C14 by the presence of the apical bud (Figure 4), if the apical bud was removed before the terminal end of the cutting was dipped in the auxin solution, greater quantity of auxin was absorbed. This increased uptake did not result in greater quantities being carried to the basal areas.

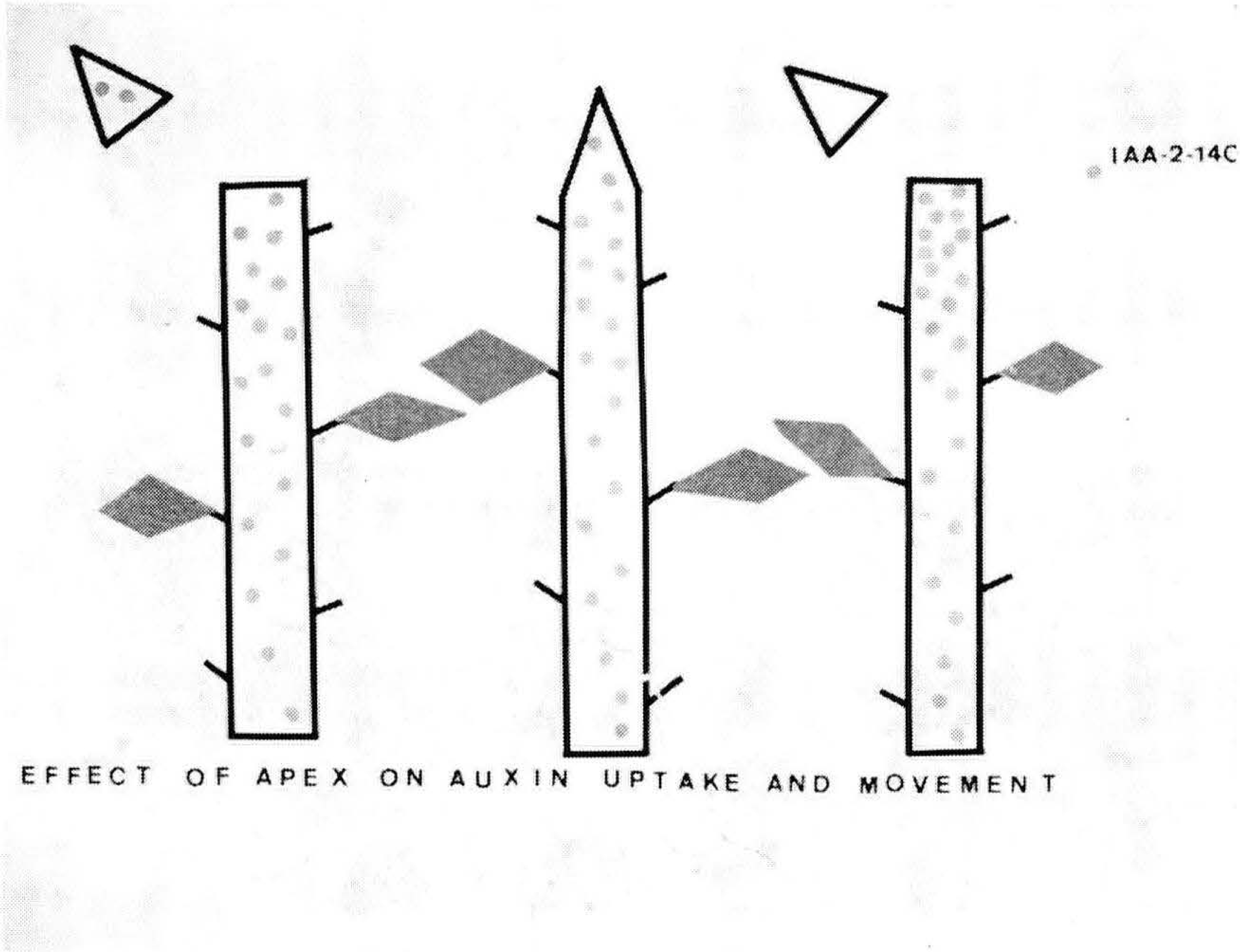

Figure 4. Effect of apex on auxin uptake and movement in cuttings of *Ilex crenata* 'Convexa'.

SUMMARY

It has been found that sufficient auxin enters the foliage and terminal bud of cuttings of *Ilex crenata 'Convexa'* to result in effective increases in rooting. When basal ends of cuttings were dipped in solutions of IAA-2-C14, more auxin is absorbed than in terminal dips. The basally applied material is carried to the apex within 24 hours. When leaves are removed from the upper end of cuttings, more radioactive auxin is absorbed by the cuttings. When leaves are absent from the terminal areas of terminally treated cuttings, however, less auxin is carried to the base of the cutting. It is probable that auxin enters through the leaf scars. Wounding the basal area of a cutting did not materially increase the amount of auxin absorbed, but if the wound was the only available port of entry, auxin did enter the cutting in that way. Removal of apex did result in increased auxin uptake of terminally dipped cuttings, but it did not result in increased transport.

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MODERATOR CANNON: We now have time for some questions.

VOICE: I would like to ask Dr. Waxman if he feels it is necessary to regulate the night and day temperatures within his structure?

SID WAXMAN: If you are referring to a fluctuating temperature between night and day, I do not think that this is necessary. When germinating seeds, this is often very beneficial but with the rooting of cuttings, I think a constant temperature will be satisfactory.

BEN DAVIS: I would like to ask Dr. Lanphear about the Simazine and Diphenamid combination? You put that on at the rate of one pound Simazine and four pounds Diphenamid. Did you reduce the amount of Diphenamid used because of the presence of the Simazine?

FRED LANPHEAR: The Diphenamid was included because of its ability to control grasses and it does this very effectively at four pounds. The main reason for reducing the amount that is used is to reduce the cost.

BEN DAVIS: I was wondering because I have been using Enide (Diphenamid) and the recommendation was to use it at the rate of six pounds per acre.

FRED LANPHEAR: If you use the Diphenamid by itself, it is necessary to use it at the six pound rate.

BEN DAVIS: Do you believe you would obtain injury if you used the six pound Diphenamid rate in combination with the one pound rate of Simazine?

FRED LANPHEAR: No, you would not have any injury; it would just be more costly.

BEN DAVIS: Did you apply the Simazine-Diphenamid combination to newly transplanted materials?

FRED LANPHEAR: Yes.

BRUCE BRIGGS: How does peat moss or ground bark compare with charcoal in absorbing herbicides?

FRED LANPHEAR: Activated charcoal is by far one of the most effective absorbers of chemicals such as Simazine. Other organic materials such as peat moss, or ground bark, will tie up some herbicides but not nearly so effectively as charcoal. This brings up a point in relation to using herbicides in combination with a mulch. Some materials cannot be used because they are absorbed by the mulch to a point where they are not as effective as they should be. However, it turns out that Casoron is not absorbed by the peat moss and therefore can be used in combination with the mulch.

BRUCE BRIGGS: Have you tried the activated charcoal treatment on peat pots?

FRED LANPHEAR: Yes, we have tried activated charcoal on peat pots and it does work. We dipped the peat pots into a 10% slurry of activated charcoal. However, one problem that you may run into, if you are planting in peat pots when the soil temperatures are warm, is that the root growth out of the peat pots is so rapid that the protection of the carbon on the surface of the peat pot is left behind. Under these conditions it may be necessary to apply a drench of activated charcoal around the plants.

MODERATOR CANNON: Our next speaker will be Mr. Edward Hume who will speak on the subject of cytokinens.

CYTOKINENS, POWERFUL FORCES TO BE CONSIDERED IN PLANT PROPAGATION

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Cytokinens, scarcely known in plant propagation are, along with the gibberellins, opening new horizons in plant manipulations that cannot be ignored by any serious student of the field. These compounds affect more and varied functions in the plant kingdom than most of us consider possible. The rate of increase in research in this field is most astonishing. This paper merely calls attention to some of the findings. Those who wish to investigate the field more thoroughly are referred to Letham (15) and Miller (17) for recent and earlier reviews of the field.

Kinetin was the first product identified in this group and has been the subject of much investigation in this field. Now all compounds of this type affecting plant response are classified as cytokinens. The list of these and the number of different plants from which they have been extracted is increasing ever more rapidly. These compounds, along with the gibberellius and auxius are the regulators of all cell division, cell enlargement, cell differentiation and the formation of plant organs in developing plants. There is evidence that cytokinens are generated in roots. Rooted leaf cuttings and cuttings treated with cytokinens behave in the same way.

There is no generally accepted method of measuring the effect of cytokinens in plants, as the oat coleoptile method is used to measure auxin activity. Of the some eleven methods that have been used, none are free of complications. This is caused by many possible actions, over wide ranges of concentrations and the complex interactions with gibberellins and auxins.

Cytokinens have been found in at least 40 kinds of plants. Because they are in nature extremely diluted, it requires very large samples and careful concentration and purification to demonstrate their presence. Probably they exist in all living tissue. More actively growing tissue generally has greater concentration; while dormant tissue, such as seeds, have levels too low to be recognized with our present methods of testing. Most of the positive tests have dealt with roots, bleeding sap, germinating seeds and especially developing fruits or nuts.

There is an interaction between cytokinens and the phytochrome mechanism as shown by the germination of light sensitive lettuce seed. Within 24 hours kinetin can be detected in seeds subjected to red light if germination is not inactivated by far red light. This contrasts with the action of the gibberellins which do not interact.

Cytokinens play an important part in cell division. This may modify the size and shape of the resulting plants. This results from interactions of cytokinens with the RNA in the nucleus in a rather complex manner. Cytokinen also affect the movement and accumulation of proteins, amino acids, and phosphorus. They can control the development of storage organs and accumulation of food stored within them (18).

The presence of cytokinens is not restricted to higher plants. They have been found in mosses, fungi, algai and bacteria. In these lower forms kinetin control extends to nonnucleate cells, indicating a direct affect of cytokinens on the cytoplasm (26). Kinetin, which has been the chief material used in research, has the chemical composition of 6-furfuralaminopurine. Its molecular weight is 215, and it is available from Calbio, Box 54282, Los Angeles, California 90054.

One method of putting it into solutions is to float the desired amount of the crystals in a container of water. Then autoclave it until it dissolves at a pressure of 15 psi. It does not dissolve in such common solvents as alcohol, acetone or carbon tetrachloride. Other cytokinens have yet to become commercially available. The most active of these is Zeatin which is identified as 6-(4-hydroxy-3 methylbut-trans-2 enyl)-aminopurine. In order to obtain 0.7 milligrams of the pure material, Miller (17) purified 60 kilograms of immature corn seeds. This compond is active at the tremendous dilution of 5 x 10^{11}M. This is a hundred times more dilute than the maximum dilution of kinetin still showing action on plant tissue. To get a better idea of the action of Zeatin, think of dissolving one gram in about a hundred million liters of water.

When tissue culture was first successful, researchers used to add coconut milk to their media to supply some then unknown substance needed to organize callus tissue into new plants. Using kinetin Raghaven (23) and others have been able to develop minature embryos from callus type tissue without the addition of coconut milk.

Flowering and reproduction can be modified in many ways by the use of cytoginens. Whittwer (24) found that kinetin inhibited the flowering of tomatoes, but accelerated it in peas. Furuta (9) showed that kinetin was synergetic with gibberellic acid in promoting the flowering of unchilled azalea. Ikuma (10) induced flowering of tobacco plants with kinetin and gibberellic acid at two light intensities.

The type of flower produced is also affected by the cytokinen level. Katsumi (11) found that both the diameter and the doubleness of a composite flower can be changed by the cytokinen concentration. Negi (19) converted a male flower into a perfect one. Cytokinens can stimulate fruit set or induce parthenocarpy (fruit formation without seed). Of special interest to plant propagators is the work of Kummerlow and Choffmann (14). They applied kinetin at 50 and 100 ppm/ to *Pinus radiata* seedlings which greatly stimulated meristematic activity, stretching normally short shoots into long ones; and stimulating renewed division of parenchyma cells of the wood. Caperson (3) also stimulated cambial activity by applying kinetin to the apical end of cotyledons.

Apical dominance in plants is controlled by the interaction of auxins, cytokinens and gibberellins. Davis (6) found that kinetin promoted the uptake of indoleacetic acid which maintained the apical dominance by inhibiting the growth of lateral buds. At the same time the IAA stimulated the downward movement of the kinetin. But Bauer (1) found that kinetin cancelled apical dominance in a moss. Panigraph and Audus (21) made similar observations on the cotoledonary buds of decapitated *Vicia Faba* seedlings.

Still another role discovered for cytokinens is their ability to overcome some of the lethal affects of nuclear radiation. Powell and Griffith (22) found that levels of beta radiation which were lethal to untreated bean leaf sections did not kill sections treated with kinetin. Cope (5) found similar results with *Lemna,* an aquatic, when they were exposed to glucose solutions containing varying levels of deutriation. Apparently kinetin can supply something de-activated by the radiation, but not far beyond the normal tolerance level.

A most extraordinary property discovered for these cytokinens is their ability to preserve the chlorophyll in a functioning condition under long periods of very low light intensity or even total darkness where the untreated leaves turn yellow and can no longer function. The mechanism for this still is not clear; but appears related to the higher nitrogen level, particularly the protein and amino acid in the kinetin treated tissue. The phosphorus is also higher which supplies a key link in the photosynthetic action. There is also a higher level of proplastids in kinetin treated plants. All these actions are, of course, involved with the various enzyme actions. The work on these is too long to consider at this time.

Kinetin also affects leaf retention. Burrows and Carr (2) placed kinetin on the pulvinar region, a hairy flattened place at the base of the petiole, or introduced it through the transpiration stream. It delayed abscission either way. These workers in another paper (4) found that lupine leaflets on treated leaves dropped their leaves faster if they were young and in the dark; but older leaves retained the leaflets longer. In the light they stayed on longer regardless of age.

Cytokinens have a peculiar role in relation to chromosomes and gene behavior. They not only interact with RNA in regular cell operation, but they may induce doubling of the number, or polyploidy. Or they may overcome the mutating action of colchicine (13).

Under some conditions cytokinens may act in controlling disease. Selmann (24) has shown that kinetin inhibits virus multiplication through an increase in the ribonuclease activity. In another experiment he found petunia leaf strips had fewer and smaller local lesions on the lower surface following mechanical innoculation of the upper with kinetin. Lovenkovich (16) indicates that kinetin is an antagonist to the toxic effect from the fungus *Pseudomonas tabacci.* Dekker (7) found that 20 ppm. of kinetin, while not suppressing the initial innoculation of cucumber leaf discs floating in the solution, did stop further growth of the disease.

There will probably be many more papers in the next few years helping us to understand more about these remarkable substances.

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MODERATOR CANNON: Our next paper will be on the subject of "Crossing Eastern Cottonwood in the Greenhouse" and will be presented by Robert Farmer, Jr.

CROSSING EASTERN COTTONWOOD IN THE GREENHOUSE

R. E. FARMER, JR., AND W. L. NANCE[1]
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Forest Service, U. S. Department of Agriculture
Stoneville, Mississippi

Eastern cottonwood (*Populus deltoides* Bartr.) is the subject of breeding programs designed to develop planting stock with potential for rapid growth, desirable wood properties, and pest resistance (4). Techniques for making controlled crosses within the species are essential to breeding, and their development constitutes an early phase of genetics research. This paper will describe techniques that are being used in the lower Mississippi Valley.

Controlled crossing techniques for the dioecious *Populus* species were developed in Europe and have been used there for several decades. The aspens (Section Leuce) may be crossed by placing bases of dormant branches in water after chilling requirements are met, forcing these branches in greenhouses, and pollinating the female flowers. Fresh pollen is obtained by similarly forcing male flowers. Fertilized catkins are matured on the branches in three to four weeks. This procedure, originally developed for *Salix*, was first used for *Populus* by Wettstein-Westersheim (11) and has been adapted for the American aspens by Einspahr and Benson (1), Johnson (7), and others.

While black poplars (Section Aigeiros) can be crossed by these means, their larger catkins with sometimes longer maturation time require more nutrition than is supplied by cut branches. Consequently, branches bearing female flowers are bottle-grafted to supporting rootstocks. The technique, as used in Europe, has been generally described by Muhle Larsen (8) and Schreiner (10). We have modified it for cottonwood. In brief, female scions are bottle-grafted to potted juvenile stock in mid-autumn. After chilling, flower buds on these grafted scions are forced and pollinated in the greenhouse. This procedure obviates climbing sometimes remotely situated trees.

METHODS AND RESULTS

Grafting

Cottonwood scions bearing female flower buds may be bottle-grafted to vigorously growing stock in the fall or in late winter immediately prior to forcing. Fall grafting may be advantageous because a functional graft is established before forcing and the concomitant depletion of the scions' food reserves. Also, fall grafting is done before the busy crossing season.

[1]The techniques described here were developed while the authors were on the staff of the Southern Hardwoods Laboratory, which is maintained at Stoneville, Mississippi, by the Southern Forest Experiment Station in cooperation with the Mississippi Agriculture Experiment Station and the Southern Hardwood Forest Research Group. Farmer is now Plant Physiologist, Tree Improvement Section, Division of Forestry Development, TVA, Norris, Tennessee. Nance is presently a graduate student at Michigan State University, East Lansing.

Scions are collected and grafted in late September or early October. At these times trees are still fully foliated in the lower Mississippi Valley, but both vegetative and flower buds are set on sexually mature trees. Male and female flower buds are readily distinguished in September (2). Scions taken in August or early September are easily grafted but tend to renew apical growth and drop flower buds soon after grafting. In a preliminary test with scions collected in late summer, 66 percent of the successfully grafted scions lost all flower buds. In 1965 and 1966, when grafts were made later in the season, 12 and 17 percent dropped buds.

Scions are shot from trees with rifles and cut to approximately 20 cm. in length. Each scion should have an apical bud and one to six flower buds. Leaves are removed before grafting. Stocks are potted seedlings or cuttings about 1 cm. in diameter at the base. An ordinary approach graft is made, and the scion's base is placed in a container of water (6). The graft is bound with string and covered with grafting tape; no wax is used. With the exception of the incision essential to making the graft, the stock's stem is left intact.

Grafts may be stored in a greenhouse or a covered lath house. Under lath house conditions in central Mississippi, grafts made early in October establish unions in two to three weeks, i. e., before freezing weather begins. During winter, potted grafts are kept in a covered lath house so that unions will not be damaged by freezing rain.

In 1966, unions were achieved with 98 percent of the 271 attempted grafts; mortality of scions from 10 individual trees varied from 0 to 7 percent. Although scion mortality was low prior to forcing, flower bud drop made 17 percent of the grafts unsuitable for crossing. The tree-to-tree range in scion loss due to bud drop was 3 to 43 percent. Twenty-two percent of the grafts with unions proved unsuitable for crossing either because flower development was poor or because the union failed during greenhouse forcing. Fifty-nine percent of the attempted grafts flowered normally after forming effective unions, and were used in crossing; success with individual trees ranged from 20 to 81 percent.

Forcing and Flower Development

In central Mississippi, mature cottonwood chilled out-of-doors remains physiologically dormant until mid-February (3). Material forced before then takes several weeks or more to resume growth. On the average, male trees flower before females (i.e., require less chilling) but there is wide tree-to-tree variation in flowering time (5) which is under strong genetic control (12). Given this information, we have developed a reasonably successful procedure for forcing flowers.

Male branches are collected in early February and placed in aerated water under long-day greenhouse conditions. Bases of branches are trimmed twice weekly. Temperature is 75-

85°F. and relative humidity is 60-80 percent. Anthesis begins in one to two weeks, depending upon the individual tree; pollen is shed three to five days after catkins appear. By making two or three collections at approximately weekly intervals, one can obtain a continuous supply of fresh pollen during the several weeks of crossing.

Bottle-grafted female scions are brought into the greenhouse a few days after male branches are collected. At this time the stock is pruned back to approximately one inch above the graft. Catkin growth, which begins in two to three weeks, is usually rapid. In 1967 growth was completed in six to eight days, and final length of catkins varied from 5.5 to 21.5 cm. Catkin length on trees generally ranges from 10.0 to 20.0 cm. in central Mississippi; most of the catkins on grafts attained lengths within this range. Flowers mature from the base to the apex of catkins. Flowers at the base are receptive within two days after budbreak.

Pollination and Capsule Development

Crossing in greenhouses is done in late February and early March, before cottonwood begins flowering out of doors. Individual males are assigned to separate greenhouses or specially designed pollination chambers in a single greenhouse. Potted scions of females to be crossed with individual males are usually forced in the greenhouses assigned to designated males. When the smaller pollination chambers are used, female scions are moved to the chambers when anthesis begins and are taken out after flowers are no longer receptive.

