A HISTORY OF MIST PROPAGATION

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It is probably very appropriate that we pause to reflect on the historical development, the theoretical aspects, and the commercial applications of the use of mist in plant propagation and to consider what the future may contribute to the further development of this technique.

It has been a herculean task to condense into a 10-minute talk the 29 year history of mist propagation and at the same time to recognize the contributions made by more than 100 different scientists and nurserymen who have authored over 300 articles and papers on this subject.

First, let us define what is meant by "mist propagation". By "mist propagation", we mean the mechanical spraying of water to maintain a film of water on the leaves and stems of cuttings. As evaporation occurs from this film of water, the temperature of the leaf tissue is reduced below that of the surrounding air and transpiration is markedly reduced. With mist, cuttings can be maintained in a turgid condition even though they are exposed to full sunlight. That this mist spraying, as well as the evaporation of water from the films on the leaf surfaces, may increase the relative humidity of the surrounding air is an important consideration, but it is not the primary objective of misting.

Apparently the first use of mist for the propagation of cuttings was by G. E. L. Spencer in 1936. Evans (9), in an article on the investigations of the propagation of cacao, published in 1951, refers to a private communication from Spencer which stated that he had used mist, although unsuccessfully, in tests on the rooting of cacao cuttings. The first written report of the successful use of mist for rooting was by Professor M. A. Rains of Howard University (24, 25). At the 1940 meeting of the American Association for the Advancement of Science, Professor Rains reported that a moist chamber with facilities for subjecting relatively large leafy cuttings to a spray of water was successful in permitting the regeneration of the root system.

In 1941, E. J. Gardner (13), a nurseryman from Wisconsin, reported in the *American Nurseryman,* that the use of a continuous mist resulted in the successful rooting of 56 of 61 varieties of softwood cuttings tried in 1939 and of all 133 varieties tried in 1940. The same year (1941), G. M. Fisher (10) reported in the *Florist Review* on the use of continuous mist for the rooting of several florist crops. Two years later, in 1943, Fisher (11) also wrote in the *American Nurseryman* of his successful use of mist for the rooting of conifer cuttings.

There is no indication from the evidence available that Spencer, Rains, Fisher or Gardner were in touch with one another; thus it seems probable that the origin of the use of mist sprays for the rooting of cuttings was developed independently by these four individuals.

Between 1942 and 1945 Pridham (23), Stoutemyer (32), Gossard (15), and Cochran (4) reported preliminary results of the use of mist for such divers kinds of plants as rhododendrons, vacciniums, chaenomeles, symplococos, pecan and peach in the *Proceedings of the American Society for Horticultural Sciences.* Stahel (30) described the use of mist in the ICTA propagation frame for cuttings of *Hevea* and other tropical trees, and Dijkman (6) used mist for the rooting of mango cuttings. In 1949, O'Rourke (22) described a method of inserting nozzles in a water line beneath the ridgepole of a small sash-type greenhouse. Brentz and Swingle (2) told of the successful use of mist for rooting elm cuttings in the *American Nurseryman* in 1950 and, at the 1951 meeting of the Holly Society of America, Diehl (5) described his success with the use of mist for rooting holly cuttings.

The intense interest in mist for the propagation of tropical and subtropical plants is attested to by the work of Evans in Trinidad and by the several reports included in the Annual Reviews of the Florida Experiment Station.

The numerous articles by Wells in the *American Nurseryman* starting in 1951 about humidification (39, 40), and later about mist (41, 42, 43), contributed greatly both to the interest and application of this technique.

At the 1953 meeting of this Society, Templeton (33) described his "Phytotektor" method for the propagation of cuttings in which he combined a humidistat and a timing mechanism to give an intermittent rather than continuous mist. He stated that he was unable to use constant mist because of drainage problems and he further questioned the necessity of continuous misting. It was also at this meeting that he described the "little aluminum painted can" which was to become the "electronic leaf" control device. Also at the same meeting, Hess and Snyder (17) described a simple and inexpensive timing mechanism for regulating intermittent mist.

The interest in the use of mist for propagation was sufficiently great that at the 1954 annual meeting of this society, an entire session was devoted to mist propagation. At this meeting Snyder (28) reviewed the literature on the subject and described and compared methods of applying mist. Hess (16) presented basic information which explained how and why mist was beneficial. Ward (37) and Steavenson (31) told of their practical experiences with mist propagation. As a result of these discussions, the numerous advantages of intermittent mist over constant mist was recognized.

The following year, 1955, Floor (12), Hess and Snyder (18), and Snyder and Hess (29) presented papers on mist propagation at the 14th International Horticultural Congress in Holland which brought the mist technique to the attention of horticulturists and nurserymen in many parts of the world.

Problems of handling mist-propagated softwood cuttings following rooting and of over-wintering these cuttings were discussed at the 1955 meeting of the Plant Propagators' Society. Templeton (34) described in detail the electronic leaf and the equipment which he had developed to "check" on the proper functioning of the leaf. During the next two or three years several variations of equipment to control intermittent mist were described. These will undoubtedly be discussed in detail later this morning.

From 1956 onward. numerous articles were written for both the scientific and trade journals which described methods of using mist for rooting cuttings with the facilities, schedules and species used in nurseries throughout the United States, Canada, the tropics, Europe, New Zealand and Australia.

Almost from the beginning, the reduction or actual elimination of problems of disease and insects was noted. Likewise the effects of mist on the leaching of minerals and other materials from the foliage was recognized. Evans (9) reported that nitrogen and phosphorus were leached during the first two weeks and that potassium was leached continuously from cuttings. More recently detailed studies of this problem were discussed by Tukey (34) and Good and Tukey (14) at meetings of this society. The use of nutrients in the mist has been described by Vanderbrook (36), Tukey (35), Good and Tukey (14) and Morton and Boodley (21).

The first and only complete review of the subject of mist propagation of cuttings was written by Patricia Rowe-Dutton in 1959 (25). The bibliography for this review contains 160 references.

Plant propagators on the West Coast recognized the importance of mist by including it as a major topic at the first annual meeting of the Western Region in 1960.

With the exception of a few reports, the use of mist for grafting has not been reported to be beneficial (3, 7, 8, 20, 26). Less spectacular than results obtained with cuttings, but none-the-less important results have been recorded for the use of mist in the germination of seeds (1, 19, 38). The germination of annuals is not only more uniform but also more rapid under mist conditions.

The development and application of mist techniques for the propagation of plants has been a cooperative effort by horticulturalists and nurserymen. We can all be proud of the role played by this society in this effort.

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MODERATOR HESS: Our next speaker is unquestionably one of the greatest innovators in the nursery industry, whether it be to create a complete mist system we have come to know as the "Phytotecktor" or ways of advertising the sale of a nursery. Harvey has made a tremendous contribution to our Society and also is a recipient of the Society's Award of Merit. Harvey will talk to us about the mechanics of misting.

MIST SYSTEMS AND THEIR CONTROLS

HARVEY TEMPLETON
Phytotektor
Winchester, Tennessee

The first requirement of a mist system is that it distribute the water as evenly as possible over the bed area. There are several reasons for this requirement. The next speakers will discuss some of the reasons for not wanting too much water in any one spot — such as leaching of nutrients from the cuttings, water-logging of the rooting medium, etc. One reason they may not bother to mention is that the cuttings will dry out and die in any spot that does not get enough water.

Even reasonably good distribution of the water is difficult to arrange. Really uniform distribution is practically impossible. There are so many different things that must be taken into account — water pressure, nozzle spacing, nozzle height over the cuttings, type and capacity of nozzle, air movement, and a long list of other things. The difficulty is complicated by the fact that nozzles throw circular patterns of water. There is no way to arrange them so they just cover a square. There will always be a lot of overlap of the circular patterns so that the overlapped areas get more water than the rest. If the misting time is reduced to decrease the amount of water in those parts of the bed, other parts will not get enough water.

The best that can be done is a compromise. One must try various combinations of nozzles, spacing, water pressure, size of beds, etc. until the best compromise is reached. Then all these conditions *must* remain constant. Changing only one thing may throw the whole arrangement out of adjustment.

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Air movement, wind in other words, can completely upset the most carefully designed mist system. For that reason I think it best to do mist propagation inside a nearly airtight structure of some kind so that the mist can be distributed in reasonably still air even on a windy day. It is easier and cheaper to arrange a tight structure than it is to design an outdoor mist system that will give even distribution no matter what the direction and velocity of the wind is.

Mist nozzles should be dependable and reasonably free from trouble. In the early days of mist propagation it was thought necessary to use low capacity nozzles so as to avoid putting too much water on the cuttings. Such low capacity nozzles gave endless trouble because of a poor distribution pattern in the first place and because the many tiny water passages in them stopped up so easily.

As soon as someone thought of intermittent mist and it was recognized that high capacity nozzles could be turned on and off by a timer and solenoid valves so that they ran only a small part of the time the trouble was largely eliminated. The best modern practice uses fairly high capacity nozzles throwing a fine spray rather than a mist. The small droplets in the spray can be made to give a much more even distribution of the water than mist can do. These large nozzles are controlled by suitable equipment so that they run only a very small part of the time.

We may have as many as six or seven hundred running at once at various times of the year, yet it is unusual for more than two or three nozzles to become clogged in a whole year.

The deflection type of nozzle is the one where the water comes out a simple hole as a straight jet of water which then hits a target above and bounces off in a flat circular pattern. The Florida 550 is an example of this type. It is, in my opinion, the only sensible *type* to use. The simple construction and the large water passages in such nozzles make it very unlikely that they can become clogged.

However, they are not trouble free. The distribution patterns of such nozzles do change radically in time because of wear and sometimes because of deposits from the water although that is usually not a serious problem with properly designed and operated deflection type nozzles.

The jet of water rushing through the hole in the nozzle tip wears the inside of the hole rapidly if the tip is made of brass or some other soft metal. Hardened stainless steel is much more resistant to this wear and tungsten carbide still more so, but also much more expensive. Once the hole in the tip wears and the jet of water is no longer precisely round the distribution pattern of the nozzle becomes quite poor.

The jet of water also wears the face of the target to a very rough surfaces — sometimes actually drills a shallow hole in it. This causes a very bad pattern. With targets of soft metal it is necessary to re-surface the face of the target after every 30 to 60 day period of use.

We have completely eliminated this trouble by surfacing each target with a small, highly polished disc of sapphire. Sapphire is the second hardest natural material known. It stays flat and perfectly smooth after long use — forever as far as I know. The tiny sapphire disc is cemented to the end of the target with a special heat curing epoxy cement. The sapphires are cheap and the operation is fairly easy.

All our nozzles now have hardened stainless steel tips and sapphire targets. Most of them can be used for long periods without any attention. That explains why we have only 2 or 3 fail in a year out of six or seven hundred we use.

The stainless steel tips are not perfect and do sometimes cause some irregularity of pattern. Tungsten carbide tips would be better but are quite expensive. I think if I were going to stay in the business, I would convert all the old nozzle tips so that the jet of water came out through a hole in a little sapphire. Such sapphires are cheap since they are made by the millions for watch jewels.

A good mist control system should take into account every condition that is causing water to evaporate from the cuttings—sunlight. temperature, and air movement. The easiest way for a control system to do that is for it to measure the evaporation directly rather than to measure any one or all of the conditions causing the water to evaporate. The system should then replace just exactly the amount of water that has evaporated — no more and no less. No less because the cuttings would dry out and die in that case. Several other speakers will explain why the control should put no more water on the cuttings than necessary — no more than just enough to replace that which has evaporated, just enough to keep the cuttings barely wet. This is important if best results are to be obtained with difficult plants or with plants that root slowly and must stay under mist a long time.

The control system should "fail safe." By that I mean that if anything goes wrong, the control should either put on more water or turn the water on and leave it on. That way the cuttings are safe in spite of the failure of the control. The excessive water is not good for the cuttings but it will at least keep them alive until the failure is noticed and corrected. If anything goes wrong the control should *not* do the opposite; that is, put on less water or leave the water off. That way all the cuttings would be lost on a hot summer day possibly long before the failure was noticed.

Now as to the relative merits of the different mist control systems:

Time clocks are, of course, the simplest. They are also the least accurate. Unless re-set continually they can be right for only one set of weather conditions or for only one time of day. Even if one stood by and re-adjusted the time clock with each change of weather, it would still not be good enough — because even that would be no better than the best judgment of the human operator. Good control systems can be much better than human judgment.

As far as reasonable principle goes, one of the simplest systems is one of the best. That is the little balancing device known generally as the Geiger control, the one where the water accumulates on a square of screen and tips over a mercury switch. Actually, it was developed in England a good while before Geiger got it. In principle it is right because it does measure directly the evaporation of the water. In practice, it is imperfect principally because it does not "fail safe." Contamination of the screen by deposits from the water causes it to put less water, not more as it should do to be safe. A large bug on the screen would keep the water turned off and kill the cuttings. Wind will interfere with its action too.

Another kind of control measures light intensity, adds it up over a period of time, and puts on water according to the accumulated quantity of light. It is measuring solar energy which is only one of the things causing evaporation of water. In principle it neglects the other causes entirely. Therefore, it cannot be really precise. The fact that it works fairly well, and it does work fairly well, is a little surprising. Its success can only be explained by a meteorological probability; that is, the probability that strong sunlight will be accompanied by higher temperature and generally by more air movement. Were it not for this usually-to-be-depended-upon coincidence, it would not work nearly as well.

In principle the Electronic Leaf is good since it does meassure evaporation directly and it does "fail safe" if the proper electronic circuit is used. In practice, it has given nearly everyone trouble — principally for two reasons — neither one a very good reason. One general cause of complaint is that impure water contaminates the "leaf" and interferes with its action. A pair of sensing elements (the "leaves") each one used on alternate days and each cleaned before use would stop that complaint. Two minutes a day should do it.

The other cause of complaint was simply due to lack of experience with the device. Almost no one was willing to attach a recorder to the electronic leaf so that they could see what it was doing. If they did not know what it was doing, how were they to learn how to make it do what they wanted it to do? Attach a recorder to it so you will know what it is doing, then give yourself a little time to get used to running it and your troubles are over. May I say that we have had at least one operating 24 hours a day every day in the year for over 12 years? Now it is no more trouble to set one up and adjust it than it is to make a good martini!

I have two suggestions for the future. First, if impure water really is a valid objection to the use of the Electronic Leaf, I suggest a relay actuated by a change in capacitance. The sensing element or "leaf" would then be a condenser constructed so that its capacitance would change depending on whether or not it was wet. If of small size or otherwise properly constructed, the conductance of the water which wet it would not be of importance. Therefore, the impurity of the water would not matter. You understand that the present Electronic Leaf is actuated by a change in resistance of the film of water on the surface of the "leaf." Therefore, an impurity in the water *might* interfere with proper action if it *did* change the conductance of the water to a great degree.

My other suggestion is as pure in principle as pure can be. It measures the amount of water by measuring the hydrogen atoms in it. Therefore, the quality of the water has nothing to do with it. If it is water — H_2O — two hydrogen atoms and one oxygen atom, the device will measure it. Of course, in this case the water must not be contaminated with some other source of hydrogen such as a hydrocarbon (alcohol or sugar, for example). But then, I don't suppose any of you intend to spray your cuttings with beer!

Seriously, the quantity of water *can* be measured "atomically" by measuring the number of hydrogen atoms in it. It can be done this way: A polonium-beryllium source is used to provide a stream of fast neutrons. Such fast neutrons are scattered and de-energized (that is, slowed down) by hydrogen atoms, the amount of scattering and de-energizing being in proportion to the amount of hydrogen atoms present. Some of the neutrons are returned, by the scattering, to a silver foil detector sufficiently de-energized so that they can be captured by the silver. The silver foil in turn emits beta rays which are counted by a Geiger counter. This in turn can be made to turn the mist off and on. It is not easy though!

Such a scheme does have advantages. The purity of the water does not matter. Nor does the physical state of the water matter. The device will measure the quantity equally well in either the solid, liquid, or vapor phase. The device will average the quantity of water over a considerable radius — say about 12 inches. It does not matter where the water is. It can be inside the cutting, on the surface of the cutting, or as a vapor in the air. Thus turgidity of the cutting, surface wetness, and relative humidity of the air can all be measured and corrected by one device at one time.

THE MILLENNIUM IS HERE!

MIST FROM A CUTTING'S VIEWPOINT

CHARLES E. HESS
Department of Horticulture
Purdue University

When softwood cuttings of plants such as *Prunus serrulata* were placed under intermittent mist or under conventional double glass, superior results were obtained under the mist as shown in Table I. Some of the reasons for better results under mist can be found by studying the micro environment and tissue temperatures under mist and double glass.

The vapor pressure or relative humidity under the two conditions is approximately the same when the mist is off, near matter. You understand that the present Electronic Leaf is actuated by a change in resistance of the film of water on the surface of the "leaf." Therefore, an impurity in the water *might* interfere with proper action if it *did* change the conductance of the water to a great degree.

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Table 1 Rooting response of *Prunus serrulata* cuttings under intermittent mist and double glass.

	Double Glass	Mist
Percent rooting	37	87
Average number of roots per cutting	6.0	8.1
Average length of roots (cm)	1.9	2.5

saturation. So the benefits of mist can not be attributed to a higher humidity. A real difference is found, however, when the tissue temperatures under mist and double glass are compared. During a typical 24 hour period, the average leaf temperature under double glass was 86° F. and under mist it was 75° F. The lower leaf temperature is caused primarily by the evaporation of the film of the water from the leaf during the time when the mist is off. Although the vapor pressure of the moisture in the air surrounding the cuttings under mist and double glass may be approximately the same, the vapor pressure within the leaves was higher under double glass because of the higher leaf temperature. The theoretical result is that the cuttings under double glass would have a tendency to transpire about twice as much water as do the cuttings under mist. The actual moisture relationships can be determined by measuring the gain or loss of fresh weight of the cuttings during the rooting period and subtracting the gain in dry weight. Cuttings under mist gained an average of 4.1 grams of water per cutting and cuttings under double glass lost an average of 1.8 grams during the 30 day rooting period.

Another environmental factor which was substantially different under mist and double glass was light intensity. In order to keep the temperature under double glass at reasonable levels, it was necessary to use shade. Double glass is a heat trap as well as a moisture trap and unless shading is used, the air and tissue temperature will reach a level at which the cuttings are damaged or killed. The light intensity on a clear day inside the greenhouse was 7000 foot candles. The light intensity under the double glass was 240 foot candles and the rate of photosynthesis is greatly reduced.

We must also remember that at the same time plants are making sugars through photosynthesis, they are using sugars in respiration. While light intensity regulates to a large extent the rate of photosynthesis, temperature has a primary effect upon respiration. Generally speaking, the rate of respiration is doubled for every 10° F. increase in temperature. Therefore, not only are the cuttings under double glass not able to maintain a high rate of photosynthesis, they are also utilizing whatever sugars they may have at approximately twice the rate of the cuttings under mist, since there was a differential leaf temperature of 11° F. By actual measurement, the sugar content of the cuttings under mist increased 138 milligrams per cutting during the rooting period and only 17 milligrams per cutting under double glass. The interaction between temperature and light intensity are shown diagramatically in Figure 1. Here cuttings are represented as storage tanks with the inlet values controlled by light (photosynthesis) and the outlet valves controlled by temperature (respiration). The cuttings under double glass were exposed to low light intensity and higher tissue temperatures. So food manufacturing was low and use was high. In contrast, under mist, light intensity was high and leaf temperature was low, and therefore, food manufacturing was high and use was low. As has been mentioned above, the cuttings under mist accumulated more than 8 times more carbohydrates than the cuttings under double glass. This larger reserve of sugars can be used both as raw material for the synthesis of substances needed for root initiation and as an energy source needed for rooting.

In summary, the reasons that higher percentages of rooting and better quality cuttings can be obtained with mist propagation can be attributed to one, a more effective technique of moisture or transpiration control through lower leaf tissue temperatures, higher rates of photosynthesis through higher light intensity, and reduced respiration because of lower tissue temperatures.

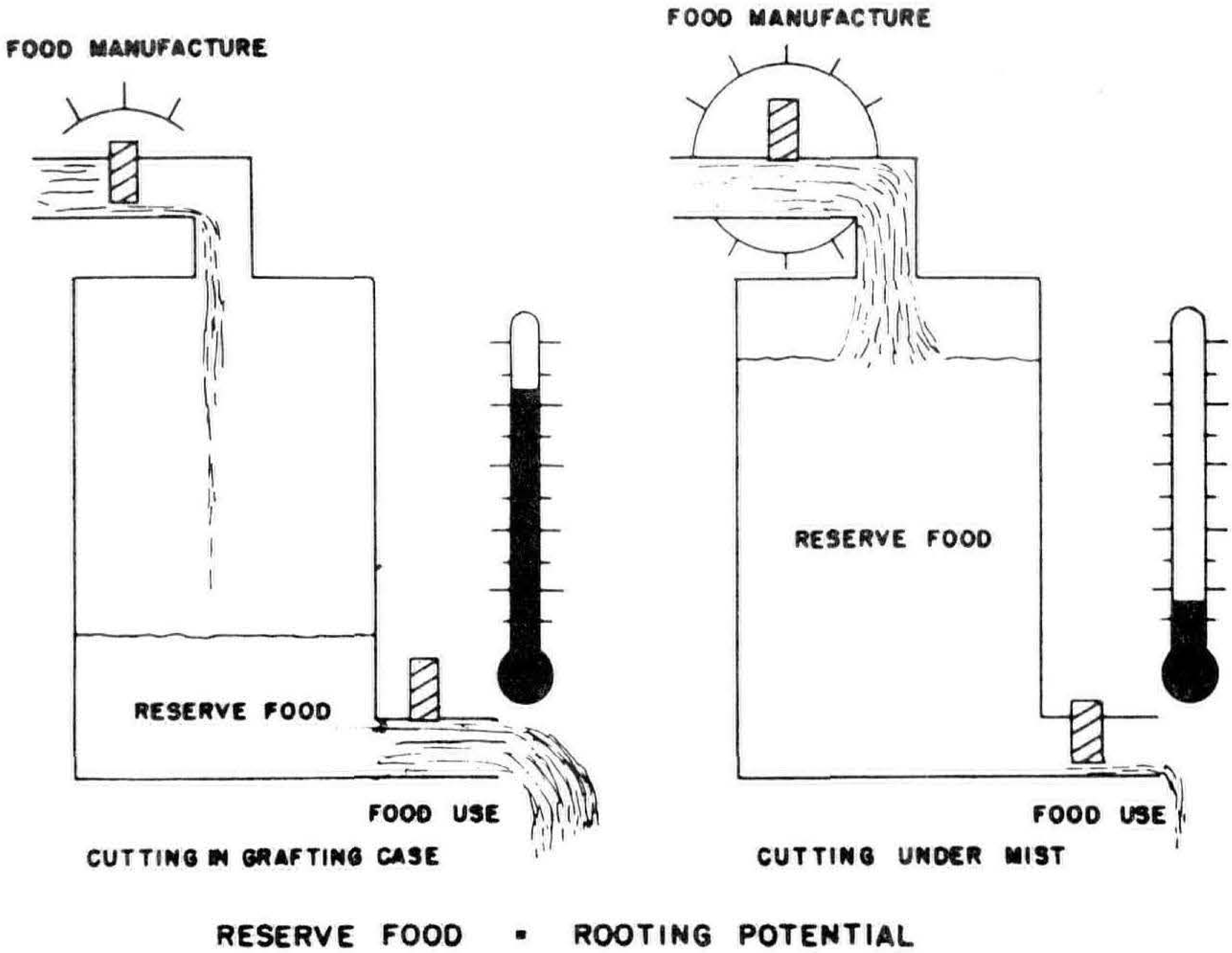

Figure 1. Diagramatic comparison of cuttings propagated in a grafting case and under mist.

MODERATOR HESS: Perhaps our balance of payments is not in too bad shape when you consider the fact that we have obtained and England has lost — or has almost lost — Jim Wells. Jim has the ability to express himself effectively and convincingly both in the written and spoken word. He has, perhaps more than any other member of the Society, shared his experience through a book, numerous articles in the *American Nurseryman* and by participation in the Society. It is an honor to introduce another Award of Merit recipient, James Wells.

MIST PROPAGATION PROBLEMS

JAMES S. WELLS
James S. Wells Nursery, Inc.
Red Bank, New Jersey

Back in 1947, when we commenced to use mist, one of the aspects which immediately became apparent was the absence of problems, particularly problems which we had anticipated. By this, I mean that we first thought that the regular application of relatively large quantities of water would produce a great deal of rotting and fungus troubles of all kinds. But this was not the case. In fact, one of the most striking features of mist propagation is the comparative absence of these problems as compared with more orthodox methods of propagation.

But as time went on, we found that a mist system did have its drawbacks, although in many instances they were quite different from those to which we had become accustomed.

MECHANICAL PROBLEMS

I think that it is in this category that most of the serious problems occur. Insufficient coverage, due to poor water pressure, is the first. Others are . . . poor coverage due to improper jets . . . highly mineralized water which quickly clogs the jets . . . improper placing of the jets over the area to be covered . . . insufficient units to overlap in all areas. These simple and truly mechanical problems resulted in many growers being somewhat disillusioned with their results. Yet these problems are quite easily overcome.

Water Pressure:

First, the question of water pressure. There is hardly a nursery which does not have a pressure of 25 to 30 PSI and there is an excellent jet which will give good atomization at this pressure. It is the Monarch H-261. However, the coverage of this jet, at this low pressure, is quite small and it is essential that jets be placed in pairs, at intervals of about 18 inches, on a 3 foot bench, the jets pointing to either side at a 45 degree angle.

On most greenhouse benches, this will give good coverage. If the bench is long, it is wise to start the delivery pipe with one inch lines, reduce down to ¾ inch, and if it is very long, reduce again to ½ inch at the far end. An alternative to this low pres-

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On most greenhouse benches, this will give good coverage. If the bench is long, it is wise to start the delivery pipe with one inch lines, reduce down to ¾ inch, and if it is very long, reduce again to ½ inch at the far end. An alternative to this low pressure problem is a good booster pump and I would advise this, if it is at all convenient, because there is really no substitute for good water pressure. By this, I mean water pressure at from 60 to 80 psi, and preferably up to 100 psi. (I always wanted to put in a booster system to operate at 500 to 600 psi, because surely this would be the best. But I have had neither the money or the opportunity to do so.)

For reasonable pressures in the 60 to 80 pound level, the Florida Jets and the MacPenny Jet are both excellent and a single line of these jets at approximately 4 feet, on a 4 foot bench, will give excellent coverage.

Mineralization:

Water may come in, absolutely clean, but it is essential that the jets be cleaned at least once a year. Mineral deposits do build up on the screens and reduce the pressure at the orifice.

Control Unit:

In the realm of mechanical problems must come those associated with the control unit used. I am sure that many of you have had troubles with Harvey Templeton's electronic leaf. There are now many versions of his original idea on the market, and all of them seem to have some problem or other. There is no question, however, that the electronic leaf control is the only one to use. For it is immediately responsive to any change in the atmospheric conditions. Once the sensing element has been correctly placed, it should give the very fine degree of control which is ideal.

Most of us have found that the electronic leaf control units manufactured in this country have been, at best, temperamental. I am afraid that there are a large number of these control units sitting on shelves, while the disillusioned grower has gone back to the previously discarded time-clock. This is a pity, because the time-clock is not as satisfactory as a good electronic leaf.

In my opinion there is only one good electronic leaf control unit. This is a fine, transistorized version of Harvey Templeton's original circuit, manufactured in England. We have been using one of these MacPenny Control Units now for two years without touching it at all. The sensing unit has been cleaned only once in this period and it continues to work regularly and precisely.

MEDIUMS

Drainage:

I am sure that many growers have run into problems with poorly drained mediums under mist, where perhaps a situation existed in which the surplus water which mist systems must apply, could not drain away rapidly after passing through the medium. Such a condition is fatal to success. Good drainage is absolutely essential for successful propagation under any form of misting.

Correct Medium:

But perhaps more important is the choice of the right kind of medium for the plant one wishes to grow and this choice appears to be more critical when a mist system is used.

Examples:

I would like to give you two examples.

1. Evergreen Azaleas of the Hinodegiri type can usually be rooted with great ease in almost any medium. Certainly millions of cuttings have been rooted in plain sand, although most growers will consider that a 50-50 mixture of sand and peat, or peat and perlite is best. These cuttings can be rooted with the absolute minimum of attention, directly in open field beds, under any adequate mist system, but only if the medium is 50 percent peat and 50 percent sand. If plain sand is used under these conditions, rooting is poor and the addition of some peat appears to be essential for good results.

2. I ran into an even more striking example, some years ago. I was attempting to root cuttings of *Chamaecyparis obtusa nana gracilis* and I had followed the procedures in the Boskoop Trial Ground Reports, that suggested soaking the cuttings in a solution of Indolebutyric Acid at 7,500 parts per million for 18 hours. This was done and the cuttings were inserted in a medium of 50% peat and 50% sand. It just so happened that I was experimenting with other mediums of live spaghnum moss for the rooting of Rhododendrons, in an adjacent area. Quite by chance, one of the cuttings of the Chamaecyparis was inserted so that the stem penetrated the spaghnum moss.

Eight weeks later, when I came to lift the cuttings, this was the only one which had rooted, out of the whole lot, and it had rooted with astonishing vigor. I was so taken with this that I immediately repeated the test by inserting cuttings, this time in shredded spaghnum moss, with first-class results. It is interesting to record, also, that under these conditions, the Rhododendrons would root in the sand and peat mixture, but did not root in the spaghnum moss.

These illustrations will show that it is essential to provide exactly the right type of medium for the plant and the conditions provided by the mist system. Because of the unknown, perhaps minute, yet quite important, variables which may arise . . . type of water available . . . type of peat one is using . . . the length of the cutting stem . . . and insertion into the medium, it is essential for the grower to experiment and record his results so that he can establish optimum conditions for his particular set of circumstances. Once these and the other mechanical problems have been solved, then one usually finds that the use of a mist system prompts rapid and vigorous rooting.

CULTURAL PROBLEMS

Hardening Up:

Once we have reached the point of having established good rooting, we run into a set of problems resulting from the removal of the cuttings from the misting environment to more natural ones . . . in other words, "hardening up."

Use of a Weaner Unit:

There is an electric control called a Weaner Unit, which is nothing more than an electric counter. It enables one to couple the Solenoid to the Control Unit, and by turning a switch, to apply mist to a bed of rooted cuttings every 3rd . . . every 6th . . . or every 12th time . . . that the sensing unit calls for mist. This reduces the amount of mist which is applied and slowly hardens up the cuttings. I have spoken with a number of growers who have used the Weaner and they are very pleased with it.

Use of Shade in Place of Mist:

There is another aspect which I would like to call to your attention. That is that shade can be substituted for mist, to a considerable extent. The purpose of the film of water maintained by a mist system, is to keep the cuttings in a turgid condition and prevent undue water loss. This works very well, indeed, particularly when the cuttings have no root system. But once they have rooted. then they are organized once more, to extract water from the medium, and the need for preventing any evaporation from the leaves is not as acute. The cutting can sustain normal transpiration and can supply the required moisture from its new root system, without stress. We can provide reasonable conditions for such rooted cuttings by applying a very heavy shade and misting either with the Weaner Unit or manually, perhaps once an hour. Then, a few days later, perhaps twice in the morning and twice in the afternoon. Then, once or twice a day, only. A regime of this kind, over a two week period, will usually bring the cuttings to a position where they are well able to stand on their own feet, in normal conditions.

Use of Special Area Designed To Combine Shade and Mist:

An alternative to these procedures would be a hardening-off area, which should be separated from the propagating area. If the cuttings have been rooted in flats, then the flats can be moved to the hardening-off area, which might be a section completely surrounded with Saran. A high overhead mist line should be provided, which could be controlled with a time-clock and the cycle of mist application steadily lengthened, until it is about once an hour, before it is discontinued.

There are no problems with hardening-up, which in my opinion, cannot be overcome easily with a little care and common sense.

Fungus:

I commenced by saying that fungus problems appeared much less than we might have anticipated and this is true with one important exception.

Incidence of Rhizoctonia:

We have found that under the close conditions of a closed greenhouse, Rhizoctonia can appear quite suddenly in the bench and spread with amazing rapidity. The benches of cuttings have to be watched for the incidence of this disease and action taken immediately to prevent undue loss. All dead or damaged cuttings should be removed at once. Any leaves which may have fallen from nearby cuttings should be removed and the whole area cleaned and groomed.

Semesan Control:

Then the immediate area of attack should be treated with double strength Semesan and the whole greenhouse treated with single-strength Semesan. We have found that this mercury compound is superior to any other in the control of this disease and if the treatment is applied rapidly, the disease is stopped in its tracks.

This seems to end the problems with which we have been faced, with the exception of the item which is to be dealt with by the next speaker, and that is "Leaching."

There seem to be certain types of cuttings which are just not responsive to mist culture and I believe that these have to be determined by trial and error. Deciduous Azaleas are among these. The cuttings are taken in a very soft condition. They are always slow to root and with the steady application of mist over a period of two and a half month to three months, the cuttings almosts invariably collapse before rooting.

I mention this because I have no answer for it and I am therefore waiting eagerly to hear the comments of the next speaker, who I hope will give me the answer to the problem.

MODERATOR HESS: Another problem which has been called to our attention by the excellent work of Dr. Harold Tukey, Jr. and his graduate students at Cornell University is leaching by mist. We are fortunate to hear from Mr. George Good who is actively working on this problem.

THE INFLUENCE OF INTERMITTENT MIST ON THE MINERAL NUTRIENT CONTENT OF CUTTINGS DURING PROPAGATION

G. L. GOOD AND H. B. TUKEY, JR.
Department of Floriculture & Ornamental Horticulture
Cornell University, Ithaca, New York

INTRODUCTION

Foliar leaching is the removal of metabolites from plant parts by aqueous solutions, (Tukey, 1962). Leaching has been shown to be of importance in plant nutrition, in the distribution and recycling of nutrients in an ecosystem, and in the quality of certain food crops. It has also been shown that many factors may affect the leaching of nutrients. For instance, the age and the maturity of the plant tissue can influence the amount of leaching which occurs from plant tissue. Young, actively grow-

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ing plant tissue is difficult to leach, whereas, more mature tissue is relatively easy to leach.

There are reports by various workers that cuttings propagated under mist undergo extensive losses of nutrients during the rooting period (See Good and Tukey, 1964). Since a large number of ornamental plants are commercially propagated under mist, it was of interest to survey cuttings from a wide range of ornamental plants to determine the extent of nutrient leaching.

METHODS

Herbaceous cuttings of carnation (*Dianthus caryophyllus* cv. 'White Sim'), chrysanthemum (*Chrysanthemum morifolium* cv. 'Indianapolis White'), coleus (*Coleus blumei*), and poinsettia (*Euphorbia pulcherrima* cv. 'Barbara Ecke Supreme'); softwood cuttings of currant (*Ribes alpinum*), two species of euonymus (*Euonymus alatus* and *E. fortunei vegeta*), honeysuckle (*Lonicera tatarica*), pachysandra (*Pachysandra terminalis*) and privet (*Ligustrum ibolium*); and hardwood cuttings of arborvitae (*Thuja plicata*), boxwood (*Buxus sempervirens*), English ivy (*Hedera helix*), forsythia (*Forsythia intermedia*) and yew (*Taxus cuspidata capitata*) were all surveyed for leaching when rooted under mist.

Forty uniform cuttings of each species were standardized as to leaf number and fresh weight. Before rooting, one-half of each group was oven dried, weighed and analyzed for nitrogen, phosphorus, potassium, calcium, and magnesium. The other half were placed in a rooting medium of coarse quartz sand under an intermittent mist of distilled water. After they were rooted, they were also dried, weighed and analyzed for the same nutrients.

The leachate from the cuttings was collected and analyzed in the same manner as the cuttings.

Chrysanthemum cuttings were used to study the redistribution of nutrients within cuttings during rooting. Three hundred and sixty uniform cuttings were selected so that each had three fully expanded leaves. The 360 cuttings were divided into six groups of 60 cuttings each and each group was inserted into a 1:1 vermiculite: perlite medium under an intermittent mist of distilled water. One of each of the groups was removed from under the mist after 0, 3, 6, 9, 12 and 15 days. Each cutting was cut into 3 segments (a) the 3 oldest leaves which were on the cutting at the beginning of the experiment, (b) the stem apex and new leaves, and (c) the basal one inch of stem and newly developed adventitious roots. The plant tissue was dried, weighed and analyzed for nitrogen, phosphorus, and potassium.

RESULTS

Influence of Cutting Maturity:

Herbaceous cuttings. In the first experiment herbaceous cuttings of chrysanthemum, carnation, coleus and poinsettia were rooted under the intermittent distilled water mist. The cuttings were analyzed both before and after rooting to determine the nitrogen, phosphorus, potassium, calcium and magnesium content. Table 1 shows the results from the analyses of two representative species of this group, chrysanthemum and carnation. There was no change in the nutrient content before and after rooting except in the case of magnesium in chrysanthemum. This indicated little or no leaching of the nutrients by the mist. Cuttings of poinsettia and coleus showed similar results in that little or none of the nutrients were leached.

Table 1 Nutrient content of herbaceous cuttings before and after rooting under intermittent mist[1]

Species	N	P	Nutrient K	Ca	Mg
			(mg/cutting)		
Chrysanthemum morifolium					
Before Rooting	25.3	4.1	25.4	8.3	3.3
After Rooting	25.5	4.8	28.1	9.7	1.3*
Dianthus caryophyllus					
Before Rooting	20.7	2.1	18.1	2.6	1.4
After Rooting	19.9	2.1	18.2	2.2	1.5

*Significant decrease at the 5% level due to leaching.
[1]From Good and Tukey, Proc Am Soc Hort Sci. (in press)

Softwood cuttings. In a second experiment, softwood cuttings of currant, euonymus, honeysuckle, pachysandra and privet were rooted under the distilled water mist. Table 2 shows the results of the analysis both before and after rooting of two representative species of this group, currant and honeysuckle. Currant showed leaching of potassium only, while honeysuckle showed leaching of potassium and magnesium. The other softwood cuttings in this group showed similar results in that little

Table 2. Nutrient content of softwood cuttings before and after rooting under intermittent mist.[1]

Species	N	P	Nutrient K	Ca	Mg
			(mg/cutting)		
Ribes alpinum					
Before Rooting	15.6	1.9	10.9	9.7	1.2
After Rooting	16.6	1.6	8.6*	9.3	1.6
Lonicera tatarica					
Before Rooting	34.8	2.3	21.5	13.8	3.0
After Rooting	36.0	2.4	17.6*	12.6	1.1*

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

Table 3 Nutrient content of hardwood cuttings before and after rooting under intermittent mist.[1]

Species	N	P	Nutrient K	Ca	Mg
			(mg/cutting)		
Forsythia intermedia					
Before Rooting	21.6	2.6	12.9	16.7	3.8
After Rooting	20.7	1.5*	10.3*	11.1*	0.8*
Ribes alpinum					
Before Rooting	13.7	2.6	10.5	12.4	1.6
After Rooting	11.6*	1.8*	6.5*	8.2*	1.6

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

or no nutrients were leached during rooting under mist. Thus, softwood cuttings proved difficult to leach.

Hardwood cuttings. Since it has been reported that more mature plant tissue is relatively easy to leach (Tukey, 1962), hardwood cuttings of arborvitae, boxwood, currant, English ivy, forsythia, and yew were taken from stock plants in September before frost. The cuttings were analyzed both before and after rooting under mist. The results of the analyses of two representative species, forsythia and currant are shown in Table 3. Unlike herbaceous and softwood cuttings, hardwood cuttings showed extensive leaching of mineral nutrients. Forsythia lost appreciable amounts of phosphorus, potassium, calcium, and magnesium, and currant lost nitrogen, phosphorus, potassium and calcium.

Thus, the maturity of the cutting plays a key role in determining the extent of nutrient leaching under mist. This is demonstrated in Table 4 where the nutrient content of both soft-

Table 4. Leaching of nutrients from cuttings of *Ribes alpinum* propagated under intermittent mist as influenced by the maturity of the cuttings[1]

Cutting Maturity	Nutrient N	P	K	Ca	Mg
Softwood					
Before Rooting	15.6	1.9	10.9	9.7	1.2
After Rooting	16.6	1.6	8.6	9.3	1.6
Nutrient Leached			2.3*		
Hardwood					
Before Rooting	13.7	2.6	10.5	12.4	1.6
After Rooting	11.6	1.8	6.5	8.2	1.6
Nutrient Leached	2.1*	0.9*	3.9*	4.1*	

*Significant decrease at the 5% level, due to leaching
[1]From Good and Tukey, Proc Amer Soc Hort Sci (in press)

wood and hardwood cuttings of currant are compared before and after rooting under mist. The softwood cuttings taken in the spring lost only significant amounts of potassium, but hardwood cuttings of the same species taken in September lost significant amounts of nitrogen, phosphorus, potassium and calcium.

Growth and Redistribution in Cuttings During Rooting:

Dry weight of all the cuttings were recorded both before and after rooting under mist. As shown in Table 5 cuttings weighed substantially more after rooting than before indicating that growth had occurred as the cuttings rooted. Herbaceous cuttings of chrysanthemum increased more than 300% in dry weight during rooting while herbaceous cuttings of carnation and softwood cuttings of currant and honeysuckle increased 50% or more. These increases in dry weight came from additions of carbohydrates from photosynthesis, as there was no increase in the nutrient content (Tables 1 and 2).

Hardwood cuttings of currant and forsythia also grew, during rooting, but not to the extent of either the softwood or herbaceous cuttings.

Since the cuttings did grow during rooting, a more detailed analysis of the growth and distribution of nutrients within parts of each cutting was made with the intent of explaining, in part, the difference is leachability of various cuttings.

Cuttings of chrysanthemum were rooted under the distilled water mist for 0, 3, 6, 9, 12 and 15 days, after which they were cut into 3 sections, (a) the oldest leaves, (b) the apex and any new leaves, (c) and the basal one inch of stem which included the new roots. Each segment was weighed to determine dry weight and analyzed for nitrogen, phosphorus, and potassium.

Table 5. Dry weight (g/cutting) of herbaceous, softwood, and hardwood cuttings before and after rooting under intermittent mist.

Maturity and Species	Dry Wt. Before Rooting (g/cutting)	Dry Wt. After Rooting (g/cutting)
Herbaceous cuttings		
Chrysanthemum morifolium	.70	1.97*
Dianthus caryophyllus	.43	.71*
Softwood cuttings		
Ribes alpinum	.66	1.08*
Lonicera tatarica	1.00	1.50*
Hardwood cuttings		
Forsythia intermedia	1.06	1.30*
Ribes alpinum	.74	.88*

*Significant increase at 5% level due to carbohydrate increase

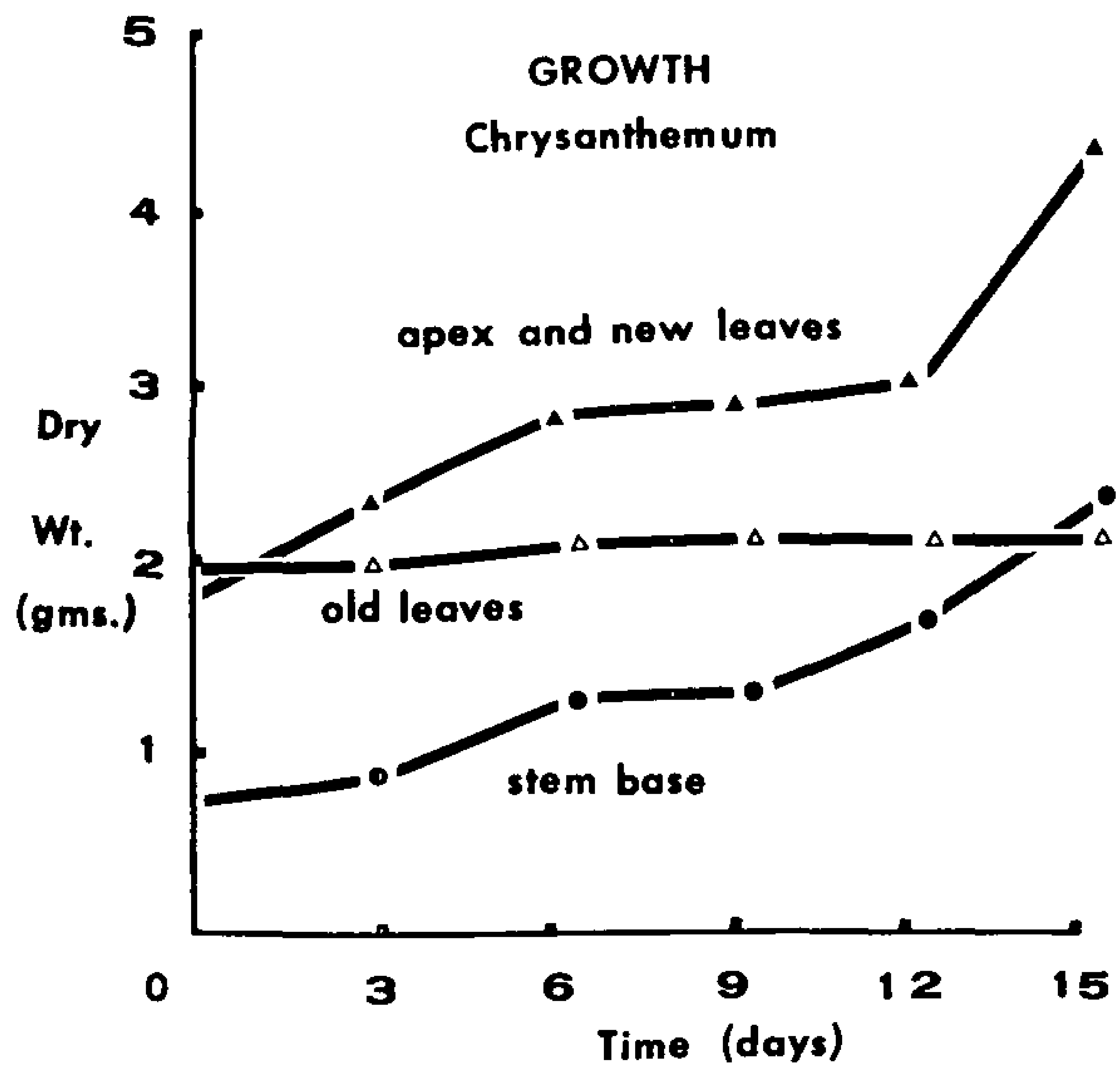

Figure 1. Growth (dry wt.) of the (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist

Comparison of the growth of the three sections of the cuttings is shown in Fig. 1. Initially, the average dry weight of the 3 oldest leaves was 2.00 g/cutting. At the end of the 15-day period, the average dry weight of these 3 oldest leaves was 2.13 g/cutting indicating very little growth in this segment during the rooting period.

The apex and new leaves made considerable growth and more than doubled in dry weight from 1.85 g/cutting to 4.23 g/cutting during the rooting period.

Likewise, the basal one inch of stem showed increases in dry weight due to the initiation and development of the roots. Originally, the segment averaged 0.71 g/cutting, but at the end of the rooting period the dry weight had more than tripled to 2.30 g/cutting.

Thus, cuttings are capable of growth particularly in the regions where new leaves and roots are being formed. How this differential growth affected the distribution of nitrogen, phosphorus and potassium is shown in the next three figures which shows the per cent of the total nutrient content in each of the 3 segments.

Fig. 2 shows that nitrogen was transported out of the three oldest leaves to the apex and new leaves particularly during the first and last 3 days of the experiment. Nitrogen transport to the new roots was greatest during the last 3 days of rooting when root growth was at a maximum. There appeared to be no translocation of nitrogen to the basal one inch of the cutting when roots were initiated during the first 3 days of the experiment.

Phosphorus (Fig. 3) was translocated out of the 3 oldest leaves to both the new leaves and roots generally throughout the rooting period. Translocation to the roots was associated with both root initiation and root development.

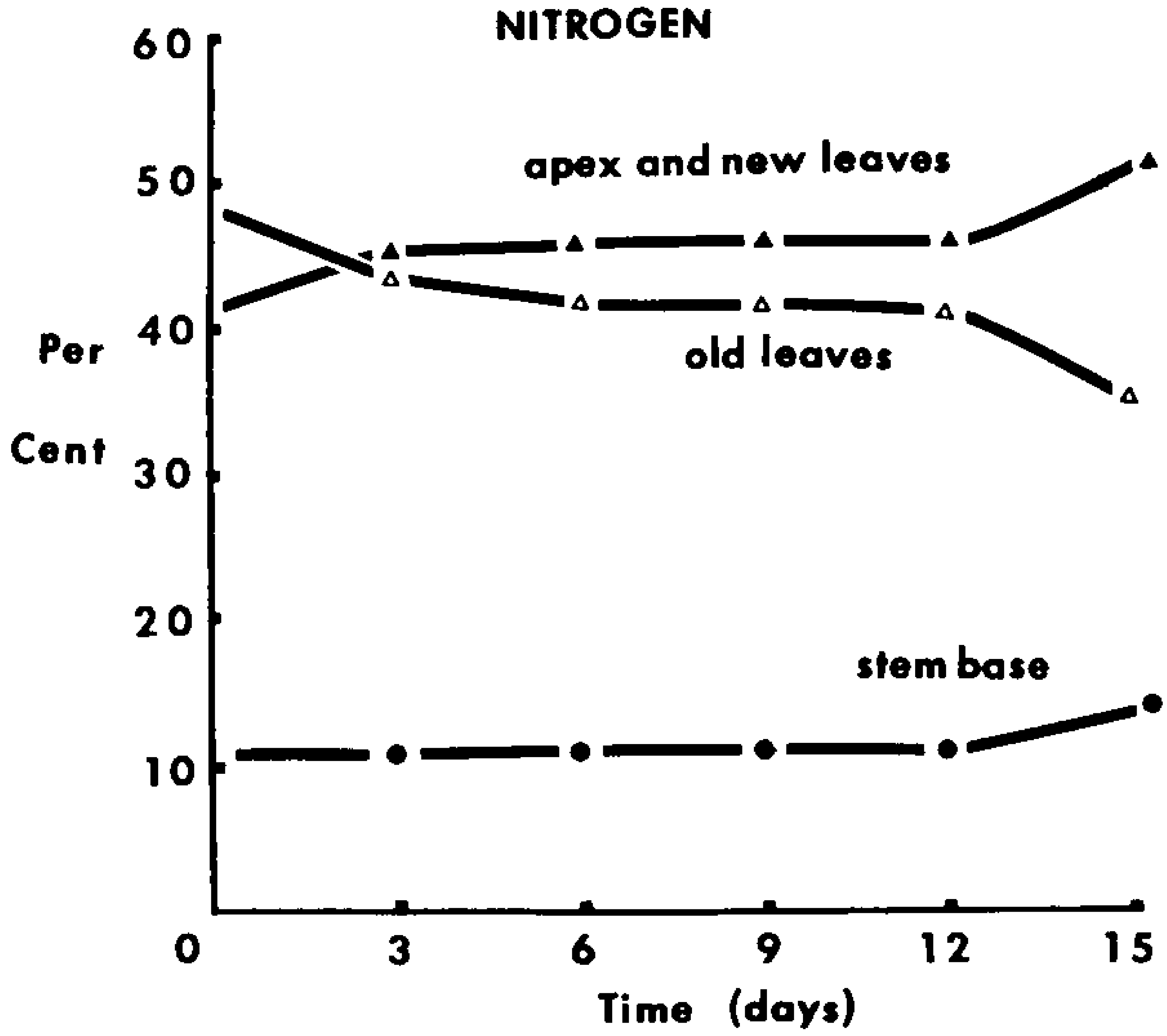

Figure 2 Distribution of nitrogen in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist.

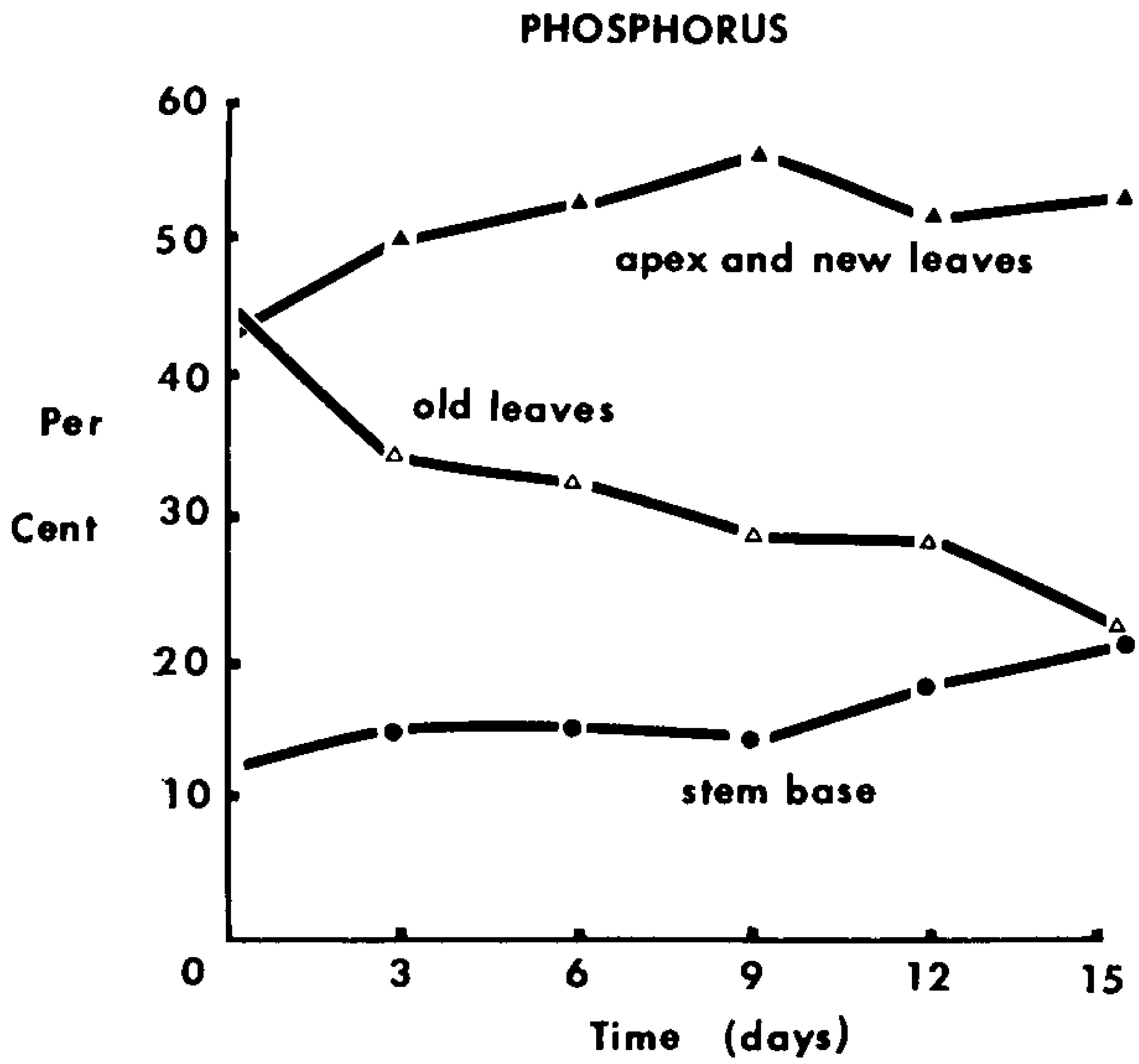

Figure 3 Distribution of phosphorus in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist.

Potassium (Fig. 4) was translocated from the three oldest leaves to the new leaves throughout the rooting period, but very little moved to the new roots.

Discussion

These experiments show that the leaching of mineral nutrients from cuttings propagated under mist was influenced by the maturity of the cuttings. Herbaceous and softwood cuttings were difficult to leach while hardwood cuttings were relatively easy to leach when rooted under mist. The fact that mature plant tissue is easier to leach than young, succulent tissue agrees with reports from other workers (Tukey, 1962).

The ease or difficulty with which cuttings were leached by the mist corresponded to the growth the cuttings made while rooting. Softwood cuttings which were difficult to leach were capable of growing a great deal during rooting, whereas hardwood cuttings which were relatively easy to leach exhibited very little growth (Table 5). From Fig. 1 through 4, it is shown that nutrients were translocated from the older leaves, which had essentially ceased growing, to the growing new leaves and roots. Previous work has shown that materials are not leached from growing tissues because they are bound up within cells where they cannot be leached (Tukey, 1962). Thus, softwood and herbaceous cuttings had a considerable portion of nutrients bound within growing tissue which accounted for the fact that these cuttings were difficult to leach. Hardwood cuttings, on the other hand had relatively little growing tissue, hence, they were relatively easier to leach.

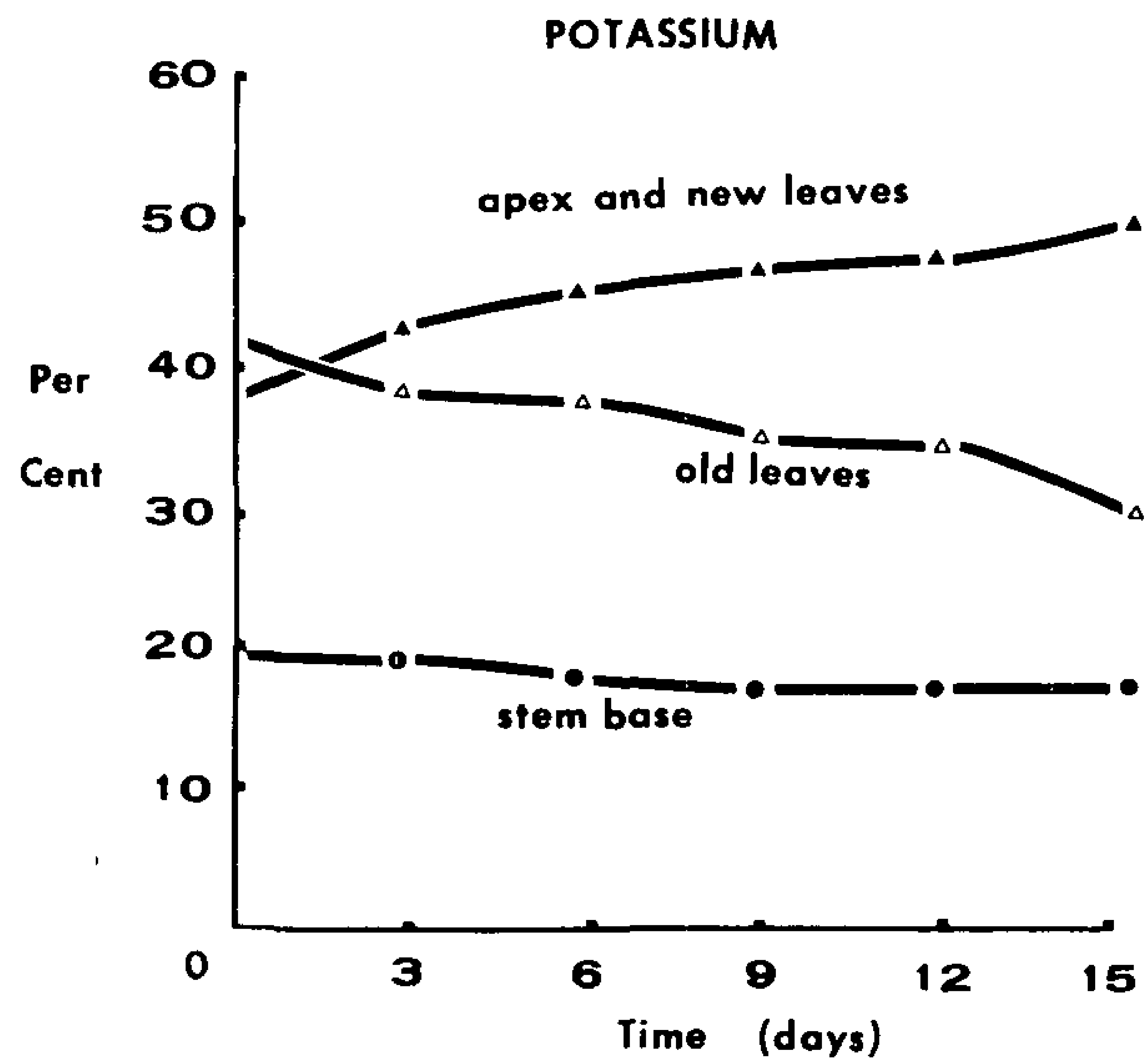

Figure 4 Distribution of potassium in (a) 3 oldest leaves, (b) apex and new leaves, and (c) the stem base (1 inch) and new roots of herbaceous cuttings of *Chrysanthemum morifolium* cuttings after 0, 3, 6, 9, 12 and 15 days of rooting under intermittent mist

There have been reports in the literature that nutrient deficiencies commonly occur in cuttings rooted under mist. These deficiencies could be due to two factors. First, mineral nutrients are leached from the cuttings as was the case with mature hardwood cuttings. Second, the cuttings grow through additions of carbohydrates from photosynthesis, and the nutrients retained in the cuttings are not sufficient for the new growth. In either case, additional nutrients supplied to the cuttings during rooting may be an important factor in rooting and in the subsequent growth and development of the rooted cutting.

Summary

Cuttings from numerous ornamental plants were surveyed in order to determine the extent of nutrient leaching when propagated under mist. Herbaceous and softwood cuttings proved very difficult to leach whereas hardwood cuttings were relatively easy to leach. Cuttings were capable of substantial growth during rooting due to the growth of new leaves and roots. Nutrients held in the older, fully expanded leaves of chrysanthemum were translocated to the growing new leaves and roots from where they were not readily leached. Nutrient deficiencies which commonly occur in cuttings rooted under mist could be due to (a) the leaching of nutrients, and (b) the diluting of mineral nutrients by additions of carbohydrates from photosynthesis.

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MODERATOR HESS: Now we will turn our attention to the area of new techniques. An obvious solution to solve the leaching problem would be to add nutrients to the mist. To tell us about his experiments with nutrient mist is Mr. John Wott.

PROPAGATION OF CUTTINGS UNDER NUTRIENT MIST

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Introduction

Many workers have reported that mineral nutrients can be leached from cuttings propagated under mist with the subsequent development of nutrient deficiency symptoms (Ang 1958, Evans 1951, Good and Tukey 1964, Sweet and Carlson

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Many workers have reported that mineral nutrients can be leached from cuttings propagated under mist with the subsequent development of nutrient deficiency symptoms (Ang 1958, Evans 1951, Good and Tukey 1964, Sweet and Carlson

1955, Tukey 1962). Losses by leaching are related to the maturity of the cutting, being greatest for hardwood cuttings and much less for softwood and herbaceous cuttings.

Nutrient deficiencies in cuttings rooted under mist are due to a) leaching of nutrients and b) growth of the cuttings during rooting causing a dilution of the nutrients within the cuttings (Good and Tukey 1964, 1965). In either case it would seem that nutrients added to the cuttings during propagation might be of benefit.

Since it is well known that a broad spectrum of material can be absorbed by stems and foliage (Wittwer and Teubner 1959), application of nutrients through the mist would be an appropriate procedure. Thus Morton and Boodley (1962) observed that poinsettia and chrysanthemum cuttings propagated under a complete nutrient mist were superior to those propagated under a water mist.

This paper presents an evaluation of the use of nutrient mist in the propagation of several commercially important ornamental plants.