We have used fresh pollen in making most crosses, since it is easily obtained. If pollen dispersal appreciably precedes female anthesis, however, pollen can be stored for a few weeks in desiccators at 10-25 percent relative humidity and 35-40° F. We have not tried longer storage.

Pollinations begin during the second day of catkin growth and are repeated on three successive days so that all flowers will be pollinated. Pollen is dusted over catkins with a small camel's hair brush.

In 1967, 160 scions were pollinated, and 51 percent were fertilized; success with scions from individual trees ranged from 0 to 83 percent. Incompatibility seemed to be the reason for failure with some crosses. Some variation in results was also associated with location of scions; crosses were generally more successful in greenhouses with a northern exposure than in pollination chambers.

Unfertilized capsules abscised within a week after catkins completed growth. Fertilized capsules completed enlargement within five weeks after budbreak (range 17 to 35 days). Final capsule diameter for individual catkins ranged from 4.8 to 6.7 mm and averaged 5.8 mm. Capsules on trees in natural stands have similar dimensions (5-7 mm) in central Mississippi. Fertilized capsules on a grafted scion are shown in figure 1.

Figure 1. Maturing cottonwood fruit on bottle-grafted cottonwood scion.

SEED MATURATION, DISPERSAL, AND GERMINATION

The first viable seed is obtained in mid-May from crosses made in late February or early March. During this two- to three-month period, mortality of catkins may be high; in 1967, 27 percent of the fertilized catkins died. A common cause of mortality may be graft failure resulting from insect infestation. Grafting tape should be removed from grafts shortly after growth resumes in the greenhouse, since numerous insects may be sheltered by it. A regular spraying schedule is essential. Some necrosis of individual capsules, apparently related to fungal or bacterial infection, has been noted.

Seed dispersal in 1966 and 1967 extended from mid-May until August, a range similar to that observed in natural stands (5). This wide range is due mostly to differences in maturation time of individual females, although some single catkins have been observed to disperse seed for a month. Each capsule contains 40 to 60 seeds.

Seed is collected as capsules dehisce, then cleaned by air (9) or by hand and germinated in sub-irrigated peat pots filled with a loam potting mixture. After approximately two weeks peat pots are transferred to nursery beds.

On the average, germination of seed from controlled crosses has been appreciably less than that for seed from natural stands. In 1967, germination of fresh seed from individual crosses varied from 14 to 88 percent; mean germination was 48 percent.

CONCLUSIONS

The method described above is providing sufficient full-sib progeny for testing, but seeds are produced on a relatively small percent of the grafts attempted. The technique is therefor expensive even though a few successfully matured catkins produce many seeds. However, average success is somewhat misleading, since the tree-to-tree range has been considerable; several females were complete failures and very good results were obtained with others. Some causes of crossing failure with individual trees may be unrelated to the technique; i.e., incompatibility is likely. Flower bud drop and other causes of loss before forcing reduce the method's utility for some trees. Spring grafting may therefore be more suitable for some females.

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MODERATOR CANNON: Mr. John Roller will you come forward and speak to us on "Open Field Propagation"?

OPEN FIELD PROPAGATION

JOHN ROLLER
Cartwright Nurseries
Collierville, Tennessee

LAND PREPARATION

The preparation of the land for open field propagation is very simple, as we practice it at Cartwrights. It consists of deep plowing, eighteen to twenty four inches deep, or sub-soiling. After this, a disc is run over the land as many times as is necessary to break up any clods and get it in good working condition. If necessary, we use a land leveler to level the field, or to give a smooth slope, but we prefer to use only a harrow as the land leveler packs the soil more than we like. After this, rows are spaced about thirty inches apart and are opened to a depth of four to six inches. The cuttings are stuck into these little furrows rather than on bedded rows.

CUTTING PREPARATION

The timing of the cuttings is governed by the weather conditions that we have that year. We like to start taking them when they are in the "summer dormancy" stage. In the Memphis area the usual starting time varies from about August 20, until early September. The cuttings planted in this type operation include all of the Pfitzer varieties, Andorra, *excelsa stricta,* Irish, *densa glauca, procumbens,* Sargents, Von Ehron and all sabinas, in fact, about any juniper that can be rooted in the greenhouse. However, *scopulorum* and most *virginiana* do not root well by this method. We think that Pfitzer juniper roots better if planted later than the other junipers and is usually the last juniper we stick. We, sometimes, delay taking part of them until we are sticking the broadleaf cuttings, which is usually mid-November. Broadleafed varieties propagated in this manner are the usual ones that are normally produced from hardwood cuttings, euonymus varieties, abelia, privet, lonicera, crape myrtle and others. We do not plant these until they have gone into dormancy, usually in November.

To take our cuttings, crews in the field use eight inch pruning shears. We like our cuttings to be about eight inches long. We start cutting at the end of the limb, trimming off the tender tip, and then cut just as far down the limb as we can

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To take our cuttings, crews in the field use eight inch pruning shears. We like our cuttings to be about eight inches long. We start cutting at the end of the limb, trimming off the tender tip, and then cut just as far down the limb as we can get eight inch cuttings. We do not care how large around the cuttings are. Some are as big as the thumb and have rather heavy branches.

As the cuttings are cut, they are dropped into burlap bags and as the bags are filled they are dipped in barrels of water. We try to keep them moist until they are stuck, at least we do not allow them to dry out and wilt. If they must be kept over, because of weather or week-ends, they are kept in cold storage and are watered down frequently. Most of the time it is only one or two hours from cutting time until they are stuck in the field. About sixty or seventy people are cutting the cuttings and as soon as twenty five or thirty bags are full they are brought to the field to be stuck. About fifteen people are needed to stick them.

Irrigation lines have been laid and water is run into the rows that are open four to six inches deep, and the cuttings are stuck right into the mud and water. A man with a one inch hose, under forty five to sixty pounds pressure, puts water in the furrows just ahead of the workers sticking the cuttings.

The cuttings are not stuck one at a time but are stuck by handfuls, of six to ten per handful, to a depth of about half their length, or about four to four and a half inches. There is a slight knack to this, and after a little practice the workers are able to get them distributed in the row on an average of one or one and a half inches apart without any skips or breaks in the row. This is important to us because our land is rather sloping and we do not want water washing across the rows. Immediately behind the stickers on each row, a worker with a garden rake pulls loose dirt from the side up against the cuttings and more or less forces the mud and soil into the trench as much as possible to fill in the voids. Just behind the rakes a worker with a hose really waters the cuttings and the middle of the rows, thus settling the soil down around the cuttings.

The irrigation lines are usually moved up twenty to twenty five rows at a time. As soon as the ground drys enough we use a Farmall Cub tractor to throw a small amount of dirt up to the cuttings and to give us a center furrow for drainage. As soon as enough ground is covered to permit, or a block is finished, we really soak them down, using either Rainbird 80 sprinklers, or a Raincrow, which will cover about an acre at a time. We wet the soil enough so that it will settle around the cuttings and fill all air spaces. This eliminates tromping or packing the soil around the cuttings by foot.

This completes the main part of the planting operation. All that remains is the normal cultivating practices and the watering. They are not allowed to dry out. Water is supplied as needed. We usually irrigate when the top one fourth or one half inch of soil is dry. The number of times they are irrigated of course, depends on the amount and frequency of rainfall. After the cuttings are rooted the frequency of watering can be reduced. This is usually the following June or July.

Cultivation is practiced as needed for soil aeration and weed control. We have used chemical weed control to eliminate hoeing as much as possible. We have used Treflan incorporated in the soil before sticking the cuttings. This worked out real well on a test plot. Encouraged by this we went all out and used Treflan over the entire planting. The results were not entirely satisfactory as our rooting percentages suffered somewhat. We came to the conclusion that the Treflan was incorporated into the rooting area and thus caused some losses. There was no consistent losses. Some varieties that root readily suffered as much as twenty five percent loss. Some varieties were not affected and some rooted even better than before.

However, this year we plan to wait until all cuttings are stuck and then incorporate the Treflan in the middles and throw it up to the row by means of a Lilliston rolling cultivator which does the job nicely by changing the angle of the cultivators. We have done this on field plants and it worked very satisfactorily.

For harvesting the rooted plants, we dig them with a converted potato digger. Using the potato digger replaces about fifteen or twenty workers that used to hand pull the plants after they had been undercut with a tree lifter. After digging the cuttings, they are root pruned, trimmed, and loaded into trucks to go to the field for planting.

There are many advantages to liners that have been propagated in the open field. Following are some of them.

1. Liners that are tough enough to withstand adverse weather conditions, because they are propagated in the open field.
2. Liners are heavier and stronger than those propagated by any other method. Some, when harvested, are equal to a potted liner after one year in the field, and grow into saleable plants one year earlier.
3. Free from diseases.
4. Large quantities can be produced with relatively little supervision and care.
5. The economy of production in comparison to liners produced in the greenhouse or in mist beds. The only method comparable in cost would be the Phytotektor method.
6. Rooting percentages that equal and sometimes surpass greenhouse cuttings.

MODERATOR CANNON: The last paper we have this morning will be presented by Mr. Don Nordine for Mr. Rodney Bailey of the Bailey Nursery Company of St. Paul, Minnesota.

BAILEY CIRCULAR MIST

Rodney Bailey
Bailey Nursery Company
St. Paul, Minnesota

In the past fifteen years there have been many types of mist propagation systems described at these meetings. The one that I have found to do the best job, most economically, employs many of the same techniques and principles with which you are familiar. As a point of reference this method shall be referred to as the Bailey Circular System. I have used this system only for the propagation of deciduous softwood cuttings in the summer.

I have selected an area that has a basic soil of loamy sand. Also, and I believe this is quite important, the area in which the beds are constructed is on a very gradual slope. Not steep but falling enough so that excess water may run off the surface rather than standing and then having to seep away.

The area is plowed and worked smooth with a disc and harrow. We are now ready to make the beds. With a dump-truck and a Melroe "Bobcat" loader, we apply three inches of sand over a 22 foot diameter circle. A metal garden edging forms the outside of the bed. With two men and the proper equipment, this bed is made ready to plant in about one half hour. Each bed will hold from 15-25,000 cuttings depending upon the variety.

For simplicity of operation, I have kept all the time clocks and solenoid valves in one central location. The water is conveyed from the solenoid valve to its respective bed by a 5/8" rubber hose. By having all of the controls in one unit, we are able to completely dismantle the system each fall, store it inside over winter, and reassemble it again in the spring with a minimum of plumbing and electrical connections to make. We merely connect the control system to our water supply and electric supply.

Each time clock controls one solenoid valve which in turn controls the water for four separate beds. Although most any rotary type lawn sprinkler will do an adequate job of misting, I prefer the Harford spike sprinkler because it is easy to move from one part of the bed to another when adjustments must be made for windy conditions.

With normal weather conditions and newly planted cuttings, the clocks will be on 5 times for about 6 seconds in each 12 minute cycle. This, of course, must be adjusted as the light, temperature, wind, and humidity conditions change. The 12 minute cycle clocks are controlled by a 24 hour clock that turns them on in the morning and off at night.

As in any system, an ample water supply is essential. The source of water is a deep well which also services the greenhouse and nursery storage buildings. Since regular line pressure of 40 pounds is not sufficient to do a good job of applying the water, we have added a booster pump and an additional pressure tank so that the pressure is maintained between 60 and 90 pounds.

As in any outside system, strong winds are somewhat of a problem. We erect snow fences around the entire area and between every second bed. In addition to the snow fence, we staple a 3 foot wide strip of burlap to it. Because our sprinklers are easily moved from the center of the bed in any direction, and because the larger droplets which have more wind resistance are thrown to the outside of the circle, we can have adequate coverage under most any weather conditions.

As soon as the cuttings are rooted, the frequency of watering is cut back gradually to the point where we water only often enough to keep the rooting and growing medium moist. This may be every two or three days depending upon the variety and weather conditions. The snow fence may also be taken down at this time.

By late July or early August, most varieties have rooted through the sand and into soil beneath. Most varieties, at this point, have a flush of growth and will grow to two to four times the size of the original cutting.

With the exception of a few items that are transplanted to the open field about August first, all are left in the beds to go dormant. At this point, with the snow fence, edging around the beds, hoses, time clocks and solenoid valves all removed, it is a comparatively small job to lift the cuttings. They are undercut and lifted from the bed with a set of tines on the front end of the Melroe loader. The dirt is shaken out and they are placed in wooden boxes and taken into cold storage. They are left in these boxes until time permits us to count and grade them. They are then rolled in polyethylene bags and left in cold storage until planting time the following spring.

In conclusion, I would like to point out some of the advantages and disadvantages of the system.

The disadvantages are:

1. This system requires very close personal attention from the time the cuttings are stuck until they are rooted. With full exposure, such as they have, it takes only a short time to lose a batch if something should go awry.
2. Three varieties, for some reason unknown to me, have been consistently poor in both stand and quality under these conditions, but have done very well under greenhouse conditions.

The advantages are:

1. Very small initial investment — about $160.00 per 100,000 cuttings for raw materials.
2. Saves labor — can utilize mechanical means for preparing the beds as well as digging beds.

3. No obstructions in working area such as pipes, framework or side boards. Six men can plant in one bed without interfering with one another.
4. Ease of observation — everything is in the open. No covers to lift or polyethylene to crawl under.
5. Low cost per cutting rooted — with labor figured at $2.65 per hour and all overhead included, we had a cost per cutting rooted of 2.3c each.
6. Superior liner — by rooting into the soil we get a large well developed liner that can go bare root directly to the field.

FRIDAY AFTERNOON SESSION

December 1, 1967

The Friday afternoon session convened at 1:15 p.m. in Ballroom A of the Admiral Semmes Hotel. Hans Hess was moderator of the first part of the afternoon session and Dr. Kenneth Reisch was moderator of the second part.

MODERATOR HESS: We are very fortunate this afternoon to have on our program Dr. Harrison Flint of the Arnold Arboretum. Dr. Flint will speak on the "Winter Storage of Young Nursery Stock".

WINTER STORAGE OF YOUNG NURSERY STOCK

HARRISON L. FLINT
Arnold Arboretum
Jamaica Plain, Mass.

Winter storage of young nursery plants has been a popular topic of discussion for a long time, but increasing production of nursery stock in containers in the North has stimulated even greater interest on the subject. My first inclination in preparing to talk to you on this subject was to share with you some of my own experiences and experiences of other people in the New England area. But in the process of visiting nurseries and other establishments, watching their practices, and assembling all this information, I began to realize that if I were to follow my original plan I would probably do nothing more than add confusion to an already confused subject. The one thing that impressed me more than anything else in these visits is that there are so many successful methods in use. I think we've all been impressed by this fact as we have listened to speakers on this subject over the past several years. So for today, let's look for a few universal facts or common denominators that we can use in comparing some of the methods that are now in use. In the process we may discover what the essentials are, and be in a better position to evaluate new methods of protection.

The first thing to remember is that young plants in containers are prone to all the winter hazards that threaten older plants established in the ground, and more besides. But, on the other hand, the fact that they are portable makes it possible to use protective measures that would not be economical in field situations.

There are four basic causes of winter injury:

1) *Mechanical damage*:

When we think of this we usually think of heavy ice and snow breaking branches of plants, but other kinds of possible mechanical damage include chewing by mice or rabbits, windwhipping of branches protruding through a snow crust, or even the collapse of an under-designed protective structure.

2) *Seasonal cold*:

Low temperatures are the obvious cause of winter injury — the thing that we all think of first. But too often we think of the lowest temperature that comes in January or February and fail to appreciate the fact that killing or damage by cold can happen at almost any time of year in the North. An established plant of a "hardy" species has the ability to harden in the fall before the onset of low temperatures. This doesn't mean that overnight it suddenly attains its full hardiness for that winter. It simply means that its progressive hardening during autumn manages to stay ahead of the progressively lower temperatures. These plants also remain dormant in late winter and early spring long enough to allow the seasonal warming trend to keep ahead of dehardening at that time of year. But young plants of the very same species can present a different situation. Young plants tend to be more vigorous than older plants, especially when rapid growth has been encouraged by good cultural methods. This vigor encourages late growth in plants of some species. Since cessation of growth is a prerequisite for hardening, such plants are likely not to have developed as much hardiness in fall and early winter as older, slower growing plants of the same species. This is why young plants of some species are destroyed or damaged by "stem splitting" at the first hard freeze in the fall but are not so susceptible to this injury later in life. This injury can be prevented by delaying the onset of freezing temperatures in autumn until plants have had time to harden sufficiently. This is usually done by trapping heat in cold frames or greenhouses, with or without auxilliary heat, or by placing plants in controlled cold storage in autumn.

Up until now we have been talking about hardiness in general. When we do this, most of us think in terms of the hardiness of the above-ground parts of plants — the stems and buds, forgetting the plant parts that are out-of-sight in the soil. 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. This, coupled with the fact that roots of potted plants left outdoors are exposed to more extreme cold than those of plants in the ground, makes root systems of container-grown plants especially prone to winter injury. Often they are damaged beyond recovery even when no direct cold injury has been sustained by stems of the same plants. My first experience with this type of injury came at the University of Rhode Island in 1958 when plants of *Cotoneaster adpressa praecox* left outdoors over winter in containers failed to make new growth in the spring, even though the winter air temperature had not fallen below zero.

In a 1964 report entitled "Watch Root Temperatures of

Some Plants", Dr. John Havis of the University of Massachusetts pointed out the importance of protecting roots of some species from winter cold. He found the killing temperature for roots of hardened plants of *Ilex opaca* and *Ilex crenata* to be about 20°F. The killing temperatures for roots of similar plants of *Cotoneaster horizontalis* and *Pyracantha coccinea* were about 15° to 18° F., but plants of several ericaceous species withstood temperatures lower than 15°F. without root injury.

In a preliminary experiment conducted at the University of Vermont shortly before I left that institution, we compared the hardiness of lower stems and roots of well-established and hardened rooted cuttings of a number of species. Both the stem-killing temperatures and the root-killing temperatures varied widely among these species, as shown in Table 1. In all cases but one, stems were considerably hardier than roots. The extreme case found was *Philadelphus virginalis* where stem and root killing temperatures were -44°F. and + 24°F. respectively. In all the species studied, the average difference in hardiness between roots and stems was about 30°F. In one case, that of *Indigofera kirilowii,* root and stem killing temperatures were nearly equal, 3° and 5°F. respectively, not surprising when we remember that this plant is frequently top-killed in several hardiness zones where the root system persists without difficulty.

In essence, prevention of root killing involves knowing what temperature roots can tolerate without injury and then keeping the temperature above this critical point. Since root-killing temperature of most species are not known, a more practical alternative may be to keep root temperatures of a questionable species above or at least close to the freezing point. Needless to say, root hardiness is an area in which additional research is badly needed.

3) *Sudden cold*:

It has been known for many years that the rate of cooling can sometimes be just as important in determining winter injury as the minimum temperatures attained. One of the most familiar examples of this is sun scalding of tree trunks, in which the living tissues of the bark are first heated by radiant energy from the sun and then freeze rapidly as the sun sets or passes behind some object. White and Weiser at the University of Minnesota have shown that the same kind of injury can be sustained by leaves of certain evergreens. The situation they found can be illustrated in this way: picture a cold, bright winter day in the northern United States, when the maximum temperature reaches only 10°F. At the same time, the temperature of evergreen leaves may be as high as 40°F., because of radiant heating by the sun. On such a day, if the sun disappears behind a cloud or other object in mid-afternoon, the temperature of the leaves will very quickly approach the temperature of the surrounding air. Since their temperatures differ by some 30° to begin with and are nearly equalized within a minute or so, it is obvious that the leaves cooled very rapidly.

Table 1 Stem and Root Killing Temperatures of Hardened Rooted Cuttings

Species or cultivar	Killing temperature (° F) Stems	Roots
Hydrangea paniculata 'Grandiflora"	-44	0
Philadelphus virginalis	-44	24
Viburnum trilobum	-44	16
Abeliophyllum distichum	-22	7
Symphoricarpos chenaultii	-15	25
Weigela 'Bristol Snowflake'	-15	19
Weigela 'Vanicek'	-15	23
Elsholtzia stauntonii	-14	12
Forsythia 'Karl Sax'	-13	18
Forsythia 'Lynwood'	-13	14
Weigela 'Bristol Ruby'	-11	18
Indigofera kirilowii	5	3

Under such conditions severe damage resulted to *Thuja occidentalis* in the Minnesota study, and it seems safe to assume that other species are affected in the same way. In milder climates than Minnesota, *Thuja occidentalis* is less prone to this kind of injury, but some of the tenderer species grown probably react in the same way. This kind of injury is not peculiar to young container-grown plants — it occurs in the field as well. But with the portability of container-grown plants, more can be done to prevent it. Probably the simplest way of protecting against this kind of injury is to shade the plants from full sun. This is often done with lath shades, but coarse burlap, saran cloth, and other materials have been used equally well.

4) *Drying*:

Because of limited space and favorable moisture and nutritional levels, root systems of well grown plants in containers are usually smaller in relation to their tops than those of comparable field-grown plants. This, together with the possibility of rapid drying and frequent freezing of the limited soil volume, makes container-grown plants unusually susceptible to dehydration when fully exposed to the winter environment. This is especially true of evergreens, as they transpire substantial amounts of water in the wintertime.

Drying of evergreen foliage is a common occurrence in some areas, and is referred to as "winter-burning", "sun-burning", and "wind-burning". It is caused by excessive water loss from foliage, whether by the effects of sun or wind, under conditions when water cannot be picked up from the soil to replace that lost. This kind of injury is sometimes difficult to distinguish from the foliage "burning" caused by sudden temperature drops, as the symptoms of both kinds of injury are dehydrated or "burned" leaves.

Prevention of injury from drying requires frequent inspection of plants and watering as necessary. Many container-grown plants have been lost during the winter simply because their root systems were allowed to dry out. Protection may also include reducing evapo-transpiration, by shading to reduce heating of evergreen foliage, by building glass or plastic enclosures to capture evaporated moisture, or both.

In summary, protection of plants against these four principle causes of winter injury involves (1) eliminating mechanical damage by suitable protection against ice and snow, and against rodents and other animals, (2) either reducing a young plant's tenderness in early winter or delaying the onset of severe cold, (3) providing some shade from full sun for evergreen plants, and (4) preventing drying of plants during the winter.

Methods of Protection

Protection of young container-grown plants can vary all the way from no protection at all to complete temperature control. The degree of protection that must be used varies with the climate in a particular location, with the species of plants being handled, and with the degree of risk that a particular organization feels is acceptable. In general, greater degrees of protection are more expensive than lesser degrees, so the economics of each situation must be weighed carefully, and each organization may do this somewhat differently. For example, at the Arnold Arboretum some plants are protected by mulching, others by placing them in an unheated polyethylene greenhouse, but the majority of our young plants are placed in a storage building in which the temperature can be maintained at or slightly above freezing during the entire winter. This building is equipped with refrigeration that can be turned on in late winter and early spring to insure that the temperature is kept below 40°. The cost of this building would prohibit its use in just about any commercial establishment, but since we are dealing with many plants that are irreplaceable or at least very difficult to replace, we cannot tolerate much risk. On the other hand, looking at the extent of plant losses resulting from inadequate protection in the Northeastern United States over the past several years, it seems that many organizations have been willing to accept too high a level of risk, and have suffered economically as a result.

1. *Mulching.* For many of the hardiest species grown in containers in southern New England, the only protection that is needed is to pull the containers closely together and mulch them to give some protection to the roots. This is true of many deciduous materials and a few evergreens such as junipers and certain yews. In some cases, containers have been tipped over on their sides, with variable results. When these methods are used, winter precipitation may supply enough moisture to pre-

vent serious drying, but it would be a mistake to assume this will be the case and neglect to check for drying regularly.

2. *Shading.* This can be done in several ways. The traditional method is to use a lath house. The one illustrated is at Imperial Nurseries in Connecticut where several very large lath houses of the type shown are in use. Roger Coggeshall at Cherry Hill Nurseries, and his predecessors there, have used to good advantage a pine grove located on the property. These large pine trees furnish almost complete shade from direct sun for plants underneath. During the winter Ghent and other azaleas are stored in ball and burlap, along with flats of rooted cuttings of junipers and yews. In this protected area, the earliest snow cover is likely to persist and the later snows of winter remain as protection rather late in the spring, giving excellent protection. This nursery has also used screens of snow-fencing about four feet from the ground over transplant beds but are now getting away from them because of problems with snow breakage and inconvenience in working under them.

3. *Unheated structures.* These fall into three categories: (1) cold frames and greenhouses (usually plastic covered), (2) more or less opaque structures that we can refer to as common storages, and (3) refrigerators in which storage temperatures can be closely controlled. These structures come in many types and degrees of elegance. Often they consist of adaptations of existing structures. For example, Imperial Nurseries is using a modified potato storage house. A large amount of roof has been broken out and replaced by fiber-glass to allow light to come through in the top floor of this building and evergreen azaleas are stored in it. Shade trees and clematis in containers are stored in the lower level, in darkness. This nursery is also using a variety of buildings formerly used for storing tobacco. Arie Radder of Imperial Nurseries has been carrying on a substantial research program to find the best ways of adapting tobacco sheds to winter storage of nursery stock. Weston Nurseries, in Hopkinton, Massachusetts, is making use of a variety of common storage structures. In one case, an existing cellar hole was roofed over with a gable roof and floored beneath it at ground level, thus providing two levels for storage. Broad-leaved evergreens such as rhododendrons, mountain laurel and andromeda are being stored in this structure. Ed Mezitt of Weston Nurseries has carried on considerable experimentation in cooperation with the University of Massachusetts staff in adapting a variety of structures on the nursery grounds to storage of plants overwinter. Probably the most elegant common storage building that I have seen is located at Corliss Brothers' Nursery in Ipswich, Massachusetts. I expect most of you have read the recent article in the November 1, 1967 *American Nurseryman* describing this building, which has been in operation for two years. The outstanding features of this building are the provisions for ventiliation and the degree of mechani-

zation that has been reached. Balled and burlapped plants and container-grown plants are placed on pallets and carried into the storage building with a forklift. Ventilation during the winter is accomplished with the fan and polyethylene tube method commonly used in greenhouses in which exhaust fans are mounted in an outer wall of the building and perforated polyethylene tubes are suspended from the ceiling serving to introduce and distribute outside air. Further circulation of the air in the storage building is accomplished by 4 Dutch Mill turbulator's spaced in this 50 x 100 foot building. Although this building is neither heated nor refrigerated it is heavily insulated. This keeps temperatures from falling much below freezing in the coldest part of the winter, but makes it possible to keep the temperature below 40°F. through March.

Refrigerated storages have been used widely for holding certain classes of nursery stock in readiness for spring shipment. Some nurseries are using refrigerated storage for holding summer-rooted cuttings for spring planting. Case Hoogendoorn of Newport, Rhode Island, has been one of the pioneers in this use of refrigerated storage in New England, through his own experimentation and his support of research at the University of Rhode Island. Obviously stock stored in refrigerated facilities must have a relatively high value per unit volume occupied.

4. *Heated structure.* These differ from the buildings and structures just mentioned only in that supplementary heat is available for use during the coldest part of the winter. They can range all the way from heated cold frames using steam lines or electric cables to heated greenhouses and storage buildings. Heated structures are not used as commonly in southern New England as they are in northern New England for obvious reasons. Where plastic greenhouses are used for winter protection, the need for heat depends upon the species grown as well as the geographical location. As a rule of thumb, for most young nursery stock currently grown, accessory heat is probably not necessary in areas with an average annual minimum temperature of -10°F. or higher, but in areas having an average annual minimum temperature lower than -10° F. it is probably very risky not to provide some accessory heat, unless the most hardy species only are being grown.

Summary

A large number of successful methods has been devised for storing young nursery stock. Without a common denominator this variety of ways to "skin a cat" seems bewildering. But a close look at the principles involved shows us what all successful methods have in common — and makes it possible to devise new methods as the need or the opportunity arises.

MODERATOR HESS: The next speaker on the program has the topic of overwintering evergreens under poly houses. Mr. John Zelenka will give the paper.

OVER-WINTERING EVERGREENS UNDER POLY IN NORTHERN CLIMATES

JOHN G. ZELENKA
Zelenka Evergreen Nursery, Inc.
Grand Haven, Michigan

Our firm, having been one of the first to attempt winter storage under northern conditions, and presently storing probably more plants than any other firm in the north, I feel that it might be enlighting to relate our experiences for whatever they may be worth. I feel it is an operation we cannot ignore.

First, may I outline the basic reasons for wanting to store evergreens over winter. First, in our location in west central lower Michigan, it is not uncommon for our spring digging season to begin around April 1st. Being a company that sells to the trade as far south as Kansas City, St. Louis, etc., we must be in a position to deliver when their selling season begins. Second, with a steady increase in retail competition, our customers require a plant in full color, free of all winter discoloration. Poly storage is one of the best ways I know to preserve good winter color. Third, is the fact that in our area common labor is more readily available in the fall than in the early spring.

These three reasons led us in 1960 to erect three non-heated glass Greenhouses (30′ x 150′). That fall we were able to store 12,000 evergreens, mostly taxus, juniper, arborvitae, ilex and spruce. These were of various sizes, ranging from 9-12″ to 2-3′, dug and potted in September and stored in the greenhouses about November 1st.

Our first season's experience was so encouraging with the exception of ilex, that we immediately wanted to expand this project. After studying the cost of glass, we were aware that more glass was impractical. After pricing from several companies, we decided on 5 Trox houses (23 x 178′) at a cost of approximately 50c per sq. ft. This looked good in comparison to $2.00 for glass.

Again the following spring our results were encouraging, with the exception of ilex. When comparing the results in the greenhouses and in the Poly Trox houses, we felt that the plants under poly seemed to show less dehydration than those under glass.

This began an even more intense study of structures. We came up with our own design of 1″ pipe 16′ x 100′ and later redesigned to 18′ x 100′. These we built for about 35c per ft., including irrigation. Since, we have erected about 60 of these structures. Each year, we have watched our operation closely, and at this time can draw some of the following observations for successful storage. Keep in mind, we are speaking of west central Michigan.

1. Select for storage plants that are of good quality and vitality. Storage will not make a poor plant look sharp.

2. Dig as early in fall as possible to enable the plant to overcome shock before severe cold weather sets in; I prefer from September 20th to October 10th. However, in the case of ilex, I prefer no later than September 15th.

3. Draw poly over houses about November 1st. Late coverage can result in dehydration of the plants.

4. Keep well watered on days when the soil in containers is not frozen. Ventilate well while watering, so that the plants will not freeze while covered with water.

5. Any time during storage, houses should be ventilated whenever excessive heat builds up due to sunshine. Otherwise, keep as air-tight as possible.

My comments so far may sound as if we have no problems. I must emphasize that whenever the 5 points I outlined were followed, our success was excellent. Our firm is probably no different from hundreds of others, and when something looks promising we have a tendency to stretch our luck. Sometimes we dig too late in the season, and at times we have left some houses uncovered too late. These were the instances where we experienced the most damage. I also mentioned earlier that ilex did not store well. However, when dug in late August, or early September and plunged into sawdust, results were excellent. They will not winter setting on top of the ground.

Most all of the evergreens we have stored were field-potted either with the Jiffy Balling machine or by hand. Though we did store some B & B, but found it very difficult to keep the ball wet unless plunged into some sort of mulch. Therefore, our experience was much more successful with potted plants than B & B.

MODERATOR HESS: Our next topic is one in which many people are very interested. The "Cold Storage of Softwood Azalea Cuttings" will be discussed by Andrew Adams, Jr.

"COLD STORAGE OF SOFTWOOD AZALEA CUTTINGS"

ANDREW N. ADAMS, JR.
Ten Oaks Nursery & Gardens, Inc.,
Clarksville, Maryland

Back in the middle of June 1964, while trimming our azaleas for the last time of the season, one of our men mentioned what a shame to throw away all those good cuttings. They were really too soft to stick and we still had lining out to do and just did not have the benches ready nor the time to stick cuttings. Azalea cuttings are normally ready here in Central Maryland anytime after the 4th of July, depending of course on the season.

We have a cold storage room 8′ x 7′ x 50′, built of concrete block with one 5-ton refrigerator unit and two circulating

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We have a cold storage room 8′ x 7′ x 50′, built of concrete block with one 5-ton refrigerator unit and two circulating fans cooling the structure. The structure is under ground with 3′ of soil on top, so it carries a temperature close to 55° year round. We keep the temperature set at 38°F, which means it will run between 35° and 40°F. It is used primarily for pre-cooling azalea plants brought in in September for the Christmas season and also for holding azaleas back from blooming too soon, for late Easter and Mother's Day. Being empty in the summer, we thought it ideal for storing cuttings until we were to stick. At first we collected our cuttings and stored approximately 500 cuttings in large poly bags, but found after several weeks they mildewed and our losses were quite high. The following year, after our initial experiment, we merely layed our cuttings out on damp burlap on racks and sprayed once a day to prevent any drying out from the circulating fan in the ceiling. Cuttings have been stored as long as six weeks, but we like to get them in the bench from two to three weeks. The results are in the 90-95% range, with the crop being between 150,000 - 225,000 stuck per year over the past three years.

We find the cuttings, being cut green, tend to harden up and are much more turgid when stored, plus the fact our rooting percentage on soft wood has been much better and we no longer bother with any hormones, which saves a lot of labor in time as well as the expense of the I.B.A. itself. On stored cuttings the foliage is much easier and faster to strip off plus the buds snap out faster.

It is now standard practice at Ten Oaks to store all softwood cuttings at least 24 hours at 38°F before bringing them to the bench for sticking.

MODERATOR HESS: We now have time for a question and answer period.

CASE HOOGENDOORN: John, you said you had difficulty with your balled and burlap material drying out. Do you pack them in any mulch such as sawdust?

JOHN ZELENKA: Case, perhaps I did not make myself clear. It isn't any more difficult to store balled and burlap plants than potted material except that the work involved is just so costly that we do not do it. We just store container grown material.

PETE VERMEULEN: I would like to ask Harrison Flint if he found any association with the vigor of the top growth with the root damage that he observed?

HARRISON FLINT: No. However, we do know that if a plant is actively growing, it is not hardy, and therefore its root system is not hardy.

PETE VERMEULEN: I am not only speaking of vigor in terms of actual growth but also the nutritional status of the plant.

HARRISON FLINT: There still remains a fair amount of confusion about the nutritional status and hardiness. There remains a lot of work to be accomplished in this area.

RALPH SHUGERT: I would like to bring up a point in relation to John Zelenka's talk. I think the key to his success is location. In our area where we have a lot of low temperatures but also a lot of clear weather and sunshine compared to the more cloudy area by John Zelenka we have run into quite a lot of problems. For example, with junipers wherever the foliage from one plant touched another, the whole area was dead. We used a plastic covered shade house which was very tight. When it was necessary to ventilate we came back and watered to keep the humidity high. Under these conditions we had a reasonable degree of success with the taxus but we had a lot of losses and needle drop with spruces and I have already mentioned the problem that we had with the junipers. In contrast the material in containers came through with good color and good condition.

BILL FLEMER: Mr. Zelenka, do you use the clear or the milky polyethylene to cover you houses?

JOHN ZELENKA: We use the clear plastic with relatively good success. However, I am sorry that we have not tried some of the milky polyethylene because I think there may be some additional merit in using it.

VOICE: I would like to address a question to Mr. Zelenka. What type of irrigation system do you use in the poly houses?

JOHN ZELENKA: We have a main line going in front of all the poly houses with an underground spur running right through the middle of the poly houses. There are risers in the houses with Rain Bird nozzles that deliver a square pattern. This reduces the amount of overlap. The entire system is equipped with automatic drains so that when the pump is shut off the water drains automatically under the soil. We try to avoid watering whenever the containers are frozen but at those times when they are completely thawed out, we take the opportunity to water them. When they have had a sufficient amount of water we shut off the system. It automatically drains out and there is no problem of freezing of the irrigation pipes.

ROBERT FARMER: I would like to ask Harrison Flint if he has worked out a quantitative method of determining root damage and does he differentiate between chilling injury and freezing damage?

HARRISON FLINT: We have used the electrolytic method of determining the electrolytes which are released from the tissues damaged by freezing. This seems to work quite well with the species that we have tested. I have not differentiated or studied chilling injury.

MARTIN USREY: I would like to ask Andy if you have observed any difference in the rooting of the cuttings which you have held over?

ANDREW ADAMS: We find that the percentage rooting is better on the cuttings which have been held in the cold storage. In fact we now store all our cuttings for at least twenty-four hours. There seems to be less problem with wilting after the storage. They seem to be in a more turgent condition.

DICK STADTHERR: Andy, are the cuttings which are stored given any artificial light?

ANDREW ADAMS: We have a string of incandescent lamps in the storage area which does provide a very small amount of light.

JAMES WELLS: I would like to make a comment on the storage of cuttings. One year we ran out of space when we were making taxus and arborvitae cuttings. This was sometime in the middle of February. We continued making the cuttings in the normal way, treating them with hormones, and packed them in deep flats on a bed of sphagnum moss. The moss was packed around the base of the bundles of cuttings. The flats of cuttings were placed in a cellar which had a few incandescent lamps much as Andy Adams described. The lamps were switched on during the day and the cuttings were given an occasional sprinkle of water. The cuttings stayed in the cellar for about eight weeks. At the beginning or middle of April they were taken outside and inserted direcly into cold frames in sandy soil where they rooted quite rapidly.

VINCE BAILEY: I would just like to add to Jim Wells' comments. We have been storing conifer cuttings in the dark in refrigerated cold storage with humidity control on a regullar basis for the past ten years. We have had very good success storing the cuttings for periods of four to eight weeks.

VOICE: I would like to ask Mr. Wells if there was any sign of callus formation at the time he stuck the stored cuttings?

JAMES WELLS: Yes, not only callus but young roots were present.

BILL FLEMER: Last winter we lost all of our Japanese cherries, three inch in caliber, and up because of bark kill on the sunny side of the trunk. I would like to ask Dr. Flint if we had whitewashed the trunks of these trees, particularly on the sunny side, if this would have prevented the injury?

HARRISON FLINT: It might have prevented the injury although I do not want to make a flat statement. It depends upon how severe the conditions actually were.

CHARLEY HESS: It was difficult year for trees in New Jersey because of a very warm spell of 70 degrees in January and March followed by some temperatures at 6 degrees above zero. Peach growers who did whitewash their trees reduced the injury that was experienced with trees which had not been whitewashed. Work is continuing to find materials which will reflect the sunlight better or provide some insulation. By using thermocouples it was possible to measure the temperature under the bark during the past winter. In January when we were experiencing the 70 degree weather the bark on the south side of the tree reached a temperature of 90 degrees. In March there was a period when the bark temperature went up to 70 degrees during the day and 6 degrees above zero at night. This places a tremendous stress on the plant and it is questionable whether whitewash alone would have helped.

BRUCE BRIGGS: We did a little work on containers this past year trying to keep the soil temperature uniform within a bed of container-grown plants. We used foil paper on the outside of the blocks of container-grown stock. The foil paper did an excellent job of keeping the temperature more uniform.

RALPH SHUGERT: The moderator for the second symposium of this afternoon's program is Dr. Ken Reisch.

KEN REISCH: I would like to bring greetings from Dr. Chadwick who was not able to come this year but wishes everyone well and hopes to be present at next year's meeting.

ROOTING MEDIUMS

K. W. REISCH
Ohio Agricultural Research and Development Center
Wooster, Ohio

Rooting mediums for cuttings have been discussed for centuries and probably originated when prehistoric man first thrust a spear into the ground. Innumerable materials have been used for this purpose and vary from field soil to sophisticated mixtures of organic and inorganic substances. Included among those which have been mentioned in the literature are sand of various types and particle size, peat moss of different forms, ashes, cinders, flue dust, sawdust, pumice, ground bark, sphagnum moss, soil, rice hulls, coffee, parchment, cocoa fiber, vermiculite, perlite, styrafoam, clacine clay, BR-8 blocks (processed wood fiber), water, and air.

A rooting medium should fulfill the following objectives:

1. Maintain the cutting in a properly oriented position.
2. Minimize moisture loss from the submerged portion of the cutting.
3. Provide a suitable environment for the elongation of roots.

Although there are various schools of thought on the characteristics of a good rooting medium, the following should be considered.

1. Inexpensive
2. Readily available and reproducible
3. Uniform and long lasting
4. Free from disease, insects, nematodes, and toxic substances
5. Easily managed
6. Well drained and with desirable air-water relations
7. Uniform temperature

Matkin (25), noting the importance of the free porosity or air space in the medium, indicated that 1) The medium should have as high a free porosity as practical under the cir-places a tremendous stress on the plant and it is questionable whether whitewash alone would have helped.

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Ohio Agricultural Research and Development Center
Wooster, Ohio

Rooting mediums for cuttings have been discussed for centuries and probably originated when prehistoric man first thrust a spear into the ground. Innumerable materials have been used for this purpose and vary from field soil to sophisticated mixtures of organic and inorganic substances. Included among those which have been mentioned in the literature are sand of various types and particle size, peat moss of different forms, ashes, cinders, flue dust, sawdust, pumice, ground bark, sphagnum moss, soil, rice hulls, coffee, parchment, cocoa fiber, vermiculite, perlite, styrafoam, clacine clay, BR-8 blocks (processed wood fiber), water, and air.