Materials and Methods

Uniform cuttings of twenty-nine ornamental species were collected from stock plants in November and early June. The complete list of plant material is given in Table 1.

Twenty to forty cuttings of each species were immediately dried, weighed and analyzed for nitrogen, phosphorus and potassium in the laboratory. Two hundred to 400 additional cuttings were divided into two groups and placed in greenhouse propagation benches equipped with mist and bottom heat in a rooting medium of peat and perlite (1:1 by volume). One group of each species was misted with tap water (water mist) at an interval of 12 seconds every 2½ to 10 minutes during the day. The

Table 1 List of Plant Materials Propagated Under Intermittent Nutrient Mist.

Berberis thunbergii[2]	*Philadelphus coronarius*[2]
Buxus sempervirens[2]	*Ribes alpinum*[1,2]
Chaenomeles speciosa[2]	*Rosa multiflora*[1,2]
Chrysanthemum morifolium[1]	*Rosa setigerum*[2]
Euonymus fortunei[1,2]	*Salix purpurea*[2]
Euonymus fortunei 'Vegetus'[1,2]	*Syringa vulgaris*[2]
Forsythia intermedia[2]	*Taxus baccata* 'Repandens'[1]
Forsythia suspensa[1,2]	*Taxus cuspidata*[1]
Hedera helix[1,2]	*Thuja occidentalis*[1]
Juniperus chinensis 'Hetzi'[1]	*Thuja plicata*[1]
Juniperus chinensis 'Sargentii'[1]	*Tsuga canadensis* 'Pendula'[1]
Ligustrum obtusifolium 'Regelianum'[2]	*Viburnum lantana*[2]
Lonicera tatarica[2]	*Viburnum prunifolium*[2]
Lonicera morrowii[2]	*Vinca minor*[1,2]
Pachysandra terminalis[1,2]	

1) fall propagation
2) spring propagation

other group of cuttings was misted at the same interval with tap water to which a complete, all-soluble fertilizer (nutrient mist) with an analysis of 23-19-17 was added at the rate of six ounces per 100 gallons of water. The fertilizer was recommended for both foliar and soil applications.

When the cuttings were well rooted, they were removed from the benches and rooting percentages and root evaluations were determined. Root evaluations were made on the basis of size of roots, number, color, and brittleness. Some cuttings of each species were then potted up and grown on to determine growth rates after rooting. The remaining cuttings were then dried, weighed and analyzed for nitrogen, phosphorus and potassium. In some species, new shoot growth was produced during rooting and this was removed and analyzed. The mineral nutrient content of the cuttings of each species before rooting was compared with the content after rooting under the water or nutrient mist system.

Results

Hardwood Cuttings

The results of the fall propagation of three representative species are presented in Table 2. *Hedera helix* cuttings from under the nutrient mist had a higher dry weight at the end of the propagation period (919 mg) than did those from under the water mist (892 mg). Under the water mist there was a decrease of nitrogen, phosphorus and potassium content as compared with the content before rooting, indicating that leaching of the nutrients occurred during rooting. In contrast, the cuttings from under the nutrient mist show a substantial increase in content of these three nutrients when compared with both the cuttings from under the water mist system and the cuttings before rooting.

Cuttings from under the water mist had a higher rooting percentage than cuttings under nutrient mist and also a slightly higher root quality.

Hedera helix was one of the species in which the new growth of the cuttings made during rooting was removed and analyzed separately. As shown in Table 3, cuttings from under the nutrient mist made more growth (dry wt.) and had a greater uptake of nitrogen, phosphorus and potassium than did cuttings under the water mist.

Rosa multiflora and *Thuja plicata* gave similar results to those obtained with *Hedera helix* in that under the nutrient mist, the nutrient content and growth were considerably greater than under the water mists. For example with *Rosa multiflora*, rooted cuttings propagated with nutrient mist were 132% heavier (dry wt.) than cuttings propagated with water mist.

The results with *Vinca minor*, *Euonymus fortunei* and *Juniperus chinensis* 'Sargentii' were similar in some respects to *Hedera helix*. For example, like *Hedera helix*, nutrients were leached from the cuttings by the water mist. Similarly, the

Table 2 Influence of nutrient mist on the dry weight, nutrient content and root development of hardwood cuttings taken in November.

Species	Dry Wt	Nutrient Content N	P	K	Rooting	Root quality
	(mg/cutting)	(mg/cutting)			(%)	
Hedera helix						
Before rooting	938	16.56	1.88	9.59	—	—
After rooting — water mist	892	13.87	1.62	7.46	91.2	4.52
nutrient mist	919	20.63	2.67	14.05	83.2	4.32
Pachysandra terminalis						
Before rooting	501	14.91	1.92	9.38	—	—
After rooting — water mist	566	13.11	1.52	5.50	100.0	4.65
nutrient mist	517	16.49	1.83	6.58	100.0	4.67
Euonymus fortunei 'Vegetus'						
Before rooting	752	16.10	1.01	5.50	—	—
After rooting — water mist	887	17.21	2.32	2.55	91.2	4.80
nutrient mist	753	17.54	2.46	2.51	89.7	4.20

Table 3. Influence of nutrient mist on the dry weight and nutrient content of the new growth of *Hedera helix* cuttings produced during the rooting period

	Water mist	Nutrient mist
	(mg/cutting)	
Dry Wt.	92	116
N	2.05	4.15
P	0.33	0.56
K	2.43	4.30

nutrient content was higher under the nutrient mist and the dry weight was increased as compared to the water mist, as seen in *Juniperus chinensis* 'Sargentii' which had more growth under nutrient mist (487 mg) than with water mist (325 mg). However unlike *Hedera helix*, rooting percentages were somewhat higher under the water mist, whereas the root quality was higher under the nutrient mist.

After removal from the propagation bench, most of the rooted cuttings of the above mentioned species from under the nutrient mist grew faster (linear growth) and were heavier after six months than were cuttings from under the water mist.

Pachysandra terminalis exhibited an indifferent response to nutrient mist. Table 2 shows that cuttings from under water mist had a higher dry weight than did either the original cuttings or cuttings from under nutrient mist. Some leaching of nutrients did occur and the potassium contents were higher under the nutrient mist, but the differences were small. In addition, there were no differences between treatments either in the rooting or the growth of the cuttings after rooting. *Taxus cuspidata* responded similarly to *Pachysandra*.

One species, *Euonymus fortunei* 'Vegetus' gave better rooting under water mist. Although the nutrient content of the cuttings was similar under both treatments, the cuttings under the water mist were considerably heavier and stronger and grew more after their removal from the propagating bench than did cuttings from under the nutrient mist.

Softwood Cuttings

The responses of representative softwood cuttings propagated in early June are presented in Table 4. All of the species, especially *Philadelphus coronarius* and *Forsythia intermedia* made large increases in dry weight during the rooting period. The growth of some species was favored by water mist and other species by nutrient mist.

Similarly, in all species, a considerable increase in the nitrogen, phosphorus and potassium content was noted in the cuttings propagated under nutrient mist as compared with the water mist and the content of cuttings before rooting. Leaching of nutrients by the water mist did occur especially with *Philadelphus coronarius* and *Salix purpurea*. Addition of nutrients to these rapidly growing cuttings not only replaced the leached nutrients

Table 4 Influence of nutrient mist on the dry weight, nutrient content, and root development of softwood cuttings taken in June

Species	Dry Wt	Nutrient Content N	P	K	Rooting	Root quality
	(mg/cutting)		(mg/cutting)		(%)	
Philadelphus coronarius						
Before rooting	520	17.95	2.17	14.98	—	—
After rooting — water mist	850	12.27	2.15	9.87	54.2	1.67
nutrient mist	930	43.14	7.68	22.23	86.2	2.80
Euonymus fortunei 'Vegetus'						
Before rooting	560	12.42	1.66	4.99	—	—
After rooting — water mist	870	13.01	1.72	4.47	98.8	2.61
nutrient mist	770	22.27	2.82	6.08	100.0	2.75
Forsythia intermedia						
Before rooting	460	10.00	1.16	5.45	—	—
After rooting — water mist	1110	13.76	1.38	8.27	100.0	3.00
nutrient mist	1010	41.67	5.23	18.50	98.8	2.88
Salix purpurea						
Before rooting	405	12.95	1.14	5.36	—	—
After rooting — water mist	590	8.61	1.41	3.87	100.0	2.81
nutrient mist	546	23.87	5.68	8.32	94.0	2.81

but increased the nutrient content by three to four times as compared with cuttings under water mist.

In the case of *Philadelphus coronarius* and *Euonymus fortunei* 'Vegetus', cuttings under nutrient mist had a higher rooting percentage with a much more desirable root system than did cuttings under water mist.

In both species, rooted cuttings from under the nutrient mist grew faster (linear growth) and had a higher dry weight at harvest than did the cuttings from the water mist. In addition more side shoots developed on those *Euonymus* cuttings from under nutrient mist, whereas the mist cuttings from water mist made only terminal growth.

Comparison between softwood and hardwood cuttings of *Euonymus fortunei* 'Vegetus' can be seen in Table 2 and Table 4. While the hardwood cuttings did not respond favorably to nutrient mist, the softwood cuttings showed a higher nutrient content, better rooting percent and root quality under nutrient mist. The softwood cuttings from nutrient mist also developed more side shoots after their removal from the propagation bench than did the hardwood cuttings from nutrient mist.

Nutrient mist does influence the root quality of *Forsythia intermedia*. Cuttings under nutrient mist had thick, fleshy roots which were very brittle, whereas those propagated under water mist had a thin, fibrous root system. This same type of root difference was noted in cuttings of *Forsythia suspensa*, *Ligustrum obtusifolium* 'regelianum' and *Salix purpurea*. In fact, in the case of *Salix purpurea*, the roots were so brittle that 50% of the cuttings failed to survive transplanting.

The cuttings of *Forsythia intermedia* potted from under the nutrient mist were darker green when taken from the propagating bench, grew faster and had a higher dry weight after six months than did cuttings from under the water mist.

Another problem was noted in cuttings of *Salix purpurea* under nutrient mist in that the terminal growth died and blackened, resulting in cuttings with a bushy appearance. Whether this was related to high salt concentrations in the nutrient mist was not determined.

Discussion

The results of these experiments verify that mineral nutrients are leached from both hardwood and softwood cuttings propagated under mist. Of the three nutrients studied, potassium is the most easily leached, followed by nitrogen and phosphorus. These results are in agreement with many other reports in the literature (Tukey, 1962).

Cuttings in these experiments, especially softwood cuttings, increased in dry weight during the rooting period. For example, softwood cuttings of *Forsythia intermedia* more than doubled in dry weight during rooting (Table 4). This also is in agreement with reports in the literature (Hess and Snyder 1957, Good and Tuksy 1965).

Mineral nutrients applied to cuttings through the mist lines were readily absorbed by the cutting and greatly increased the nitrogen, phosphorus and potassium content of both hardwood and softwood cuttings as compared to cuttings propagated under water mist. This was particularly true with the fast growing softwood cuttings as shown in Table 4. The amount of nutrient uptake is influenced by the plant species and the nutrient itself. For example, all three nutrients were readily absorbed by hardwood cuttings of *Hedera helix*, but not to the same extent by *Pachysandra terminalis* (Table 3).

The response of cuttings to nutrient mist is specific for each species. For example, hardwood cuttings of *Hedera helix* and softwood cuttings of *Philadelphus coronarius* absorbed large quantities of nutrients from the mist, rooted well and made better growth after rooting than did cuttings which did not receive nutrients. In contrast, *Euonymus fortunei* 'Vegetus' propagated as a hardwood, made better response under water mist. Still other species, such as hardwood cuttings of *Pachysandra terminalis* and *Taxus cuspidata* were indifferent to nutrient mist.

Rooting and root quality is also influenced by nutrient mist. Some cuttings such as *Hedera helix* and *Salix purpurea* had a slightly higher rooting percentage under water mist than nutrient mist whereas others such as *Philadelphus coronarius* rooted better under nutrient mist. Under nutrient mist *Forsythia intermedia* produced a thick, brittle root system which was somewhat difficult to transplant.

The problem of the die-back in *Salix purpurea* points out that perhaps the concentration of nutrients in the mist may be important. Salix, which is fast rooting and fast growing, may not require high concentrations of nutrients during the entire misting period for maximum benefit.

Plants which produce new growth in the propagating bench and have an adequate supply of nutrients during rooting will grow faster after their removal from the bench. For example, *Philadelphus coronarius* nutrient mist cuttings produced twice as much growth (dry weight) as the water mist cuttings. Others which do not make as much growth during rooting, such as the hardwood cuttings of *Pachysandra terminalis* and *Euonymus fortunei* 'Vegetus' were not beneficially affected by nutrient mist in their growth after removal from the propagating bench.

Summary

Nutrients applied through the mist lines were readily absorbed by both hardwood and softwood cuttings. However, cuttings which were actively growing during rooting, particularly the softwood cuttings, were more favorably influenced by nutrient mist than were slow growing cuttings. Uptake of nutrients from the mist is specific both for the plant and the nutrient, while rooting also varies with the plant. Rooting percentage and root quality were better under nutrient mist with some species, while others were more favorably influenced by water

mist. Those cuttings which show a definite uptake of nutrients and growth while in the propagation bench continue to grow at a faster rate after their removal from the propagation bench than do cuttings which do not receive nutrients.

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MODERATOR HESS: Another technique which has had a tremendous impact upon horticultural industries is the control of plant growth and development by regulation of day length. Dr. Sidney Waxman was among the first to combine the techniques of mist propagation and day length control. He will now tell us about some of the results and implications of this combination.

PHOTOPERIODIC TREATMENT AND ITS INFLUENCE ON ROOTING AND SURVIVAL OF CUTTINGS "LIGHTING UNDER MIST"

SIDNEY WAXMAN

Plant Science Department
University of Connecticut
Storrs, Connecticut

My talk will be confined to the use of light given during the night for the purpose of extending the daylength to which the cuttings are exposed. As you know, many trees and shrubs that are given long days will not become dormant in late summer or fall, as they normally do, but will continue to grow for an extended period of time. This can be accomplished by illuminating the cuttings every night until they have rooted.

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A sufficient amount of light to obtain a photoperiodic response can be obtained by placing 75-watt bulbs with reflectors three feet apart and three feet above the cuttings.

The light intensity should be no lower than 30 footcandles and the temperature no lower than 60 degrees Fahrenheit. The lights do not have to be operated continuously, but may be flashed on for five seconds every five minutes throughout the night.

During a 14 hour night, for example, an accumulation of only 14 minutes of light would be expended by flashlighting intermittently. A discussion on flashlighting was presented during the 1962 meetings and is in the Proceedings for that year.

There are many reasons for lighting cuttings at night and they are still based on the fact that long days delay the onset of dormancy while short days hasten dormancy.

Larger concentrations of substances that promote growth are usually present in plants as a result of long day treatment. whereas larger concentrations of inhibitors of growth are present as a result of short day treatment (3).

The response to photoperiodic treatment is by no means the same with all plants. There are some species that exhibit no response whatsoever, i.e. no obvious response.

The behavior exhibited by the many species that do respond is not necessarily uniform. Some of the most sensitive species will react faster than others that are less sensitive. There will also be differences in response among the same species, because the cuttings are of different stages of growth or because of the environment about the stock plants from which the cuttings were taken.

Photoperiodic treatment should be used for a specific reason and should not be applied indiscriminately. If the rooting and eventual growth of a particular species presents no problem, then there is no reason to use lights. Unfortunately, there are many plants that do present problems not only in rooting but also in eventual survival. By the appropriate control of the photoperiod, (i.e.) by long day or by short day treatment some of these problems can be solved.

For example, timing in taking cuttings of some of the deciduous azaleas is critical. Metcalf (1) reported that *Rhododendron calendulaceum* cuttings rooted poorly if the cuttings were taken after June 22. He found, however, that cuttings taken in July or August and given long photoperiods, while under mist, would have a higher percent of rooting than cuttings receiving natural daylengths. By the use of long day treatment, he was able to extend the period during which cuttings of the flame azalea could be taken and rooted.

Experiments in which *Cornus florida rubra* cuttings were given daylength treatments of 9, 18 and 24 hours while under mist showed that rooting occurred on all cuttings regardless of daylength. There *were* differences, however, in the *size* of the root systems. The average number of roots per cuttings differed considerably; the cuttings subjected to 18 hour days had three times the number of roots as those cuttings subjected to nine hour days and 1½ times as many roots as those given natural days (Table I). In similar experiments, Piringer reported earlier and heavier rooting of holly under long photoperiods (2).

A serious problem in the propagation of some deciduous azaleas, the pink dogwood, *Viburnum carlesi* and others is not only in rooting, but in the overwintering and eventual survival of the rooted cuttings. For various reasons, these plants suffer low rates of survival the first winter. Possible causes of the death of these cuttings may be the result of low carbohydrate level, and/or insufficient hardening of the tissues. As a result, stems may split and buds may blast or wither, depending on the temperatures the cuttings were stored at. Although the exact causes of this problem have yet to be precisely determined, there are some suggestions that may be used to insure a higher rate of survival of these troublesome cuttings. For example, the deterioration or defoliation of the leaves before the cutting has had sufficient time to build up a reserve of stored foods, may be one good reason why these cuttings die during the time they are stored.

Long photoperiods very often will delay defoliation and by doing so, will give the cutting a longer period of time not only to build up a supply of sugars, but also to further increase the size of the root system. The delay of leaf abscission by long photoperiods is all that can be expected for certain plants. With other more sensitive species, long photoperiods will cause the development of new leaves and stems.

Cornus florida cuttings which were rooted in mist, while exposed to 18 and 24 hour photoperiods, produced an additional flush of growth three weeks after they were potted, while the 9 hour and the natural day plants remained dormant. In either of these instances where defoliation is delayed or where additional buds develop the chances for survival are increased. However, because the cuttings are kept green and active for longer periods of time than they normally are, they would have to be subjected to short days, until they have had a chance to harden off. It would be necessary to leave the rooted cuttings in the greenhouse for a longer period of time, under natural daylength to permit them to harden off before they can be overwintered in a cold frame.

Table I. The Effect of Photoperiodic Treatment on the Rooting of *Cornus florida* cuttings.

Photoperiod	Percent Rooting	Avg. Number of Roots/Cutting
9 hours	100	8.5
18 hours	100	25.4
24 hours	100	23.7
Normal Day	100	15.4

Another way to overcome the problem of overwintering these difficult species is to keep them under long photoperiods throughout the entire winter. The plants receiving this treatment will continue to produce new growth, until spring, at which time they should be placed outdoors. This last treatment is expensive because of the greenhouse space required and should of course be done only if there is no other sure way of carrying the plant through the winter.

Summary

Long photoperiods:

1. Keep cuttings in an active state of growth.
2. Can, in some instances, increase the percent rooting.
3. Can, in some instances, increase the size and number of roots developed.
4. Extend the season during which cuttings of deciduous azaleas may be taken.
5. Retain foliage and extend the time during which additional roots may develop and carbohydrates are produced.
6. Can induce a short spurt of vegetative growth with the development of additional buds often necessary for survival the following spring.
7. Can keep plants in active growth throughout the winter after which they may be planted out in the spring; a guarantee of survival.

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3. Waxman, S 1959 The development of Woody plants as affected by photoperiodic treatments Ph D Thesis Cornell University.

MODERATOR HESS: Mist propagation can be looked up as a form of automated syringing. Carrying the concept of automation to an even greater level is Peter Vermeulen who will tell us about his experiences with rooting-growing media.

ROOTING-GROWING MEDIA

J. PETER VERMEULEN

John Vermeulen & Son, Inc.
Neshanic Station, New Jersey 08853

By no stretch of the imagination should I be considered an authority on rooting - growing media. At our nursery we are keenly interested and rather heavily engaged in the commercial aspect of the propagation technique of rooting cuttings in a rooting - growing medium in containers. My comments therefore may be useful to others. This is perhaps what Dr. Hess had in mind when he asked me to participate. Having asked him

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I imagine it safe to say that from the time he stuck his first cutting, man has been concerned with the medium. Through the ensuing years, as he gradually became more sophisticated in his knowledge of the art and craft of plant propagation, there developed a long list of media that have been tried and tested, accepted and rejected and sometimes tried again. Most often mentioned in recent literature are: soil, sand (variously referred to as brick, concrete, plaster, bank, pit, silica, torpedo, etc.), peat-moss (German, Canadian and Michigan), sphagnum moss, sifted ashes, flu ash, fly ash, pumice, sawdust (several kinds), wood shavings, rice hulls, bark dust, water, cinders and more recently the manufactured media, vermiculite, perlite, calcined clay particles and shredded styrofoam. I do not recall where or when but Hans Hess mentioned stored cuttings of *Ilex crenata* 'Helleri' I believe, untreated and with nothing around the basal ends, rooting in sealed polyethylene bags. The literature is replete with various combinations of the mentioned media, either unadulterated, mixed in varying proportions or in alternate layers or both.

I am not familiar with information relating to the first use of a rooting medium as a growing medium but certainly soil must have been. Possibly it was in using the technique or layering, later that of sticking hardwood cuttings and still later softwood cuttings. A look through our own proceeding shows papers on rooting in soil by George P. Blythe (1), Henry Homer Chase (2), Merton Congdon (3), Roger Coggeshall (4), Robert J. Eshelman (5), Leslie Hancock (6), Donald J. Moore (7), F. L. O'Rourke (8) John B. Roller (9), Hugh Steavenson (10), Harvey Templeton (11), Martin Van Hof (12), Phillip W. Worth (13) and Pieter G. Zorg (14).

As the practicality and economic benefits gradually encouraged growing plants in containers it would seem natural that nurserymen would 'discover' the technique of rooting and growing plants in the same medium in a saleable container. In our own society the technique has been discussed by Charles Hess, Sr. in 1955 (15), J. B. Hill (16), Kenneth W. Reisch (17) and Henry Weller (18) in 1957, my self in 1959 and again in 1963 (19) and J. H. Tinga and Charles Hayes, Jr. in 1963 (20).

It is interesting to note the media mentioned in these papers. Hess used equal parts of vermiculite, perlite and styrofoam (15). Hill used "the standard sand-peat mixture", no proportions given (16), Reisch used equal parts soil, peat and sand (17), Weller's comments concerned growing perennials from cuttings to maturity under mist in plastic bags but he did not name the medium used (18), Tinga and Hayes reported a project to test the rooting for very large cuttings in containers and listed 4 mixes consisting of equal parts of: 1. bank sand and German peat, 2. bank sand and Canadian peat, 3. coarse perlite and German peat, and 4. coarse perlite and Canadian peat. They further reported no significant difference in rooting with any of the four. (20). Robert Ticknor in 1960 reported successfully rooting *Rhododendron catawbiense grandiflorum* in plant band and peat pots using a mix of equal parts of sand and sphagnum peat, (21). My paper in 1959 reported using 1 part soil, 1 part peat (German) and 20% by volume of shredded styrofoam; and in 1963 a medium consisting of 53% German peat, 17½% #1 Horticultural perlite, 17½% finely shredded styrofoam, 9% clean fine sharp deep pit sand and 3% soil (19). The latter is now our "standard mix" for all "in container" propagation.

I must comment here on an area of confusion. The perlite we use is purchased from PerAlex of New Jersey, Inc., Paterson, N.J. It is offered in two grades, Horticultural #1 which is coarse and Horticultural #2 which is fine. Technical data in our files on Sponge Rock from Paramount Perlite Co., Paramount, California, indicate seven grades available, No. 000, No. 00, No. 0, No. 1, No. 2, No. 3, and No. 4. Their graduations, however, run opposite to that of PerAlex with #000 grade being the finest or smallest particled and #4 being the largest or most coarse. Particular danger exists here in that reports on propagation and/or growing media using perlite generally mention only the grade number and not the particle diameter. An initial attempt this week to relate the difference in particle size to the grade numbers used, by comparison of furnished typical screen analysis, proved inconclusive since the screen sizes used did not correlate properly. This will be pursued in an attempt to eliminate the confusion and I bring it in here only so that there may be awareness of it.

This past summer we tested two other mixes. One of equal parts of German peat and #2 Horticultural perlite (PerAlex) and one of 2 parts German peat, 1 part sand and 1 part finely shredded styrofoam. The reason for the testing of new mixes is in part because of my belief that soil, even though in small percentage, by reason of its introduction of micro-organisms, contributes to the eventual development of a more effective root system and consequently a better plant. Others in our organization do not particularly hold to this belief and are attempting to prove their point. I must say that the results initially seem to be in their favor. It remains to be seen however how the roots and the plants will develop and we certainly will continue our tests.

Looking through the literature published on rooting media it appears there are sundry media used but that throughout there is a consensus on the particular physical properties a medium must possess. These can be summarized as: 1. that it must hold the cutting in position rather firmly without excessive compaction, 2. it must provide at the same time both sufficient drainage and adequate water retention, and 3. it must provide for a proper oxygen-water relationship. Dr. O. A. Matkin in his recent article in the Plant Propagator presents some very interesting and useful information on the physical properties of propagating media (22).

A prime requisite in the rooting process is the prevention of moisture loss from the cutting until such time as roots are formed and the cutting can provide its own water supply. The water in a medium is of only little value to the cutting since there is insufficient uptake through the stem. In mist propagation this water loss is prevented by artifically supplying a film of water on the leaf surface to prevent water loss from the cells. Surplus water falls down into the medium which dictates that the medium must be well drained. It it were not, the water would displace the oxygen which is necessary to prevent cellular breakdown or rotting. Oxygen is also necessary in the chemical and physiological processes involved in root initiation. Dr. Matkin refers to this drainage requirement of a medium in terms of free porosity, water retention and wet density. He suggests that, in mist propagation, free porosity should not be less than 20%, explaining that free porosity is the air space within the medium after drainage. He further advises that the medium be as deep as possible in order to provide a place for the excess water to settle, thereby permitting the zone of the medium surrounding the cutting an oxygen-water relationship conducive to root initiation. The type of medium used will dictate the depth of the medium according to its free porosity and water retention properties.

Because we are concerned after rooting with growing, attention must be given those physical properties considered ideal in a growing medium. An excellent reference on growing media is "The U. C. System for Producing Healthy Container - Grown Plants" (23). The properties required in a good rooting medium are likewise required in a growing medium. Additionally a growing medium must be capable of receiving added nutrients, retaining them for a sufficient length of time, meanwhile releasing a balanced supply to the plant. Since adding nutrients brings with it a salinity problem the drainage or leaching properties of the medium become doubly important. We have found that an application of Aqua-Gro, a non-ionic organic wetting agent, at the rate of 1 teaspoon to 4 gallons of water, in the initial watering appreciably aids drainage. Another property is that the medium must permit maintenance of a proper pH for optimum rooting and subsequent plant growth.

Economic Considerations

General economics can not be overlooked especially in a commercial application of this technique. It would seem that many of a long list of ingredients can be utilized in creating a practical rooting-growing medium provided the forementioned requirements are met. One of the prime considerations in economics is consistancy, both that of performance and availability. A good program can not be sustained with an ever changing medium. In this regard a sufficient and constant supply is more important in the long run than initial price. S. Challenger

(24) and G. Smith (25) in 1961 both discussed the use of locally procured sawdust in preference to expensively imported peat-moss in work they have done in New Zealand.

Weight of the medium is principally a commercial consideration. If light in weight, more containers can be handled by a given person in a given time with less effort. Also, if light in weight, shipping costs are substantially reduced. However if too light in weight, stability of the container in the growing area may be a problem in nurseries subject to much wind.

Another saving results from the more rapid and uniform growth generally achieved. This tends to reduce or may even eliminate costs of culling and grading. It also enhances the saleability of the crop.

The most appreciable saving however results from labor saved in transplanting and handling. Jack Hill referred some time ago to the phrase "down-time" coined at C. W. Stuart. I will take the liberty of refining or combining the phrase to "up and down time" or since this is the age of alphabetese — UP DOT. With only a bit of imagination one can perceive the huge savings in UPDOT using ROCISECIROGME, which means "Rooting Cuttings in Selling Containers in Rooting - Growing Medium." Seriously, however, I see the desirability of a suitable standard term for this propagation technique and suggest for the consideration of our Glossary Committee the terms ROO TICON meaning "rooted in containers", SEEDICON meaning "seeded in containers" and PROPICON to cover all phases of propagation in containers.

Next year we are going to try a system whereby we will be taking the mist to the cutting — a portable mist system so that we can bring our filled containers to the greenhouse bench or growing area, insert the cuttings, apply the mist, remove it when ready and then watch them grow. With Jack Hill's "Black Box", no UPDOT and using PROPICON we should soon catch up with PHYTOTEKTOR — and retire.

Containers

The present media available, properly used, permit rooting in almost any container, provided there is adequate drainage. About the only limiting factor I see concerns the type of roots produced by the item being rooted. Some plants tend to send the roots out of the container through any opening of appreciable size or through the walls of the peat pots to the extent that they must be later cut apart. To contain these roots and still stay with the peat pot we have successfully use the POLY-SKIN pot which is a thin walled peat pot with a skin or covering of thin polyethylene. Unfortunately they are no longer available. Plastic pots of many grades and sizes are economically available and are quite satisfactory. For lining-out stock that has to be shipped they do present a bit of a problem in packing and they do require labor to remove the pot before planting. The PULLEN Hard Pot was tried this summer with success but it too must be removed prior to planting. For lining-out stock that must be shipped we would like to see the POLY-SKIN pot back on the market. Better yet, what we really need is a peat-moss or similar pot so treated that root penetration will be prohibited for a chosen period of time after which the pot will deteriorate to permit root penetration and development. I do not believe this to be outside the realm of possibility considering all the other technological advances we have experience in recent years. This may be considered a challenge to the pot industry.

Materials Propagated

Time does not permit a detailed list of materials propagated using PROPICON. A quick mention, however, will tend to substantiate the practicality of it. While we are not rushing pell-mell into it, we are convinced that before too long a rather large percentage of our rooting will be directly in containers. This past summer we handled a little over 29,000 in this manner with percentages ranging from 0% to 100%. The 0% was on some Flowering Crabapple that were hard when stuck. Several cultivars rooted practically 100% however. In general, percentages centered around 85% to 100%. I realize that mentioning a 100% strike in this Society raises some eyebrows but I will stand behind the claim. Successfully rooted were the following: *Acer palmatum,* 5 cultivars; Deciduous Azaleas, 31 culivars of Exbury, Ghent, Knaphill, Mollis and Slocock hybrids; Evergreen Azaleas. 5 cultivars; *Cotoneaster horizontalis* and *adpressa praecox; Cornus florida plena* and *rubra* and *kousa chinensis; Franklinia alatamaha, Ilex crenta* 'Glory' and 'Green Thumb'; *Ilex glabra compacta; Ilex opaca pyramidalis* ('Brilliantissima'); *Juniperus chin.* 'Armstrong', Nick's Compacta' and *pfitzeriana* (only 40%); *Juniperus hor. plumosa, chin. glauca* 'Hetz' and 'Kallay Compact'; *Magnolia,* 6 cultivars; *Prunus serrulata,* 3 cultivars; *Pyracantha,* 4 cultivars; *Rhododendron catawbiense* hybrids, 20 cultivars; *Cotinus cogg.* 'Royal Purple', and *Ginkgo biloba,* male selection.

Nutrient Mist

Dr. Hess asked me to include some work we had done with nutrient mist. In preparing this paper I have not had the opportunity to review that of Mr. Wott but do not feel there is any danger of repetition since our experience has been limited.