A rooting medium should fulfill the following objectives:

1. Maintain the cutting in a properly oriented position.
2. Minimize moisture loss from the submerged portion of the cutting.
3. Provide a suitable environment for the elongation of roots.

Although there are various schools of thought on the characteristics of a good rooting medium, the following should be considered.

1. Inexpensive
2. Readily available and reproducible
3. Uniform and long lasting
4. Free from disease, insects, nematodes, and toxic substances
5. Easily managed
6. Well drained and with desirable air-water relations
7. Uniform temperature

Matkin (25), noting the importance of the free porosity or air space in the medium, indicated that 1) The medium should have as high a free porosity as practical under the circumstances; 2) The medium should be as deep as possible since the depth of the medium column affects the air supply; and 3) No layer of coarse material should be placed in the bottom of rooting containers since this shortens the column and raises the water table in the medium.

Much work has related to the effects of various mediums and medium factors on rooting; however, there has been no research to indicate that the medium has any direct effect on root initiation.

This discussion should be prefaced with the statement that numerous investigators and commerical propagators have found variable success with rooting plants in different mediums, thus indicating that there is no one best medium for all plants and all conditions. The variable results are due to plant type, condition of the cutting, season, light, temperature, drainage, means of providing water, type of structure, hormone treatments, etc.

Also, although the medium does not have a direct influence on root initiation, it may have a marked effect on root elongation, type of root system, plant survival, and success in transplanting. For example, Wells, in his book on plant propagation, indicated that many cuttings will root readily in a peat and sand mixture, but roots of some will rapidly begin to rot due to unfavorable air-water relations.

Effect of Mediums on Types of Roots

In 1932, Long (23) published the effects of mediums of sand, peat moss, and a mixture of the two on the rooting of cuttings from 42 different plants. He found that finer roots were produced in peat moss than in sand. However, when the peat moss was kept at a low moisture content, the coarseness of roots approached those formed in sand. He also studied sand mediums with different size particles from fine sand to fine gravel. There was little difference in the roots until during hot summer weather when finer roots were found in the coarser medium. This was attributed to the heavier watering necessary and the greater water content in the fine gravel during this period. Chadwick (4), working with taxus, also found that roots were more fibrous and less brittle in peat moss than in sand. Franklin (11) indicated that roots formed in vermiculite were more fibrous than in sand; however, Bos (3) found the opposite on cuttings of *Philadelphus coronarius 'Aureus'* rooted in these two mediums.

In a summary of a discussion group, Flemer (10) reported that some firms had found more fleshy and brittle root systems on cuttings rooted in perlite. Also, Gifford (13) reported that peat and perlite provide a good medium for rooting chrysanthemums and that preliminary tests showed that roots in perlite were not as soft and shipped better than those produced in sand and peat.

Results with Various Types of Mediums

A number of articles have described the use of field soil as a rooting medium. Templeton, (36) describing his famous Phytotector system, indicated the value of using soil as a rooting medium because of lower initial cost and reduced costs as a growing-on medium. Roller (33) used field soil, with peat moss added, to propagate *Ilex cornuta 'Burfordi'* and Chase (6) rooted *Juniperus* in the open field. Discussing the Burlap Cloud method, Hancock (17) described the rooting of summer softwood cuttings in soil sifted through a screen.

Sand has long been considered a standard and universal rooting medium; however, very few have reported this material as the ideal medium. Dodd (7) indicated that vermiculite was superior to sand in rooting most magnolias but that sand was just as effective for Star Magnolia. Wells (40) reported that many types of mediums have been used to propagate ilex and that sharp sand only was recommended for the *Ilex crenata* types. It is interesting to note that Hitchcock (19), in 1928, found that *Ilex crenata* cuttings rooted poorly in sand. Esper (9) indicated that sand was found least desirable for rooting evergreens. Many writers, such as Kemp (22) pointed out the importance of sand particle size and the variation in results can be attributed to the relationship between the number and extent of capillary and non-capillary pores in the different sand types. This was illustrated in the work of Matkin (25) who found that free porosity or air space, on a volume basis, was only 1.2% in fine sand, 9.5% in typical propagating sand, and 29.9% in peat moss.

Numerous reports of specific mediums for different species and cultivars have been recorded. Chadwick (5) and Doran (8) gave recommended mediums for cuttings of several deciduous and evergreen plants. Hitchcock (19) classified 96 varieties of cuttings into those which root readily in sand, in peat, or in either. It is important to note that, in this early research, the majority of plants were found to root successfully in either sand or peat or in a mixture of the two. Myrhe and Schwartze (26) also reported 35 species and varieties of broadleaf and narrowleaf evergreens which rooted well in sand as well as in a sand-peat mixture.

Houston and Chadwick (21) reported that softwood cuttings of 20 deciduous and evergreen plants rooted better in vermiculite than in two different grades of silica sand. Gray (14) found that tsuga cuttings rooted best in a medium of 1/3 sand, 1/3 peat moss and 1/3 fine styrafoam. In general, however, much of the research with types of rooting mediums has indicated relatively little difference in effectiveness. O'Rourke and Dedolph (27) found no one medium consistently superior in rooting cuttings of seven plant species. They used sand, arcillite, and perlite plus equal volumes of sphagnum peat and mixtures of styrafoam and peat, and arcillite and peat. Pridham (30) found no significant effect of mediums of cinders, sand, or vermiculite on rooting evergreen cuttings. Hall and Cannon (15), working with *Rhododendron carolinianum* cuttings noted that the medium was of less importance than timing or hormone treatment. Mediums used were composed of German peat moss combined with sand, perlite, and weblite. Also, Tinga and Hayes (37) found no significant differences in rooting large cuttings of several plants in four medium types and Germany (12) indicated that firethorn will root in practically any medium. He found good results with common brick sand, vermiculite, and perlite as well as mixtures of sawdust and peat.

Effect of Medium pH

Some attention has been given to the effects of pH on the rooting of cuttings; however, in many instances, the effect of pH differences in the medium were confounded by factors of aeration, drainage, etc. In some early research, Hitchcock and Zimmerman (20) found that *Azalea amoena* cuttings rooted better in peat at pH values of 3.70 to 4.68 than in peat near the neutral point. Roof (34) rooted softwood cuttings of several plants in sand adjusted to pH values of 4.3 to 8.5. In general better rooting occurred at pH values of 6 to 8 but this was not conclusive. With some species, he found a high percentage of rooting in the mediums adjusted to pH 5 and 6. Parker and Kamp (29) found significantly better rooting on cuttings of coleus, carnation, and chrysanthemum in mediums with pH values of 7 and 8 than at any other pH. VanDrunen and Kamp (38) found similar results on Hatfield yew cuttings with little to no rooting at pH levels of 5 and 6 and best rooting at pH 7. This subject is also somewhat controversial since numerous cuttings, including yew, have been successfuly rooted in sand, peat, and other mediums with low pH values. Also, in relation to this same factor, Mahlstede (24) indicated that a low pH, under 4, inhibited callus formation on cuttings.

Variant Medium Types

Some propagators have used rooting mediums established in layers. Halward (16), in propagating *Cercidiphyllum japonicum* cuttings in cold frames, used a mixture of loam, peat moss, and sand with a layer of 1½ inches of sand on top. Shammarello (35) described a medium for rooting rhododendrons in a sashhouse as being composed of a layer of gravel underneath a layer of two grades of sand mixed with peat moss on which an electric heating cable was placed. The same mixture was then placed on top of the cable. Baldseifen (1), using a modified Nearing Frame, placed layers of shredded peat moss, peat moss mixed with course sand, and a ¼ inch covering of sand on top for rooting deciduous azalea cuttings. Ravestine (31) described a unique medium for rooting magnolia and viburnum hardwood cuttings. Two and one-half inches of peat moss was put in the bottom of the bench and covered by a thin layer of peat moss. The cuttings were laid on top of this followed by a layer of sphagnum moss and a cover of peat moss. The layers were moistened as they were added and no additional watering was necessary.

Rooting Growing-on Mediums in Containers

Several workers have reported the use of mediums for both rooting and growing-on and the most detailed medium was proposed by Vermeulen (39) who suggested the term Propicon to cover the broad area of propagation in containers. The medium was composed of 53% German peat moss, 17½% #1 Horticultural Perlite,, 17½% finely shredded styrafoam, 9% fine sharp deep pit sand, and 3% soil. Tinga (37) successfully rooted large cuttings of several species directly in containers in four types of mediums and Reisch (32) reported the use of a medium composed of ⅓ soil, ⅓ peat moss, and ⅓ sand to root hardwood cuttings in 1 gallon plantainers. In other work, Hess (18) used a light weight medium ⅓ vermiculite, ⅓ styrofoam, and ⅓ peat moss to root cuttings directly in plant bands under mist, which provided rooted plants ready for shipment.

Current Aspects

With the advent of mist propagation techniques, some changes have occurred in the concept of desirable medium types. Numerous mediums have been used successfully with equally numerous variations in misting systems. As discussed by Matkin (25), free porosity or air space in mediums used in mist propagation should not be less than 20% by volume.

Although there have been few reports of the commercial rooting of cuttings in air, this has been effectively accomplished by chance, when a cutting roots on top of the surface under a mist line, or by intent, as in a recent research study at The Ohio Agricultural Research and Development Center. In this work, rose cuttings were successfully rooted in air with the bases extending into a mist chamber. This technique enabled the workers to treat the roots with varying concentrations of calcium and chelate compounds to determine effects on root anatomy and absorption.

One of the newest innovations in rooting mediums, a block composed of softwood kraft wood pulp with a hole for inserting the cutting, appears to have considerable promise. Beck and Adams (2) described these 1.5 inch cubes, known as BR-8 Blocks and manufactured by the American Can Company, as follows. The wood pulp is stabilized against decay by polymerizing acrylonitrile in the fibers, and nutrient ions are sprayed onto the block. Each block weighs 4.5 grams and absorbs more than ten times its weight in readily available water. Roots readily penetrate the structures and subsequently develop well in surrounding soil. Geraniums have been satisfactorily rooted and grown to flowering in 3-inch BR-8 Blocks. Studies, using these blocks with floriculture crops at the Ohio Agricultural Research and Development Center, have indicated that they can be used effectively under mist and must be steam pasteurized to prevent rot organisms from developing on the cuttings. In these trials, cuttings of poinsettia, carnation, rose and geranium were rooted and grown on successfully.

Conclusions

1. Numerous types of mediums can be effectively used for rooting cuttings.
2. Aeration and drainage are two critical properties of any medium.
3. The success or failure of a medium is dependent on both its physical properties and the management program.
4. Many of the discrepancies in the literature can probably be attributed to a failure to recognize and report differences between medium types, especially with various grades of sand, peat moss, etc., as well as differences in natural and man-made environmental conditions.
5. There is no mystical significance associated with a given medium for a specific plant.
6. The trend of current and future approaches to propagating mediums, stresses the added feature of a growing-on medium to save labor, cost, improve handling efficiency, and result in less disturbance to the root system.

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MODERATOR REISCH: The next two speakers on this afternoon's program are fellow travelers. I had the pleasure of being with them on a trip to California last spring. The first speaker is Earl Robinson who will talk on the subject of "Peat-perlite as a Rooting Medium."

PEAT — PERLITE AS A ROOTING MEDIUM

EARL H. ROBINSON
Medford Nursery, Inc.
Medford, New Jersey

At Medford Nursery we have tried to mechanize as much of our operation as possible. The first area we worked with was the propagating bench. The tedious and time-consuming job of filling and emptying benches did not appeal to us. Certainly a more efficient use of greenhouse space was possible. We looked to our western friends and found that they felt somewhat the same way.

We began by using a poured concrete bench suspended by a 12 x 16 x 4 cinder block protruding under the concrete slab on the wall side and 1¼" pipe legs on the other side. Copper tubing spaced at 6" centers graduated from 1" to ¾" to ½", was used for our heat source. This formed a radiant heat slab. The 180° water is tempered down to 90° to give a good even heat. The two benches are zoned separately. The two zones enable us to have two different temperatures in each bench, or to shut one bench down completely. The air temperature is on another zone. This allows us to efficiently keep flats warm and air cool. We also make use of the polyethylene tubing combined with exhaust fans that thermostatically control cooling—(Acme system). Our mist system is controlled by a counter-weight on a screen—(Mist-o-matic control).

The rooting medium to go into the flats was our next problem; drainage, aeration, and weight being critical. Our first peat-perlite mix of ½ sphagnum peat and ½ medium grind perlite, by volume in a standard flat remained too wet when the flats were placed directly on the concrete bench. We decided it was necessary to place the flats on lath to elevate them above the bench slightly. We also went to a deeper flat; namely, 4" in depth. This also remained too moist, as indicated by browning of the end of the stem, and rooting only on the upper portion of the stem.

In our second mix we used ⅓ sphagnum peat moss, ⅔ perlite, and watered this down with Aqua-Gro, and Morsodren. The results were greatly improved—heavy rooting with a root system that was much finer. Morsodren, available from E. C. Geiger, is an excellent fungicide for cuttings.

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Recently we have increased the perlite slightly, which tends to aerate the medium more. It seems almost impossible to over-water now. The proportions are one contractor's wheel barrow of Canadian peat to three four cubic foot bags of medium perlite. The reason for the peat is to anchor the cutting and induce a fibrous root system. We have not used a coarser perlite, as we are afraid of a coarser root development. Mixing is done by hand on a clean floor washed down with LF-10, a hospital disinfectant. Plans are in the process to blend the medium with a rotating drum. The 4″ flats are cleaned and washed down with LF-10 and filled with rooting medium and compacted dry. Prior to inserting cuttings, the flats are soaked, by watering with Aqua-Gro and Morsodren. Cuttings are dipped in Jiffy-Gro and Captan, 1% to 2% powder and inserted into the flats. Flats are accumulated and moved into the greenhouses and watered thoroughly.

As soon as the plants have initiated roots, they are removed from the propagating bench and placed in a growing house to harden before potting. After the cuttings are removed from the flat, the excess peat and perlite are used in the potting mix. By removing the flat of rooted cuttings as soon as they are rooted, there is room for another flat of cuttings immediately. The use of flats divides the propagating area into smaller areas of like size. This allows us to keep the house producing a maximum capacity.

The peat and perlite allows us to have the necessary aeration in the rooting media, as well as making the flats light in weight—a very important factor is being able to use women to handle this material from start to finish.

MODERATOR REISCH: At this time the paper on rooting mediums by Harvey Gray will be presented by Ralph Shugert.

RALPH SHUGERT: Before I present Harvey Gray's paper I would like to read this brief letter. It is dated November 27th 1967.

Dear Ralph:

I am writing you this note flat in bed with some unknown germ. It does not seem likely that I will be up and around for this meeting.

Enclosed is a copy of the talk I had intended to give you on Friday. Perhaps you can arrange for someone to present it for me.

Wishing you and the entire Society an extremely successful meeting, I am

Sincerely yours,
Harvey Gray

EXPLORING ROOTING MEDIA

HARVEY GRAY
State University
Farmingdale, New York

Many plant propagators recognize the value of oxygen in a rooting medium. This is evident in the literature of our Society. The word "sharp" occurs frequently when sand is used to support the cutting while in the process of rooting. Other defining words are used throughout the literature.

It is NOT my intention to discuss details concerning sterility, nutrient content, or pH of the rooting media. Rather, my concern is the oxygen content available in the media for active rooting.

B. A. Briggs states (I. P. P. S. Proceedings, 1966) if constant over-wetting of the cutting stem occurred when using the "air rooting" technique, poor rooting followed; if not, good rooting resulted. This demonstrates the necessity of a favorable water/oxygen relationship in the medium.

On Long Island plant propagators seek a commercial source of water washed "concrete grade" sand for the rooting medium. Very often the amount and value of the washing can be questioned. The mechanical analysis of a lot of sand delivered for the purpose of rooting a variety of cuttings showed 20% very fine sand and 5% silt.

Remember when the propagator pounded the sand around his cuttings in the sand bench? If the sand was a course, sharp grade, this was imperative; but if it was clogged with fine sand and silt, the rooting of cuttings was less than satisfactory. A friend of that era often made reference to the "milk bottle test" to determine a sand's potential as a good propagation medium. This test is as follows. First take ½ cup of sand in a quart bottle; add ¾ quart of water. Shake vigorously and allow one minute to settle. To read the results note the density of silt and clay in suspension. Note the quantity of very fine sand on top of the settled-out sand. If a very dense suspension of silt and clay exists, the sand should not be used. Also if a wide band of very fine sand appears in the settling, less than satisfactory results will develop. To clean a silt-loaded sand by washing is a laborious and costly task.

It is here, with sand containing very fine sand, silt, and clay that such materials as fibrous peat, vermiculite, perlite and styrofoam come to the aid of the propagator. Singly or collectively these materials in varying proportions are added to the sand. The addition of these materials decreases the bulk density of the sand. This results in oxygen bearing pores, and naturally the oxygen increase in the medium. When using a sphagmum moss peat medium, inorganic substances such as vermiculite, perlite, course sand and styrofoam lessens the soggy moisture build-up of the high water holding capacity of the peat.

The problem of imbalance in the water/oxygen relationship is intensified with misting. Excess water applied to maintain cutting turgidity, needs to be carefully avoided. Short blasts of mist at proper intervals should be the mode of application. Misting intervals of thirty seconds or longer, applied with time-clock regularity, may be cause for over watering and water/oxygen impalance.

This past season our nursery management students set up a series of tests with various media to demonstrate the points I have outlined. All cuttings were carefully selected for uniformity. The cuttings were misted with short blasts. the intervals between misting under the control of the 'Mist-a-matic'. The sand used in these demonstrations contained 25% very fine sand and silt. An average grade of sphagmum peat was used as well as horticultural grade perlite and #4 vermiculite. The species used in the demonstration were *Rhododendron obtusum, Cotoneaster microphylla,* and *Pyrocantha coccinea.* Twenty different media blends and straight materials were used. Sand, when used alone, produced the poorest results on all three species. Peat alone produced somewhat better percentages of rooting than sand alone. When peat in a blend of an equal volume of perlite or vermiculite, or a mixture of peat, perlite and vermiculite were used, the best results followed.

This test does not rule out the choice of sand as a good rooting media, but it does indicate the value of a clean sharp sand, free of very fine sand and silt. It also indicates a satisfactory alternative to washing the sand available to us. Further work along this line must be done to substantiate the concept of the water/oxygen balance imperative in a rooting medium.

MODERATOR REISCH: Our next speaker on the panel is a fellow citizen from Ohio, Mr. Richard Bosley, who will speak on ground bark as a growing medium.

GROUND BARK — A CONTAINER GROWING MEDIUM

RICHARD W. BOSLEY
Bosley Products
Mentor, Ohio

Introduction

The use of wood residuals, as a container medium, is becoming quite popular. Many nurseries are using proportions running as high as 80-100%. This utilization of wood residual materials has been made possible by the development of methods of stabilizing the product against nitrogen withdrawal from the growning medium.

I wish to acknowledge the great service that Dr. O. A. Matkin and his Soil and Plant Laboratory, Inc., has made to the industry as a whole and more specifically to our nursery in the development of wood products into suitable growing media.

The problem of imbalance in the water/oxygen relationship is intensified with misting. Excess water applied to maintain cutting turgidity, needs to be carefully avoided. Short blasts of mist at proper intervals should be the mode of application. Misting intervals of thirty seconds or longer, applied with time-clock regularity, may be cause for over watering and water/oxygen impalance.

This past season our nursery management students set up a series of tests with various media to demonstrate the points I have outlined. All cuttings were carefully selected for uniformity. The cuttings were misted with short blasts. the intervals between misting under the control of the 'Mist-a-matic'. The sand used in these demonstrations contained 25% very fine sand and silt. An average grade of sphagmum peat was used as well as horticultural grade perlite and #4 vermiculite. The species used in the demonstration were *Rhododendron obtusum, Cotoneaster microphylla,* and *Pyrocantha coccinea.* Twenty different media blends and straight materials were used. Sand, when used alone, produced the poorest results on all three species. Peat alone produced somewhat better percentages of rooting than sand alone. When peat in a blend of an equal volume of perlite or vermiculite, or a mixture of peat, perlite and vermiculite were used, the best results followed.

This test does not rule out the choice of sand as a good rooting media, but it does indicate the value of a clean sharp sand, free of very fine sand and silt. It also indicates a satisfactory alternative to washing the sand available to us. Further work along this line must be done to substantiate the concept of the water/oxygen balance imperative in a rooting medium.

MODERATOR REISCH: Our next speaker on the panel is a fellow citizen from Ohio, Mr. Richard Bosley, who will speak on ground bark as a growing medium.

GROUND BARK — A CONTAINER GROWING MEDIUM

RICHARD W. BOSLEY
Bosley Products
Mentor, Ohio

Introduction

The use of wood residuals, as a container medium, is becoming quite popular. Many nurseries are using proportions running as high as 80-100%. This utilization of wood residual materials has been made possible by the development of methods of stabilizing the product against nitrogen withdrawal from the growning medium.

I wish to acknowledge the great service that Dr. O. A. Matkin and his Soil and Plant Laboratory, Inc., has made to the industry as a whole and more specifically to our nursery in the development of wood products into suitable growing media.

Past Proceedings

For your information you might like to check the 1963 Proceedings of the International Plant Propagators' Society which contained an article entitled "Ground Bark as a Growing Medium for Container Nursery Stock" by F. A. Rigby. I will try to bring you up to date on what has happened between then and now.

What Are We Looking For?

What are we looking for when selecting a container medium?

1. Physical and chemical characteristics.
2. Availability
3. Cost
4. Disease Problems?

Physical Characteristics

Let's talk first about some of the physical and chemical characteristics of organic amendments that we might be looking for and bark specifically.

One of the first physical characteristics that comes to mind is the aeration and drainage factors. The sudden water logging of a medium previously only moist will kill the roots of most plants, with or without parasites. The continuous development of roots provides, among other things, the essential means of adjusting to a changing environment. Perhaps a better approach though is to have a medium which is difficult to overwater or will assume adequate air within the medium shortly after a heavy rain or irrigation.

Good drainage can be achieved with course material, either organic or inorganic. The next factor we might consider though is moisture retention and this will limit the particle size. We might say then why not use just the right size of sand? It is cheap, won't break down and can be made clean.

The fertility retention capacity or cation exchange capacity of most sand is very low and so you would have trouble keeping the plant fed.

A number of factors then point to using an organic amendment in our growing medium. Many growers have used sphagnum peat for many years with good results but at a rather high cost and after a wet year in Germany, questionable availability. After rather extensive investigation we were encouraged to use ground bark as the organic constituent in our can mix.

We use bark from two sources that have a mixture of about 30% oak, 30% maple, 20% cherry, some birch, no elm or walnut as these two woods are not suitable for paper making. Both of the mills we get bark from produce paper products and are careful to remove the bark from the log without any wood content. Most of this bark is from growth about 5-8″ in diameter and is usually smooth, on the log, rather than old shaggy material.

One of the first problems becomes reducing the particle size to the 85% in the 0-1/8" size needed. It is best to encourage the mill to do this as the equipment can be expensive and have high power requirements. At the Tom Dodd Nursery we did see an old silage hammer mill doing a very good job of reducing pine bark so this might be a possibility. Once you have the particle size the next problem becomes satisfying the nitrogen.

N Treatment

I would like to stress at this point that there can be great differences in bark from one source to another. The two sources we get bark from are only 150 miles apart and both use second growth native hardwood. One source we have to treat with much more nitrogen than the other, one has a pH of 8.35 and the other 4.6 with a very high potassium (2880 ppm) content. I would like to *stress* that if you try bark do it on a limited trial basis and with the help of either the university extension service or a laboratory. The precise control of nitrogen will determine, most likely, how successful you will be.

There are several ways that bark can have its nitrogen requirement fixed. The best way is that developed by Dr. Matkin of the one minute exposure, in a closed auger to a measured quantity of anhydrous ammonia (NH_3). Pine bark for instance would require about 3-6# of anhydrous ammonia and upon emerging from auger would be ready for use. The total nitrogen content of the product will be 1.5% based on dry weight. The treatment cost would be about 60c a yard for nitrogen. The rate is about one yard a minute but the equipment might cost several thousand dollars. The resulting nitrogen is neither leachable or available to the plants until the bark breaks down which is very slow.

Another method of nitrifying the bark is with bloodmeal. We have used this method in the past and although it is the most expensive form of nitrogen (anhydrous ammonia being about the cheapest) and it smells bad, it can be used at once as a medium. Rates of 10-20# per cubic yard would be a starting point. The other material we have used is urea although if you are growing azaleas you must be alert to the possibility of a biuret poisoning problem if you continue to use slow release fertilizers on your crop. All of this seems like a lot of trouble to go to but take a close look at your peat cost compared to a cost of say $2-2.50 a yard delivered for bark (1c a gallon using 100% bark).

Old Bark

Old bark often has a *higher* nitrogen requirement. Stick to fresh material which will be more consistent and less trouble.

Cation Exchange Capacity

The nutrient retention, or binding power, of a material is dependent upon a capacity commonly termed "Cation Exchange Capacity." Organic amendments have a relatively low nutrient retention capacity compared to the typical loam soil. In comparison to sand though the organics have a fairly substantial cation exchange capacity and thus will enhance nutrition retention in a mix.

Root Rot

The question will arise in your mind — will I need to sterlize the bark? There is the distinct possibility that it will contain pathogens as the logs most likely contacted the soil in their journey to the mill. In the case of the use of urea to nitrify bark we stock-pile it for a week and have noted 125° temperatures in the stack. Perhaps we could boost this to 140° which would kill the undesirable pathogens. In the case of the closed auger treatment surely the exposure to an atmosphere of ammonia gas would do the job.

Our Mix

You might be interested in what mix we came up with at the Bosley Nurseries using bark. The figures are based on one yard:

¾ yard bark (0-⅛")
¼ yard medium sand
20# blood meal
1½# triple superphosphate
20# dolomite lime (high magnesium)
10# calcium carbonate
1# iron sulfate, ferris or ferric

I give you these figures with considerable reservation because you should determine by test and/or trial what level of additives you need.

Volume

Let's look at the bark availability and see if it will still be around 10 years from now. There are two main sources that you can look to and they are paper and veneer mills. The Mobile, Washington and Clarke Counties surrounding where you are sitting have an estimated annual wood chip consumption of 411,630 cords. The use in this area is great enough that serious studies have been made regarding direct field to factory transportation of wood chips by pipeline. Growth of new wood is greater than consumption. Air pollution promises to rule out burning the great volumes of bark in the future.

One of the paper mills we get bark from produces 580 cubic yards a day or almost ⅔ of our annual consumption! They get a heat value of about 50c a yard, if they burn it. But they can only burn about 80% a day leaving about 100 yards a day to be hauled away somewhere! A plant barking a 40' log 2' in diameter will produce 240 tons of bark in an eight-hour day. A plywood plant producing 207,000 square feet of ⅜" plywood per day may fill 10 boxcars with bark at the same time. We feel that bark is widely available and will be for a long time. That it is a good growing medium when properly treated and it is worth your while to try it. There is great concern as to what to do with all this bark in this country and Finland. Its agriculture suitability seems a much sounder approach which could materially reduce air pollution in certain areas.

MODERATOR REISCH: Are there any questions for the panel?

VOICE: I noted in Ken Reisch's paper that he stated that the rooting of cuttings in air was not commercially feasible. However, I remember last year some excellent slides presented by Bruce Briggs showing the rooting of cuttings in air which appeared very interesting to me.

BRUCE BRIGGS: At this time I agree that the practice is not sound commercially but I would not say that in the future the practice is not sound. The techniques have not been worked out to the point where you could have assembly line production. When you attempt to root cuttings in air you run into problems such as you would with any new medium. Some of the problems you can't even anticipate. We need to have research on the type of equipment necessary to keep the air moist around the base of the cuttings and we also need work on temperature control.

CASE HOOGENDOORN: I would like to ask Dick Bosley how long it is before the bark breaks down and doesn't he run into a problem of nitrogen deficiency?

DICK BOSLEY: We add nitrogen to the bark before it is used. The amount of nitrogen to be used to satisfy the breakdown requirement has to be determined by trial. If this is properly determined, it will satisfy the needs caused by breakdown and you can proceed with a normal nutritional program for the plant material. The bark is very long lasting and this is one of its desirable characteristics.

CASE HOOGENDOORN: Could you not use old bark that has already decayed?

DICK BOSLEY: Our experience has been if you use old bark from the bottom of large piles that it actually takes more nitrogen. Also, there is a problem that there are more fines. It's best to stick with fresh bark and you have a more consistent product to work with. With the older bark you don't know exactly how old it is and it would be necessary to run a test on each batch.

VOICE: I would be interested in knowing the cost and the source of the bark that you use.

DICK BOSLEY: The cost is between $2.00 and $2.50 per cubic yard. I don't have the exact figures but probably 50c per cubic yard of that cost is for the bark and the balance is for trucking.

AUSTIN KENYON: With the mixture of ¾ of a yard of bark per yard of mix and 20 pounds of blood meal how long must it be composted before it can be used?

DICK BOSLEY: It can be used immediately.

AUSTIN KENYON: Is the bark which is priced at $2.50 a yard ground when you receive it?

DICK BOSLEY: Yes, it is ground.

HENRY WALKER: Do you have any problems in transplanting to permanent locations when using the bark medium? Does the bark tend to fall away from the plant after it is taken from the container and does the plant have any difficulty becoming established in soil after having been grown in the bark medium?

DICK BOSLEY: In order to grow in a container you must have a medium which provides the proper aeration and drainage. These requirements are not always totally compatible with the final field soil. There is a great need for public education on how to plant container-grown plant material. It has to be handled a little bit differently than balled and burlapped plant material. We get good root distribution in the container and so there is no problem at all of the medium falling apart. The problem lies in the interface between the container medium and the soil in the final location. With some soil types the water does not seem to go through this interface.

E. STROOMBEEK: Do you have to check the pH of each lot of bark or does it seem to settle down after the nitrification process?

DICK BOSLEY: Nitrification seems to raise the pH and fertilization tends to lower it. We run a pH determination each time a fertility reading is taken.

RALPH SHUGERT: Our final session this afternoon deals with new plant introduction. Al Fordham of the Arnold Arboretum is moderator.

MODERATOR FORDHAM: Our first presentation is by Ed Mezitt who will describe rhododendron P. J. M.

RHODODENDRON P. J. M.

EDMUND V. MEZITT
Hopkinton, Massachusetts

Rhododendron P. J. M. is a hybrid of *Rhododendron dauricum sempervirens* and *Rhododendron carolinianum* made in 1940. It is very floriferous blooming every single year on every stem, and its winter foliage of rich mahogany tones is very attractive.

Propagation is not entirely without some difficulty. Being an early grower similar to Rhododendron mucronulatum but also a woody type, it cannot be treated as a softwood cutting during the summer but must be started before the buds develop too much in the fall. If top growth starts before the roots, the bark per yard of mix and 20 pounds of blood meal how long must it be composted before it can be used?

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We use sand and peat mixture as a medium, hormodin powder 3, or the last few years hormodine powder C, on cuttings started around October 1st for best results. Intermittant mist is necessary although the polyethylene tent has worked, if kept shaded so heat will not build up.

One big advantage of this plant is the ease in growing, once rooted, and the fact that with some pruning during the first two years so that a solid base is formed, every plant is like a pea in a pod, heavily budded, and extremely attractive for market in leaf or flower.

MODERATOR FORDHAM: Our second presentation will be by Peter Vermeulen who will describe *Pieris Japonica* 'White Cascade'.

PIERIS JAPONICA 'WHITE CASCADE'

This cultivar of the Japanese Andromeda, originated as a seedling in the nurseries of John Vermeulen & Son, Inc., Neshanic Station, New Jersey, in 1953 and sold later as a young plant to Raymond P. Korbobo, 13 Oak Drive, Middlesex, New Jersey. Mr. Korbobo and Dr. Ben Blackburn recognized together its distinct character. In the words of Mr. Korbobo, it has "Perfectly clear white flowers; full flower clusters; fully clothed with foliage all around; flowers stay clear white for five weeks; produces heavy flower set each year." It was named White Cascade' in cooperation with Peter Vermeulen and is being propagated extensively by John Vermeulen & Son, Inc., Neshanic Station, New Jersey. Plants will be offered for the first time this year in their wholesale catalog No. 94 for Winter-Spring 1968.

MODERATOR FORDHAM: Our third presentation is by Laddie Mitiska who will describe *Euonymus* (*E. sachalinensis*)

EUONYMUS (E. sachalinensis)

A deciduous form similar in growth to *Euonymus europeus*, except more graceful in branching habit. Twigs are smooth and clean-looking; terminal buds are ¾" long and covered with maroon colored scales. Leaves are smooth and 2½ to 3½ inches long. Flowers are greenish-white and rather inconspicuous. Red fruits, which are five-angled, are borne in small clusters on long hanging stems. As the fruits open, the bright orange seeds are suspended on a delicate filament before dropping.

This species is most interesting when the bright green foliage emerges from between the maroon scales of the buds; during the display of the red hanging fruits climaxed with the dropping of the orange seeds, and finally with the plum-colored foliage before leaf drop.

Rate of growth after the first few years shortens considerably. Our original specimen, now 25 years old, is eight feet tall and wide and very symmetrically shaped. Annual average growth has shortened to less than two inches. Truly, this little known species of Euonymus is a gem that deserves more use in modern gardens.

Propagation is easily accomplished by seeding. Seeds are fall sown as soon as ripe and covered with a light mulch. Protect from rodents. Seed need not be cleaned. Germination will take place very early the following spring. In fact, we can collect hundreds of volunteer seedlings each year from beneath our one large specimen.

Propagating stock in the form of two-year seedlings is available from our nursery.

MODERATOR FORDHAM: Our next presentation will be by Bruce Briggs who will describe a new form of *Chamaecyparis Lawsoniana.* The Chamaecyparis lawsoniana "Golden Showers" is a golden form of lawson cypress that was selected in the nursery here. It is more dwarf than Westermannii, flat top when young and moderately pyramidal when mature, branchlets drooping. The sprays cream to light yellow, color not affected by hot sun. Roots well from cuttings.

MODERATOR FORDHAM: Harrison Flint will present the next two plants *Abies koreana prostrata* and *Sorbus alnifolia.*

Abies koreana prostrata (Prostrate Korean Fir). Probably the same *Abies koreana* 'Prostrate Beauty' (den Ouden, 1965). Presently available in only a small number of nurseries in the U. S., but worthy of wider introduction. This variety is a wide-spreading form, not normally exceeding 4 or 5 feet in height, but it grows more vigorously than the tree form of *Abies koreana,* and in time will send up an occasional leader, which must be pruned out to maintain the spreading form.

Propagation: Softwood cuttings taken in early to middle June in New England and placed in a peat-perlite medium under mist have rooted in good numbers (50 to 60%) in two to three months. Effective concentrations of rooting substances have included 0.3% and 0.8% IBA in talc but combinations of IBA and NAA should be tried, and may prove superior to IBA alone.

Sorbus alnifolia (Korean Mountain-ash). This tree has been available in only a few nurseries, but in the last few years the Arnold Arboretum has supplied seeds to several wholesale nurseries. This should result in its becoming more widely available soon. This tree differs from most mountain-ashes in its ultimate size (60 feet in height) and in that it is a relatively hardwooded species, not susceptible to borer attack in the Arnold Arboretum. It has bright yellow-orange fall foliage in our area and its fruits persist for some time after the foliage is gone. Its trunk structure and silvery-gray color make it interesting during winter as well.

Propagation: Seeds of *S. alnifolia* have demonstrated double-dormancy, requiring both warm and cold stratification. This can be accomplished by sowing in outdoor seedbeds or by stratification in moist peat in the greenhouse for 5 to 6 months, followed by 3 months at 40°F. The exact timing has not yet been worked out.

MODERATOR FORDHAM: The next group of plants will be presented by Albert Johnson from the Department of Horticultural Science, University of Minnesota.

Viburnum Sargenti: Large flowers and fruit.
Coronilla Varia: A golden form increased by division or cuttings.
Malus 11 *AB*: A rosey-bloom increased by grafting or budding. Will be named and introduced.
Pinus Banksiana: Weeping form propagated by grafting.
Pinus Banksiana: Dwarf plants grown from seeds produced by witches' brooms.
Azalea Hybrids: Mollis azaleas crossed with *Rhododendron roseum* and *R. nudiflora.*
Gymnocladus Dioecus: A globe form propagated by grafting.
Ulmus Americana: A fine semi-weeping type propagated by grafting.

MODERATOR FORDHAM: Next will be Joe McDaniel from the University of Illinois.

The three trees I am showing and recommending are already in commercial propagation at Midwestern nurseries. The first two are cultivar forms that I selected at the University of Illinois. The third is a native coniferous species in the Eastern Gulf and Southern Atlantic Coast regions, in which some clonal propagation is also started in Illinois.

Diospyros virginiana 'John Rick'

Up in Zones 5 and 6, the Oriental *Diospyros Kaki* can't take our coldest winters. Fortunately, for those who like good persimmons, for eating or just to look at, a few nurserymen and native fruit hobbyists over the past 80 years have made some very worthwhile cultivar selections in the American persimmon, *D. virginiana.* The oldest still propagated is 'Early Golden', selected from the wild by E. A. Riehl at Alton, Ill., before 1890. It occasionally bears male flowers on some shoots, and when this happens it can be self-pollinated. The seedlings of 'Early Golden' are more likely than most to have good, early-maturing fruits on the approximately half of its seedlings which come female. Two cultivars that are apparently its seedlings are 'Garretson' and 'Killen'. 'Killen', also bearing occasional male flowers is the seed parent of the recently named 'John Rick'. It is an open-polinated seedling, but the other parent is probably the male cultivar 'William', selected by me at the Illinois Agricultural Experiment Station. 'John Rick', named for a late fruit and nut experimenter at Reading, Pa., has larger fruits than other persimmons in the 'Early Golden' line, appears equally hardy to Zone 5 when budded or grafted on seedlings of comparably northern source. When planted outside of native persimmon areas(it will need as pollenizer a male of the hexaploid (90 chromosome) race, the prevalent race north of the Ohio River. Fruit shape, as well as size and beauty, the 'John Rick' probably in a class by itself, as a commercially promising American persimmon. The calyx is a prominent part of most American persimmon fruits. In 'John Rick', the calyces are relatively small, flexible, and set deeply into the cavity at the end of the fruit, thus are less likely to puncture adjacent fruits in a container. Tree and scion sources of 'John Rick' (and pollenizers) include: Louis Gerardi Nursery, O'Fallon, Illinois Talbott Nut Nursery, R. R. 3, Linton, Indiana, and Valley View Nursery, 748 South Queen St., York, Pennsylvania.

Fraxinus excelsior 'Northland'

This appears to be both one of the hardiest and one of the most vigorous and insect-resistant Ash cultivars under Zone 5 conditions in the Midwest, where some previous introductions in this European species (under its proper name or aliases) have been virtual failures. It was selected under prairie conditions, from seedlings of a mature tree growing in central Michigan, and has until now shown no winter injury between Urbana, Illinois, St. Louis, Mo., and Shenandoah, Iowa. The source of the seed parent is unknown, but it grew to maturity in the home landscape planting of W. K. Kellogg (the original), now part of the Michigan State University Biological Station on Gull Lake near Hickory Corners, northeast of Battle Creek. 'Northland' originated at Urbana, Illinois, from seed collected on one of two similar trees in the Kellogg estate. When it was two years old, and the most vigorous of some 50 seedlings from that source, it was first budded on Green Ash stocks in the Louis Gerardi Nursery, O'Fallon, Illinois. One year later, the budlings had made straight, stout whips taller than the unbudded green ash seedlings adjacent to them. Further commercial propagation tests have been made at the Earl Cully Nursery, R. R. 5, Jacksonville, Illinois, and at the Mount Arbor Nurseries, Shenandoah, Iowa. Cully currently has the largest number of 'Northland' ash trees, and can supply budwood. It has shown no incompatibility on green ash understocks. Gerardi, who has had most experience in transplanting this cultivar, reports no borer damage to date, and 100% transplant survival in landscaping.

'Northland' has dark green leaves, held until hard frost, with the typical odd-pinnate arrangement of the species (usually 9 to 13 leaflets, with an occasional basal leaflet re-divided).

No fruit has yet been seen on this young clone, but it belongs to a monoecious species, so can be expected to make some seeds when mature. Growth of young trees is vigorous, narrow-columnar, with primary branching mainly at less than a 45° angle with the straight trunk.

One other cultivar of *F. excelsior* reliably hardy in the Morton Arboretum is Hesse's Ash. In contrast to 'Northland', *F. excelsior Hessei* has leaves reduced to as few as one leaflet, and its tree form is globose.