In 1964 during our summer mist propagation outdoors we introduced nutrient mist to our rooting cuttings. We used three mist beds, each 800 square feet and each with separate misting lines but we had only one proportioner. We therefore alternated the application so that each bed received nutrient mist every third day and regular mist the other two days. The nutrient used was Peter's soluble 20-20-20. Mist was controlled by clocks and the interval was adjusted according to the variables in weather. The average setting was one minute of mist every four minutes from approximately 8 a.m. to 8 p.m. Nozzles used were the Flora-Mist with .020 orifice, spaced 30 inches apart, 120 nozzles per bed. At 25 lbs psi each nozzle delivered 3 gallons of water per hour, each bed receiving a total of 108 gallons per day. The average crop remained in the bed 45 days so received a total of 1,500 gallons (108 being rounded out to 100 to compensate for drift and other factors and the bed receiving mist only every third day). At 4 oz. per 100 gallons each crop of approximately 17,500 cuttings received about 4 lbs. of nutrient.

We are not just sure what we achieved. From all appearances we had real healthy rooted cuttings. Foliage was retained well into fall after hardening off. *Prunus kwanzan, Acer palmatum* cultivars and *Cotinus cogg.* 'Royal Purple' exhibited new growth that we had not experience before. An unsatisfactory result was that plants were not sufficiently hardened off and when we experienced a temperature of 18 degrees the first week of October many were split. Those that survived however came through and broke dormancy very well this spring. I should say plants were stored in a polyethylene covered deep frame, unheated. This year the frame is heated. Also this year, because of several reasons, we did not use nutrient mist. Since our results on everything were as good or better than that of 1964, we can't really say at this point that nutrient mist gave us any appreciable immediate benefit. We will, next year, run additional carefully controlled tests and will have some sort of a report at a future date.

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MIST SYMPOSIUM

DISCUSSION

DR. HESS: Jim, at what time do you start the hardening off process?

JIM WELLS: It's impossible to answer precisely; this is where common sense comes into the picture. I do believe that most cuttings are improved by a gradual reduction in misting as rooting develops. I think that you need to have a small bunch of roots on the bottom of the cuttings, 6-10 roots possibly, an inch or more in length beginning to become attached to the rooting medium. That is the cutting is beginning to establish itself again as an individual. About this time I think that a modest reduction in mist application is adopted. And this [reduction] needs to be slowly increased in amount as the plant develops over a period of 2 or 3 weeks.

Now the difficulty in doing this lies particularly with the type of control such as a timer. It requires an on the spot interpretation of conditions by someone and this is almost impossible. Here is a real value of the electronic leaf control. One of the simple, very nice things which I think the control from England has is the sensing unit which has 2 carbon electrodes imbedded in a block of plastic. The sensing unit can be placed in any position in the bed in relation to the misting head. This provides an infinite variety of positions available to you in relation to the mist coming from the jet and landing on the sensing unit. I don't think there's any hard and fast answer to your question, Charley. I think the plant has to become essentially established on its own roots and then it requires a gradual tapering off.

MERTON CONGDON: I don't think I have anything to add to what Jim Wells has said, but in our operation we go by the general appearance and condition of the cutting as we reduce the mist. We have not found under our open air mist propagation that the reduction of mist in the hardening off process has been any problem.

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DR. HESS: How do you handle cuttings which have different rates of rooting?

MERTON CONGDON: This is taken into consideration in planting the beds.

PETE VERMEULEN: In our case we handle this by dividing the bed into segments in which the mist is put on at different rates. We can move the cuttings from one section of the beds to another. This is predicated on the fact that the cuttings are stuck in flats or pots and so they therefore can be moved.

HARVEY TEMPLETON: We control all of our mist beds from one electronic leaf and we harden the cuttings off by using a series of timers. The first step would be a little bit before Jim recommends it. That is before all the cuttings are quite rooted. We don't want to wait too long because cuttings deteriorate very rapidly under mist once they have roots on them. The quicker you harden them off the better. The first step is to change one electrical connection on each bed and switch it over to a time circuit, which is one minute of mist every 15 minutes limited to the daylight hours. In the summertime this is from about 7:30 in the morning to about 5:00 in the afternoon. Now that may be surprising but the fact is that as the temperature cools off in the afternoon, cuttings just won't need much mist; just cut it off a whole lot earlier than you think you can. Then after placing them under that regime for 3, 4, or 5 days, we shift them over to another control circuit giving one minute of mist every 30 minutes limited to an even shorter interval in the middle of the day and eventually they are shifted over to one minute of mist every hour. And then the mist is cut off entirely. We now do this by the book based on our experience with the cuttings in previous years.

JAMES WELLS: I would just like to add something to what Harvey said about records. This may seem far removed from misting but it isn't. The important thing that I would urge you to do is to take clear records so that you can recreate in your mind, 5 years from now if you want, exactly what you were doing five years back. We have run into a lot of problems in rooting rhododendrons from time to time and this last summer I decided to throw out everything we had been doing and go right back to where we were 7 years ago. I went back to my records, found out what we were doing, duplicated exactly what we did, and we got beautiful results this year. I don't know whether that says very much for the last 7 years, but it does say something for records.

HANS HESS: I would like to make just this comment about how we harden off our cuttings. All cuttings are in boxes. When they're at the point where 75% have initiated roots, we pick them up from the mist which is in full sunlight and put them in a storage frame with sash and shade on them and with 2 hand syringing a day we can harden them off without any loss whatever.

DR. HESS: This question is directed to Harvey. You said that you did not use your electronic leaf for hardening off.

HARVEY TEMPLETON: Yes, that's right because in principle you couldn't possibly harden a cutting with an electronic leaf because it's designed to keep the leaves wet at all times. Now of course Jim's McPinney Weaner unit is a very good deal. I should dream one up and use it in place of my timers. The only reason I haven't done it is that all our records are based on the use of the timer and I don't want to start all over again using the Weaner.

DR. NELSON: We have never used hardening off at all. We transplant right into the field or seed beds and particularly in the field we got good results as long as we could put sprinkler irrigation on for 5 minutes 3 or 4 times a day. This doesn't even wet the ground; it just keeps the foliage wet a bit. We did this at Ottawa.

DR. WAXMAN: I didn't hear anyone mention the light operated interval switch. It has a control on it with which you can regulate the amount of mist applied. In this way you can very easily reduce the amount of mist during the hardening off period.

MARTIN VAN HOF: The way we do it is this: we shut off every other fog nozzle, we keep the time the way it is and that's all there is to it.

LEONARD SAVELLA: I would like to ask Sid Waxman if there was any difference in growth in the field of the pink dogwood which was rooted under lights as compared with natural day length.

DR. WAXMAN: In this particular group they were kept indoors and lighted and were not put out in the field. But I do have data on a group that was rooted under lights, kept in a greenhouse for a year, and then planted in the field and growth was fine. We have had cases, however, where there has been a delay of growth. If you light them until spring and put them in the field, you will get a delay of growth. If you light them to say November or December, turn the lights off and put them through a cold period and then they will grow normally.

DR. SNYDER: Dr. Mahlstede called to my attention an omission I made in my paper. I did not recognize the tremendous effort made by the field trials committee and many members of this organization on mist trials and the reports that were presented. This occurred in, I think, 1955 or 1956.

JIM WELLS: I would like to ask Sid Waxman a question. I was a little confused with the slides this morning. I would like it very much if he would run through what the light did and of what advantage it was to the cuttings.

DR. WAXMAN: The cuttings that were taken early in June are no problem — they root quite well. But once you get beyond June and into July only those cuttings that were lighted formed a decent number of roots.

JIM WELLS: The lighting of the cuttings in July enabled the leaves to be retained longer than on cuttings that were not lighted. It that right?

DR. WAXMAN: That's right. There were no additional growth but the leaves were retained.

PETER VERMEULEN: Was there not a paper on the use of lighting on deciduous azaleas given at the Western Region meetings last year?

BRUCE BRIGGS: Yes, the experiment station at Victoria has worked with Bill Goddard for over two years. The work that they have done has shown a much increased growth response with the use of lights but after the second year they didn't give that tremendous surge of growth with lights. Another thing I'd like to mention is in regard to the early and late cutting. For example, Exbury azaleas taken early root very well, but taken later in the summer they root poorer. With an increase in fluorescent light you help the rooting. But at the same time you can take azaleas that have been put in the greenhouse and stimulated to grow and you can take your cuttings even late on towards the summer and they'll root tremendously fast and retain their foliage and be equal to the cuttings taken in early spring. So there again you have a condition maybe of food, of co-factors, maybe condition of tissue, maybe it's a lot of factors involved.

DR. HESS: Bruce, were the plants in Goddard's experiments given a cold exposure between the first and second years?

BRUCE BRIGGS: No, he kept them growing year round; no rest period at all. He kept the temperature up at 60 or 55° F. because below those temperatures there is absolutely no influence of light.

HARVEY GRAY: A further comment on this and I direct my remarks to Sid. This is in regard to seedlings of Naphill azaleas rather than to cuttings. The seed was sown on the first of January and these plants were brought along rather rapidly without any additional light until the 20th of June when the day length begins to shorten by 2 minutes each day or whatever that happens to be. Now we followed this along in the greenhouse and were careful not to let the temperature drop below 60° F. The lights were carried on a continuous basis rather than intermittently or by a flashing system to bring the light up to a period of 18 hours. However, the control plants that were away from this particular exposure were equal some 3 months later to those which received the light. Now I would like to ask Sid, how you explain that?

DR. WAXMAN: Well, to go back to my talk, there are some plants that respond to photoperiod and others that do not. I have never worked with Naphill azaleas so I can't tell for sure. But if it was a plant that didn't respond to photoperiod, then there would be no difference between the treatment and the control.

DR. HESS: Sid, do you feel that the azaleas should be given a rest period or can you bypass this with long days?

DR. WAXMAN: You can bypass the rest period but you end up with a leggy plant. It's far better to get a certain amount of growth and be content with that, turn off the lights, let them get dormant naturally on short days, give them a cold period and then you get a better plant. You'll have more buds breaking all around. If you keep the plants under long days continuously, you will find the terminals growing but not the lower lateral buds.

VOICE: Is there any difference between incandescent, fluorescent, or mercury vapor lamps?

DR. WAXMAN: I have never worked with mercury vapor but I do not see why it should not be just as good. It seems to be more efficient than the incandescent lamp. It has a higher intensity and the wave lengths are similar to the fluorescent lamps.

GEORGE GOOD: I would like to ask Dr. Waxman what is the effect of long photoperiods on the hardening off of the cuttings.

DR. WAXMAN: Anyone who is ready to use long days on his cuttings must also be prepared to protect these cuttings after they are rooted. You have a time lag before you can subject the cuttings to low temperatures. If you have a plant in long days and suddenly give it short days, it may keep growing for about three weeks. Then you need some more time under short days to harden off the plant. So if you use long days you must be prepared to protect the cuttings from freezing weather for a longer period of time than they ordinarily would if they didn't light the plants.

E. STROOMBEEK: I would like to mention something about leaching under mist. For two years I have been following the practice of spraying the mist bed twice a week with fertilizer, about a tablespoon to the gallon, and there was less chlorosis on evergreen azaleas and cottoneaster cuttings as compared to unsprayed cuttings.

PETER VERMEULEN: The problem of light on reducing hardiness also raises one on nutrient mist as I think was borne out in my discussion this morning when we had difficulty with a rather severe frost. Have others had similar problems?

JOHN WOTT: We have not had experience in this area as the cuttings were kept in the greenhouse over the winter under natural photoperiod after being removed from the mist.

DR. HESS: Have you encountered any problem of algae growth under nutrient mist?

JOHN WOTT: This has been a problem that we have encountered. The algae appears to like the nutrient mist as much as the cuttings appear to like it. Therefore, the algae appears much faster and grows better under nutrient mist. We have not experimented with any controls for the algae as yet.

PETER VERMEULEN: That was indoors. Outside with higher light intensity, we had less algae.

JOHN WOTT: This could be; we haven't done this.

VOICE: In relation to hardening off has anyone used some of the B-9 or Phosphon materials? We harden them off with the growth retardants before moving them out into the cold. I was wondering if a lower application of these growth inhibitors wouldn't help alter the carbohydrate-nitrogen relationship and harden the plants off pretty well.

DR. HESS: We'll have a paper on the effects of growth retardants and hardiness from Dr. Conrad Weiser.

JIM WELLS: I'd like to make a brief comment on that. We've tried two or three of these chemicals on rhododendrons and then having done so just filed the information away. In relation to this hardening off, we grow a variety called *Roseum superbum* which is a very vigorous growing variety, completely hardy in our area but it does have a tendency to make a late growth in September. If we apply a dose of either CCC or B-9 in early June when the first flush of growth is being made on the plant it will stop it making the third flush of growth in September. The plant makes two perfectly normal flushes of growth and then stops. You have to be critical, of course, as to the concentration, but it doesn't apparently effect the plant in any other way except stop that late growth.

BRUCE BRIGGS: A comment that I'd like to make in regards to some research done in Western Washington Experiment Station. They have done some research on rooting of blueberries. They studied the effects of fertilizer upon rooting. He found that a dry application in the rooting mix of a basic fertilizer was of much advantage in final output of your rooted cuttings. It didn't help the percentage that rooted but it did help the final results and the plants were larger, uniform and the leaflets did not die.

DR. HESS: Pete, have you considered the incorporation of a fertilizer in your rooting-growing medium?

PETE VERMEULEN: I wouldn't say we haven't considered it, we have considered it, but we haven't looked too favorably upon it. Several years ago we tried to incorporate nutrients into the media at rooting but not in relation to rooting in containers. We found no appreciable value from it; we did after rooting do some fertilization on cuttings, and we did get some appreciable benefit. The question was raised this morning as to whether or not these new slow-release fertilizers would have some benefit. We haven't used them in the "PROPICON", but we have used them in growing established plants in containers and we've had some rather disastrous results from it when we used them in the greenhouse. Outdoors we have had very good results. Apparently when we use them in the greenhouse we had a much more rapid breakdown of the fertilizers than is normal under outside temperatures. Therefore we had a high nitrogen buildups which was detrimental to the roots and actually killed them. Other than that I haven't any other comments.

DR. SNYDER: A great deal of florist crops are propagated in peat pots in the mediums in which the plant is growing. They commonly use 1/3 peat and 1/3 perlite and 1/3 soil to which is added certain of the mineral materials. In other words they use for propagation the same rooting medium including some fertilizers as they use in the final potting up of the materials. They do not add any additional fertilizer, though, until they have been potted up or panned and are growing along. So with florists crops they do incorporate some fertilizer in the "PROPI-CON."

DR. HESS: Just a kind of a summary statement here. So far the application of nutrients in mist has not accelerated root initiation for most plants. The question is then, what happens to the subsequent growth of the cuttings after they have rooted. Here positive results have been obtained in that those cuttings which have been fed seem to take off better. But as far as initiation per se, I haven't seen any consistent, real clear-cut evidence that the process has been accelerated by the use of nutrients. As John pointed out, it is a question now of when to apply nutrients during the rooting period.

Now let's turn to another area, that of light intensity. I mentioned that you can use higher intensities under mist under outdoor propagating conditions. Should full light intensity be used or should there be a light shading? Harvey, what are your opinions on this subject?

HARVEY TEMPLETON: When we started off years and years ago with a humidistat and timer control, the control was very, very poor. So we felt that we had to shade the cuttings. We used 46% saran shade. That worked all right but after we got our better control, we concluded that they didn't have enough light because with certain plants we would get fungi in the bed. Now my experience is that you can correct that problem completely by giving the plants more light. So we took all the shade off the plants and grew them under just one sheet of 2 mil. polyethylene. And that eliminated the trouble.

Now we still use shade on some plants. My guess is that with the exception of a few plants like this dwarf cypress and male *Ginkgo* and a few others, we would be better off with a higher light intensity. No shade at all or at least very little.

HANS HESS: We started out by using about 50% shade and we thought this was quite the thing. In the fall we took the Saran off and one season we were short on time, so we planned to put the Saran on later and we never did put it on. We found out that we had better success with the full light as Harvey brought out. We have no shade whatsoever until we harden the cuttings off then we shade them as I mentioned before.

JAMES WELLS: I'd just like to comment on the use of this Saran material. We are convinced that there is a real difference in the quality of shade. When you apply shade through a Saran cloth it seems to me you are reducing the total light intensity by about 50% depending on the mesh that you use. Now when you use a lath shade, you are applying bars of shade which is quite intense and between each bar of shade there is of course an equally intense bar of direct light. This bar of direct light is moving across the plants quite rapidly. We have not measured it, but we have observed it closely and it is in fact moving across the plant. I think that if it moves across fast enough so that the plant material does not heat up before shade appears again from the next bar of shade we are having sufficient light intensity to stimulate the plant to continue normal photosynthesis. I believe that there is a real difference in the system you use to apply shade.

DR. HESS: What about heating cables under mist conditions?

PETE VERMEULEN: I would like to mention first that there are a number of different types of saran and we use one that gives about 20% shade.

BOB BODDY: We grow a considerable number of plants under in Southern California. In the last two years we switched from wooden lath to saran shade. I don't know the exact effect of this on plants, but I've noticed an effect on people — under the wooden lath in the summer time, it's quite cool and very pleasant, under the saran shade in the summer time it is uncomfortable and it's hot. Also we found dust accumulates on the saran and you have a very close feeling. In the winter time under wooden lath at night time when we have frost it will be warmer under the wood lath and it will be colder under the saran. This is the effect on people. The plants seem to do equally well under both conditions, but I do believe that it gets hotter under the saran in the summer time when we are trying to keep it cool.

DR. HESS: I believe a light shade, no more than 20%, will allow sufficient light through for photosynthesis and at the same time reduce the amount of mist that has to be applied. Reducing the amount of mist reduces leaching and drainage problems associated with large amount of mist. Also, the shade will help contain the mist when it is on and reduce uneven distribution because of wind from any one direction.

HARVEY TEMPLETON: In regard to the question of whether plants will grow better under full sunlight or saran screen, I just remembered an experience I had about five years ago. I built a semi-circular quonset type shade house, 108 feet long and about 14 feet wide. We filled it in early summer with plants in polyethylene plastic bands. We were trying it out so we used all the plants we had, a few hundred of each. We started with all of the plants under saran which gave 46% shade. When it came to about July, I had the good sense to wonder if these plants would grow in the full sun or not. In order to see what the effect of full sun would be, we took off every other 10 foot section. Sixty days later you could stand at one end of the house, look down it, and see just a series of stair steps. In every case the growth was better under the full sun as compared to the shade. Now that's in Tennessee in the middle of the summer.

DR. WAXMAN: I recall some work Bill Snyder and I did with the rooting and growth of Taxus that were rooted under shade, lath, and full sunlight. It was not so much on rooting as on the survival and growth.

DR. SNYDER: That goes back quite a long time. The cuttings were rooted and then brought out in the full sun or high light intensity and low light intensity. The plant material under the shade for the first two years had higher survival and were larger plants. That carried through to the fifth year out in the field. One other point I would like to make. There are a number of plants that are known to do better in the shade or very poorly in full sunlight. Many tropical foliage plants, e.g., cocoa and *Hevea,* have rooted better with the light intensity reduced up to 50%. I think plants which do not grow well under full sunlight will do best if shaded while under mist.

HARVEY TEMPLETON: In my opinion and what I can read, most plants — not shade plants now — but field crops and so forth grow best with at least as much sunlight as they get in central United States. This compares with a set of figures that show that alfalfa in England grows best at 250% of available light in the summer.

DR. WAXMAN: Tomorrow I will discuss our experience with blueberry cuttings propagated under a range of light intensity.

DR. HESS: Let us go back to the question of bottom heat and mist, Pete.

PETER VERMEULEN: We have had some experience with heating cables. In our area in North - Central New Jersey we get some periods during the middle of the summer when we have some relatively low temperatures and the medium temperature drops below the optimum of 65 - 70° F. Therefore, we tried some heating cables. These experiments were on jumper varieties with the heating cable 6 inches below the top of the medium. We had exceptionally good results. The following year we put heating cables under the entire frame and extended the range of plant material tested. We feel, very frankly, that we can not get optimum rooting unless we maintain the medium temperature at 65 - 70° F. There is also a side benefit from using the heating cables for propagation. That is by using the same frames for winter storage — we close the frame and cover it with polyethylene and turn on the heating cables. We pot our cuttings and put them back in the frames. We actually get a very low air temperature which is good for plant establishment while the medium temperature is warm enough for good root development.

THURSDAY AFTERNOON SESSION

December 9, 1965

The afternoon session convened at 1:00 p.m. A question and answer session led by the mist symposium panel was held at the beginning of the afternoon session. The discussion is included in the Thursday Morning Session of the Proceedings. At the conclusion of the mist symposium discussion, Vice President Peter Vermeulen introduced Mr. David G. Leach who served as moderator for the balance of the afternoon session.

MODERATOR LEACH: We have three talks this afternoon with five minutes for questions after each talk. Our first speaker this afternoon is Dr. C. J. Weiser from the University of Minnesota. Dr. Weiser is a plant physiologist who specializes in problems of plant hardiness and as we all know he comes from about as tough a section of the country as anyone in this Society.

PRINCIPLES OF HARDINESS AND SURVIVAL AS THEY RELATE TO NEWLY PROPAGATED PLANTS[1,2]

CONRAD J. WEISER
Horticultural Science Department
University of Minnesota
St. Paul 1, Minnesota

Plant survival at low temperatures has been a vexing problem since man first gathered the fruits of the fields to provide sustenance for himself. Today a nurseryman in the Great Plains or an orange grower in Florida would both agree that low temperature injury is a most serious problem. In fact on much of the earth's surface low temperature is the single most limiting factor to plant growth and survival.

In the discussion to follow, we will attempt to provide a basis for the panel discussion to follow. I will emphasize research at the University of Minnesota, not because it is necessarily the best but because time is limiting and it is most familiar to me.

There are a number of factors which complicate the study of plant hardiness. Winter damage can be caused by several different environmental stresses. For example, desiccation, early fall or late spring frosts, rapid temperature changes, and extreme low temperatures in midwinter can cause damage either individually or in combination. It is obviously necessary to establish what type of stress is causing injury before you can intelligently cope with it. Unfortunately the cause of injury may be quite different in different years or in different parts of the same plant.

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[1]Scientific Journal, Series Paper number 5860 of the Minnesota Agricultural Experiment Station
[2]The author expresses his gratitude to Bailey Nurseries, Newport, Minnesota for cooperation on some of the studies reported here and to the Louis W and Maud Hill Family Foundation for support of the research

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Newly propagated stock is frequently not well established, not in the best nutritional status, often has limited food reserves and probably has recently been subjected to an abrupt change of environment. It's easy to see why not many researchers have been willing to add these additional variables to a problem which already has too many intangibles.

To complicate matters even further, we still don't know the answer to the two basic questions: How does freezing kill plants? and, How do some plants acclimate to resist freezing injury? Attempts to find practical means of reducing injury or increase a plant's cold resistance are often frustrated for lack of the basic knowledge.

To contribute something positive to the discussion, let's consider what *is* known. Ice crystals in the plant are the factor which kills cells. Ice within a cell (intracellular) is invariably lethal while ice between cells (extracellular) may or may not cause death.

If a hardy plant is exposed to gradually lowering temperatures the first ice forms between the cells where water is purest. As the temperature continues to decline, water moves out of the cell to extracellular ice nuclei and the cell sap becomes increasingly more concentrated with a lower freezing point and less water available to freeze. Most hardy plants survive this type of freezing, probably by avoiding intracellular ice formation. It has also been observed that the permeability of the cell membrane to water increases as plants harden. This may be one facet of the cold acclimation process.

If a hardy plant is exposed to rapidly decreasing temperature over the freezing range, however, injury frequently occurs. In such a case it is thought that water cannot move out of the cell fast enough to keep pace with declining temperature. When this happens, the cell contents supercool and then suddenly freeze intracellularly, causing death. This was illustrated by a study on American arborvitae (1) which would resist -125° F. when freezing was slow (9° F per hour) but which were killed at 15° F. when freezing was fast (18° F. per minute). Rates of this magnitude were measured on arborvitae foliage outside in winter when the sun's radiation was suddenly interrupted by shading from a building or some other obstruction.

If small pieces of living tissue are cooled extremely fast by plunging them into liquid nitrogen at -320° F., water in the cells may be converted into a solid vitrified state with no injurious ice crystals. There are cases where plant tissues have survived such treatment when they were warmed rapidly enough to avoid ice crystallization during warming. This observation substantiates the statement that ice crystals and not low temperature are the cause of damage.

There are several hypotheses about the destructive action of ice crystal formation. Some of the more frequently mentioned ideas include: A) A mechanical hypothesis considers that crystals puncture cell membranes or in some way disrupt cell continuity. B) A second hypothesis is that the removal of water from cells to ice crystals concentrates the salts in the cells to such an extent that proteins are irreversibly salted out and denatured. C) Levitt (2) has suggested that freezing injury is due to the formation of disulfide linkages between adjacent proteins when they come too close together due to water removal to ice crystals. D) Heber (3) has hypothesized that certain proteins need a water shell around them to maintain continuity. Death of cells results when freezing of water removes this water shell. At present, the first and fourth hypotheses seem the most reasonable.

How do plants develop resistance to freezing injury and what can we do culturally to protect them? These questions would be easier to answer if we knew which of the hypotheses of injury, if any, are correct.

Considering the first question, there are some ways in which cells could theoretically escape injury by avoiding freezing especially of the intracellular type. 1) High solute concentrations in the cell might give a freezing point depression just as a salt added to water lowers its freezing point. However, this usually can account for only a few degrees of protection. 2) Some insects are known to produce antifreeze substances such as glycerol and certain alcohols. But in plants, appreciable quantities have not been found. 3) Increases in water binding chemicals such as hydrophillic proteins may reduce the amount of free water available for freezing. Numerous workers have found that protein increases with cold resistance and we have recently verified this in red-osier dogwood (4). 4) Supercooling has been considered by some to be a means by which plants effectively avoid ice crystallization. Our studies usually indicate only a few degrees of supercooling however. Further, supercooling may be dangerous to a cell in that when crystallization finally occurs, it is very rapid and violent and is more likely to be intracellular. However, the cell membrane is a barrier to ice crystals and the possibility exists that the cell contents may supercool considerably even in the presence of extracellular ice. 5) Increases in membrane permeability to water have been observed during hardening and could enable plants to avoid intracellular ice by rapidly moving water out of the cell to extracell lular ice.

In this regard recent work by Kuiper (5) has indicated that decenylsuccinic acid, when taken up plant roots, increases the water permeability of the membranes six-fold. He also reports an increase in cold resistance of bean leaves and pear blossoms of as much as 10° - 12° F. after treatment. In nature an increased unsaturation of plant lipids during hardening has been observed in some plants including red-osier dogwood (6) which could account for increased water permeability of membranes.

In addition to escaping intracellular ice, there are some ideas about how plants may resist injury from extracellular ice. 1) It has been observed that hardened plants have a more elastic protoplasm than their non-hardened counterparts. This greater elasticity may allow the protoplasm to resist breaking and other mechanical disruption during frost plasmolysis or extreme dehydration. No one knows what makes the protoplasm more elastic. 2) Perhaps the most commonly observed chemical change in hardening plants is an increase in sugar and a decrease in starch. Heber (4), Sakai (7), Tumanov (8) and others have found that sugars can exert a considerable protective action against freezing. Heber thinks the sugars can substitute for water molecules as the protective shell around sensitive proteins by virtue of their -OH groups. Salts reversed the protective effects of sugars and other polyhydroxy compounds.

As introduction to the question of cultural means of increasing a plant's hardiness, we should first consider the phenomenon of natural acclimation. Figure 1 shows the seasonal cold resistance of the living bark of one year old red-osier dogwood twigs.

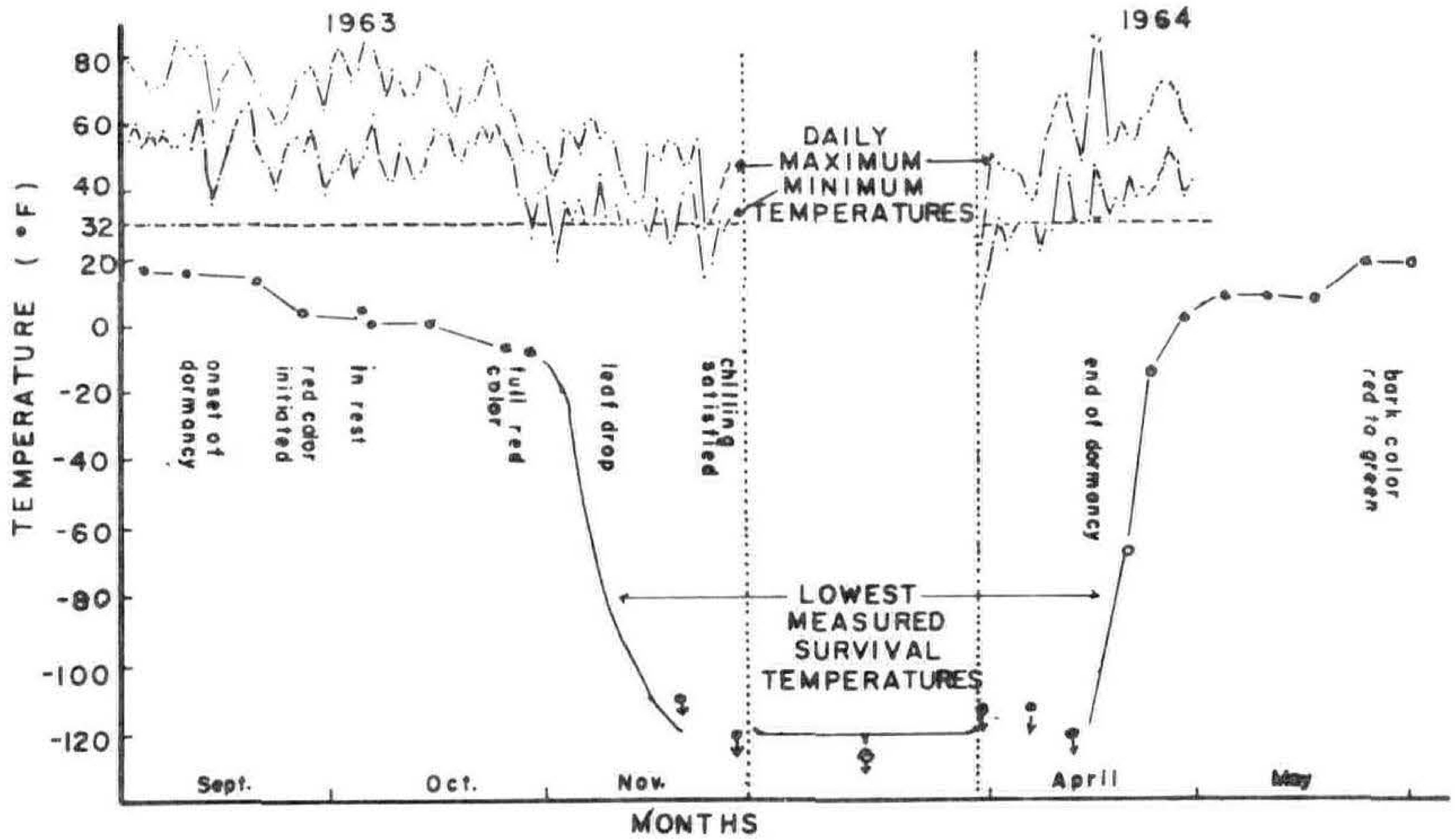

Figure 1. Seasonal changes in the cold hardiness of red-osier dogwood bark and other phenological changes ♀ indicates that the bark was not injured at the lowest test temperature.

The hardiness in this study was determined by exposing excised stem sections six inches long to a series of low temperatures in thermos bottles in a deep freeze (4). Thermocouples were used to measure the tissue temperatures which was gradually lowered at a rate not exceeding 9° F. per hour. After freezing, injury was determined by visual examination of bark correlated with regrowth ability and tetrazolium tests.

Cold acclimation occurred in two stages in the autumn. The first stage of hardening (to about 0° F.) occurred before any frosts in the fall. The second, and more dramatic stage occurred immediately after the first fall frosts and reached an undetermined level somewhere below-120° F. Hardiness was lost in the spring at the time growth started. This same pattern has been observed several years on American arborvitae as well as dogwood.

In trials to artificially cold acclimate dogwood plants in controlled environment chambers, we found it necessary to *first* expose them to short days and then freezing temperatures. The short day treatment induced rest period and in some way preconditioned the plants so they were capable of acclimating rapidly when exposed to freezing. Frost was necessary for maximum acclimation. For example, 35° F. following short days did not induce any cold resistance. Also short days or freezing temperatures alone did not induce any acclimation, nor did a simultaneous short day and freezing treatment. It would be very useful to understand the nature of the short day induction response and the triggering mechanism of freezing temperature. A number of people are studying this and perhaps someday someone will be able to artificially induce cold acclimation.

The relationship of rest period, dormancy, and cold resistance is worth considering because of its practical cultural implications. Although the relationships are not fully understood, it is evident in the woody plants we have studied that: 1) Cold acclimation in the autumn begins at the time growth ceases due to short day rest induction. 2) Cold resistance is undiminished during the winter even after the chilling requirement for breaking rest has been satisfied. Arborvitae (1) and raspberry (9) maintained hardiness even when exposed to unseasonable dehardening conditions after rest was ended. 3) Cold resistance disappears with the beginning of spring growth. In summary, dormancy seems to be necessary for acclimation. Rest period may play a role in the induction of cold acclimation but does not appear to be absolutely essential for maintaining maximum cold resistance during the winter.

A great number of physiological changes occur during cold acclimation which may or may not be causally related to the process. In dogwood we have noted a decrease in starch and an increase in soluble carbohydrates (mainly raffinose) (10); a sharp increase in malic acid at the time of acclimation; an increase in proteins and polar amino acids in proteins (4); increased unsaturation of some lipid components (6); an increase in organic phosphorous and a decrease in inorganic phosphorous and an increase in ribonucleic acid. At this time it is difficult to say which if any of these changes bear a causal relationship to cold hardening. Perhaps the most likely relationship is between increase in sugars and hardening.

On the basis of this rather confusing background, let's go back to the beginning and see what possibilities there may be for increasing the survival of newly propagated plants.

The first step is to correctly diagnose the problem. In many respects, this is a most difficult step. We spent two years establishing that winter burn on arborvitae was commonly due to rapid temperature changes in Minnesota instead of desiccation. The third year we designed a shading experiment to eliminate rapid temperature change and most of the plants in the trial sustained cambium damage from what we believe to be an early fall frost instead.

Some species have certain organs or tissues which are especially subject to injury. The susceptibility of flower buds of forsythia and apricots is well known. Pellett (11) found that winter damage on some usually hardy junipers was due to root killing when they were grown in containers. In Minnesota, we have some strong reservations about the widespread use of Malling roots for apples because of their limited hardiness.

Recognizing the inherent limitations of the species, there are a number of factors we can influence to enhance prospects of survival:

Well established plants have a better chance of survival than newly rooted cuttings or seedlings which are undergoing transplanting shock and other stresses in addition to those imposed by winter. Proper timing of propagation, transplanting, and hardening off can overcome many of these difficulties.

Mineral nutrition has been shown to influence hardiness in some instances. In contianer grown arborvitae and juniper, Coultas (12) recently found that high levels of nitrogen increased injury while high levels of potassium generally reduced injury. This substantiates much earlier work. More unusual, however, was his observation that high phosphorous levels also predisposed plants to high injury. This is not generally recognized but may be a problem in intensive nursery culture where nutrients are maintained at a high level for maximum growth.

The reason that high K and P tend to decrease and increase winter damage respectively is not known. High N promotes vegetative development which does two things that may increase injury. Late autumn growth may delay hardening (13). This is especially true in plants which do not go into rest period early in response to shortening day length. Smithberg (14) found in red-osier dogwood that native clones collected at southern latitudes went into rest later than northern collections. All 35 clones in her study ultimately reached a high level of cold resistance (below -125° F.) by mid-winter but southern and maritime collections which grew late in the fall were already injured. Many of our choice ornamental and fruit plants are being grown north of their natural range and are subject to the same type of problem.

The second deleterious effect of nitrogen induced growth is the depletion of the carbohydrate reserves of the plant. If sugars have a direct protective action on cold sensitive proteins as suggested by Heber (3) this could reduce the plants capacity to harden.

In summary, the production of maximum growth by high levels of N and P fertility are sometimes not compatible with maximum cold hardening. High levels of K are generally beneficial. In tender species which have a tendency to grow late in the autumn, it would be advisable to withhold N and possibly P late in the growing season to slow down growth and promote the accumulation of sugars. Although our discussion has centered around high fertility levels, it is generally recognized that unthrifty plants suffering from low fertility are also subject to winter damage. Cultural practices such as heavy late shearing or pruning which induce late fall growth in some plants have the same undesirable effects as high nitrogen fertilization.

Light is important in hardening plants for two reasons. As we have already mentioned, short days are the triggering mechanism which induces rest period and preconditions plants to respond to the hardening influence of low temperatures. It is important that plants to be overwintered out-doors, are exposed to short days in the autumn. This is especially a problem if artificial illumination is used to lengthen the day during or immediately after rooting of cuttings or seed germination.

While hardening may be inhibited by long days we want the plants to accumulate sugars through photosynthesis. This means that bright light during the short day is desirable. The common practice of shading newly rooted cuttings to harden them off after mist propagation limits their already depleted carbohydrate reserves and probably reduces their capacity to acclimate to cold. Shading during autumn should be kept to an absolute minimum.

The undesirable effects of shading on winter survival were graphically illustrated to us in a study where the effects of late and early fall shading, fall pruning, and high and low nutrient levels on winter survival of one year old globe arborvitae were evaluated. The plants shaded early in October with a 50 percent lath shade covered with burlap was severely injured while the control and those shaded later, in early December, were injured much less. In this study the pruning and nutrient status had little if any effect.

While intense sunlight favoring maximum photosynthesis is desirable during the autumn hardening period, it is often not desirable later in the winter (1) because it contributes to rapid temperature changes in foliage or bark and to desiccation. Some type of shading put on as late as possible probably has merit for protecting many evergreens. In Minnesota rhododendrons (*R. catawbiense* and *R. maximum*) have survived -35° F. when they are protected by heavy shade. We are presently testing reflective flocking agents which are sprayed on plants with a water soluble adhesive as a protection from this type of injury on rhododendrons, strawberries, *Pachistima canbyi* and American arborvitae. A large number of plants can be treated in a short time in massed plantings such as a container stock area in much the same way as Christmas trees are flocked. A major problem is to find an adhesive which will wash off readily in the spring and yet withstand fall rains.

Temperature is also critical to the process of cold acclimation. As pointed out earlier, freezing temperature is necessary for the development of maximum hardiness in dogwood following the photoperiodically induced first stage of hardening. In the case of late propagated stock, it is important not to make the transition from the protected environment of the propagating area to an outdoor overwintering area too abrupt. At the same time, plants need low temperatures to harden providing it's not too low too soon. Good timing and semi-protected hardening areas such as cold frames offer a possible solution to the problem.

Little is known about root hardening, but in dogwood, low temperature exposure contributes to root hardening which can reach -4° F. (6). In apple rootstocks, preliminary field data indicate that the hardiness of roots is essentially the same under mulch as under bare soil or snow cover. The gradual cooling of the soil mass in nature probably gives ample time for root hardening in most cases but in containers, root injury is more of a problem as in the case of juniper (11) and needs further study.

Water is often discussed in relation to hardiness. Obviously if there is little free water in plant cells, there will be less available to form ice crystals. The danger in this reasoning is that withholding water may retard the cold acclimating process and also contribute to desiccation injury. The moisture level in plant tissues is lower in winter than summer (11), but this is largely internally controlled and heavy watering does not increase tissue moisture appreciably unless the plants are quite desiccated.

It is doubtful that withholding water is beneficial in hardening most plants and may actually interfere with natural hardening. Probable exceptions to this are plants which do not go into rest in the fall and need unfavorable conditions to stop their growth. Some herbaceous plants such as spring bedding stock develop a few degrees of hardiness from exposure to low water, high light, and cool temperatures but the contribution of low water to this type of hardening is uncertain. Caution is called for in withholding water except in special cases.

Special techniques of a mechanical and chemical nature are being used to aid in overwintering plants. The most widely used mechanical type of protection is the temporary plastic shelter erected over nursery beds and blocks of container stock. These shelters are kept reasonably air-tight to prevent drying out of stock over winter. They are apparently quite successful. If an appreciable degree of shading is involved, plants should be covered as late in the fall as feasible. Many evergreens maintain good color under such shelters. A complete discussion of this and other mechanical means of protection such as mulches, mulch in cold frames, and refrigerated storage would require more time than we have here.

Chemical protectants for the most part have the property of either reducing desiccation or retarding growth. The beneficial effects of such treatments have generally not been too exciting. A polyvinyl chloride (Wilt Pruf) had no detectable influence on foliage moisture levels in overwintering arborvitae foliage (1) but Smith and Chadwick (15) have reported that an acrylic copolymer (Foli-Gard) was more effective than Wilt-Pruf in reducing water loss from transplants.

Growth retardants such as B-Nine, Cycocel (16), Maleic Hydrazide and others have increased hardiness to a limited extent in some plants. The major potential of these chemicals may lie in their capacity to stop fall growth on species which don't go into rest.

The report that the water permeability increasing substance decenyl succinic acid (5) induced a substantial increase in hardiness was very encouraging, but the lack of substantiating evidence from other sources suggests the need for further critical work.

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JACK HILL: I would like Dr. Weiser to go through step by step the process which leads to cracking of stems in *Arbor vitae.* Would you repeat that in the ABC form?

DR. WEISER: The cracking of the stem showed up in the spring as a kind of peeling back of the bark from the wood. We think that was due to a fall frost that injured the cambium. It didn't show up until the following spring. But we don't have any definitive information on this. I wish we had good data to support it but we think this is what caused the injury. Do you have this type of problem?

JACK HILL: Yes we do. I think there are very few people in the room who are not familiar with this problem. When you say a fall frost — we always have a fall frost — what is the difference, if any, in the frost which causes the damage.

DR. WEISER: We had plants in rather high nutrition that had been sheared rather heavily and they were let's say pushing in the fall. Our first frosts in the fall were rather severe — we didn't have any 30° F. or 29° F. frost — we had one that went down to about 19 or 20° F., the first frost of the fall. And at this time this is one place where the curve of frost resistance and the environmental tension do come close together. In the fall in *Arbor vitae,* it is a critical stage. Most of our data were recorded in the two previous years when we had not had any of that type of injury. We had only peripheral winter burn.

CARL GULLO: Dr. Weiser, where do you get the decenylsuccinic acid and at what concentration do you use it?

DR. WEISER: It is available from a chemical supply house. I don't remember the name right now. It's used at 10^{-3} molar concentration. But in Wageningen, Holland, and in East Malling and in Germany research workers have used the material without success. I am sure some of the other people in the room tried this.

DR. LANPHEAR: We tried this on the roots of *Taxus* to see if we could increase hardiness and we were not successful.

DR. WEISER: This has been the experience of most people. Maybe some one here from Connecticut is familiar with Dr. Kuiper. He has published in Science, has shown pictures, and has some very striking results — showing a very marked increase in the hardiness of bean plants and also the flowers of apple and pear. So far no one else has been able to repeat the work.

DR. FLINT: Have you tried bringing this material in direct contact with tissues, without having to go through external surfaces?

DR. WEISER: We have in progress some root up take studies which is how Dr. Kuiper did it. So far we haven't tried any any spraying, its been mainly trying to reproduce what he reported.

DR. FLINT: Have you tried any excised tissue?

DR. WEISER: No.

DR. FLINT: I gather from the literature that perhaps part of the problem, anyway, may be getting the material into the plant to begin with. It might be interesting to see what the effect would be on excised tissues.

DR. WEISER: It's a paraffin like material, its rather hard to dissolve without dissolving it in hot alcohol first and then in water.

MODERATOR LEACH: Unfortunately Mr. Wagner ran into some mechanical difficulties at home and is not able to be with us. However, Bill Curtis, president elect of the International has kindly consented to give Mr. Wagner's paper. This reminds me of the fellow who gave up smoking because he feared cancer — he took to chewing toothpicks and died of Dutch Elm Disease.

BILL CURTIS: Before I begin I should point out that the C and R nursery is located in Wenatchee, Washington and they have entirely different growing conditions, I think, than many of you people do here, at least entirely different from what we have in Western Washington and Western Oregon.

PRE-EMERGENCE WEED CONTROL IN NURSERY STOCK

RUDY WAGNER
C & O Nursery
Wenatchee, Washington

It is a real pleasure to be here with you to-day to discuss a common problem which we all seem to have, WEEDS. As it is the nurserymen's most costly problem, we are all searching for ways to bring down the high cost of weed control. In the spring of 1961 we at C & O Nursery decided to do something about it, and tried using Chemical weed control in our ornamental stock. I am here to-day to tell you of some of the experiences we have had in the last four years.

The term pre-emergence when in reference to weed control means an application of chemicals after planting but before emergence of weeds. The selection of the chemical to be used for pre-emergnce weed control will depend on whether it is being used or applied as a direct or an over all spray on lining out stock. Certain sprays cannot be used on liners even if it is directed at the base of the plants, without taking some chance of producing some injury. But the same chemical may be used quite safely as a granual applied in dry form when the foliage is dry, with good results. We have selected Simazine as the chemical in our operation and we are using it exclusively for the time being as it has performed very well in tests made at one of the state experiment stations. Pre-emergence treatments seemed the best method to use in our case. Most weeds are much easier to kill about the time they germinate and it is very important to kill them before they get established.

In pre-emergence applications of Herbicides a thin film of chemical is applied on the surface of the soil which will prevent growth of young weed seedlings. They are killed before they even become visible. We apply the herbicide as an over all spray and find this the easiest and most accurate way of application as it is very simple and can be accomplished with little difficulty. This brings us to the equipment to apply the herbicide. The

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Any material that will kill certain types of plant growth while allowing others to grow is dangerous if carelessly used. When using any of the materials on the market to-day it will certainly pay to follow the manufacturers' recommendations. With this in mind we sprayed our one-year established stock with very good results and no injury to the plants. But our big problem still remained. As we are using great amounts of manure previous to planting our new liners, this gives us a bumper crop of weeds but the manufacturer says to use this herbicide on established stock only. Now in order to find out what will happen if we disregard the manufacturer's warning, we did so in spring of 1962 and sprayed immediately after planting and one heavy watering. We used the same rate of chemical as we used on the one year old stock. No sooner did we finish spraying when hot and windy weather set in and heavy irrigation was needed, but we did not realize until too late that we had leached some of the herbicide down to the root zone. Bringing herbicides in contact with young roots is inviting trouble, which we got, but learned a great deal by it. The results were as follows:

1. Weed control excellent
2. Three species of plants a total loss
3. Pines and spruces were badly burned but came out of it during the growing season. The remaining plants suffered only minor damage but came out of it quickly.

With the lesson we learned by this we knew we were nearer our goal of two sprays. The first spray immediately after planting and the second the following year instead of spraying the second and third years after planting. We are using the same rates in both applications, 2½ lbs. actual per acre in our area and type of soil. We find two sprays over a two year period works fine in our case, a third application is not needed as we have from 50 to 60 percent control left the third year, from the previous two applications. The soil surface is partly covered the third year by the plants and would not make spraying practical. I would now like to sum up our method in using herbicides in the nursery:

We have adopted the pre-emergence over all spray program, spraying once a year in the spring only. Fall spraying we find not practical as there is great danger in run off and heavy concentration could result in the lower part of the field. We have built a boom for our 100 gallon Hardie sprayer. The boom is 12 feet wide and 40 inches above the ground with four Tee Jet nozzles No. 6502. The nozzles are aimed directly between the rows with a four foot spread near the soil surface, but no overlap is tolerated. With this equipment we are able to achieve a very even distribution of the chemical. We are now using 2½ lbs. of actual herbicide in 60 gallons of water per acre. As I have mentioned, the importance of an even distribution of the material is essential or real trouble will quite possibly develop.

Before spraying, the soil surface must be clean and free of all weeds at the time of application. To get good control reduce cultivating to a minimum in order to keep the herbicides in the upper level of the soil. Pre-emergence will control most all germinating weed seeds but will not control established weeds and certain perennial weeds such as quackgrass, artemesia and others.

Watering newly planted stock that has been sprayed must be handled very carefully. Over head irrigation is the only practical spray in areas with little rainfall like ours. I would like to point out that if herbicides are used as a pre-emergence the action can be greatly affected by conditions such as soil moisture, rain fall, temperature, soil type, weed species present and other factors. It would therefore be impossible to suggest weed control treatments that could be safely used in various sections of the country. In 1963 - 1964 we had real good results with 80 to 90% of all germinating weed seeds controlled in 3 - 4 months and a somewhat lower percentage for the remainder of the growing season. This year the first weeds appared the latter part of September. We are now able to control our weeds in 5 man hours to the acre per month and this includes spot hoeing of some perennial weeds that may show up.

To-day the growers of nursery stock realize the necessity of reducing operational costs. Chemical weed control therefore can not be overlooked as a money saver. Unfortunately the use of plant growth regulators for weed control is still very young and every grower should get all the information possible and compare it with his needs. Due to many reasons no one can or should make any definite suggestions other than to share his own experience gained by using herbicides in his operation.

There are many chemicals on the market to-day and it would be unfair to say that one is better than the other. As I have worked with only one chemical, I believe the more you know of a certain product the better and safer are the results. So until something more promising comes along, we will continue with the chemical we have been using in the last four years (80% W Simazine). The per acre cost for treatment comes to approximately $16.00 for material and labor in our operation.

I am glad that there are growers who are very cautions about going into a new program of this sort on a large scale.

However we are far past that stage and I am convinced that chemical weed control is an important part of the nurserymen's production practices at the present time. There are five points we must bear in mind:

1. Timely application of an adequate amount of herbicide to weed free soil will prevent or interfere with seed germination and seedling establishment.
2. Follow recommendations and precautions in regard to the crop and operation.
3. Realizing herbicides are not an easy way out of an accumulation of perennial weeds.
4. Applying the chemical when the weed seeds absorb water and begin to germinate will give the best possible control.
5. Proper application techniques are important for effective control, but also for crop safety and economy.

Calibration of Spray Equipment

For most sprayers calibration is a simple but necessary procedure. With any given sprayer one must determine the volume output of the sprayer at the speeds and nozzle pressures to be used in application. This is accomplished by the following procedure: FILL THE SPRAYER TANK WITH WATER, DRIVE 660 FEET WITH THE SPRAYER OPERATING AT THE SAME SPEED AND NOZZLE PRESSURE AS WILL BE USED IN ACTUAL PRACTICE. MEASURE THE AMOUNT OF WATER REQUIRED TO FILL THE TANK, THEN COMPUTE THE VOLUME OUTPUT IN GALLONS AS FOLLOWS:

$$= \frac{\text{Gallon required to refill tank x 66}}{\text{Spray width in feet}}$$

The desired output can be attained by varying the speed, nozzle size and pressure.

100 Gallon Hardie sprayer

1 cylinder Wisconsin

Plungers 1½″

Pressure can be reduced as low as 50 lbs.

BRUCE BRIGGS: I might mention that he has quite a dry condition there and might be comparable to the middle states such as Nebraska and Iowa. This makes a difference and must be considered in weed control. In the west side of Washington, we have a lot more rain and the results in some ways are different.

CARL WILSON: I can see the advantages of weed control in the field, but what do you do with containers? I have not found any manufacturer that knows how to handle this problem.

BRUCE BRIGGS: This is one of our big problems — the control of weeds in containers. About five years ago there was some work at the Experiment Station in containers. At that time they ran a whole spectrum of herbicides. The best results was the granular simazine applied at the rate of about 2½ pounds of the material (80%) or 2 pounds actual. But he did receive some damage. There were three or four products that looked good. I am curious to see if anyone has had some experience, one of these is combination with nitrogen and in the West it looks real good. We have run Chloro I.P.C. and a lot of these others, we still found IPC wouldn't do it because it worked by breakdown by the root system. We received injury and finally did without it.

JOHN ROLLER: I am sure someone here has some experience with Dacthal and Casaron. Dacthal is very safe for container plants, however, it's rather expensive material and short lived. We've had less experience with Casaron, but it looks like it might be good, either as a spray or as a granular.

BRUCE BRIGGS: We have tried both of those materials. One thing we objected to Dacthal was too short a life. This is our problem because in containers it's not a matter of weeds in the mix, you can sterilize this. It's a matter with the blow in with us, the weeds that come in the next fall. And this is the problem we have to fight. Maybe this isn't true here. With the other product, Casaron, it looks good, but with us it hasn't done any more than simazine. It is not as toxic, you can use it on a broader basis of plants. We did have some trouble with this year on some things such as *Daphne cneorum*. We feel it needs a lot more research. We are still holding on to simazine.

ROBERT DEWILDE: Just a comment on this weed control in containers; if you will attend the round table discussion on weed control, I'll give you a solution for weed control in containers that we feel is quite satisfactory. It will last you at least three years control with no problems.

MODERATOR LEACH: Our next speaker this afternoon is Dick Bosley, from Bosley Nurseries who is going to give us a slide tour of California container nurseries.

SLIDE TOUR OF CALIFORNIA CONTAINER NURSERIES

RICHARD W. BOSLEY
Bosley Nurseries, Inc.
Mentor, Ohio

In April 1965 I spent 4 days in California visiting some of the larger container growing nurseries. I would like to share some of the things I saw with you.

The first stop was at the Oki nursery in Sacramento. Mr. George Oki, who is well known to the Society through the many papers he and his Production Manager, Mr. Kubo, have presented, was a most gracious host. Their organization is divided into two companies, (1) the Sacramento Nursery, which is the growing organization and, (2) Oki Nursery, which is the sales firm.

While we were in the office we looked at the IBM punched card data processing equipment that Oki Nursery has been using for several years for the routine accounting functions of order writing, invoicing, accounts receivable, accounts payable, and receive some damage. There were three or four products that looked good. I am curious to see if anyone has had some experience, one of these is combination with nitrogen and in the West it looks real good. We have run Chloro I.P.C. and a lot of these others, we still found IPC wouldn't do it because it worked by breakdown by the root system. We received injury and finally did without it.

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ROBERT DEWILDE: Just a comment on this weed control in containers; if you will attend the round table discussion on weed control, I'll give you a solution for weed control in containers that we feel is quite satisfactory. It will last you at least three years control with no problems.

MODERATOR LEACH: Our next speaker this afternoon is Dick Bosley, from Bosley Nurseries who is going to give us a slide tour of California container nurseries.

SLIDE TOUR OF CALIFORNIA CONTAINER NURSERIES

RICHARD W. BOSLEY
Bosley Nurseries, Inc.
Mentor, Ohio

In April 1965 I spent 4 days in California visiting some of the larger container growing nurseries. I would like to share some of the things I saw with you.

The first stop was at the Oki nursery in Sacramento. Mr. George Oki, who is well known to the Society through the many papers he and his Production Manager, Mr. Kubo, have presented, was a most gracious host. Their organization is divided into two companies, (1) the Sacramento Nursery, which is the growing organization and, (2) Oki Nursery, which is the sales firm.

While we were in the office we looked at the IBM punched card data processing equipment that Oki Nursery has been using for several years for the routine accounting functions of order writing, invoicing, accounts receivable, accounts payable, and serves to gather sales data which can later be used with production records to forecast sales and project production requirements. This equipment will allow them to move smoothly into IBM data processing equipment which they have on order. The Yoder Brothers are now using an IBM 1401 tape-oriented computer to schedule production much as Oki will. These people are keenly aware of the many phases of management as evidenced by this name plate leading into the propagation area. Evereyone knows their job title and what their job range is.

A great deal of attention has been given to cleanliness in propagation in recent years. Mr. Kubo, the production manager for Sacramento Nursery, outlined the procedures used for sanitation by them in the 1962 proceedings. It is based on the U.C. System. You can see in the pictures that they actually do what they preach. This room was spotless, but more importnt, it was arranged so that it was very easy to clean. The area was also arranged so that there was no unnecessary through traffic flow which may track in pathogens. In the background can be seen controlled climate rooms in which cuttings or seed can be held for one reason or another. The interior of their propagation greenhouses show the same care in sanitation that the cutting make-up room did. The house is painted each year and washed down with a disinfectant. The benches are treated with Cuprinol after each crop. Few people are allowed into these antiseptic areas.

Ventilation is by fans at one end exhausting air which was drawn through mats with water dripping over them at the other end of the house. When the air passes through the mats it is cooled as the humidity is very low during some of the hot summer months. It is possible to add a fungicide or algaecide to the water running over the mats if you wish. The mist system is controlled by a device that measures solar energy and translates this to plant moisture need. The external view of the propagation house better illustrates the header pipe that drips the water over the brown mats and also the fan towers at the far end. These greenhouses are steam heated with pipes under the benches and poyethylene skirts. The steam is also used to sterilize flats of medium prior to sticking cuttings. In this area of California the temperature goes below freezing in the winter and the heat is needed not only for propagation but also to protect tender containered plants.

This picture illustrates poly covered houses used for growing tender material and the next picture illustrates the newest type of greenhouse they are using which is covered with clear PVC. It is a very pleasant, bright structure and I am sure could be put to very good use in the east for year around growing of container material.

Many nurseries have to build their own equipment and the people at Oki are masters of the art. You probably read the article in the 1964 proceedings by Mr. Dick Oki entitled: "*Specialized Equipment, Canning, Material Handling Systems.*"

This small spray rig has a Bolens propulsion unit and was manufactured from there back by Oki. I show this to illustrate that often we may have some unit that is still useful from one respect that may be adaptable for another use. This Bolens was formerly a high clearance cultivator and has now become a spray rig. I might mention that *most* of their spraying is done by a mist blower. I am sure that they are proud of their auto assembly facility. They manufacture this rugged looking, versatile cargo truck. They found that the battery operated units did not have enough capacity to travel the distances needed every day so they developed and manufacture this unit. It is powered with a four cylinder Chevrolet engine with an automatic transmission and is very substantial. This is one of the trucks on the production line. They have a well equipped shop that can handle major construction jobs. All of us are involved in material handling and container grown plant material is particularly well suited to handling on pallets. This shows their order loading area and illustrates how the large pallets can hold a good number of the 1-5- or 15 gallon containers that they grow in. The pneumatic tired fork lift truck can even go into muddy fields and lift loaded pallets. As you can see here they place a pile of empty pallets behind their truck at the beginning rather than tying up inside space. As the load is finished off this stack at the rear provides a place for the men to stand.

Many of the California growers use a container medium which has a very high organic content. Very often the great part of the organic content is Redwood sawdust that has been treated with Nitrogen. Oki uses a container mix of 1/3 sand, 1/3 Redwood sawdust, and 1/3 rice hulls as reported in the 1962 proceedings. The sand etc., is dumped in the background and then loaded, with a tractor, into *this* device which conveys it up to the revolving drum which mixes it and then *another* conveyer which can swing THROUGH A 180° arc, piles the medium into a semi-circular pile from which the containers are filled. This system can blend 150 cubic yards a day. The medium is brought up to an optimum fertility level in the mixing and *then this* level is maintained through periodic laboratory checks and constant dilute feeding through a proportional injector in the water system. So-called "canning machines" are highly developed at Oki Nursery. This picture shows the detail of two dies which are driven by air cylinder into the medium of the two containers. Automation people will tell you that if you wish to increase output that it is much better to do this sort of thing rather than make one cylinder work twice as fast. This machine works in the can placement area rather than at the medium pile location. They feel it is better to move truck loads of medium to the machine rather than have many trucks moving the finished can to the field. On the left of the green machine is a truck that supplies painted, crimped one gallon cans. The truck on the right supplies medium. Some of the other support equipment consists of a rather large air compressor, a gasoline powered generator and special palletized racks that hold flats of liners in peat pots ready for the machine. A crew of five people *and* this equipment pot and place 10 - 12 thousand plants a day.

After the woman places the peat pot plant into the impression left by the die the plants run down the conveyor to the men. This woman had not trouble making these men work very fast. They would pick up 4 cans at a time. The conveyor arm is on wheels allowing it to swing in an arc that is at right angles to the forward travel of the machine. This allows them to cover a rather wide bed without ever walking very far from the end of the belt.

In container growing, drainage is very important and this shows how the run off is handled in one location. I would imagine that they had the land graded to start with so that the water is always under control. Many of the growers in California have settled on growing in 1, 5, and 15 gallon cans. I saw no evidence of plastic containers in the few nurseries I visited. The customers completely accept the used food can. There would be *problems* in stacking plastic containers when they are trucked. This detail picture shows a novel way of staking rather large trees.

Proportional feeding through the irrigation seems to be standard practice with the better growers that I visited in the west. This shows the system that is now in use at the Oki Nursery. It is manufactured by BIF Industries in Providence, R.I. It is a proportional injector; that is, it will inject the same proportion of concentrate liquid to water over a flow range of 10-1, with an accuracy of + or - 2% of the set rate. The green object in the foreground is a deep well turbine pump. The flow meters and injector pumps are in the background. The small black drums are for sulfuric acid which is injected to overcome the bicarbonate content of the water. They had installed *this* equipment as it was better able to tolerate the acid and sand in the water and is more accurate at the lower flow rates of its working range. Another advantage to this equipment is that you can use full strength or perhaps I should say a constant strength concentrate liquid. When you receive a report from the laboratory to change the proportion you simply turn a dial on the flow transmitter and you are in business. With other equipment you would have to wait until the tank runs out to change the batch strength and there is always the chance of making a mistake in figuring the dilution.

Many of you will recognize the Smith injector shown here. This is at the Bordier Nursery which is located on the Irvine Ranch. This is a new location for them and they were starting with a clean sheet of paper, so to speak. They were being forced out of their former location due to a bad smog situation. The large wooden tank is for fertilizer concentrate and the silver tank is for a head of air. Their pump turns on with a drop in line pressure.

The Bordier people mix their potting medium in an interesting way. They put the ingredients into individual piles and then scoop through it with a front end loader. The tractor turns the piles over several times. It seems to work and represents low capital outlay. As you can see there is a high Redwood sawdust content.

Empty cans are loaded on a trailer and then filled with a loader and scraped off. The liners are easily hand planted into this very light mix right on the trailer which is then towed with a JEEP to the placement area. The beds have been graded, covered with coarse stone, and sprayed with a weed control prior to placing the containers. Sprinklers are set to have at least 100% overlap.

When transplanting from one gallon to five gallon containers the larger cans are lined up around the medium pile in a wagon train fashion, sometimes in a double row as the next picture illustrates. The cans are filled from the pile and the plants dropped in; then the man on the shovel puts more medium around the roots with the aid of the second man holding the plant. This works very fast with a limited amount of handling of either medium or containers. After they have finished a wagon is driven around the pile while the plants are picked up.

At the Keline - Wilcox Nursery, large trees are grown in their special break-away boxes. The sides are held together with steel strapping so that the box is re-usable when the tree is planted. This firm does a fine job with these trees and their quality material is in great demand. As you can see, they water with small tubes. The system is controlled with a time clock and so a large area can be watered with a rather modest pump and injector equipment.

This last picture showing Dr. John Rodebaugh, of The Soil and Plant Laboratory, standing next to one of these tree boxes of Keline - Wilcox, gives you an idea as to their large size.

I would like to suggest that the growers I visited were very friendly and open with information which would not be true in most industries.

PROPAGATION OF RHODODENDRON CAROLINIANUM FROM STEM CUTTINGS[1]

THOMAS HALL[2] AND T. F. CANNON
North Carolina State University
Raleigh, North Carolina 27607

Commercial producers of *Rhododendron carolinianum* have been limited to propagation by seed or "cutbacks" (collected plants with the above-ground parts and the majority of the root system removed), since the literature indicates that most previous attempts to root stem cuttings have met with poor success.