Pond Baldcypress, *Taxodium ascendens.*

Some botanists in the U. S. Forest Service call this merely a variety, and term it *T. distichum* var. *nutans.* The mature trees are distinct, and occur usually in different habitats, so I follow the usage of those who regard Pond Baldcypress as a separate species. It can be seen wild in parts of Mobile County, Ala., and elsewhere in coastal areas of South Carolina to Florida and Mississippi. It is particularly prevalent in the beautiful cypress ponds near Tampa, Florida. Like the better known, and more northward and westward ranging common baldcypress (*T. distichum*) it is hardy very much north of its native limits and grows well in non-swampy sites when transplanted. In cultivation from Pennsylvania to Illinois, at least, it seems to be equally hardy, though somewhat smaller in ultimate bulk, when compared with the better known species. With its shorter needles appressed closely to the twigs, it gives a different appearance from *T. distichum,* once past the first juvenile years, and normally casts less shade. On its own roots, it seldom if ever develops the "knees" that *T. distichum* shows in wet or flooded sites. From a decorative standpoint it has still another distinction. Its foliage stays fully green until frost, while many trees of *T. distichum* regularly show a brownish discoloration by August.

The Earl Cully Nursery is propagating a number of *Taxodium* clones by grafting, including a *T. ascendens* clone whose original tree is the more attractive of two old specimens in the Morris Arboretum. It grafts with no difficulty on *T. distichum* seedlings. I have tried one lot of cuttings of that clone with no success, though I did get some rooting from both 2-year and 100-year-old clones in *T. distichum.* Grafting appears the most practical method for cultivar propagation of *T. distichum* as well as *T. ascendens.* While Cully field-grafts with dormant scions in the spring, it is also feasible to graft in late summer with well-matured scions.

FRIDAY EVENING SESSION

December 1, 1967

THE PLANT PROPAGATORS' QUESTION BOX

DAVE DUGAN — Moderator

MODERATOR DUGAN: How can Turkish filbert be propagated other than by seeding?

BILL FLEMER: It can be grafted on *Corylus avellana* understock. The understock will sucker some but the grafted plant grows perfectly well.

MODERATOR DUGAN: Is there such a thing as Japanese oak and where can it be purchased?

JOE MCDANIEL: There are two or three of them. They grow as evergreens. They look like a holly tree at a distance without the berries. They are available in a few nurseries in the Southeast. I noticed Tom Dodd had a couple of trees in his back yard but I did not notice any acorns.

MODERATOR DUGAN: What is the proper way to plant a peat pot?

PETE VERMEULEN: As we mentioned the other day, make sure the peat pot is soaking wet when you plant it. Then either take the rim off the top of the peat pot or else plant it deep enough so that the rim is below the soil level. If there are roots coming through the pot, there is nothing else to do but if they have not broken through the peat pot as yet, just crack the bottom of the pot a little bit to help the roots go through. If anyone wants more detailed information, the Jiffy Pot Corporation of America has put out a brochure which contains a number of helpful hints on the use of peat pots. The address is West Chicago, Illinois.

GERALD VERKADE: I find with fine-rooted plant materials such as rhododendrons and azaleas, that after the plants have been in the field for two or three years and are then dug up that you still find the original peat pot. How do you get rid of the peat pot then?

MODERATOR DUGAN: Dig a larger ball! What concentration of kinitin and gibberellin is used for breaking dormancy of azalea buds?

ED HUME: I am sorry that I do not have the concentration of kinitin.

ROBERT FARMER: A 1% concentration of gibberellic acid will break the dormancy of most anything. I have not had experience with azaleas but this would be at least a concentration to try.

MODERATOR DUGAN: When storing crab apple grafts, at what temperature do you keep them and how moist?

BEN DAVIS: We pack them in wire bound crates in damp shingle toe. The crates are lined with waterproof craft paper. The temperature of the storage is 50°.

VINCE BAILEY: We store crab apples in two ways. We store them first for a couple of weeks at 50° and then we transfer them to the 36° room until planting time. Some of the grafts are placed directly in the 36° storage and I am not sure that there is too much difference between the two treatments.

MODERATOR DUGAN: You store them at the warmer temperature to allow the callus to form and then you put them in the lower temperature area.

VINCE BAILEY: Yes, that is correct.

JIM KYLE: We store our grafts in vermiculite. We use a gallon and a half of water to a six cubic foot bag of vermiculite. We have had excellent success using the vermiculite. We also tried storing them warm to allow callus formation and then put them in the lower temperature storage but we have had just as good success by placing them directly into 38° storage.

BILL CURTIS: We only have a few thousand apple grafts so that we just store them upright in wooden boxes and cover them with moist sawdust and store them out-of-doors under fir trees.

MODERATOR DUGAN: Has anyone had a proven method for germinating domestic peach seed? I would say that the person asking this question should check the experiment station at Geneva, New York.

JOHN ROLLER: We have very good success by fall planting the peach seeds.

BEN DAVIS: We have a procedure that we have used ever since my grandfather was in the nursery business. We soak the peach seeds for seventy-two hours to be sure that they have plenty of moisture in them in case there are no fall rains. During this soaking process the empty seeds float off. After the floaters have been removed we take a hundred or so seeds out and crack them with a hammer to see how many are good or viable. Based on this information we determine how thick the seeds will be planted in the field. We plant the seeds in the fall and put a ridge of soil over top of them. In the spring when we see the roots starting develop we knock the ridge off with a rotary hoe which gets rid of the first crop of weeds and allows the seedling to germinate.

MODERATOR DUGAN: You can send your peach seeds to Geneva, New York, at the Cornell Experiment Station and they will test the peach seeds for you.

JOHN ROLLER: I have found that one good way to keep peach seeds rather than try to store them dry or anything like that is to just spread them out on top of the ground and then fall plant them.

MODERATOR DUGAN: Sid, did you compare the growth after propagation of the cuttings rooted under florescent lights with the cuttings rooted in the greenhouse?

SID WAXMAN: Yes, we did make that comparison using the chrysanthemum. There was no difference in the growth of the plants between those propagated in the greenhouse and those propagated under the fluorescent lights setup.

MODERATOR DUGAN: Would you tell us how many fluorescent lights you used and what was the wattage?

SID WAXMAN: On a four-foot bench we used two tubes, 75 watts. That would be two eight-foot tubes at 75 watts, or two four-foot tubes at 40 watts each.

MODERATOR DUGAN: In the past we have associated good rooting under mist with higher light intensities. In Dr. Waxman's paper he obtained good rooting with lower light intensities. Should we conclude that we should be using shade with our misting systems?

SID WAXMAN: The purpose of the fluorescent light treatments was not to cut down light but to provide additional propagating space.

CHARLEY HESS: I think an important factor here is that you have to start with a cutting that has a reasonable amount of food reserves, particularly when going into a low-light intensity situation. You may recall when we used the grafting case for propagation, before mist was introduced, the light intensity was as low as 240 foot candles. This was necessary because in order to reduce the heat in the grafting case it was essential to shade. But under those conditions we could not use a real soft cutting because it did not have the reserves and it would break down or rot before rooting could occur. When mist was developed it was possible to use very soft cuttings and the light intensity that was possible with the mist permitted photosynthesis and the actual accumulation of carbohydrates during the rooting period. Herein, I believe, lies the answer to the apparent inconsistency. If you have a cutting which has some substance to it, you can use a low intensity light situation for propagation but you cannot use an extremely soft cutting, particularly one that is slow to root under these low-light conditions.

MODERATOR DUGAN: Dick Vanderbilt's paper stimulated a lot of questions this morning. Dick, what pH do you suggest for the rhododendrons?

DICK VANDERBILT: I would prefer not to have the pH lower than 5.5. Because of the *Phytophthora* problem I prefer not to go much higher than 5.5 either. If it were not for *Phytophthora,* I would go as high as 6.

JIM WELLS: I agree with Dick's suggestions under the conditions in which he grows; that is, in a container. But when you are growing in the field and you do not have precise control over your conditions, in particular drainage, then I believe it is desirable to go to a much lower pH. I believe Dick White's paper stated that in the laboratory the growth of the *Phytophthora* was inhibited by pH's of 4.25 or below. Above 4.25 the organism could develop. Now that was under laboratory conditions and it has been my experience under field conditions that the lower the pH, the less the problem is with *Phytophthora.* I do not believe that we can pin point a pH that is right for all conditions.

MODERATOR DUGAN: What does Phytophthora do to the rhododendron?

DICK VANDERBILT: The plant looks as though it does not have enough water. An easy way to separate Phytophthora from other diseases such as *Rhizoctonia,* is to take a knife and cut into the stem going down below ground level and if you see any brown streaking in the cambium; you have *Phytophthora. Phytophthora* gives a reddish-brown or cinnamon color, whereas *Rhizoctonia* does not.

MODERATOR DUGAN: Do you find the rhododenrons grown in the wooden baskets are easier to overwinter than in metal containers?

DICK VANDERBILT: By storing our rhododendrons in the poly houses, as I described last year, we have had no difficulty in overwintering either in the baskets or in the metal cans. We see no difference.

MODERATOR DUGAN: People in the Midwest are refusing to accept rhododendrons and azaleas which are balled and burlapped with burlap treated with copper naphthenate. Are you possibly running into a problem using the bushel baskets treated with copper naphthenate?

JIM WELLS: I do not believe that the copper naphthenate is detrimental to rhododendrons. I have planted young seedlings in flats that were freshly dipped in copper naphthenate and had no problem whatsoever. This is not the way to do it but we were in need of flats.

PETE VERMEULEN: I used to be of the same opinion but this past winter we had an experience which has changed our minds. We dipped flats in copper naphthenate and filled them with medium and stacked one on top of the other. When the azalea seed was planted and germinated there were two strips down the length of each flat in which the seedlings did not germinate. The only thing that we could account for the lack of germination in these areas was the strips which were on the bottoms of the flats and were in contact with the top of the medium when the flats were stacked.

CARL GULLO: I would recommend that anyone who uses flats treated with copper naphthenate treat them about a week or two before you plan to use them.

MODERATOR DUGAN: Pete, what solvent did you use for your copper naphthenate?

PETE VERMEULEN: We used Stoddard's solvent.

MODERATOR DUGAN: I just wanted to point out that there are some people who try to save about 10c gallon and use gasoline rather than Stoddard's solvent or dry cleaning fluid which is actually what Stoddard's solvent is. The gasoline is very toxic to the plant materials and should not be used.

SID WAXMAN: We have run some tests with burlap treated with copper napthenate to determine if there was any injury. What we did was to soak the burlap in a good concentration of copper naphtehenate and cut it into small squares and place it in pots with chrysanthemum cuttings. There was absolutely no injury to the roots of the chrysanthemum cuttings.

BILL CURIS: We purchase used sacks and treat them with copper naphthenate. We have found that if you use close mesh sacks that you run into some problems. As long as you use an open mesh sack then there is no trouble when they are treated with copper naphthenate. Apparently the roots just cannot get through on the close mesh sacks.

MODERATOR DUGAN: There is a question on how you handle your newly rooted rhododendron cuttings and at what time do you begin fertilization?

DICK VANDERBILT: From the rooting bench the cuttings are potted in quart containers and are fed immediately with a weak solution of 20-20-20. The concentration is 4 oz. to 100 gallons. They are not fed again for perhaps a month depending upon the soil tests. If the nitrogen level is above 10, we will not feed but wait until it drops to around 7. At this point there is no lime or superphosphate added to the medium which is one half peat moss and one half perlite. We water in Dieldrin to control the *Taxus* weevil at this time and also add chelated iron. The Dieldrin is applied at the rate of 4 lbs actual per acre and the chelated iron is applied at the rate of 2 oz. per 100 square feet.

MODERATOR DUGAN: This question is addressed to Fred Lanphear. Do you water in newly planted beds before you apply Simazine and Diphenamid or after the application?

FRED LANPHEAR: We have done it both ways. If there is a choice, it is better to water the plants in first, which will provide a type of seal and prevent the herbicide from gettting down into the root area.

MODERATOR DUGAN: When including a herbicide in a mulch what amounts do you use?

FRED LANPHEAR: The herbicide that we use in combination with a mulch is Casoron. If you use the 4% granular form, you would mix 6¼ grams per cubic foot of the mulch if you were applying the mulch 2″ deep.

JIM WELLS: Wouldn't you have more effect if you applied the Casoron to the soil and then applied the mulch on top.

FRED LANPHEAR: We were getting complete weed control by mixing the herbicide into the mulch. An important reason for putting the herbicide in the mulch is to obtain an easier way of applying the herbicide uniformly. By controlling the depth of the mulch, you also control the amount of herbicide that is applied. This is particularly useful in landscape situations where you have irregular areas and it is difficult to calculate the amount of herbicide that should be applied when it is used as a spray or as granular material.

VOICE: What was the mulch that you used?

FRED LANPHEAR: We have worked with peat moss, with shredded bark, crushed corn cobs and composted sawdust. All worked equally well as far as the herbicide combination is concerned.

CHARLEY HESS: Fred, if you apply the herbicide to the ground and then apply the mulch on top would you not run into problems with weed seeds blowing in on top of the mulch and getting established?

FRED LANPHEAR: This is a good point and is particularly true when you are working with a mulch that might not be weed free.

MODERATOR DUGAN: Harold Pellett reports that once he used one pound Simazine with four pounds Diphenamid that he had injury on Forsythia, purple leaf winter creeper, and *Spiraea Vanhouttei.* This work was conducted in Nebraska on a clay loam soil during a year with a higher than normal rainfall. Do you have any comments on this?

FRED LANPHEAR: I would recommend that the herbicide combination be tried on a small scale to determine how it functions in your particular location. Also, as I mentioned this morning, it is possible to treat the plants with activated charcoal before planting. Weather conditions will dramatically effect the response of a herbicide. In working with the combinations of herbicides we are trying to build in a degree of weather proofing so that results will be more consistent even with differences in weather conditions.

MODERATOR DUGAN: Have you tried the combination of herbicides on *Pachysandra* and *Vinca?*

FRED LANPHEAR: Yes, we have.

MODERATOR DUGAN: Does anyone have a control for bind weed?

PETE VERMEULEN: We had a bind weed problem in spruce and hemlock and sprayed with 2,4-D and had good control. This was quite a number of years ago and I don't remember the rate.

HARLAN HAMERNICK: In Nebraska I have used Banvel D which is not volatile as the 2,4-D and it did a tremendous job. It is slower acting than 2,4-D but it does an excellent job of killing bind weed.

VOICE: I understand that Banvel D is dangerous to use around trees and may give troubles as late as five years after application.

MODERATOR DUGAN: Yes, I think in the East where we have a little more rainfall that it is best not to apply Banvel D in the drip line or closer to shade trees.

LEN STOLZ: I would also warn you to be cautious about the use of Banvel D. It has been used on home lawns and has caused malformations on ornamentals and trees with rates as low as 1/4 pound active material per acre.

JOERG LEISS: I read a paper this summer that someone has used Tordon for bind weed control and had very excellent results. This was applied to open fields and not among nursery stock.

JOHN KNAPP: We have used an Amchem product called Weedone and it has given excellent bind weed control even among the chrysanthemum plants in the yard when we sprayed very carefully.

MODERATOR DUGAN: There is also a product called Lithate which is a lithium salt of 2,4-D. It makes 2,4-D nonvolatile so you have no problems from the fumes. As long as you spray carefully and do not get droplets on the desirable plants you will not have any problem.

ED AMBO: No one has said anything about Dacthal. I wonder if someone has had some experience with it?

HUGH STEAVENON: We like Dacthal because it is so safe on many plant materials which might otherwise be injured by herbicides.

MODERATOR DUGAN: Does anyone have Botrytis problems in the polyethylene covered houses?

ARIE RADDER: We had a little problem and we went to the Connecticut Experiment Station and they recommended that we use Botran; it was very satisfactory.

ANDY ADAMS: We have found Hermil or Daconil to be very effective.

DICK VANDERBILT: Daconil can only be used at warm temperatures. At the lower temperatures we have found it to be completely ineffective. The only place that we see *Botrytis* is on dead leaves or flowers, primarily in the miniature roses. I have never seen it on the general run of container stock.

MODERATOR DUGAN: What is used to control *Phomopsis* or juniper blight and when is it applied?

RALPH SHUGERT: We use Puratized Agricultural Spray. We start applying it on our juniper seed beds just as soon as the new growth on the tip of the seedling starts to develop and then we spray weekly throughout the season until the temperature gets down to about 24° or 25°. We use the Puratized Agricultural Spray at the rate of one quart per hundred gallons of water.

MODERATOR DUGAN: I would like to ask Harrison Flint if hardening can be accelerated by varying nutrient levels such as using higher levels of potassium?

HARRISON FLINT: There has been some research conducted with agronomic crops in which greater hardiness has been obtained by using high levels of potassium. Whether the rate of hardiness was speeded up or not, I am not certain.

CLARENCE BARBRE: I had seen an experiment in Florida where high levels of potassium were used on *Camellia alba plena*. There were two blocks that were treated with potassium and one block in between which was not. I was there in the spring and the two blocks which were treated had no losses and the block that was not treated contained a 25% loss of plants. They used 20 lbs. of potassium sulfate per 1000 square feet.

MODERATOR DUGAN: Does the humidity in a polyethylene winter storage house have any effect upon the hardiness of the root systems?

HARRISON FLINT: I don't know whether it has a direct effect but it may indirectly effect hardiness. By having a higher humidity the water or moisture content of the soil in which the plants are growing will probably also be higher. If the moisture level is higher, there is a greater amount of specific heat available and therefore it would take a lower temperature to achieve freezing than if the containers were dry. In this way by keeping the soil moist, higher humidities may indirectly reduce injury to the root systems.

MODERATOR DUGAN: Has anyone had any experience in overwintering Japanese maple cuttings outside?

JIM WELLS: I think two things effect the successful overwintering of Japanese maple cuttings. The first is rooting them early and getting them to make some new top growth. In addition we plunge them in a frame covering the pots with some mulching material and we do not allow them to freeze.

MODERATOR DUGAN: Has anyone a successful technique for the rooting of *Kalmia latifolia?*

BILL CURTIS: I have a neighbor who makes cuttings in March. He puts them in sand and peat medium with bottom heat and no hormone treatment. He gets about 75% to 80% rooting year after year.

MODERATOR DUGAN: How do you propagate Eucalyptus vegetatively?

BOB TICKNOR: I have taken about 40 cuttings. One of the cuttings rooted and then it died. The people from Australia say to use the shoots from the base of the tree and they will root. However, they do not tend to grow upright and rather grow almost as a ground cover. Personally I think that seed propagation is the best answer.

AL FORDHAM: I would like to comment on the question of rooting *Kalmia latifolia.* We have good success rooting Kalmia using a combination of IBA and NAA at the rate of 1000 parts per million of each. We propagate the cuttings under polyethylene tents in the fall.

MODERATOR DUGAN: Has anyone had experience rooting *Mugo Pine?*

BOB TICKNOR: We make our cuttings in December and use Jiffy-Gro diluted one part Jiffy-Gro to nine parts water. The cuttings are made in the middle of December and placed in a polyethylene house and we use bottom heat. We get about 80% rooting.

CASE HOOGENDOORN: Are these cuttings from one plant or are they from a whole group of plants?

BOB TICKNOR: In my work I am using a single clone. I have a friend who is following John McGuire's recommendations and propagating the *Mugo Pine* during the summer. He has propagated 15 or 20 clones and finds that some root easily and others do not root at all. Al Roberts is the one who is doing this work.

MODERATOR DUGAN: This is a question directed to Charley Hess. What do you consider the most potentially successful approach to propagating 80- to 100-year-old Black Walnut by cuttings?

CHARLEY HESS: There are a number of techniques that could be tried. One would be to graft them on young seedlings and try to get a degree of rejuvenation. Another technique would be to force growth of branches in darkness to obtain etiolated shoots. The etiolated shoots can be placed under mist and with a moderate shading can be allowed to re-green. Under these conditions the top will become green but the base in the medium will stay etiolated and have a greater capacity to initiate roots. In each case the goal is to try to rejuvenate the tissues and then you could use the newly rooted plants, the few that you obtain by these techniques, as a source of future cuttings. In cases where the mature trees have been cut down a source of juvenile tissue can be obtained from the stump sprouts. The stump sprouts often have many characteristics of a young seedling.

MODERATOR DUGAN: There is a question for Mr. Hume on the introduction of hormones by changing atmospheric pressure.

EDWARD HUME: This was the subject which I had intended to talk about. We introduced dilute hormone solutions into the cuttings by reducing the atmospheric pressure or by creating a vacuum. We found that it was necessary to decrease the atmospheric pressure and then raise it again at the end of the treatment slowly or else there was injury. Also, we could not use a complete vacuum because this would also injure he cuttings. About one half the normal atmospheric pressure was satisfactory. We used a number of plants in our experiments including pfitzers and boxwood. One interesting thing that we observed was that we had in the case of boxwood more stimulation of rooting when we introduced a sugar solution than when we used hormones.