The time required to produce "landscape-size" plants from seed is longer than would be required for the production of plants from either "cutbacks" or stem cuttings. The use of "cutbacks" has been extensive in North Carolina, but several disadvantages of this procedure will preclude its use in the future. Available plants of good quality for "cutbacks" are becoming limited and landowners hesitate to allow further exploitation. Since the preparation for planting results in large wounds on these plant parts, microorganisms frequently damage or destroy a large number of "cutbacks" and lower the efficiency of the procedure.

Propagation by stem cuttings would insure the producer of plants with less variation in flowering and growth patterns. This report deals with the effect of timing, media for propagation and hormone treatment on rooting of stem cuttings of *R. carolinianum*.

Procedure: Terminal stem cuttings were obtained from unfertilized, partially shaded, natural stands of *Rhododendron carolinianum* in Avery County, N.C. All cuttings, except those taken in November, were gathered at random from a large number of plants with a minimum age of five years. November cuttings were taken from plants in a nursery row which had been planted with "cutbacks" in the previous planting season. All cuttings were secured near the fourteenth of each month for ten consecutive months beginning in July, 1961.

The cuttings, three to five inches long, were wounded by removing a strip of bark about ¾ inch long from one side of the basal end of the stem. The basal ends of the cuttings then were dipped, for 10 seconds, in a 50% ethanol solution containing 5000 ppm of indolebutyric acid. All cuttings were stuck under intermittent mist in a propagation bench with bottom heat controlled to 70° F. Air temperature in the greenhouse was maintained at 60° F. during the winter and as low as possible at other times during the year.

Media consisted of equal volumes of (1) German peat moss and sharp sand, (2) German peat moss and perlite (horticultural grade) and (3) German peat moss and Weblite, a sintered clay-shale (-10 +14 grade).

Following twelve weeks in the propagation bench, cuttings

[1]Part of an M.S. thesis written by Thomas Hall under the supervision of T. F. Cannon.
[2]Present address Winston-Salem, N. C.

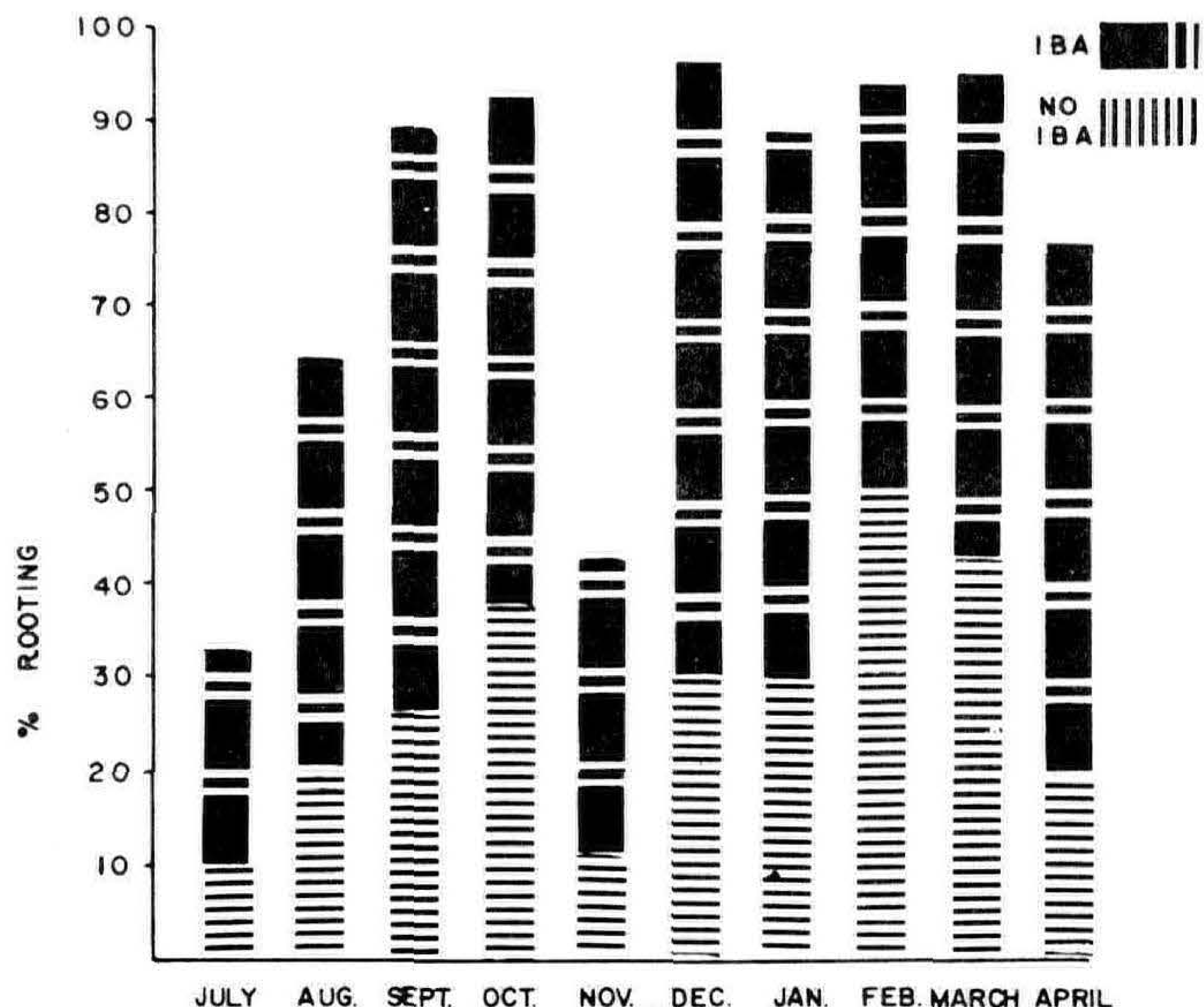
were removed and graded according to the root ball diameter: up to ½ inch, ½ to 1½ inches, and more than 1½ inches.

A split-plot design was used and all data were statistically analyzed. Four hormone treatments were replicated three times in each of the three media.

Results: Rooting percentages were low in July and August, higher values were recorded throughout the fall and winter months, and a decrease was noted in April (Chart 1). At least 90% of the IBA treated cuttings rooted if they were made in the months of September and October or the period December through March. Rooting percentages for July, August and April were 36, 66 and 79, respectively. Less than 50% of the November cuttings rooted, a result probably related to the vigor of the stock plants from which they were taken. These plants were one year from "cutbacks," in full sun and fertilized, in contrast to the unfertilized, shade grown stock plants used in other months.

If IBA was not used to treat the cuttings, less than 50% of the cuttings were rooted, except in the month of February when 51% were rooted.

Data presented in Chart 2 indicate that the peat-weblite combination produced the highest rooting percentage in most months. In contrast, the peat-perlite combination appeared to



	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
IBA-5000 ppm	33	65	90	94	43	98	90	95	96	77
No IBA	10	20	26	38	11	30	30	51	43	20

%

Chart 1. The effect of month of taking cuttings and IBA treatment on rooting of stem cuttings of *Rhododendron carolinianum*. Values are expressed as percentage of cuttings rooted after twelve weeks in the propagation bench.

be the least desirable in many months. Statistical analysis indicated that these were not significant differences each month during the sampling period.

How well these various media would perform under different misting cycles is not known, since one time clock controlled the mist in all plots used in this study.

The peat-weblite medium usually resulted in a larger number of cuttings with root balls in excess of 1½ inches in diameter. In contrast, the peat-perlite combination resulted in a larger number of cuttings with rootballs under ½ inch in diameter. Such differences are shown for December, January and February in Chart 3. A large number of cuttings in the larger grade probably indicates faster rooting and the possibility of earlier transplanting of these cuttings.

Conclusions: Commercial propagation, by stem cuttings, of *Rhododendron carolinianum* is feasible. Data indicated that most success would be obtained by taking cuttings in the late fall and winter months.

The results indicated that the use of IBA, at 5000 ppm in 50% ethanol, as a 10-second dip was highly beneficial. The use of the hormone could change an unsuccessful operation to a successful one.

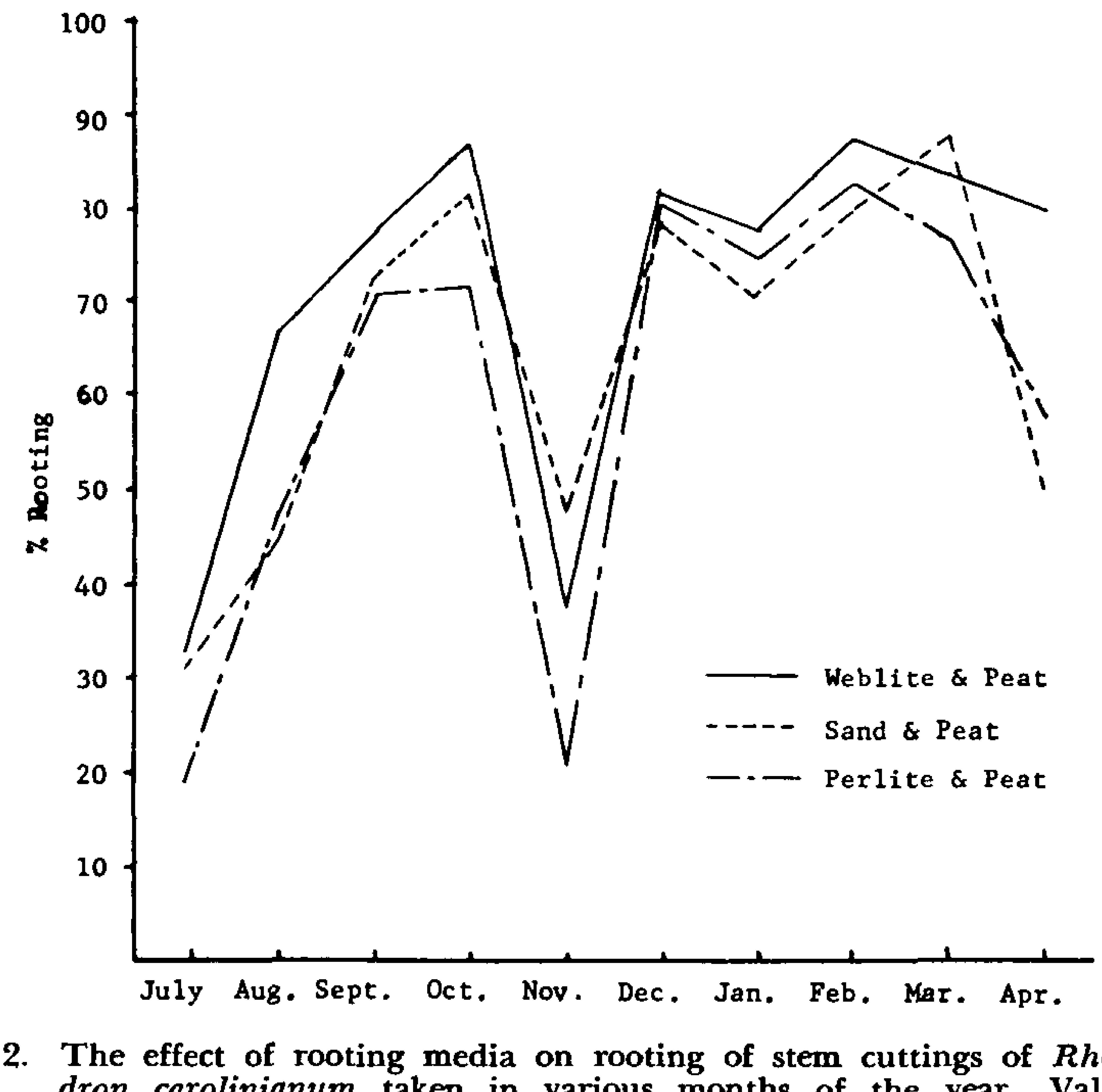


Chart 2. The effect of rooting media on rooting of stem cuttings of *Rhododendron carolinianum* taken in various months of the year. Values are expressed as percentage of cuttings rooted after twelve weeks in the propagation bench.

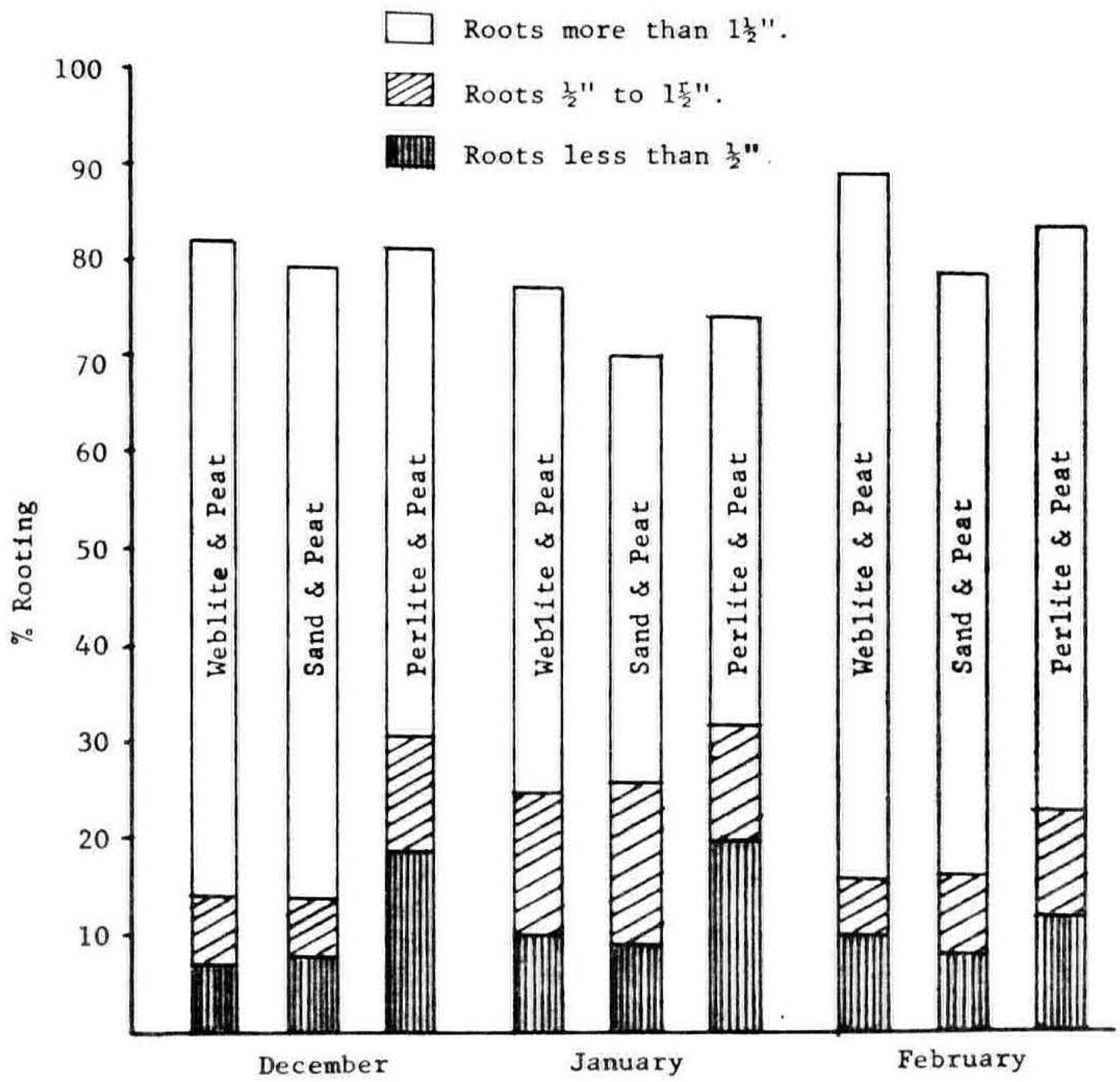


Chart 3. The effect of rooting medium on rooting and root length of stem cuttings of *Rhododendron carolinianum* in three different months. Values are expressed as percentage of cuttings rooted after twelve weeks in the propagation bench.

The propagation medium used was of less importance than timing or hormone treatment; however, the data indicated that cuttings may root faster and be transplanted earlier when the peat-weblite combination is used.

MARTIN VAN HOF: I would like to ask Dr. Cannon if those rhododendrons are all of one clone.

DR. CANNON: I cannot say that they were all of one clone; they were seedlings. All had fairly uniform flowering and growth characteristics. But they were seedlings. They were from a natural stand.

CASE HOOGENDOORN: I didn't hear you mention percentages of rooting. What were the percentages?

DR. CANNON: We had, during the winter months at least 90% rooting when we used hormone. If we did not use hormone we had generally under 50%.

JIM WELLS: Dr. Cannon, have you tried any cuttings without wounding? I harp back to a presentation at this Society, three years ago I think Dr. Chadwick said that wounding was of no value. Do you agree?

DR. CANNON: No, I do not. We have tried cuttings without wounding and they met without success. In addition to that we have found that most of the roots that arise on these cuttings will arise from the wounded area. We have very few roots from the back side of the cuttings, for example.

DR. HESS: Tom, what is weblite and secondly what do you attribute that big drop in rooting in November to?

DR. CANNON: Weblite is a sintered clay shade. This is the description that was given me. Actually it is a clay-shade combination that has been ground and then heated. It is through the heating process that it is expanded to some extent. It provides very excellent aeration and moisture control in the medium. In other words the particles will hold a considerable amount of water but yet provide the aeration that is necessary. We feel that aeration was the cause of the difference we got between the media.

The drop in November we felt was primarily the vigor of the cuttings. These November cuttings were quite large as compared to the thin cuttings that we had taken in the other months. We think it was the vigor of the stock plants. The November cuttings were from fertilized plants in the nursery row. As it happened the man who cut the cuttings couldn't get up the mountain to get the cuttings in November so he took them from nursery rows.

HANS HESS: The next topic is a new misting nozzle with self contained, adjustable timer. Our speaker is Mr. Werner Rexer.

NEW MISTING NOZZLE WITH SELF CONTAINED ADJUSTABLE TIMER

WERNER REXER
Rexer Forest Nursery
La Salle, Ontario

A few years ago, it got into my mind, that all the intermittent-misting units are operated by a solenoid and some kind of a device. The solenoid-value itself, the way it is designed, needs little power, the water supply line, thinking in the way of hydraulics, can be boosted to create power, a thousand times stronger than needed.

From the day this idea entered my mind, I had only one thought, to design and build a valve, powered by the supply of water, and operated by the evaporation of water, fully adjustable, for misting, light and heavy field irrigation. I was fully aware of the difference between theory and practice, and such a valve may have to be rebuilt a hundred times before being practical for production. I decided then, that just to prove my point that such a valve could be built, and to stay within my budget, to design a small valve for one nozzle only, with adjustable timing, all in one unit.

This type of nozzle, would be impractical for the use in large scale propagation, however, it would be handy for experimental purposes, and for isolated patches of cuttings, since each will arise from the wounded area. We have very few roots from the back side of the cuttings, for example.

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This type of nozzle, would be impractical for the use in large scale propagation, however, it would be handy for experimental purposes, and for isolated patches of cuttings, since each nozzle is individually adjustable, and the cost of such a nozzle will be only a fraction of any standard intermitting misting system now available.

When we think of a timing mechanism, especially adjustable, we think of many wheels and springs, that are required to make it work. In modern inventions, we often overlook the ways and means our ancestors lived by, the timing device in this valve is based on the theory, that when one opens a valve where there is water under pressure, and set it to a steady drip, it will continue to do so, the more the tap is opened the faster the water will drip.

In this nozzle, the water dripping through the valve, is compressed by means of a piston with two different diameters, the small one faces the full pressure of the line, and acting as the spring, the large one is facing the steady buildup of water, fed from the valve, making the piston move slowly, a part of a small and simple designed valve follows the move of the piston, and when the chamber is filled to a certain point, the valve opens, forcing the water out, and closing again.

I am not sure yet, of how and when the hydraulic system will find its place in our industry, but I do know, the advantages and the uses are many, the installation alone is like placing a tap in the line.

VOICE: The question I have regarding the adjustment of that value. How long does it take to adjust that valve?

WERNER REXER: You can adjust it for one second or two seconds, anywhere up to 10 minutes. This is for the time off. The time on will always be the same.

HANS HESS: May I ask you this question? What approximately will be the cost of this valve?

WERNER REXER: This would depend upon the material used to make the valve. We could make it out of aluminum alloy, but that would wear too fast. I do not have much on the way of cost as yet.

HANS HESS: I along with many others will look forward to when you will have the nozzle ready for the market. Our next topic is success and failure in the propagation of *Tsuga canadensis* by cuttings. Mr. Carl Grant Wilson of Cleveland, Ohio.

SUCCESS AND FAILURE IN ROOTING TSUGA CANADENSIS

CARL GRANT WILSON
Cleveland, Ohio

The following is such a peculiar observation that if I had not observed it myself I would discount it 100%. But it occured under my direct observation.

I am sorry I cannot deliver this paper in person but the illness of my wife makes it imperative that I get her out of this nozzle is individually adjustable, and the cost of such a nozzle will be only a fraction of any standard intermitting misting system now available.

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I am sorry I cannot deliver this paper in person but the illness of my wife makes it imperative that I get her out of this severe northern weather until she recovers. This paper will, therefore, be read by my guest, John Fortney, or someone else assigned by the committee.

The Observation

In 1962 I had about 200 12/18″ Tsuga canadensis in 5″ containers sitting on a 4 foot pile of sawdust where I intended to leave them for the winter. These were spaced about 5″ apart. They needed pruning to bush them out so I pruned them and left the prunnings fall on the sawdust. This prunning was done at the end of October, 1962.

In April 1963 I moved the above to sell and was astonished to pick up some 20 6/8″ cuttings that were rooted; some with 4 to 6 roots from 1″ to 2″ long. This was the first time I had ever seen *T. canadensis* rooted.

I thought I had made a discovery. So, to check on it I did the following:

In April 1963 I put in the following hemlock propagation in peat moss:

1st: — 100 — No treatment, as check.
2nd: — 100 — Using Hormodin #3.
3rd: —100 — Using 1% Indolebutyric Acid
4th: — 100 — Using 2% Indolebutyric Acid
5th: — 100 — Using 3% Indolebutyric Acid
6th: — 100 — Using 4% Indolebutyric Acid

All were wounded, morning sun only, and they were sprayed with water four or five times a day.

Results: All died by September, 1963. 100% failure.

Can anyone explain why, in 1962, the cuttings with no treatment and LAYING ON TOP OF THE SAWDUST should root but on a carefully prepared test as outlined above should result in 100% failure?

It occurs to me that one angle I may have overlooked in the above account is "Juvenility."

The 1962 trimmings dropped on the top of the sawdust were, undoubledly, juvenile, in that they were trimmings from 12/18″ stock.

The cuttings I put in peat moss in April 1963 were taken from stock plants 6 to 8′ high.

Seems to me I would still consider the 6 to 8′ Hemlock in juvenile condition.

ED HUME: I'd like to find out what kind of sawdust that was used.

KLASS VAN HOF: I wondered why you didn't continue using sawdust. Maybe your mistake was going to peat moss.

DR. HESS: I noticed in looking over Mr. Wilson's manuscript that the first year the cuttings were not treated in any way; the second year they were wounded.

CARL WILSON: The sawdust is just plain sawdust out of a sawmill. It was all mixed up. They don't keep that sawdust separate. The reason I wounded them is because I have listened to Jim Wells.

JIM WELLS: This happens to be the second time that I have seen or heard of this same procedure. A neighbor of mine trimmed hemlocks and threw the trimmings on the brush pile in his garden, and the following spring he came up with a handful of this stuff, brought it to me so I saw it. He said, "Look, I've just gathered this from the top of the brush pile" and there was a great mass of roots from these trimmings. I took cuttings from the plant from which he had made trimmings and we rooted them in the greenhouse. I believe the answer is in the actual plant — a clonal difference between plants. We did root quite a lot of these particular hemlocks from this one tree, but I never bothered to take it any further because I wasn't interested in hemlock. But the coincidence of the system is rather remarkable.

ROY NORDINE: A question regarding this kind of sawdust. Was this sawdust old or new and was it from the sawdust in the woods or fresh sawdust from a finishing mill?

CARL WILSON: This is brand new sawdust probably less than 2 weeks old. Jim, I want to thank you. I thought I was maybe off my rocker.

PETER VERMEULEN: As a propagator in New Jersey, this is not in relation to Hemlock, but the procedure is almost the same. Tillman Gray in Manalapan Nursery used to root *Thuja orientalis* Berckmann's golden by taking the cuttings and piling them outside the greenhouse and letting them freeze for about 3 months. Then he brought them into the greenhouse inserted them in a medium of sand and they will root practically 100% for him. Now we might draw a correlation there.

HANS HESS: The effect of clonal selection of hemlock upon rooting is brought out very strongly at Curtis Nurseries in Calicoon, New York. They are growers of a lot of hemlocks. They have collected a lot of dwarfs in the woods and they have, I guess, the biggest collection of various types of hemlocks of any nursery in the country. And they have found that there are certain ones of these selections which root readily and then there are others which are virtually impossible to root. I think it might be a good future program to have one of the Curtis boys here or John Ruby to explain this to us. But this is very definitely brought out. There are types which they have been rooting very successfully for a number of years and other types which they have given up on and do not root at all.

We have as the next topic, cutting propagation of *Magnolia grandiflora* by Mr. William J. Curtis, Wil-Chris Acres, Sherwood, Oregon.

ROOTING OF MAGNOLIA GRANDIFLORA

WILLIAM J. CURTIS
Wil-Chris Acres
Sherwood, Oregon

It is a great privilege to be here to present my method of propagating *Magnolia grandiflora* from cuttings. *Magnolia grandiflora* from cuttings is not at all difficult, at least I have not found it so. In Western Oregon Grandiflora will grow late — in fact on November 11 when I began to outline this paper several *Magnolia grandiflora* Pioneer were in bloom and one-year old plants were ready to break into flower.

We have just now stuck our cuttings for this year — I feel cuttings should not be taken until the terminal bud is well developed. The loss of the terminal bud will give a crooked tree to line out. The lower branches taken from two or three year old field grown trees are best. This growth is pencil size or less, and will run from three to twelve inches in length. Cuttings 18″ long or longer will root but take up too much bench room. This side shoot has a well developed terminal bud. We sever it from the three year old field grown tree with a sharp knife, leaving a piece of last year's wood on the cutting — we are taking a heel-cutting.

These cuttings are taken to the propagation house, washed thoroughly, for being close to the soil line, they can be covered with mud. A thin slice of wood is removed from this heel, just enough to trim the cutting to ease its entrance into the firmly packed sand. Remove several of the leaves and make a heavy scar or slice on one or both sides of the cutting. This scar is about one inch in length. A standard 4″ deep flat filled with firmly packed sharp and is used for the rooting medium. The cuttings are dipped in Hormodin #3 and stuck 30 to 40 to the flat, depending in the size of the cutting. A bottom temperature of 75 to 80 degrees has given the best results. Water heavy daily. The cuttings will be ready to pot or can when the terminal bud shows a little activity. I take the cuttings from the flats myself, trying not to break a single root. If necessary, I will tear the flat to pieces to keep from damaging the roots.

We use a pot or a container of a size into which the roots should go for the best growing conditions. The majority will go into 1-gallon containers, a few in 2-gallon containers. The smaller ones into 4″ standard pots, which will be filled with roots before the summer is over, then shifted into 1-gallon containers. These liners stay in the greenhouse until November, at which time they are over-wintered in a plastic house that is not heated unless we have several days of 20 degree weather.

Our soil warms up more slowly than yours does here in the East. By May first they are lined out in the nursery, two-foot spacing in the row 84″ apart. We plant a low growing or upright growing plant between the rows of magnolias — a crop we can dig in two years, for the finished crop of magnolias take three years, tho we dig 25% 3/4 at the end of the second year. The third year will give us a heavy 4/5 and 5/6 crop from which we take our cuttings.

DICK STADTHERR: What is the condition of the wood when you stick these, or do you stick them each part of the year?

BILL CURTIS: We generally put in the cuttings of *Magnolia grandiflora* along the first part of November and the wood is good and firm and the terminal bud is well developed. I think that is the secret. Now, I have talked to them in California about putting in *Magnolia grandiflora* from cuttings and they say they don't have good success because they get a flower bud, and then they get a dog leg plant. From my observation in working with these, if you take that shoot down lower to the ground in most cases there is no flower bud. The flower buds will generally form near the top. If you have some crooked ones, let them grow into shrubs because a lot of people prefer *Magnolia grandiflora* as a great big bush, so we still don't lose them.

STEVE O'ROURKE: I would like to ask you a question pertaining to the rooting temperature of the cuttings. The 85° F. temperature is high. I would like to know if there is any correlation between the high rooting temperature for the cutting and that for grafting. If Jim Wells or anyone else in the room has grafted *Magnolia grandiflora,* I would be very glad to have their name.

JIM WELLS: We gave up grafting magnolias years ago, Steve. Any magnolias that I have grown in the last fifteen years have been rooted from cuttings. That includes all the magnolias. But I haven't grown *Magnolia grandiflora.* But in rooting the magnolias we have maintained a bottom temperature of 75° F. for the ordinary ones. And certainly what Bill says is borne out by the temperatures the fellows use in Semmes, Alabama. I understand they shut their house up and it gets over 100° F.

DICK STADTHERR: What percentage of rooting are you getting? You haven't told us anything about that.

BILL CURTIS: Well, on the smaller sized cuttings, that is 4 - 8″, many a time we have 100%. And, of course, maybe we stick a hundred and ten in the flat. That always helps. I had planned on this ahead of time, so I took the pictures ahead of time and I lost my percentages, I did some counting and on the smaller cuttings, we would get 100% time after time. These are all in four inch deep flats. But on the larger ones, if you put them in too thick, you will be making a mistake. Don't get those large ones in too thick — don't crowd them too much. Because you won't have very good percentages on those large cuttings if you crowd them. You may have to get down to 25 cuttings per flat with those large cuttings. But that's the secret I think in getting the percentages, not having them too thick and then you must have heavy bottom heat, real stiff bottom heat. We didn't have too good luck when we used normal bottom heat such as 65 - 70° F., like we do with many others. Even on the *Magnolia soulangeana* types we used real stiff bottom heat 75-80° and 85° F. and if you watch your water you won't have any trouble. But when you have that high a temperature you just about have to flood them every day.

DON SHADOW: Were these cuttings under constant mist or intermittent mist?

BILL CURTIS: We put these in old fashioned way. We just took a hose and syringed. By November we're not using any mist in Western Oregon. The Lord provides for us outside. it's plenty moist.

DON SHADOW: Are the *Magnolia soulangeana* cuttings taken in the fall or are those taken in the summer?

BILL CURTIS: The *M. soulangeana* type cuttings and *M. stellata* are taken in the month of July. We try to take those cuttings from plants which are lined out the spring before. By putting in cuttings in July we take them out and plant them early in spring or in August. These cuttings at that time in late July may have grown 5 or 6″, and we take them and allow 3 leaves from the bottom. You can break the top off in your fingers — the soft tip. And if possible, we take a heal, but it doesn't seem to make too much difference. When I first started, we used heals because from the old stock plant of the *M. souangeana* or *M. soulangeana rustic rubra* or *M. stellata* you would not get very much growth or at least we wouldn't get very much growth. But from a new vigorous growing plant you get a shoot 7 - 8″ long in late July.

JIM WELLS: Bill, I notice that you wounded these cuttings. Have you tried any without wounding?

BILL CURTIS: When a thing works I don't change it.

JIM WELLS: Then I see you've found a value from wounding.

BILL CURTIS: I think a long time ago I read an article, by somebody, I don't remember who it was, 20 years ago or so, somebody wrote an article in *American Nurseryman* about wounding Rhododendrons. And where I was working that time we tried it; it worked, and whenever I find that something works I stick with it.

VOICE: What medium do you use in your containers.