MODERATOR DUGAN: A question for John McGuire. Should the wound in holly be shallow, or a light wound, or should it be a heavy wound down into the wood?

JOHN MCGUIRE: Actually the research that I discussed earlier was in relation to the entry of auxins into the cutting. We wanted to see how a wound would effect the entry. We used a light wound and it did improve the uptake of the auxins into the stem.

MODERATOR DUGAN: What is the source of activated charcoal?

FRED LANPHEAR: There are two sources that come to mind now. One is called Darco and the other is called Nu-

Char. One of these products is available from the Atlas Chemical Company. Until recently the charcoal was only available in large quantities such as used in laundries. However, they are now putting up an agricultural package. I don't have the name here but I will be glad to send it to anyone who would care to write.

CLARENCE BARBRE: I would like to make a general comment about activated charcoal. There are many, many different sources and the degree of activation is considerably effected by the treatment used. Before you do a lot of work with the activated charcoal you should know the source and the degree of activation or otherwise you may get very variable results, if you do not know exactly what you are using.

MODERATOR DUGAN: Is there a time factor in grafting *Fagus sylvatica* varieties?

JOERG LEISS: Fagus sylvatica is one of the last things that we graft. We like to do it on a very quiet and cool day and find that we get much better results.

MODERATOR DUGAN: We have a number of compatibility questions here which may be answered by yes and no. The first — is albizzia compatible with wisteria?

VOICE: No.

MODERATOR DUGAN: Is *Kalmia latifolia* compatible with *Pyrus japonica* or rhododendron?

VOICE: No.

MODERATOR DUGAN: What is an understock for *Pinus Bungeana?*

PETER VERMEULEN: *Pinus Strobus.*

JOERG LEISS: As a general rule you use three-needle pines on three-needle understocks and five-needle pine on five-needle understocks.

MODERATOR DUGAN: Is *Euonymus Bungeana* compatible with *Euonymus radicans*?

CASE HOOGENDOORN: Yes.

MODERATOR DUGAN: Why is it that some cuttings form callus which leads to root formation and in other cases there are just masses of undifferentiated cells?

CHARLEY HESS: This may be due to an improper balance of growth substances. The basis for this speculation is from some work that was done in tissue culture by Skoog who found that if the purine level in the medium was high in relation to the auxin level, that vegetative buds were stimulated. If the auxin level was high in relation to the purine level, then roots were formed and if the auxin level and purine level were about the same, then there was just undifferentiated growth. Thus it was possible to determine what the tissue cultures would do by altering or regulating the relative concentration of purines and auxins. So in some cuttings which just form masses of callus the purine and auxin levels might be balanced in such a way that you do not get differentiation. It may be necessary to add other growth substances to establish the proper relative concentration which is favorable for root initiation.

MODERATOR DUGAN: What is the best method of propagating *Juniperus chinensis maneyi* using dormant cuttings?

VOICE: We root them in the greenhouse using Hormodin #3. When part of the cuttings are rooted we pot them up and stick the rest back and then they come along giving us about 70% rooting in all.

RALPH SHUGERT: I take them in the last week in December using Hormodin #3 and a double wound. My rooting averages about 35% to 40% which is still cheaper than grafting.

MODERATOR DUGAN: What is an understock recommended for *Amelanchier?*

HARRY HOOPERTON: We find Washington Hawthorn the best.

JOERG LEISS: I feel that the grafting of Amelanchier is not in the best interest of *Amelanchier*. It is maybe okay for the propagator but the grafts don't last and they do not make up into a tree. The best solution is to root them from softwood cuttings. They root quite readily.

HARRY HOOPERTON: But how do you get any growth from cuttings? We have five to six foot whips in the first year when we graft them.

JOERG LEISS: That's the problem. You get rapid growth the first couple of years, five to six feet, and that's where they stay.

HARRY HOOPERTON: We don't find that problem. We have good trees two to three inches in caliber when they have been grafted on Washington. We have also had some grafted on *Sorbus* but they are a real problem because of the tremendous amount of suckers that form from the *Sorbus.*

MODERATOR DUGAN: What can be done about the problems of blind eyes in rooted cuttings of *Clematis?*

BILL CUNNINGHAM: I you use double node cuttings, you will not have any problems. You may lose the buds that are above the rooting medium, but you will have shoots developing from the second node which is below the medium.

MODERATOR DUGAN: Is there any possibility that when a drench or a substance such as Terrachlor is used on Sphagnum moss that the fungicidal effect of the Sphagnum moss will be lost?

CHARLEY HESS: We have been trying to isolate the fungistatic material in Sphagnum moss and in doing this work we have found a bacteria in the Sphagnum moss which apparently can synthesize a material which inhibits the growth of *Pythium* and*Rhizoctonia.* As you know, it is recommended that you do not sterilize Sphagnum moss or else you will lose its desirable properties as being fungicidal. What may be happening is that you are killing the bacteria which actually synthesize the fungistatic substances or the substances which inhibit the growth of the *Pythium* and *Rhizoctonia.* Therefore, you could speculate that drench or a substance designed to kill bacteria in the rooting media or germination media would have a good chance of destroying the bacteria in the Sphagnum moss which produce the damping off inhibitors.

MODERATOR DUGAN: How effective is the application of water to the roof of the greenhouse in reducing the temperatures inside?

BILL FLEMER: We have used that system for many, many years. Although it does take a lot of water, it is highly effective. We can lower the inside temperature by 10 or 15 degrees. In our experience we find cuttings which will actually root better under these conditions than under mist where perhaps they are being leached.

MODERATOR DUGAN: What is the seed treatment for *Cornus kousa?* Should the seed be dried or planted immeditely?

AL FORDHAM: Fresh seeds require about 3 months of cold stratification which will then lead to complete germination.

MODERATOR DUGAN: What is the best method of germinating *Cedrus atlantica* and *Cedrus Deodara?*

AL FORDHAM: I think the best way is to give the seeds about 2 months cold stratification and then you will get uniform germination. If you plant seed immediately without stratification, you will get germination but it will be erratic.

SATURDAY MORNING SESSION

December 2, 1967

The Saturday morning session began with a symposium on rootstocks at 8:30 a.m. in Ballroom A of the Admiral Semmes Hotel. Ralph Shugert served as moderator. The symposium was followed by the annual business meeting. The minutes of the business meeting appear at the beginning of the 'Business and Technical Sessions' of the Eastern Region.

MODERATOR SHUGERT: Our first paper this morning will be a slide and tape presentation by Brian Humphrey and Peter Dummer. This idea was started last year by President Stu Nelson in order to give us a chance to hear and see some of our foreign members. It was very well received and we are very pleased that Brian Humphrey and Peter Dummer agreed to do it again for us this year. They will discuss "Stock-Scion Relationship."

STOCK/SCION RELATIONSHIPS

B. HUMPHREY & P. DUMMER
Hillier & Sons, Winchester
ENGLAND

HUMPHREY: Pete Dummer and I are sitting here in Winchester, one time Capital of England, when the Romans were around anyway. We are going to look at a few slides together concerned with the subject which we have been asked to talk about which is Stock/Scion Relationships. We are going to treat with this in a very practical way and we hope some of the information that comes out during our discussion will be of use to you in your propagation efforts.

The first point we want to make is that the stock and the scion retain their identity although of course we all know one influences the other as has been shown on many occasions by East Malling Research Station. Here we have a fairly fast growing scion of Fraxinus angustifolia worked probably onto F. excelsior and you have got this rather ugly union which you can see, I am ashamed to say, at Kew Gardens. Now what is your comment on this one Pete?

DUMMER: I am glad you let me get a word on this Brian, because if I was grafting this particular plant, I would have at least grafted it at ground level.

HUMPHREY: I quite agree with you Pete, working at ground level would have been preferable. Now this next shot brings out another aspect of what we should look for in the stock. These Abies are probably worked onto Abies alba or A. nordmanniana, but we think we have got a better one than that now Pete.

DUMMER: Yes there is a far better stock now, that is Abies cephalonica.

HUMPHREY: And why is that do you think?

DUMMER: Well, with us it is a healthier stock altogether, better root system and also it grows on lime and acid soils.

HUMPHREY: Of course that is very important in Winchester because we have a lot of chalk around here and the top soil is very shallow. I think local people at least will be much happier if they buy their Abies with cephalonica roots instead of alba or nordmanniana. Now this next one is Rhododendron Loderi and it is worked on ponticum.

DUMMER: It is yes, ponticum stock. We are trying to get away from this stock for several reasons, among them that ponticum stock tends to get woody very early.

HUMPHREY: Yes, well you can see this is correct in this shot can't you?

DUMMER: Yes and in fact we are now rooting Cunningham's White because it retains it's green wood very much later.

HUMPHREY: And we think that young green wood at the point where you are putting on the scion is a definite advantage.

DUMMER: Definitely, because it calluses more quickly and makes a union earlier.

HUMPHREY: Yes, of course Cunningham's White is a rather dwarf growing sort isn't it? I don't know whether we can find anything a little more vigorous.

DUMMER: Well, I think what we are really after of course is something with a long stem, say for instance, Pink Pearl or Elegans, something like that which roots easily.

HUMPHREY: Ponticum is causing us trouble with this disease Phomiopsis which it gets so badly doesn't it?

DUMMER: It does yes, the stem can be girdled by the disease and if you start grafting, the stock and scion die rapidly.

HUMPHREY: Yes, as soon as they get a bit of heat, the stocks die out and the disease spreads up into the scion and it is a lot of effort wasted. Here is another practice which we rather frown on these days and in fact it is hardly necessary, that's on the right-hand side there. Cytisus grafted onto Laburnum.

DUMMER: Well Brian, we do not practice it these days because we get all these things quite easily from cuttings.

HUMPHREY: Yes, but of course you do get a fairly large plant quite quickly by grafting from Laburnum I suppose, but it is a fairly expensive procedure I would think.

DUMMER: It is and it makes a very bad union as well, it swells out.

HUMPHREY: Yes, this is a fairly usual sign of a union which is not too happy and is rather incompatible. It is due to excessive callus formation causing swelling isn't it? Well now the next slide is another mixed genera, it is Sorbus aria which we commonly bud onto our native Thorn, Crataegus, you might think it is rather an odd combination, but in fact that Sorbus grows very much better on Crataegus than it does on Sorbus aria seedlings.

DUMMER: Of course Sorbus aria seedlings, Brian, themselves are with us, a small tree.

HUMPHREY: Yes they, grow wild quite close to here, just a matter of half a mile away it is growing wild and you hardly ever see one over about 15 to 20 ft. Well now, while we are looking at this Sorbus, Pete, you could tell us quite a story about some of the rarer species which we graft at Hilliers I think, some of the problems there of compatibility.

DUMMER: Yes, I suppose the most difficult one or some of the most difficult ones are the micromeles group, and I had an occasion a few years ago of having some scions and no stocks to put them on.

HUMPHREY: What were the scions Pete?

DUMMER: Sorbus epidendron, very rare plants and folgneri and one or two other choice species and one or two Kingdom Ward species which belong to the micromeles group. As I said, we did not have any stocks which should be alnifolium, so I decided to put one in between. So what we actually did was to graft meliosmifolia onto Thorn and then graft these rarer species onto meliosmifolia.

HUMPHREY: I see, rather like double working Pears. You have not tried double budding using this technique and these species?

DUMMER: No we have not.

HUMPHREY: Well now Pete, we seem to have now got on to what is the real meat of this talk, compatibility and the relationship between stock and scion. This is a shot of Quercus coccinea Splendens grafted and the union doesn't look too happy does it?

DUMMER: No it does not Brian, I think myself that the wrong stock was used. I think with coccinea Splendens, one should aim for coccinea seedlings rather than rubra although it belongs in a rubra group, ideally it should be grafted onto coccinea seedlings.

HUMPHREY: Yes, well the next slide seems to prove your point there, the tree has broken away at the union. I wonder if we aren't splitting hairs a bit here, don't you think possibly in this particular case that another interesting factor could be the cause of this, and that is the rather crude grafting technique.

DUMMER: Yes, I think the graft in this case was a cleft graft and you can actually see that part of the wedge is still intact.

HUMPHREY: Of course Oaks are notoriously difficult to produce a good union aren't they, they take many years.

DUMMER: Yes, it is a hard-wooded tree, it takes three or four years in a young state to really get going.

HUMPHREY: So in fact the stocks we would use for Oaks would be what?

DUMMER: One of the Red Oak type, that is rubra, coccinea or palustris for working with that group.

HUMPHREY: What about schumardii, schneckii, some of these rarer things? Scochiana, I suppose would grow too, but we are beginning to find that in fact many species that we felt were happy on these stocks are not so happy. For instance, velutina Rubrifolia is best worked on velutina isn't it?

DUMMER: It is yes, scochiana, kellogii and texana seems to do fairly well on palustris.

HUMPHREY: And now what else would we use, Quercus phellos for one or two?

DUMMER: Well, we use phellos of course for it's own hybrid x ludoviciana which is a very fine tree.

HUMPHREY: Cerris is rather an odd stock isn't it?

DUMMER: It is Brian, yes.

HUMPHREY: Quercus cerris Variegata won't grow on anything else but cerris will it?

DUMMER: No it is quite true.

HUMPHREY: But castaneaefolia which is in the cerris group is alright on robur.

DUMMER: Yes it is, and another one for instance is libani which comes in the cerris group, we have got trees at Chandler's Ford which are over 40 years old and they were grafted onto robur, but nothing really wrong with them.

HUMPHREY: Well, we are back to Rhododendrons aren't we on this next slide Pete, any thoughts on incompatibility here?

DUMMER: Well, of course there are a few Brian, a few species that come to mind, we have never proved lacteum to be compatible on ponticum at all.

HUMPHREY: No we seem to fail regularly on that one.

DUMMER: And of course, these larger leaf ones like grande, sinogrande.

HUMPHREY: Yes, but you might expect to see that, they are so different from ponticum. Lacteum is a bit of a surprise isn't it really?

DUMMER: It is yes. Of course there are a few more difficult ones, for instance, thompsoni and barclayi.

HUMPHREY: Barclayi is a barbatum hybrid isn't it?

DUMMER: Yes, and of course barbatum itself is very difficult.

HUMPHREY: Our friends in the States may be surprised to hear in fact that we are grafting some of these species. The reason for this is that we have stock mother plants on our nurseries which have been selected as being especially true to type and we graft a certain proportion of our Rhododendron species as true to type selected plants, grafted, vegetatively propagated plants. I suppose what we should do is to raise some of these species from seed and then graft onto the seedlings.

DUMMER: Well, we have done this, the last couple of years, and every year now of course we are sowing a certain amount of seed for this particular purpose.

HUMPHREY: Yes, I am sure this will pay off.

DUMMER: I am sure it will yes.

HUMPHREY: Well, now this next slide shows a grafting case full of Walnut grafts and they would be on regia now I suppose Pete.

DUMMER: They would be now Brian, because as you know, East Malling Research Station has found incompatibility after 25 years with the stock nigra.

HUMPHREY: Yes, this is delayed incompatibility. As far as nurserymen are concerned, we are happy to work regia on nigra because nigra is resistant to grafting disease and it has the added advantage as well as being resistant to Boot-lace (Armillaria) Fungus which is quite a problem in England.

DUMMER: Of course it makes a better stock from our point of view.

HUMPHREY: You must not forget the conifers, Pete, and the next slide shows a Pine, Pinus strobus seedling and it is important to match up the number of needles on stock and scions on the Pines isn't it?

DUMMER: I quite agree with you Brian, that the needles should be matched up if we are going to get compatibility.

HUMPHREY: In other words, a five-needled Pine on a five-needled Pine stock and a three-needled Pine on a three-needled Pine stock and so on. This is fairly simple I think really. Well here next is a batch of Acer seedling stocks. We have got quite a lot of things to say about Acers, Pete haven't we?

DUMMER: Well, its a very large family Brian, and to start off with, the film shows in the front here the common one, at least our common one, pseudo-platanus.

HUMPHREY: And palmatum behind.

DUMMER: I suppose the pseudo-platanus comes in for practically everything, three parts of them anyway.

HUMPHREY: Yes, you do some of the American species on pseudo-platanus don't you? Nigrum for instance.

DUMMER: Nigrum does very well on pseudo-platnus, coriaceum.

HUMPHREY: What about this lovely thing we have got from Strybing Arboretum?

DUMMER: Oh yes, if anyone is there at the meeting they will be pleased to know that this Acer pentaphyllum is going very well now and it is in fact, we presume, related to mandschuricum. As we have never had any seedlings of mandschuricum to graft at the time, it was put onto pseudo-platanus and the plants now are 4 or 5 ft. high after only two years from grafting.

HUMPHREY: And what other Acer stocks would you reckon to use to carry out our grafting programme.

DUMMER: Well, I suppose one of the most important ones after pseudoplatanus would be cappadocicum. We graft x lobelli onto cappadocicum because it has milky sap.

HUMPHREY: This is a good guide actually isn't it, whether the Acer is milky or non-milky as to what you put on them.

DUMMER: Actually, we class the Acers in two separate groups, milky and non-milky, but of course they can be split down again, for instance, platanoides and cappadocicum are both milky.

HUMPHREY: But are not necessarily interchangeable are they? Lobelli for instance, won't grow on platanoides very well, but it will on cappadocicum.

DUMMER: Yes, that is quite true. In this last year we have tried lobelli on campestre which is another milky one. We are keeping our fingers crossed.

HUMPHREY: Yes, this is interesting, campestre would be much easier and cheaper for us to get. This is a native tree and if in fact lobelli does grow on campestre, this will be a very good thing. Lobelli, if you don't know over there, is a wonderful tree, naturally fastigiate a hybrid, a first class street tree, very important commercially. Other American species, Acer rubrum, saccharium and saccharum, I expect our audience know more about their characteristics than we do.

DUMMER: We use rubrum quite a bit and one species we like to graft on it is franchetti.

HUMPHREY: Now while we are on Acers, Pete, this next one is interesting, this is a rather feeble scion of Acer hircinum. The tree was dying and Mr. Garner was around this particular summer and he recommended this technique.

DUMMER: Yes, that is right, it is in fact a bridge graft as you can see.

HUMPHREY: His idea was that the sap had to go through the scion and had to keep it alive until it made a union wasn't it?

DUMMER: Yes that is quite right, if you see that little white patch in the middle there, the skin in fact has been removed and a knife scraped all the way round it and then rubbed round with a cloth dipped in formalin so that there is no possibility of sap flow at all, so that if the stock is going to keep alive, sap has got to pass through the scion.

HUMPHREY: It is a very good idea and did in fact work didn't it?

DUMMER: It did work, but unfortunately, the stock used here was saccharinum and it should have been saccharum. We did not have saccharum stocks at that time.

HUMPHREY: So the scion grew away for a little while and then died out.

DUMMER: That is quite right, yes.

HUMPHREY: Incompatibility took over.

DUMMER: This is an interesting graft really, because if anyone does get any rare material in a poor state of health, they can in fact get over the problem by using this particular type of graft.

HUMPHREY: Well, enough about Acers I suppose. Now we are looking at some Prunus grafts and here again there is a fairly complex picture isn't there?

DUMMER: This is quite right, yes.

HUMPHREY: We are using avium aren't we, cerasifera, padus and persica. Anything else, I don't think so is there?

DUMMER: No I don't think so Brian, I think we have covered the main ones anyway.

HUMPHREY: Avium I suppose takes the bulk doen't it?

DUMMER: Oh it does, yes.

HUMPHREY: But cerasifera is rather interesting perhaps in that Prunus mume grows well on this.

DUMMER: Yes it does very well on cerasifera.

HUMPHREY: And Prunus padus appears to take padus varieties doesn't it?

DUMMER: Yes. very easily.

HUMPHREY: And of course the Rum Cherry, Prunus serotina varieties, are worked on padus aren't they? And then there is this maackii which you turned up some information on.

DUMMER: Well, for years, you know, we struggled to graft this because we thought at one time that it was related to padus, one year down at our Eastleigh nursery, I tried a few on avium, little pieces of wood the size of matchsticks, and the first year they jumped to 40 ft. high.

HUMPHREY: Jolly good. So Prunus avium is the stock then for Prunus maackii, a rather rare, but choice species.

DUMMER: And incidently, it is a very beautifully Chinese tree with peeling bark.

HUMPHREY: Yes, and Prunus serrula which is grown for its bark is also happy on avium isn't it?

DUMMER: Quite true, yes.

HUMPHREY: Well now here is a Magnolia graft, a side graft, this picture was actually taken in Holland and here again we have got an interesting and complex situation with the *Magnolias* haven't we?

DUMMER: Yes, Brian, I suppose the two main stocks are kobus and soulangeana which are used generally.

HUMPHREY: Now some people would be surprised at you saying soulangeana, for instance the Japanese use kobus for pretty well everything and so do the Dutch I believe.

DUMMER: Yes, but this is not our choice.

HUMPHREY: Yes, soulangeana is most important for us. Soulangeana is used as a stock obviously for soulangeana varieties and also for stellata, presumably if you wanted to graft that, although it can root from cuttings well and also these beautiful Himalayan species campbellii and sargentiana robusta. And kobus then, you would use for cordata wouldn't you, and salicifolia.

DUMMER: And of course, its forms, concolor etc.

HUMPHREY: And what about these large leaved species like macrophylla, what would you use for that?

DUMMER: Macrophylla, we would put on tripetala or officinalis.

HUMPHREY: This next one, on the face of it, it looks straight forward enought doesn't it, it looks like one of the Exbury hybrids (Azaleas).

DUMMER: That's true, Brian, it is in fact the variety Berryrose.

HUMPHREY: The Exbury's are of course quite straight forward aren't they, but what about some of the other ones which we graft?

DUMMER: Oh some of the others can be difficult. We are sure there is some incompatibility, for instance with schlippenbachii. We have got a beautiful white form at the nursery and it will not grow well except on schlippenbachii seedlings.

HUMPHREY: Yes, and pentaphyllum is exactly the same isn't it? They seem to grow away for a time and then die out don't they? It appears to be delayed incompatibility.

So really suggesting a possible division concerning stock/scion relationships, you have two or three groups: — 1) You have the group that will readily form a union, the scion will grow away very vigorously and very well and then at some later date, any time from three years onward, you get signs of incompatibility, commonly known as delayed incompatibility: 2) You have the type of union that if you can get the two to stick together for life, but there is some evidence of early incompatibility: 3) Then you have the ideal group at the end where you get ready union, ready compatibility and partnership for life, the ideal marriage.

DUMMER: Brian, I think when one is using stocks like this, one should always try to graft if possible onto closely related seedlings, in that way you can be sure because no person wants to wait twenty years and then find out that the union is not compatible.

HUMPHREY: Quite. We do in fact use some form of guide, we use Rehder's Manual of Trees and Shrubs as an initial indication don't we? We really base our combinations on botanical characteristics and work it from there, it saves a certain amount of hunting anyway doesn't it?

DUMMER: It does, yes, but of course it is not always right.

Sometimes with things like Azaleas for instance, one should not worry too much, if one can get a union for a while and plant deeply enough, the scion will eventually form roots. In other words, carry out nurse grafting.

HUMPHREY: Well, I think, Pete, our time must be up by now, we have had a very pleasant evening sitting here together looking at these pictures and we hope very much that the tape reaches you over there on time and that the slides reach you as well and the projectionist is clever enough as I am sure he will be, to match the two together. We wish you all every success for a really good meeting.

Goodbye to you all.

MODERATOR SHUGERT: Our second paper on rootstocks is being presented by a gentleman who has also traveled a good distance to be with us. He is president of the Western Region of the International Plant Propagators' Society and his topic is "Bloom Production on Selected Garden Rose Rootstocks." It is my pleasure to introduce Bob Ticknor.

BLOOM PRODUCTION ON SELECTED GARDEN ROSE ROOTSTOCKS

R. L. TICKNOR AND A. N. ROBERTS
Oregon State University
Corvallis, Oregon

Introduction

Nursery performance of sixteen rose rootstocks budded with five scion varieties, Etoile de Holland, Lowell Thomas, Picture, Pres. Hoover and White Prince, were reported at the Western Region meeting in 1963 (2). The majority of the rootstocks rooted well with the exception of O. S. U. 1 and 8, P.&D. 5214 and 5360, and Dr. Huey. On a comparative basis, five of the rootstocks, D-1, Ginn, P.&D. 5222 and 5234, and Van, proved to be outsanding for bud stand with the five scion varieties used in this trial. Four other rootstock-scion combinations were outstanding, O. S. U. 1 and Burr with Pres. Hoover, Burr with Etoile de Holland, and 5250 with Picture.

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Materials and Methods

Since producing rose bushes in the nursery is only the first part of the use of this plant, garden trials were initiated to answer questions on length of life, vigor, transplantability and bloom production of the most successful scion-rootstock combinations. Trials were planted at Oregon State University's North Willamette Experiment Station, Aurora, and Lewis-Brown Horticulture Farm, Corvallis, in Nevember, 1962. Six plants of each scion-rootstock combination which survived the nursery trial were planted at both of these locations.

In addition, selected scion-rootstock combinations were sent to Iowa; Long Island, New York; and Minnesota; but because of drought and fire information was received only from Minnesota. The first year results at Aurora, Corvallis and Minnesota were reported by Ticknor, et. al. (3).

Bloom records were recorded periodically for each individual plant throughout the season for three years at Corvallis and for four years at Aurora. Lowell Thomas and Pres. Hoover did not establish well on all rootstocks. Many plants were lost the first season, particularly on the D-1 and Ginn rootstocks. Desiccation of the plants at the time these scion varieties were dug appears to be the reason for these losses.

Notes were taken on suckering of the different rootstocks, although suckering was not a major problem with any of the rootstocks.

Results and Discussion

The bloom production results of the five scion varieties on the 11 or 12 stocks are presented in Tables 1 to 5. Statistical analysis was done for each variety to establish an L. S. D. (least significant difference) so that bloom production significantly better than the average for the variety could be indicated.

It was found that bloom production was influenced by several factors: scion variety, rootstock variety, location, and number of years the plants have been growing in a location. Lowell Thomas and White Prince had lower average bloom production per plant than the other scion varieties. The rootstock variety exerts a strong influence on the performance of the scion variety. From observation this effect is more pronounced on weak growing scion varieties which tend to be more specific in rootstock requirements than do strong growing scion varieties. Location had an influence on bloom production in this trial. Soil type was the major difference between the locations 65 miles apart which have very similar climates. Bloom production was higher in the well drained sandy loam soil at Aurora than in the clay at Corvallis. The first year in the garden is a year of establishment with low bloom production. Bloom production on some stocks improves with time such as Vandermoss budded with Pres. Hoover which produced only 28 blooms the first year but produced

396 blooms, the highest in the trial, the third year. In contrast, Welch produced a statistically significant 108 blooms the first year when budded with Pres. Hoover but produced only 147 blooms the third year. This latter number is significantly below average for bloom production for that year and variety.

Some comments about the bloom production and adaptibility of the different stocks are as follows:

OSU 1: Good only with White Prince but poor with Lowell Thomas and Picture at Aurora and average at Corvallis.

OSU 6: Good with Pres. Hoover and White Prince but poor with Etoile de Holland, Lowell Thomas and Picture. No suckers.

Vandermoss: A variable rootstock good with White Prince at both locations. Good with Lowell Thomas and Pres. Hoover at Aurora but poor with Etoile de Holland and Picture. At Corvallis it was either poor or average with the latter four varieties. Possibly better adapted to light soils.

P.&D. 5222: A good stock with Etoile de Holland, Lowell Thomas and Picture but poor with Pres. Hoover and White Prince. A thorny stock. No suckers.

P.&D. 5234: A good stock for Lowell Thomas and Picture but poor with White Prince. A thorny stock.

P.&D. 5350: Rather an average stock, really only good with White Prince at Aurora. A thorny stock.

Brooks: Probably the best stock in the garden trial. But stand with Etoile de Holland was so poor that plants were not available for garden trial.

Ginn: Generally a good stock except with White Prince. Also gave poor nursery results with this scion variety. More prone to suckering than any other stocl- in trial.

Welch: Generally a good stock the first two years but does not seem to hold up. Has been dropped by Oregon growers because of winter injury problems.

D-1: Poor bloom production except with Etoile de Holland the first two years. Looked good in nursery trials. No suckers.

Burr: Generally a good stock but appears better adapted to lighter than heavy soils. Most widely used rootstock in Oregon at present. Also used in northern California.

Dr. Huey: Consistently poor under our conditions. Possisibly better adapted to the warner soils found in the southwest.

A wide variety of rootstocks, most of which were not maintained as clones, were in use in Oregon when Roberts started rose rootstock trials at Oregon State University in 1948. One of the objectives of these trials was to find a single rootstock which would give superior performance in both the nursery and the garden. While this objective has not been completely achieved since several rootstocks are in use today . In practice the growers in Oregon, Texas and the Northwest use multiflora stocks while those in Arizona and Southern California use Dr. Huey. At present, most roses produced in Oregon are grown on the Burr strain of *R. multiflora;* thus while we do not have a universal stock, in practice in the Northwest we almost have one.

Up to 1964, a considerable number of roses were also grown on the Welch strain in Oregon. In that year, the temperature dropped to 6° F. in December, damaging the stems of Welch so they could not be used for cuttings. The one grower who was using Burr at that time supplied wood for cuttings to the other growers that year.

Work by Furuta (1) supported by leaf samples from our Oregon trials has given a possible explanation for the use of Dr. Huey in southern California and *R. multiflora* in the northwest. Leaf analysis shows that plants growing on the same soil will have higher boron content on *R. multiflora.* In areas where boron approaches toxic levels Dr. Huey is the better stock, but where boron is often deficient *R. multiflora* is the better stock. In addition, Dr. Huey is quite subject to mildew in Oregon and does not produce good wood for propagation.

Average Bloom Production Per Plant of Etoile de Holland Roses on Several Rootstocks at two locations

	Aurora				Corvallis		
	1963	1964	1965	1966	1963	1964	1965
OSU 1	99	140	167	162	79	140	116
OSU 6	87	105	133	141	85	96	89
Vandermoss	94	112	141	153	60	66	75
5222 P&D	74	146	202**	199	103**	147*	120
5234 P&D	125**	155	173	210**	87	133	112
5350 P&D	92	158	172	189	74	128	134
Ginn 58-L-2	106	195**	185**	236**	80	192**	165**
Welch	96	146	135	171	108**	188**	146**
D-1	123**	184**	160	163	79	124	134
Dr. Huey	81	135	112	178	65	87	73
Burr	90	161	163	204**	67	111	122
Average	97.0	148.8	158.4	182.3	80.6	128.2	116.9
LSD 5%	14.8						
LSD 1%	21.1						

Average Bloom Production Per Plant of Lowell Thomas Roses
on Several Rootstocks at Two Locations

	Aurora				Corvallis		
	1963	1964	1965	1966	1963	1964	1965
OSU 1	37	49	41	97	26	57	58
OSU 6	27	51	77	131	30	55	55
Vandermoss	44	73	108**	165**	30	50	52
5222 P&D	50	69	75	120	30	77*	132**
5234 P&D	48	106**	91*	128	30	85**	70
5350 P&D	32	55	79	129	36	63	59
Brooks-48	92**	129**	106**	194**	32	60	68
Ginn 58-L-2	48	63	46	60	42	83**	82**
Welch	94**	78*	70	124	55**	107**	62
D-1	49	56	105**	85	25	30	28
Dr. Huey	34	43	38	96	23	42	38
Burr	39	27	73	135*	36	76	74
Average	49.5	66.6	75.8	122.0	32.9	65.4	64.8
LSD 5%	11.4						
LSD 1%	16.1						

Average Bloom Production per Plant of Picture Roses
on Several Roostocks at Two Locations

	Aurora				Corvallis		
	1963	1964	1965	1966	1963	1964	1965
OSU 1	63	133	100	131	66	143	180
OSU 6	62	110	127	122	61	121	147
Vandermoss	66	137	114	112	51	110	111
5222 P&D	86	149	141	171	66	162**	220**
5234 P&D	60	155	162*	202**	64	150**	198**
5350 P&D	100**	169**	155	151	70	141	179
Brooks-48	104**	158	180**	206**	83**	175**	258**
Ginn 58-L-2	80	170**	180**	197**	48	110	196**
Welch	108**	172**	162*	174	72*	127	141
D-1	66	117	119	133	42	101	150
Dr. Huey	66	123	128	152	30	99	133
Burr	121**	198**	178**	234**	66	164**	21
Average	81.8	149.2	145.9	165.4	59.9	133.6	177.0
LSD 5%	11.6						
LSD 1%	16.3						

Average Bloom Production Per Plant of President Hoover Roses on Several Rootstocks at Two Locations

	Aurora				Corvallis		
	1963	1964	1965	1966	1963	1964	1965
OSU 1	75	133	205	276	67	111	107
OSU 6	79	158	262**	295*	66	164*	110
Vandermoss	28	196*	396**	389**	16	66	141
5222 P&D	57	107	108	160	44	129	124
5234 P&D	66	166	207	246	48	148	129
5350 P&D	66	120	178	227	46	130	141
Brooks-48	38	93	182	301*	80	122	115
Ginn	91	270**	188	275	45	110	128
Welch	108*	131	147	203	83	144	118
Dr. Huey	67	125	120	168	48	67	80
Burr	27	77	280**	247	93	154	164*
Average	63.8	143.2	206.6	253.3	57.8	122.2	123.3
LSD 5%	37.5						
LSD 1%	53.4						

Average Bloom Production Per Plant of White Prince Roses on Several Rootstocks at Two Locations

	Aurora				Corvallis		
	1963	1964	1965	1966	1963	1964	1965
OSU 1	77**	67	87	191**	47*	68*	69
OSU 6	68	79**	106**	191**	41	87**	85**
Vandermoss	64	62	93*	165*	33	64	81**
5222 P&D	25	68	60	113	24	44	34
5234 P&D	49	52	68	126	38	47	54
5350 P&D	70*	51	93*	215**	33	61	65
Brooks-48	77**	64	106**	223**	43	102**	93**
Ginn 58-L-2	52	68	85	105	32	31	47
Welch	69	59	96**	118	43	49	79**
D-1	47	39	48	75	32	47	38
Dr. Huey	60	43	58	121	35	29	34
Burr	68	55	83	180**	31	64	71
Average	60.5	58.9	81.9	151.9	36.0	57.8	62.5
LSD 5%	9.3						
LSD 1%	13.1						

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MODERATOR SHUGERT: Thank you very much Bob for a very interesting and thorough paper. The next paper will also be presented by a member of the Western Region. The paper is on the "Morphology of Arizona Cypress on Hetz Juniper." It has been written by Dr. Fred Widmoyer and Dr. Darrell Sullivan. The paper will be presented by Darrell Sullivan.

MORPHOLOGY OF ARIZONA CYPRESS ON HETZ JUNIPER

FRED B. WIDMOYER AND DARRELL T. SULLIVAN
New Mexico State University
Las Cruces, New Mexico

For the past several years there has been an increase in the number of papers discussing the relationships of stocks and scions of ornamental plants. The basic phenomena occurring during the re-establishment of graft's were presented at the 12th Annual Meeting (Widmoyer, 1962). Snyder (1963) pointed out that the major areas of propagation research of ornamental plants are consentrated on the rooting of cuttings and germination of seeds. Budding and grafting have received the major attention for fruit crops. As a result of continued research and experience, the use of vegetatively propagated rootstocks has become standard practice (Fletcher, 1964). Most propagators recognize the value of graftage over seedage or cuttings as a technique, as well as the associated disadvantages.

In selecting a stock for any plant, choice is limited to those which have a close botanical relationship. Generally, seedlings of the species are chosen as the scion. Grafts between genera are not unusual, but as a general rule, are limited to relatively few plants. Some ornamental plants which may serve as examples are: *Syringa* (lilac) on *Ligustrum vulgare* (privet); *Cotoneaster* on *Crataegus* (hawthorne); *Chaenomeles* (flowering quince) on *Sorbus* (mountain ash); and *Pyrus* (pear) and *Malus* (apple) on *Crataegus oxyacantha.* Notice particularly the absence of the narrow-leafed evergreens.

Several years ago the cutting-graft procedure was described. This technique was especially valuable when the potted stocks were not on hand at the proper season. To be of the greatest use, the stock-scion must form a quick union. The stock must root readily. The stocks need to be slightly larger than for cuttings to facilitate handling. Healing of the wound is necessary for a successful graft. This process is accomplished by the action, principally, of the cambium layer. Any other

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Examination of this diagramatic section of the *Rosa* and *Chaenomeles* stem reviews the anatomy of a woody stem. In grafting, the vascular system of the stem is of the most interest. Externally is the phloem and internally, the xylem. The cambium layer is a continuous layer between the vascular bundles and the rays. The cambium is a meristematic layer which, by cell division, produces alternately, potential phloem and xylem cells. Young phloem cells are more likely than xylem to retain, or revert to, a meristematic condition.

The xylem has both tracheids and vessels in these genera. The gymnosperm has only tracheids and also resin ducts in the phloem and xylem. The resin may be beneficial in grafting by preventing drying or helping translocate growth material. It may be detrimental as a mechanical barrier between stock and scion.

The pith is generally of limited size in the evergreen, as compared to deciduous plants. The parenchyma cells, which make up the pith, perform storage functions.

The potential development of a graft union of evergreens is shown in the photomicrographs using *Cupressus arizonica* on *Juniperus scopulorum* (Blue Heaven). The Arizona cypress has a rather narrow climatic range across the Southern United States. Most are produced by seedage, which are not uniform as ornamentals or Christmas trees. Cuttings produce satisfactory trees, but are costly to produce, and are not usually available. In recent years selected clones have been grafted on seedling stocks. Numerous losses have been attributed to root rot and other problems. The root system is shallow, and plants are uprooted by winds. *Thuja* has been used experimentally as a rootstock to adapt the plant to higher moisture and salinity areas.

Hetz juniper and *Thuja* offered several desirable attributes — easily rooted and well adapted to heavy, dry soils, long-lived and easily transplanted when compared to *Cupressus*. Side grafts were used in October, November, and January of 1965.

Although propagators and researchers constantly stress the importance of 'closeness of fit', microscopically wide separations are generally observed. In any graft union, several phenomena probably occur simultaneously. Proliferation of the parenchyma cells produces a functional callus. Both stock and scion may produce new cells by division of any cell capable of division. Wound necrotic tissue may be surrounded by increasing cell numbers. They are compressed into the graft interface by new cells from both stock and scion, frequently appearing as islands in the union.

Differentiation of certain parenchyma cells will become, or revert to, cambial cells, completing the cambium of both stock and scion. In the early growth of a graft, undulating growth can be attributed to this regeneration. This cambial layer begins to produce xylem cells toward the pith and phloem cells toward the outside. Cells in a graft do not 'rearrange' themselves, but are the result of new cells being produced which differentiate into new functional units. This results in a successful graft union. None of the grafts using *Thuja* survived. Cell proliferation did not occur at the graft interface, nor did the stocks root under the conditions used.

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MODERATOR SHUGERT: Before we get into our question period I would like to make one comment about nomenclature. I heard the term or the name *Juniperous scopulorum* (Blue Haven) is in fact (Blue Heaven). This clone was introduced to the trade by Plumfield Nurseries in Nebraska in about 1926 or 1927.

KEN REISCH: I would like to ask Dr. Ticknor if he has seen any problems or a decline with Dr. Huey understock?

BOB TICKNOR: We have not seen any decline; the plants continue living but they are not very vigorous and there is a low bloom production.

MARTIN VAN HOF: I noticed in Dr. Sullivan's slides that the scion was growing faster than the understock. These grafts were only two years old. Now in the future will it not develop that the difference in growth rates between the scion and the stock will be such that they will easily break off at the union?

DR. SULLIVAN: I do not believe the differences in growth rates is as great as you have indicated. However, we will have to wait for several years before we can be sure.

DICK STADTHERR: Dr. Ticknor, did you use any of the Ames varieties for your understock trials? I was thinking of varieties 4 and 5 and was wondering how you propagated them.

BOB TICKNOR: We did not use those varieties. The D 1 that we used was from Ames and in the past couple of years we've had one or two others that have gone through the screening trials at the Texas Rose Foundation. We placed some of them in the growers' fields because we could not incorporate them into our trials and from our observations they were not good as far as the nursery stock was concerned. We had about four of them but I don't remember at this time what the numbers were.

MODERATOR SHUGERT: At this time I would like to turn the program over to Dr. Stu Nelson for the business meeting.

PRESIDENT NELSON: Ladies and gentlemen I believe we should give a real show of our appreciation to Ralph Shugert for a terrific program. Combined with a large number of firsts I believe we have had one of the best programs ever here in Mobile. Thank you very much, Ralph, for a job well done.

[Editor's note: The minutes of the business meeting appear at the beginning of the 'Business and Technical Sessions' of the Eastern Region.]