BILL CURTIS: We use about ⅓ of soil and ⅔ fir bark.

VOICE: Do you fertilize?

BILL CURTIS: Oh, yes. But I couldn't tell you exactly how much fertilizer we use. But I know one thing we put in what they call saldusto that will kill a lot of our insects that feed on the roots. I know that's one item that we do use. Unfortunately I do not recall exactly what we do use.

VOICE: Do you use a liquid fertilizer or dry?

BILL CURTIS: Well, we use a dry fertilizer, I know we use some bone meal. We generally allow a four inch pot of fertilizer to a wheelbarrow of the soil and, of course, we use a full bail of peat. But this material we use for the *Magnolias* is just the fir bark and the soil and we figure about a 4" pot of fertilizer to the wheelbarrow load of material. That's a pretty safe mixture to use and, of course, we vary it and use some bone meal and we use some other organic materials. The plants in the greenhouse are fed once a month with 25-10-10 soluble fertilizer through an applicator.

HANS HESS: Our next topic for this morning is weed control using compressed air, a new concept. Mr. Asper Laursen was originally scheduled to give this paper but since he is unable to be here, it will be read by Mr. Ernest Otto Timm.

WEED CONTROL USING COMPRESSED AIR, A NEW CONCEPT

ASPER K. LAURSEN
Bowmanville, Ontario, Canada

An entirely new concept in physical weed control was developed and tested in Europe 12 years ago, and is now used successfully in hundreds of nurseries in Denmark, Germany, Holland and other countries.

The machine, a so-called weedblower, is basically a turbine-unit mounted on a cultivator and powered from the tractor's P.T.O.

Through an universal shaft and a transmission the turbines are brought up to between 15 - 20,000 R.P.M.

The strong jet of air, thereby created, is channeled through flexhoses down to a steel nozzle on a cultivator base, at an 90° angle to the plants in the nursery-rows.

Proper cultivation in the nursery rows will create a small ridge of soil along the base of the plants.

The weed blower works on the principle, that, when very young, the weed seedlings' root system is much shorter, and weaker, that that of the established nursery plants.

So when the weed seedlings appear on the soil ridge in the nursery rows the jet of air will remove the weed seedlings, together with the small soil ridge, entirely without disturbing the nursery plants, which have a much deeper root system.

Immediately behind the air outlets are cultivator teeth which build up a new ridge of clean soil around the plants.

In Canada I have worked with this machine for six years, and found it very useful. In large nurseries with long rows, it is possible to clean a block of nursery stock, between the plants *in* the rows, at the rate of 800 plants per minute, using a weed blower that takes two rows at the time.

In hardwood cuttings planted in the fall, and hilled up to prevent winter heaving we used the machine to uncover the cuttings in the spring, as well as to control the weeds amongst them.

At Brookdale-Kingsway Nurseries in Bowmanville where I am now employed, we bud a considerable amount of understock, fruit trees, shade trees, roses, etc.

This summer we tried the weed blower to clean the soil bark and the soil and we figure about a 4″ pot of fertilizer to the wheelbarrow load of material. That's a pretty safe mixture to use and, of course, we vary it and use some bone meal and we use some other organic materials. The plants in the greenhouse are fed once a month with 25-10-10 soluble fertilizer through an applicator.

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This summer we tried the weed blower to clean the soil away from the rootnecks prior to budding, it worked exceedingly well, we saved a considerable amount of hand labor, and there was no "bark scratching" on the understock.

The weedblower can of course also be used for uncovering the budded roses early in the spring prior to stubbing.

Several large nurseries in Canada are now using this new concept in weed control, forest-nurseries, owned by Provincial Government, as well as private nursery firms.

As the machine is available, custom made, to fit most tractors, and row distances, it can fit into most nursery-operations, except perennial-nurseries.

It can be used supplementary to a chemical weed control program or it can do the entire job.

Where I am now employed as propagator, the labour saved by uses of the weedblower, was turned into a better and larger production of softwood cuttings, and our fields were cleaner than ever before, without the worry of possible damage from chemical weed killers, or men with menacing hoes.

For anyone intersted, the machine can be seen in operation at our nurseries in Bowmanville, Ontario next summer.

CASE HOOGENDOORN: Can this machine be used for any weeds, regardless of size?

ERNEST TIMM: No, they can not be any higher than a foot, otherwise the roots are too well established.

JOHN ROLLER: Mr. Timm, could you give me the cost of that machine.

ERNEST TIMM: $1600.

RALPH SHUGERT: Mr. Timm, would be $1600 be for 1, 2, or 4 rows?

ERNEST TIMM: For 2 rows.

RALPH SHUGERT: What would one row cost?

ERNEST TIMM: About $1500 because you've still have the big unit there. It's just more hoses or less hoses, just more shoes or less shoes, to add the additional rows.

RALPH SHUGERT: Where is this manufactured?

ERNEST TIMM: In Denmark.

RALPH SHUGERT: No manufacturer in Canada or in the United States that you know of?

ERNEST TIMM: No.

RALPH SHUGERT: In your observation of the machine, when you were hilling over seed rows or hilling over buds how high can you have you soil mounded and the machine will still remove the soil? Will it take soil away up to 12″ high?

ERNEST TIMM: Yes, it would. Just last week we demonstrated it for a man who would like to use it for a stool bed like an EM type of any number. That's what he wants to use it for. Now you know how high they would be at least this high. The thing is that as you try to blow more soil you have to go slower, but you can do it.

CASE HOOGENDOORN: What is the amount of air pressure you have?

ERNEST TIMM: I'm sorry I don't know.

VOICE: Did you notice any effect of the static electricity that you obtain when you blew that air over the soil so fast?

ERNEST TIMM: No. It is no problem at all.

J. RAVENSTEIN: Is this machine available in the United States? Can you tell me the name of the dealer; I've been looking for this fellow for five years.

ERNEST TIMM: See me, I have some literature in back of the room.

HUGH STEAVENSON: It looks from one of the slides as though the soil was being blown away from the roots pretty badly. How do you get the soil back?

ERNEST TIMM: You have cultivating teeth right behind it.

HUGH STEAVENSON: Your teeth bring it right back?

ERNEST TIMM: Yes, you bring it right back so that if you want to blow next time, they are ready. Most people blow and leave it level. Next time they cultivate up the ridge, and the next time they blow it level again.

HUGH STEAVENSON: How about wet soil or damp soil?

ERNEST TIMM: The last time I was out, it rained 3 days solid and I had an appointment on Monday. And driving up that day I was quite worried if the thing would work. We had no trouble at all. In fact, that's when this slide was taken, after three days solid rain. And the thing is if you do get into heavier soil you can't go as fast, but you can still do it. You can do it even in heavy clay in the spring.

VOICE: How far does it move the soil laterally?

ERNEST TIMM: Well, you get a shield which the soil blows against. It will not blow into the next row. The soil blows against the shield and the cultivating teeth are right behind.

VOICE: Doesn't it create a problem for the operator when working in dry soil?

ERNEST TIMM: Well, he uses a bathtub at night.

HANS HESS: Our next speaker will be Mr. Hoy C. Grigsby who will tell us of his work with captan and the rooting of pine cuttings.

CAPTAN AIDS ROOTING OF LOBLOLLY PINE CUTTINGS

HOY C. GRIGSBY

Southern Forest Experiment Station

Forest Service, U.S. Department of Agriculture

Crossett, Arkansas

Since 1942, when researchers began selecting the southern pines for specific traits, there has been increased interest in propagating them from cuttings. But in spite of an early concern with rooting techniques, accomplishments have been quite modest.

In 1961, I reported obtaining up to 52 percent rooting of loblolly pine (*Pinus taeda* L.) cuttings with indolebutyric acid

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In 1961, I reported obtaining up to 52 percent rooting of loblolly pine (*Pinus taeda* L.) cuttings with indolebutyric acid

(IBA) treatment under intermittent mist, but could not regularly repeat this success in subsequent research (3).

In 1962, the Boskoop Trail Grounds in Holland reported good results with ornamental conifers from a combination of IBA and Captan (1). A little later Van Doesburg (2) doubled the rooting of conifers by adding Captan to IBA. Wells (5) at the thirteenth annual meeting of the Plant Propagators' Society, stated that the combined treatment decidedly improved the quality and quantity of rhododendron cuttings. Vanderbilt (4) tested the rooting response of the rhododendron hybrid cultivar Chionoides to 16 compounds, principally fungicides containing no hormornes. He reported that 88 percent of the cuttings treated with Captan and with Sevin were well rooted. None of the other treatments were as effective.

In mid-December of 1963, I installed a loblolly pine study in which one treatment was obtained by combining equal amounts of 10 percent Captan and 1.6 percent IBA. It produced 24 percent rooting, or two and one-half times more than the Hormodin No. 3 treatment which, until then, had been the most successful stimulant. This accomplishment would not be considered a success by most propagators, but it was encouraging nevertheless because loblolly pine is hard to root and the cuttings had been taken later than the time considered optimum.

In November 1964, I began a follow-up study in which ten treatments with stimulants, principally Captan and IBA applied in various strengths and by several methods, were used on cuttings from 6-year-old loblolly pine trees. Some cuttings received a wounding pre-treatment before being dipped into the powder mixtures or the liquid concentrations.

The design was a split-plot randomized block with two bottom temperatures, 72° and 78° F. It was replicated five times. Night air temperature was maintained at 72° F. Day temperatures ran higher, especially on sunshiny spring days, when the average was 82° F. The rooting medium was half coarse sand and half perlite of horticultural grade. Mist was provided by Supreme A-6 Humidomist nozzles, one for each seven square feet of bench space, operating 30 seconds of each minute during daylight.

After 190 days in the bench, the Captan - IBA treatments were superior to those with IBA alone. The best, 25 percent Captan and 0.8 percent IBA, produced 40 percent rooting. This was three times better than the Hormodin No. 3 treatment. Quick-dip applications of IBA at 200, 500, and 1,750 ppm; napthaleneacetic acid at 500 ppm; and 30-minute hot soaks of 105° F. before IBA treatment; all produced little rooting. Wounding with three equally spaced slits in the basal inch of the cutting before treatment with IBA did not significally increase rooting.

Livability and rooting of cuttings were increased by the higher concentration of Captan and the higher bottom temperature (Table 1).

Table 1. Effect of two concentrations of Captan (each in combination with 0.8 percent IBA) and two bottom temperatures on the livability and rooting of loblolly pine cuttings

Bottom temperature	Percent living		Percent rooted	
	10 percent Captan	25 percent Captan	10 percent Captan	25 percent Captan
72° F.	39	63	10	23
78° F.	79	98	29	40

At the end of the study (190 days) the living cuttings for the treatments without Captan ran from 2 to 50 percent and the rooted cuttings for these treatments ran from 0 to 13 percent.

The combined treatments produced more roots per cutting, and the roots were stronger and better distributed around the base of the cutting. (Figure 1).

The cuttings were drenched with a mercury-base fungicide every 10 days. This treatment aided in keeping down slime molds and had no apparent deleterious effect.

In summary, the combined Captan - IBA treatments were clearly superior to all others in their ability to stimulate rooting and produce quality roots. The highly significant differences

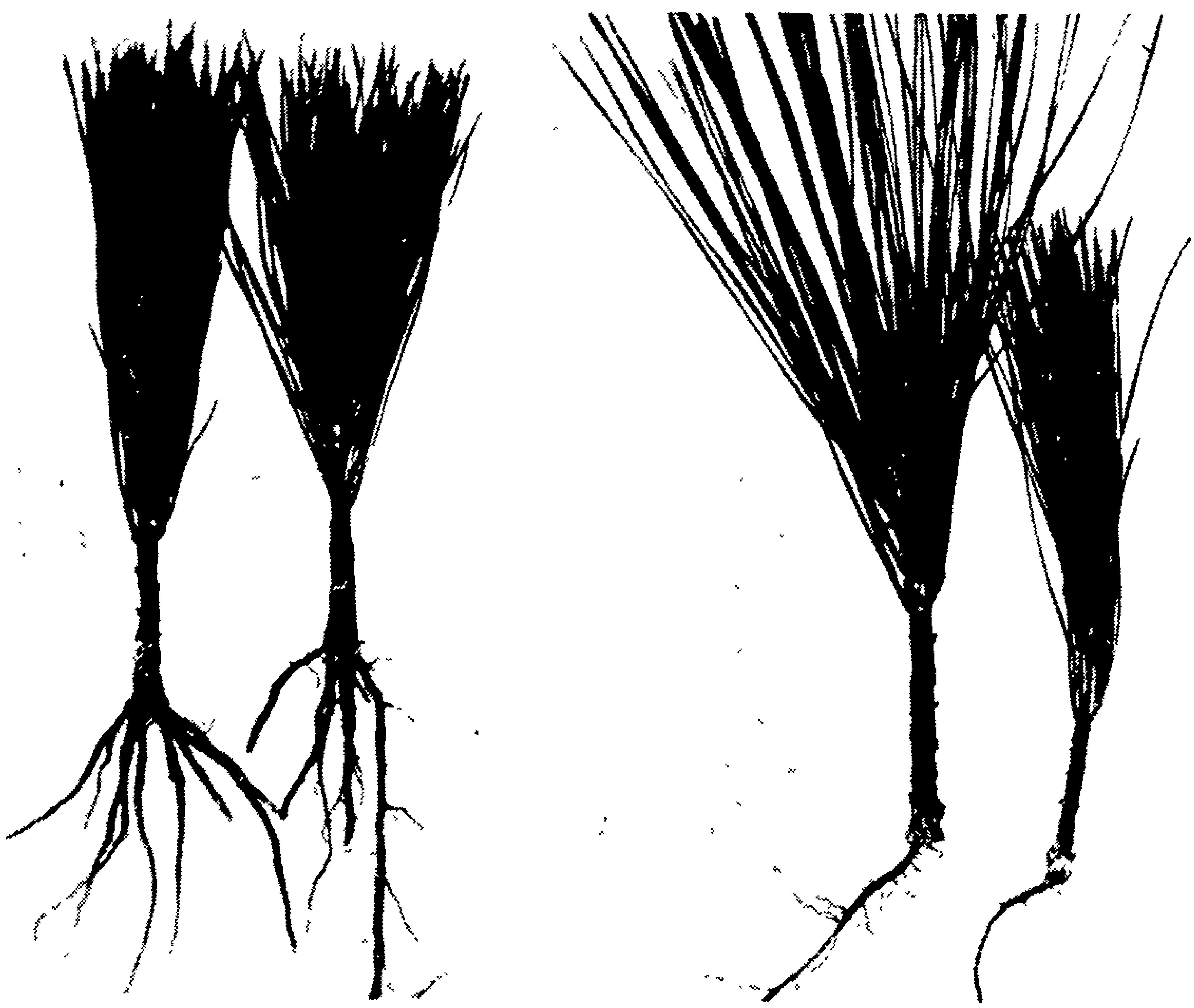

Figure 1. Six-year-old loblolly pine cuttings after 104 days in the propagation bench. The two on the left were treated with 25 percent Captan and 0.8 percent IBA. Those on the right were treated with 0.8 percent IBA alone.

(0.01 level) in the efficiency of the two Captan levels indicate that concentrations higher than 25 percent may produce even better results. Differences (0.05 level) between the two bottom temperatures suggest that the optimum temperatures may be above 78° F. Night air temperatures probably should not run lower than 75° F. (3).

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BRUCE BRIGGS: Was any attempt made in the research to eliminate the captan applied to the cuttings, but rather applying it as a drench to the rooting medium?

HOY GRIGSBY: That's one of my treatments this year; I tried it for the first time.

CASE HOOGENDOORN: Have you tried to root other varieties of pine besides this particular variety like *P. cembra* or *P. mugo*.

HOY GRIGSBY: No, I have not, Case. I have tried short leafed pine which is another one of the southern pines and it roots a little better than loblolly.

JOHN THOMPSON: Have you tried phygon with the captan?

HOY GRIGSBY: No, I have not.

BOB DEWILDE: Do you associate your increase rooting response to control of pathogens or to some biological activity in captan?

HOY GRIGSBY: Frankly, I do not know. I hope that some of these treatments that I've put in this year will give an answer to this. This is the first time I applied captan alone. There is a possibility that it does possibly react with the IBA or has some stimulatory effect.

DICK FILLMORE: I would like to ask the reason for putting the nozzle on the high trees. I am sure it must be a very important one.

HOY GRIGSBY: Really I just threw that in as a matter of interest. It has nothing to do with the vegetative propagation. That's in my controlled breeding work and it takes three years to get seedlings from pine if you count the year in the nursery and you don't like insects to interrupt the work.

VOICE: Was your percentage captan based on 100% active ingredients or based upon a percentage of 50% or whatever they use?

HOY GRIGSBY: It's the commercial captan. It is based on whatever is given on the package and if we want 25% captan in the final mix, we start out with 50%.

DICK STADTHERR: What size trees are you using? Are these big trees or small trees from which you are propagating?

HOY GRIGSBY: I have tried all ages. We have not had good results in any of these as you have seen here, but the older trees do root more poorly as you would expect and in working out these techniques we're working with six year old trees.

HANS HESS: The next subject this morning is on the effects of medium, pH, and root inducing chemicals upon the rooting of *Gardenia jasminoides*. It will be given by Dr. Booker T. Whatley.

THE EFFECTS OF MEDIA, pH, AND ROOT INDUCING CHEMICALS ON ROOTING OF GARDENIA JASMINOIDES

BOOKER T. WHATLEY, MCKINLEY MAYES & JACK H. JEFFERSON
Southern University
Baton Rouge, Louisiana

A limited amount of published information on the propagation of *Gardenia jasminoides* is available. Southern growers propagate gardenia cuttings in open nursery or in cold frames. The cuttings. six or seven inches long, are made in late winter or early spring. The cuttings are stuck in sandy soil which covers two-thirds their length (1, 5).

Watkins (5) in Florida has reported that high humidity,, constant temperature and moisture are necessary for speedy rooting. The media used have been clean, sharp builder's sand, peat or sphagnum moss. Gardenias being susceptible to root-knot and other diseases, sterilized or fresh media are required. Root inducing chemicals are not essential, but larger root systems are formed in shorter periods on cuttings that have been dusted with one of the root-inducing agents.

Hartmann and Kester (2) reported that leafy terminal cuttings may be rooted in the greenhouse under glass from fall to spring. A mixture of one-half sand and one-half peat moss was a good rooting medium. These authors further stated that gardenias were difficult to transplant and should be moved only when small.

Laurie *et al* (4), in Ohio, reported that tip cuttings four to six inches long taken between December and March and treated with a growth substance hastens rooting, which may be expected in four to six weeks.

Materials and Methods

A 2 x 3 x 5 factorial experimental design with three replications and ten cuttings plots was employed to study the effects of media pH and root-inducing chemicals on rooting of *Gardenia jasminoides* cuttings during a 45-day period.

[1]The authors express their appreciation to Dr Barton R Farthing, Professor and Head, Department of Experimental Statistics, Louisiana State University, for his advice and assistance regarding the statistical analysis

whatever is given on the package and if we want 25% captan in the final mix, we start out with 50%.

DICK STADTHERR: What size trees are you using? Are these big trees or small trees from which you are propagating?

HOY GRIGSBY: I have tried all ages. We have not had good results in any of these as you have seen here, but the older trees do root more poorly as you would expect and in working out these techniques we're working with six year old trees.

HANS HESS: The next subject this morning is on the effects of medium, pH, and root inducing chemicals upon the rooting of *Gardenia jasminoides*. It will be given by Dr. Booker T. Whatley.

THE EFFECTS OF MEDIA, pH, AND ROOT INDUCING CHEMICALS ON ROOTING OF GARDENIA JASMINOIDES

BOOKER T. WHATLEY, MCKINLEY MAYES & JACK H. JEFFERSON
Southern University
Baton Rouge, Louisiana

A limited amount of published information on the propagation of *Gardenia jasminoides* is available. Southern growers propagate gardenia cuttings in open nursery or in cold frames. The cuttings. six or seven inches long, are made in late winter or early spring. The cuttings are stuck in sandy soil which covers two-thirds their length (1, 5).

Watkins (5) in Florida has reported that high humidity,, constant temperature and moisture are necessary for speedy rooting. The media used have been clean, sharp builder's sand, peat or sphagnum moss. Gardenias being susceptible to root-knot and other diseases, sterilized or fresh media are required. Root inducing chemicals are not essential, but larger root systems are formed in shorter periods on cuttings that have been dusted with one of the root-inducing agents.

Hartmann and Kester (2) reported that leafy terminal cuttings may be rooted in the greenhouse under glass from fall to spring. A mixture of one-half sand and one-half peat moss was a good rooting medium. These authors further stated that gardenias were difficult to transplant and should be moved only when small.

Laurie *et al* (4), in Ohio, reported that tip cuttings four to six inches long taken between December and March and treated with a growth substance hastens rooting, which may be expected in four to six weeks.

Materials and Methods

A 2 x 3 x 5 factorial experimental design with three replications and ten cuttings plots was employed to study the effects of media pH and root-inducing chemicals on rooting of *Gardenia jasminoides* cuttings during a 45-day period.

[1]The authors express their appreciation to Dr Barton R Farthing, Professor and Head, Department of Experimental Statistics, Louisiana State University, for his advice and assistance regarding the statistical analysis

The root-inducing chemicals used were 3-indoleacetic acid and 3-indolebutyric acid at levels of 0, 25 and 50 ppm respectively in talc. The root-inducing mixtures were prepared according to the method described by Jefferson (3).

Three of the media used were vermiculite, perlite and the Southern University potting mix. The following is a description of the Southern University potting mix;

Ingredients by Volume

1 Part Top Soil
1 Part Course Sand
1 Part Peat Moss (Acid)
2 Parts Sawdust (Old)

Additives Per Cubic Yard

3 Pounds Superphosphate
10 Pounds Dolomite Lime
pH 6.4
Steam treatment for 45 minutes at 180° F.

Two additional media were prepared by adding two and four pounds of aluminum sulfate per cubic yard of media respectively to the Southern University potting mix.

The pH of the media under investigation were vermiculite, 6.0; perlite, 7.2; Southern University potting mix, 6.4; Southern University potting mix with two pounds of aluminum sulfate added, 5.1; and Southern University potting mix with four pounds of aluminum sulfate added, 4.3.

The cuttings used were terminal soft wood and three nodes in length (3½ to 4 inches) from three-year-old stock plants. All leaves were removed from the second and third nodes. The cuttings were approximately five mm in diameter at the base. The rooting mixture was applied and the cuttings stuck in 2¼ inch round jiffy pots containing the respective media. The potted cuttings were placed on the propagation bench and watered in. The cuttings were then propagated under mist with bottom heat.

The data were obtained by counting the number of roots that penetrated the peat pot in 45 days. (October 13 to November 26, 1965).

Results and Discussion

The mean number of roots that penetrated the jiffy pots in 45 days for the respective media were vermiculite, 14.0; perlite, 1.4; Southern University potting mix, 5.6; Southern University potting mix with two pounds of aluminum sulfate added, 7.4; and Southern University potting mix with four pounds of aluminum sulfate added, 5.9. Highly significant differences were found between the media used (Table 1).

No significant differences were found between 3-indoleacetic acid and 3-indolebutyric acid regardless of the level used. No significant interactions were found between any of the factors under investigation.

TABLE 1. ANALYSIS OF VARIANCE

Source of Variation	d./f.	S.Sq.	M.Sq.	F
Replication	2	206		
Media (A)	4	14,965	3,741.3	27.35**
Acid (B)	1	36	36.0	.26
Levels (C)	2	50	25.0	.18
Media X Acid (AB)	4	752	188.0	1.37
Media X Level (AC)	8	549	68.6	.50
Acid X Level (BC)	2	615	307.5	2.25
Media X Acid X level (ABC)	8	330	41.3	.30
Experimental Error	58	7,936	136.8	
Sampling Error	810	45,983	56.8	
Total	899	71,422		

Summary

A 2 x 3 x 5 factorial experiment with three replications were employed to study the effects of media, root-inducing chemicals and three levels of these chemicals on rooting of *Gardnia jasminoides* terminal cuttings. Vermiculite was found to be significantly better than the other media tested. Perlite was by far the least desirable of the media. 3-Indoleacetic acid and 3-indolebutyric acid at 25 and 50 ppm were no better than the control. The essentiality of root-inducing chemicals at the levels used was not shown.

The data seem to indicated that rooting media for this species should be from medium to slightly acid.

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HARRISON FLINT: What temperature do you try to maintain in the rooting medium?

DR. WHATLEY: The thermostat was set at 68° F. plus or minus 2 degrees.

DICK FILLMORE: I'm not clear on the volume of vermiculite which was added to the basic mix or whether or not it was used in pure form.

DR. WHATLEY: Vermiculite and perlite were used in the pure form.

JIM WELLS: Any misting system?

DR. WHATLEY: Yes, we had it under intermittent mist. One minute every fifteen minutes during daylight, from about 7:30 a.m. to about 4:30 in the afternoon.

HANS HESS: Our next topic this afternoon is by Sid Waxman on the propagation of blueberry cuttings under various light intensities.

PROPAGATION OF BLUEBERRIES UNDER FLOURESCENT LIGHT AT VARIOUS INTENSITIES

SIDNEY WAXMAN
Plant Science Department
University of Connecticut
Storrs, Connecticut

Introduction

The trend in propagation as well as in the growing of plants has been toward a more controlled environment. For example; shading, bottom heat, mist and the plastic tent, all are forms of environmental control. By rooting cuttings under controlled conditions more consistently uniform results may be anticipated.

Although the use of such expensive controls as growth chambers, in which light, temperature and humidity are closely regulated, is not economical; structures can be used in which these environmental factors are more easily and perhaps less expensively controlled.

For example, a roof-covered pit house, built 7 - 10 feet into the soil and insulated, may be the most ideal unit for the rooting of cuttings. The buffering effect of the soil surrounding this unit could prevent temperatures from getting too high in the summer and too low in the winter. With such temperature control the relative humidity would not vary appreciably. Sudden losses of water vapor from the leaves on a partly cloudy day could be avoided in this type of structure because the light source is always under control and at a uniform intensity.

The deciding factor as to whether the use of such a structure is economical lies in the light energy input required, i.e., in the cost of lighting. There is no need to provide a light intensity equal to that of the sun. Although the sun may provide up to 12,000 footcandles of light, most so-called "sun-loving" species can grow normally with a maximum of 2,000 footcandles. "Shade-loving" plants, are able to grow at intensities as low as from 200 to 500 footcandles.

An experiment was made to observe the response in rooting of a shade-loving plant (blueberry) to various intensites of light in a plastic tent and under a mist system. Specifically, the object of the experiment was to determine the minimal range of light intensity under which root initiation and development may occur.

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Materials and Methods

Two benches, one for mist propagation and the other for propagation under a plastic tent were constructed of galvanized sheet metal.

The plastic tent bench was completely covered with 4 mil polyethylene, and was tightly sealed. The mist bench was uncovered, but had side walls of polyethylene to confine the mist spray to the bench.

Heating cables, set at 70° F., were placed in each bench beneath a peat-perlite medium; 65% :35% by volume. In the mist system an electric timer activated a solenoid value which turned on a mist spray for three seconds every 10 minutes. Within the plastic tent the cuttings were sprayed only when the tent was opened for inspection, about once every three weeks.

The experiment was done in an unheated room that received no sunlight. Each bench was illuminated with six 8 foot cool-white flourescent lamps plus six incandescent bulbs. The flourescent lamp fixtures were hung from chains attached to the ceiling and were placed over the benches at an angle so that the light striking the cuttings ranged from a minimum of 110 foot-candles to a maximum of 365 footcandles. Seven varieties of blueberry cuttings, six to eight inches long, were obtained from a commercial blueberry farm on July 12, 1965. Each cutting was wounded at the basal end by removing a thin strip of bark one half inch long. A mixture containing 10 parts of 50% wettable Captan and 100 parts Hormodin No. 3 was applied to the base of each cutting.

Flourescent lamps, controlled by a timeclock, were operated for 20 hours daily.

In ascertaining the rooting response, only cuttings having a root-ball (roots plus attached media) 1½ inches in diameter

Table I. Rooting of Blueberry Cuttings under Mist While Exposed to Various Intensities of Fluorescent Light

Percent Rooted*

	110-195 Footcandles	195-280 Footcandles	280-365 Footcandles
Atlantic	83	72	66
Coville	86	96	100
Jersey	92	80	72
Pemberton	100	89	96
Rancocus	74	78	53
Wareham	100	93	92
Weymouth	64	88	56
Mean	86	85	76

*Includes only cuttings with Root-balls 1½" in diameter or larger or greater were considered rooted. Cuttings having smaller root systems were considered as being too meager to be potted and were classified as not rooted.

Results and Discussion

Rooting was first observed four weeks after the cuttings were made. In October when the cuttings were removed from the benches, most had root balls approximately three inches in diameter. The mean percent rooting on cuttings under mist and those in the plastic tent were similar except for the cuttings subjected to the 280 to 365 footcandle range (Table I and II).

The highest rooting percentages occurred at the intermediate low intensities, whereas the lowest percentages were observed at the highest intensities.

There was a greater decrease in rooting at the high intensity range in the plastic tent than in the mist bench (Table II).

It was also observed that the color of the foliage under the high intensity range gradually changed from deep green to bronze.

At the intermediate range the foliage was reddish green while at the lowest intensity the foliage remained a dark green. These changes in foliage color were also observed on the mist treated cuttings.

Leaf temperatures within the plastic tent were approximately 4.5 degrees higher in the section receiving the high range of intensity than were those located in the low intensity range while those in the mist bench were relatively uniform throughout (Table III). The decrease in rooting and increase in chlorophyll destruction at the highest intensities of fluorescent light were more prevalent on cuttings in the plastic tent.

These responses may be attributed to the intensity of the fluorescent light, per se, or to the combined effect of high inten-

Table II. Rooting of Blueberry Cuttings under A Plastic Tent while Exposed to various Intensities of Fluorescent Light

Percent Rooted*

	110-195 Footcandles	195-280 Footcandles	280-365 Footcandles
Atlantic	72	69	54
Coville	80	82	65
Jersey	100	76	80
Pemberton	86	100	80
Rancocus	71	65	59
Wareham	71	93	48
Weymouth	100	92	36
Mean	83	82	56

*Includes only cuttings with Root-balls 1½" in diameter or larger.

Table III. Temperature Readings Within the Plastic Tent*

Degree Fahrenheit

Light Intensity	Leaf	Air	Medium
110-195 fc.	74.3	75.6	71.6
195-280 fc.	77.0	80.4	74.0
280-365 fc.	78.8	82.4	75.2

*Temperatures taken with Thermistor probes

sity and high temperature. Stoutemyer and Close using an intensity of 400 footcandles also reported bronzing of foliage and decreased rooting (2). They reported that the problem was overcome by decreasing the intensity of light.

Just why this type of injury occurs under fluorescent light at about 300 - 400 footcandles is difficult to explain since similar cuttings propagated in a greenhouse either under mist or in a plastic tent received considerably higher intensities of sunlight and yet exhibited neither bronzing nor poor rooting. Also, temperatures within the plastic tent in the greenhouse were mainly in the 90's; higher than those in the plastic tent under the fluorescent light.

In the earlier experiment, cuttings of *Rhododendron mucronulatum* propagated in plastic trays in a growth chamber having cool-white fluorescent and incandescent light sources exhibited similar responses. Bronzing and decreased rooting occurred on trays of cuttings receiving from 285 to 1200 footcandles, while cuttings receiving 92 to 220 footcandles had a higher percentage rooted.

Generally, the highest percent rooting occurred on the cuttings receiving the lower ranges of intensity employed in this experiment. The mist and the plastic tent method of propagating the blueberry were equally effective at the low and intermediate light intensities.

New shoot development occurred from the base of all varieties with the exception of Weymouth. Initiation of new shoot growth occurred in response to the long photoperiods employed (3). Similar varieties propagated in the greenhouse under normal photoperiods did not develop new growth. The length of the new shoots varied from two to six inches, some having grown as long as the original cuttings.

Apparently, the energies of light used in this experiment may have been more than what was required for the blueberry to develop roots. With shade-loving species as the blueberry, the use of artificial light in an insulated building may be feasible because of the low energy input required.

Summary

Blueberry cuttings taken during July rooted rapidly and at high percentages with fluorescent and incandescent lamps as the sole light sources.

Both mist and the plastic tent technique of propagation were effective. The highest percentage of rooting occurred on cuttings exposed to low and intermediate intensities of light. At the highest intensities rooting was reduced and the foliage discolored especially under the plastic tent. New growth developed on most varieties in response to the 20 hour photoperiod treatment.

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JOHN ZELENKA: I would like to know what time of the year these cuttings were taken. Were they soft wood cuttings?

DR. WAXMAN: They were taken July 12th; the plants had made their growth and stopped. The terminals were firm.

JOHN ZELENKA: They were firm; they were not in the active growing stage?

DR. WAXMAN: No.

JOHN ZELENKA: In what medium were they rooted?

DR. WAXMAN: Peat and perlite, 65:35.

JIM WELLS: Sidney, it wasn't quite clear to me the relationship between temperature in the rooting medium and the light intensity. Did you say that you had a higher temperature under the plastic and it went up to 85 - 90° F.? Is that correct?

DR. WAXMAN: You are comparing the mist and the plastic. The temperatures under the mist were cool, the medium as well as the air. Under the plastic the temperatures were very high. At the highest intensity area it got up to 97° F. and remained there. At the lower end of the same bench it was about 88° F. And they all rooted in a matter of 4 weeks and could stand this very, very high temperature.

ARIE RADDER: Sid, did you have the lights on 24 hours or did you use less?

DR. WAXMAN: Twenty hours in this case.

HANS HESS: Next, Dr. Stu Nelson will give a progress report on root promoting actiivty in juvenile and adult phases of *Malus robusta* 5.

PROGRESS REPORT OF ROOT PROMOTING ACTIVITY IN JUVENILE AND ADULT PHASES OF MALUS ROBUSTA 5 APPLE ROOTSTOCK

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Since World War II, juvenility in plants has gained a certain prominence in the research of a number of countries. Specifically with *Malus*, reports of juvenility began to appear in European literature in the late 1940's and a summary of this was published in 1956 by Blair. MacArthur and Nelson (3) to substantiate the finding of the juvenile and adult forms in *Malus* and *Pyrus* at Ottawa. Subsequent to that report, both physiological growth phases were clearly evident on the same tree of a German rootstock-stembuilder selection received from Professor Maurer of Berlin in the late 1950's.

Of prime interest to the propagator is the fact that the juvenile form of *Malus* roots readily from softwood cuttings while the adult roots poorly; not only in low percentages but also with few points of attachment (11). Although there have been reports of the successful rooting of apples, I feel that the situation is fairly well summed up in the East Malling Report for 1964 (1) and I quote, "Some 30 scion varieties of apples have been propagated on their own roots: none were found to root as readily as even the shyest-rooting commercial rootstocks."

The quest for information on juvenility is of prime commercial importance as the propagation of own-rooted fruit trees would eliminate rootstock problems in all their ramifications. Conversely, if it was found, by chance, that the adult growth phases contained the controlling growth substance and the juvenile could be so treated, tremendous saving of time to the plant breeder would greatly accelerate the long program now required. Although many environmental treatments have been tried in an attempt to shorten the juvenile period, it has been generally accepted that these have not been successful or could not be applied to any appreciable breeding program. Recently, (Andersen (2), a marked shortening of the juvenile period was achieved by grafting to the very dwarfing rootstock, 3431, although considerable extra work is involved. Although the rooting of material is of greater importance to this group, we cannot ignore the other possibility and the plant breeder who is closely associated with us.

Even though juvenility in *Malus* had been identified at Ottawa and work with other crops by Hess (5) strongly suggested a further area of investigation, it was not until 1962 at the University of Saskatchewan that this work could be started. The first phase of the work by Quamme and Nelson (13) terminated in 1963. Briefly, it was found that a typical cofactor response, adopting Kefford's (9) extraction methods, was found in the acid-ether fraction of the juvenile phase. The alkaline-ether fraction failed to give a cofactor-type response although increased rooting occurred near the base line of the chromatogram in both the adult and juvenile phases. The aqueous extract showed severe inhibition of rooting and did not vary in the two growth phases. Straight-growth tests with Avena coleoptiles were also conducted (Nitsch (12)) and although some promotion was present, it was not significant between the two growth phases and the greatest promotion occurred on the chromatograms in areas other than that of the cofactor response.

Subsequent to this work, another student, Miss Hwang (7), concentrated on the alkaline-ether fraction using thinlayer chromatography and varying solvent systems. The solvent system of normal hexane, ethyl acetate, as suggested by Hess (6), proved to give us the best visual separation under daylight and ultraviolet light but, although responses in rooting have occurred, it was not demonstrated to the workers' satisfaction that a cofactor response existed in this fraction of *Malus*. In this work, the acid-ether fraction was obtained in each extraction. As suggested by Kefeli and Turelskaya (8), toluene was used to remove fats and pigments. The alcohol extract was washed three times with toluene immediately after the sample was macerated and filtered. The area that only gave a cofactor response in the juvenile form for Quamme and Nelson (13) was now giving a cofactor-type response in both phases. This may be similar to the findings of Zimmerman (14) with *Pinus*. Obviously, by chemical manipulation, using toluene, something was removed from or released in the adult extract that allowed it to behave in the same manner as the juvenile. To date, no clues have been obtained from further studies with the toluene fraction.

During the summer, a chemistry technician was obtained and seconded to the Department of Chemistry under the direction of Dr. J. M. Pepper. A completely chemical approach was taken and exhaustive soxhlet extractions, with varying solvents, were made by the Department of Chemistry. The water soluble portions of the crude and fractionated extracts were returned to the Department of Horticulture and bioassayed with the mung bean rooting test without chromatographic separation. A number of root-promoting solutions were obtained and are illustrated in the three tables. Values listed in the upper left are number of runs, number of roots on water check and number of roots on the IAA (10^{-6}M) check respectively. Values under the columns represent the mean percentage increase in rooting over the respective check treatments.

(a) As shown in Figure 1, root promotion was found in the ether and alkaline water soluble fraction. It will be noted that ether alone gave practically no response but when the ether was washed with NaOH, the rooting-promoting substance(s) went into the water portion. When the water portion was reacidified, the root-promoting substance(s) were again ether soluble and were taken up in water when the ether was evaporated. It

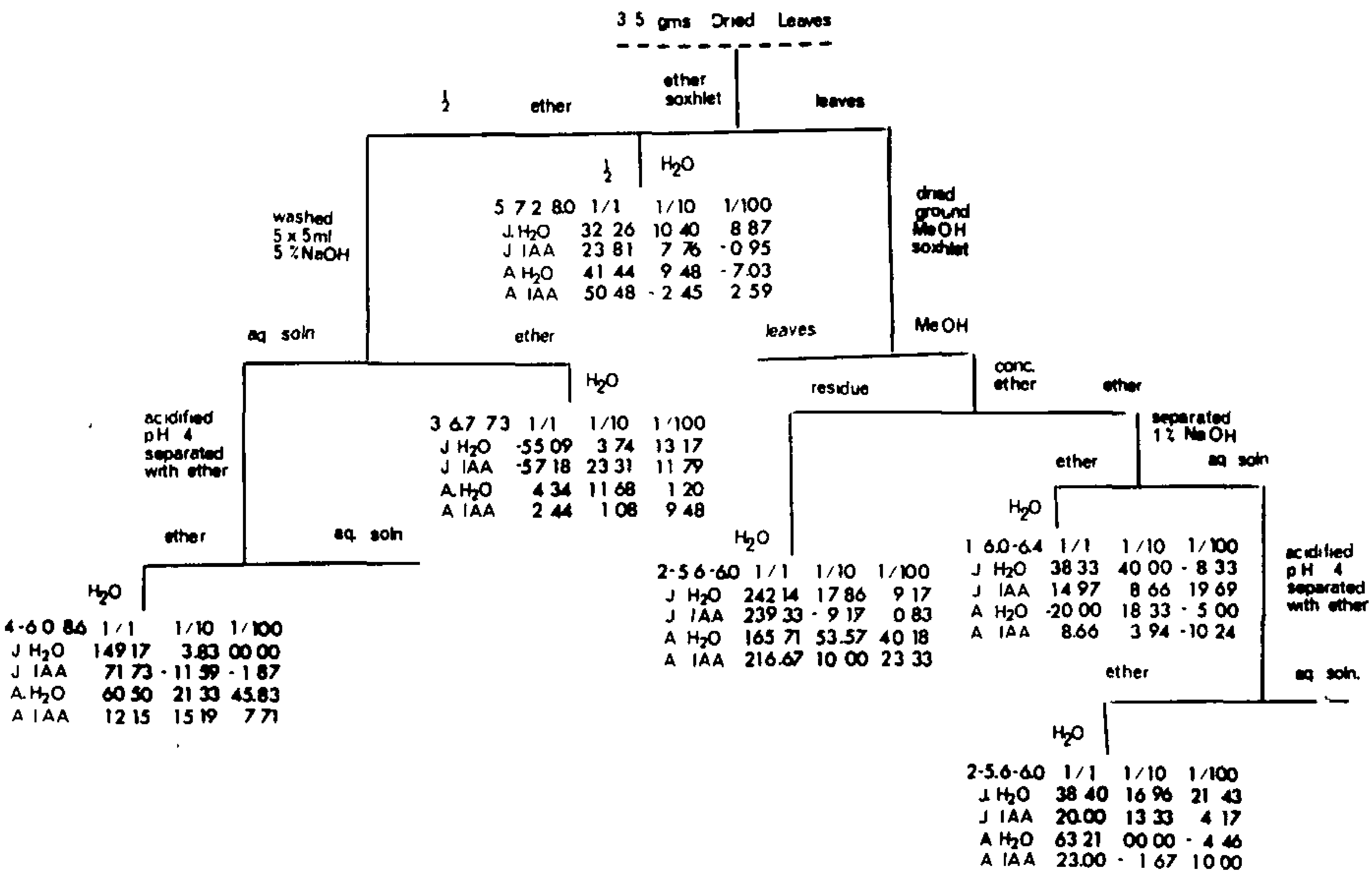

Figure 1. Average rooting response (over check treatment) of mung bean cuttings in solutions from various stages of ether, methanol and water extractions.

should be further noted that an inhibitor became evident in the ether after the alkaline wash. The level of root activity and inhibition was greatest in the juvenile.

(b) Also in Figure 1, another solution is exhibited that contained substance(s) which were ether insoluble, methanol soluble and water soluble. This root promotion was found in both of the growth phases.

(c) Rooting responses were obtained from both the juvenile and adult growth phases (Fig. 2) from substances that were benzene insoluble, methanol insoluble, ether soluble and water soluble.

(d) Also in this Figure is exhibited a solution that contained substance(s) that were benzene insoluble, methanol soluble, ether soluble and water soluble. The very high response is likely the result of the greater amount of original material.

(e) Still referring to Figure 2, another area of root promotion was from substance(s) that were benzene insoluble, methanol soluble, ether insoluble and water soluble. This residue showed considerable phytotoxicity but the 1/10 dilution yielded rooting levels far higher than experienced for this dilution in any of the other extractions.

(f) Finally in Figure 2, substance(s) that were benzene soluble, ether soluble, alkaline water soluble, but returned to the ether portion when reacidified and were finally water soluble when the ether was evaporated.

Because of fewer solvents in (a), it is possible that the substances discussed in one of (c), (d) or (f) could be the same as (a). Also (e) could be the same as (b).

Figure 3 illustrates extractions where the order of methanol and ether was reversed. It was noted that, where the root-promoting substance(s) were both methanol and ether soluble, it seemed preferable to use methanol first in the extraction.

As shown in Figure 2, one cofactor type of response was found in the juvenile phases but not in the adult. The substance(s) was benzene soluble, ether soluble and remained in the ether when it was washed with NaOH but was water soluble when the ether was evaporated.

It will be further noted that final aqueous separations were ignored in the extractions. This was because of the earlier findings of Quamme and Nelson (13). Obviously from work this fall however, there is considerable root-promotion in aqueous solutions but in most cases, a dilution of 100 times was needed.

As stated in the title, this is a preliminary report. The root-promoting substances discovered in these extractions will have to be further fractionated by chromatography so that they

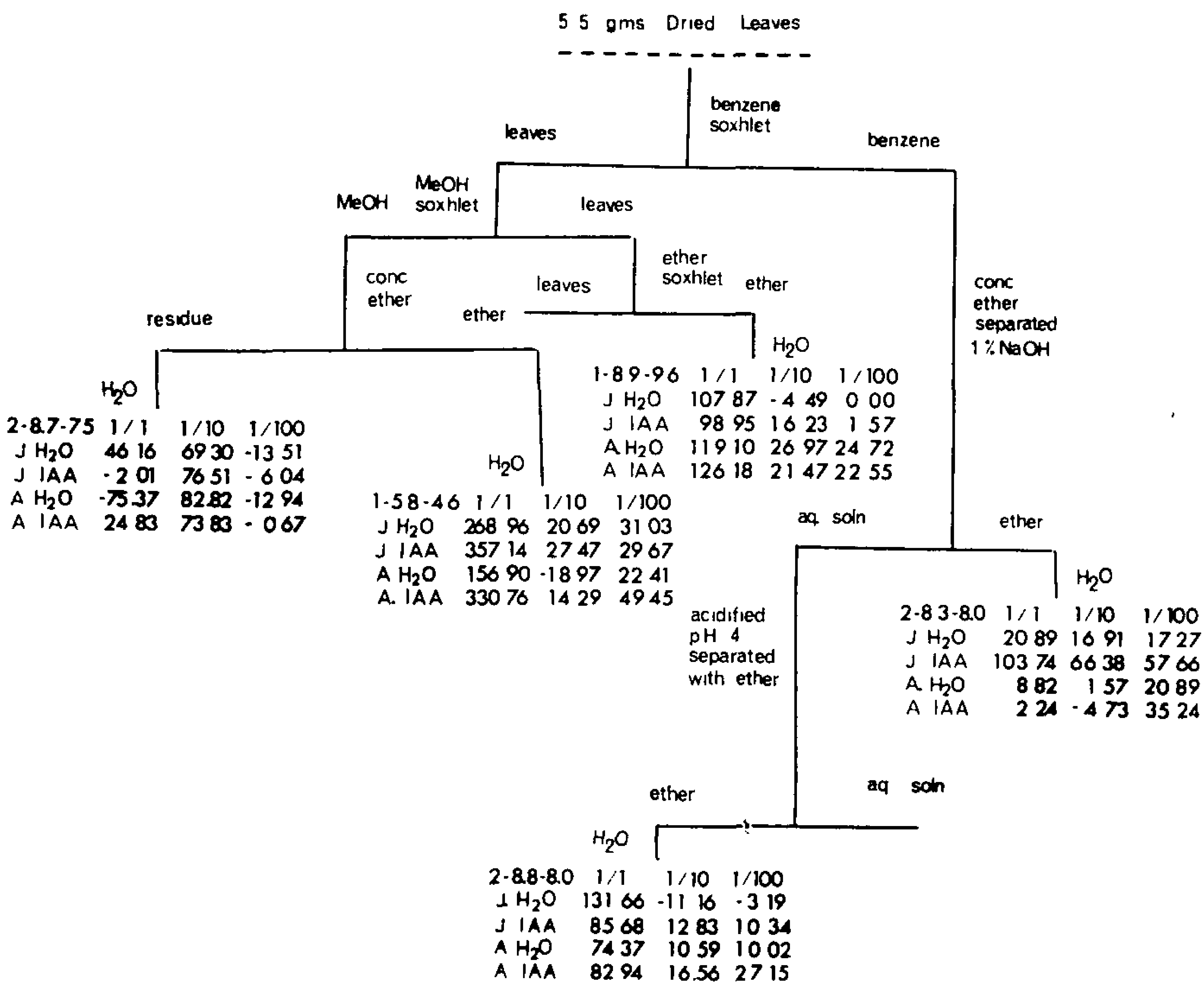

Figure 2 Average rooting response (over check treatment) of mung bean cuttings in solutions from various stages of benzene, ether, methanol and water extractions

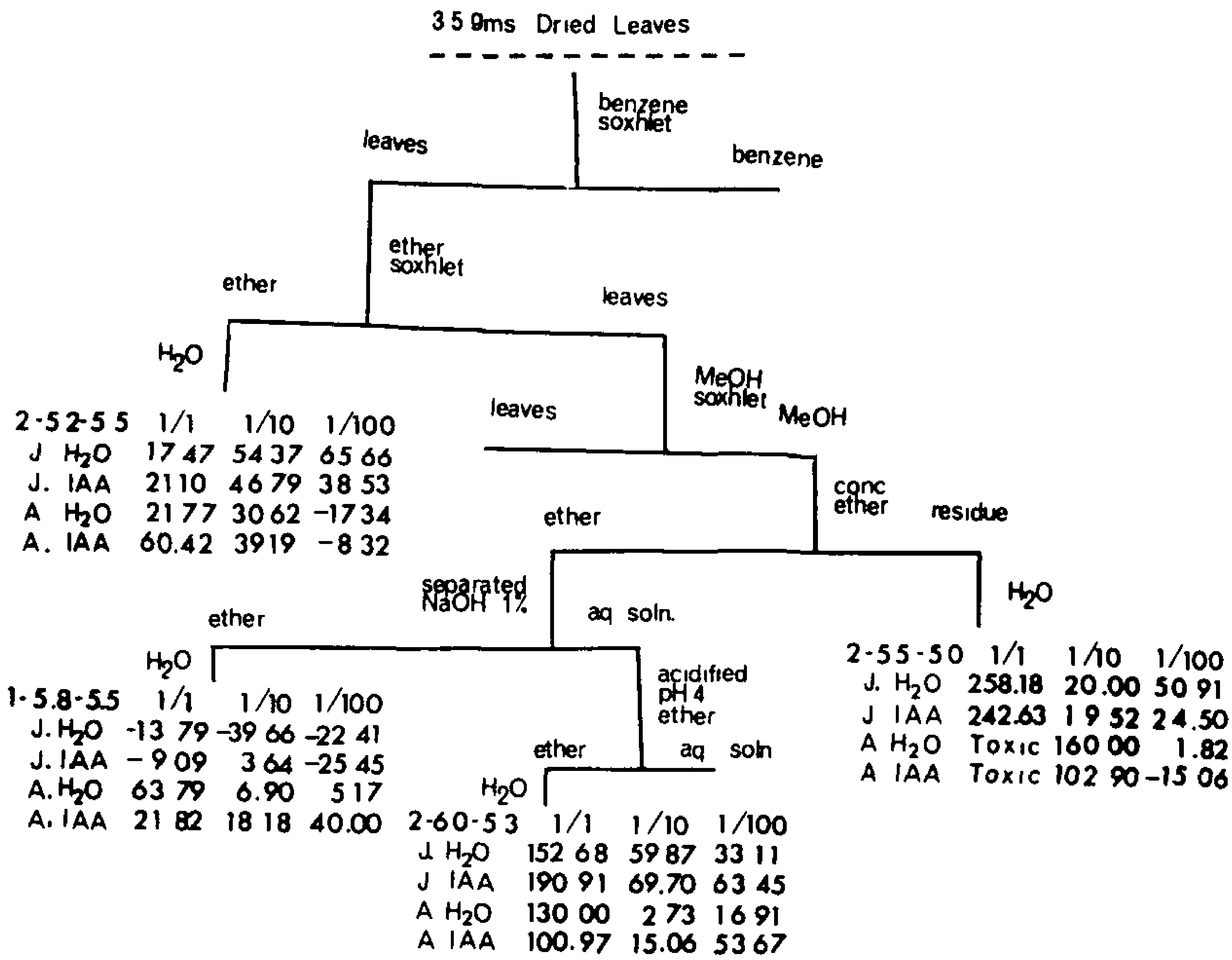

Figure 3. Average rooting response (over check treatment) of mung bean cuttings from various stages of benzene, methanol, ether and water extractions.

can be characterized. An attempt will be made to correlate them to the root-promoting substances reported by Luckwill (10) but of the "auxins" he reported in apple, only two were said to have root-promoting activities. Furthermore, the cofactor response found in this study will have to be characterized by chromatographic methods. This cofactor-type response is obviously not the same as that reported by Challenger, Lacey and Howard (4) as theirs was obtained in the acid fraction. The cofactor response, originally reported by Nelson and Quamme (13), however, may be the same as that reported by these workers in England but appearing at a different Rf. because of isopropanol:water (8:2) was used at Saskatoon and isopropanol:water:ammonia (8:1:1) was used in England.

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HANS HESS: Our next speaker this morning is Ralph Shugert who will talk about *Phomopsis* blight.

CONTROL OF PHOMOPSIS BLIGHT IN JUNIPERUS VIRGINIANA SEEDLINGS

RALPH SHUGERT
Plumfield Nurseries, Inc.
Fremont, Nebraska

One of the most serious plant diseases of *Juniperus virginiana* is Phomopsis blight (*Phomopsis juniperovora*). In our seedlng operation at Plumfield Nurseries, *Juniper virginiana* is a valuable crop, since we drill one hundred pounds of seed each year, and take off about one hundred and fifty thousand seedlings, 2-0 and 3-0, annually.

Anyone who has grown an extensive amount of *Juniperus virginiana* is well acquainted with cedar blight. I have never seen seed beds of this species that have not been infected with this insidious fungus to some extent. This particular fungus has the disconcerting characteristic of attacking the growing tip of the evergreen, thus necessitating a good spray program throughout the growing season.

Over the years the Plains nurseries, including Plumfield, have tried several fungicides but the control has not been satisfactory. For many years Bordeaux mixture was used, and this was followed by a material called Special Semesan, which is no longer manufactured. In the late 1950's Puratized Agricultural

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Spray (Phenyl mercury triethanol ammonium lactate) was first used in the control of Juniper blight with good success. To determine the effectiveness of P.A.S. (Puratized Agricultural Spray) a series of tests was conducted by Dr. Glenn Peterson, Plant Pathologists with the U.S. Forest Service. These tests were held in cooperation with Plumfield Nurseries and the Out State Testing Program of the Plant Pathology Department, College of Agriculture, University of Nebraska. The tests that Dr. Peterson reported on, in the Plant Disease Reporter (Vol. 44, No. 9) September 15, 1960, were made to test the efficacy of P.A.S. and three other fungicides for the control of Phomopsis blight. Tests were made in 1-0, 2-0, and 3-0 seed beds with nine sprays during the summer on the two and three year beds, and six applications on the one year beds. In addition to P.A.S., at the rate of one and one-half pints per fifty-five gallons of water; the other fungicides used were Kromad, Cyprex at 0.2 pound per ten gallons of water, and Actidione at 1.6 ounces per ten gallons of water. The dosage on both Cyprex and Acti-dione was reduced after several applications to 0.1 pound and 0.11 ounce per ten gallons of water respectively. The results of these 1959 tests showed that all the fungicides used reduced Phomopsis blight when compared to the check. Both Cyprex and Actidione showed toxicity, and P.A.S. was far superior to the other fungicides used, particularly in the 2-0 seedling beds. Also the P.A.S.-treated plants averaged nearly two and one-half times more weight than the checks. Blight incidence in the 3-0 beds from the experimental bed and in other beds throughout the nursery was very light. Treatments did not significantly influence the amount of blight in these 3-0 beds.

Following the tests of 1959, another comprehensive series of tests was conducted in 1964. The purpose was to determine what rate of P.A.S. would be most effective against Phomopsis blight, and whether control could be improved if spreader-stickers were used. Also it offered an opportunity to test some new fungicides. All the experimental beds were sprayed weekly, from May 19 through September 11, 1964. Tests were conducted on both 1-0 and 2-0 beds. Materials used and treatments with rates per one-hundred gallons of water, were as follows: P.A.S. at 2 pints, 1½ pints, and 1 pint; P.A.S. at the above rates with triton B-1956, 3 ounces; P.A.S. at the above rates with Plyac at 3 ounces. Both Triton and Plyac are spreader-stickers. The new fungicides tested were Difolatan at one pound; Brestan at one-half pound; D.A.C. 2787 at one and three-quarter pound; Polyram at one pound.

These 1964 tests conducted by Dr. Glenn Peterson, were reported in Vol. 49, No. 6 of the *Plant Disease Reporter*. The tests concluded that good control was obtained with P.A.S. in both 1-0 and 2-0 seed beds, and the most effective rate was two pints per one hundred gallons of water. It is to be noted here that very good results were obtained with P.A.S. at the other two rates used also. The other fungicides used did not provide satisfactory control, and the addition of spreader-stickers to P.A.S. did not improve the fungus control. In fact, it was quite apparent that the seedlings treated with P.A.S. plus a spreader-sticker had a marked color change—a yellowing of the seedlings. The average blight incidence for all P.A.S. treatments in 1-0 seed beds was 3.2% compared with 34.8% for non-treated plants. In the 2-0 beds, P.A.S. averaged 9.9% as against 49.5% for non-treated plants.

As a result of Dr. Peterson's tests in 1959 and in 1964, we are presently using P.A.S. at the rate of two pints per one hundred gallons of water, on all of our *Juniperus virginiana* seed beds. This includes all 1-0, 2-0, and 3-0 seedlings. We start our spray pogram in mid-May and religiously adhere to a weekly program. This past year we sprayed every Wednesday, and if we encountered rain on that day the spraying was completed the following day. It is my contention that weekly spraying of *Juniperus virginiana* seed beds is mandatory if you are going to bring off vigorous, thrifty seedlings. Anytime you have a crop of over one hundred thousand of anything, it will behoove you to do anything and everything in your power to insure that crop.

Quite frankly, I don't like the cost factor of P.A.S. When purchased in case lots its cost is $12.00 per gallon, which we apply every week to cover our beds. This cost plus seven man hours at $1.60 per hour, plus tractor-sprayer cost, plus overhead, certainly have added to the cost of producing this species. You compensate for this by increasing the price of the plants to give the proper profit margin. As best as I can determine our spraying cost annually — for *Juniperus virginiana* only — is $4.40 per thousand seedlings. This is based on a production of one hundred and fifty thousand seedlings, and using realistic equipment and overhead cost percentages. Like other growers of this species, we are hopeful that a fungicide will be available someday that will be less expensive, and not have to be applied weekly.

In conclusion, I would like to acknowledge the excellent scientific approach that Dr. Peterson used to perform these tests. I am also grateful for the use of his data and conclusions. We are indeed fortunate to have a Plant Pathologist of his magnitude in Nebraska. This again points out a situation that has been discussed many times at our Plant Propagator Society meetings, the importance of communication between the professional nurseryman, the Universities, and related governmental agencies. We all travel the same rocky road . . . by working together we can make this road much smoother.

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MARTIN VAN HOF: Ralph, I think you have made a mistake. Did you say at one point that the cost was $44.

RALPH SHUGERT: No, I said the cost per thousand seedlings was $4.40.

MARTIN VAN HOF: Our pathologist from the University of Rhode Island has worked with us in Newport County on Juniper Blight or *Phomopsis*. Now it is too bad that none of them are here, but we do have some representatives from the University. I wonder if they could give us any data on that work?

RALPH SHUGERT: Martin, I have received through the very good fortune of being on the Rhode Island Nurseryman's mailing list, the article on Phomopsis Blight that was printed in your Trade Association Newsletter. Dr. Peterson has seen it also. Now the results you had in Rhode Island did not work in Nebraska. We did not get Phomopsis control with the material you were using in Rhode Island. We couldn't understand why or what the reason was that the Rhode Island Station was not using PAS (Puratized Agricultural Spray) in some of its tests and I didn't bother to write them. I have the reports of these papers, the reprints from the Plant Disease Reporter which I'll be glad to give you to take back and use.

MARTIN VAN HOF: From last year?

RALPH SHUGERT: I have all of them.

MARTIN VAN HOF: '64 and '65 too?

RALPH SHUGERT: Right.

DON CATION: Ralph, have you tried any other mercury beside puratized? There are 4 or 5 of them, one of them is fixed which is in a powdered form and to get the same strength you, I forget what it is, an ounce or something like that per gallon, which is just a little cheaper. We did work with the various mercuries against scab and they are all fairly equally effective against apple scab.

RALPH SHUGERT: No sir, Mr. Cation we did not. The reason as to the new fungicides tried in the 64 tests, Dr. Peterson wrote to all the chemical manufacturers explaining what the purpose of the test was going to be. It was going to cost both the Out State Testing Bureau and the Nursery a fair amount to conduct the test. He received several replies from chemical companies stating that some of the mercuries they had on the market were not recommended for control Phomopsis. This may be because there were not enough tests out. While we did get tremendous results from Cyprex on cherry leaf spot, the tests on *J. virginianum* just did not do the job. No better than Bordeaux. I'm optimistic enough to believe there will be a fungicide out that we can apply that is going to be longer lasting.

DR. REISCH: Ralph, how prevelant is that disease in your area on landscape material?

RALPH SHUGERT: It is not severe. But the disease is in all nurseries and quite frankly it is more apparent in the federal nurseries — we don't have state nurseries in Nebraska. And the incidence of the Federal Nurseries is bad enough in seed rows that a million and three quarters *J. virginianum* seedlings were destroyed. Now we don't find it too bad, just in isolated plots. Here again, Dr. Peterson's theory is that if plants are spaced wide enough apart, and you don't have this high concentration of plants as in the seed bed or the seed row the problem is reduced. It is very, very, minor in landscape work.

CASE HOOGENDOORN: Now you talk about *Phomopsis* blight in *Juniperus virginiana.* Do you also get that in Hetzi, Pfitzer or any other varieties?

RALPH SHUGERT: Mr. Hoogendoorn, I noticed in a Rhode Island paper they listed a bunch of host plants susceptible to this blight. I have never witnessed it in Nebraska or anything except *J. virginiana.* We also grow quite a few *J. scopulorum* from seed — almost as much *J. scopulorum* as we grow *J. virginiana* and I've been told that I don't have to spray the *J. scopulorum.* Very rarily do you ever see it get it. If the disease which shows up is *Phomopsis,* I have a type of insurance program and spray the 2-0 beds, but only two-zero. And even though the disease is light in 3-0 *J. virginiana* beds, again it is an insurance policy, we also spray the 3-0 beds. No, I have never seen it, sir, on any other than *J. virginiana.*

HANS HESS: Our final paper this morning is by R. E. Odom and W. J. Carpenter, Jr. on endogenous auxins and the rooting of cuttings. The paper will be presented by Dr. Odom.

ENDOGENOUS ACIDIC AND NEUTRAL AUXINS AND THE ROOTING OF CUTTINGS[1]

R. E. ODOM AND W. J. CARPENTER, JR.[2]
Kansas State University
Manhattan, Kansas

Environmental and internal factors influence initiation of roots on stem cuttings. Indole auxins have been shown to be a major internal factor in root initiation. Other essesntial chemical substances have been found, but all require the presence of auxins.

The presence of and changes in endogenous indole auxins in bases of several species of herbaceous and woody cuttings during rooting were determined. The five herbaceous species were *Alternanthera bettzickiana* 'Aurea Nana,' *Coleus blumei, Chrysanthemum morifolium* 'Dawn Star,' *Pelargonium hortorum* 'Pink Cloud,' *Dianthus caryophyllus* 'Alaska.' Those species root readily but their root emergence varies from approximately 2 to 15 days. The two woody species studied were *Pyracantha coccinea lalandi,* which is somewhat erratic in rooting, and *Carya illinoensis,* which is considered a nonrooter.

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[2]Graduate student and associate floriculturist, respectively This article is based on the PhD dissertation of the senior author

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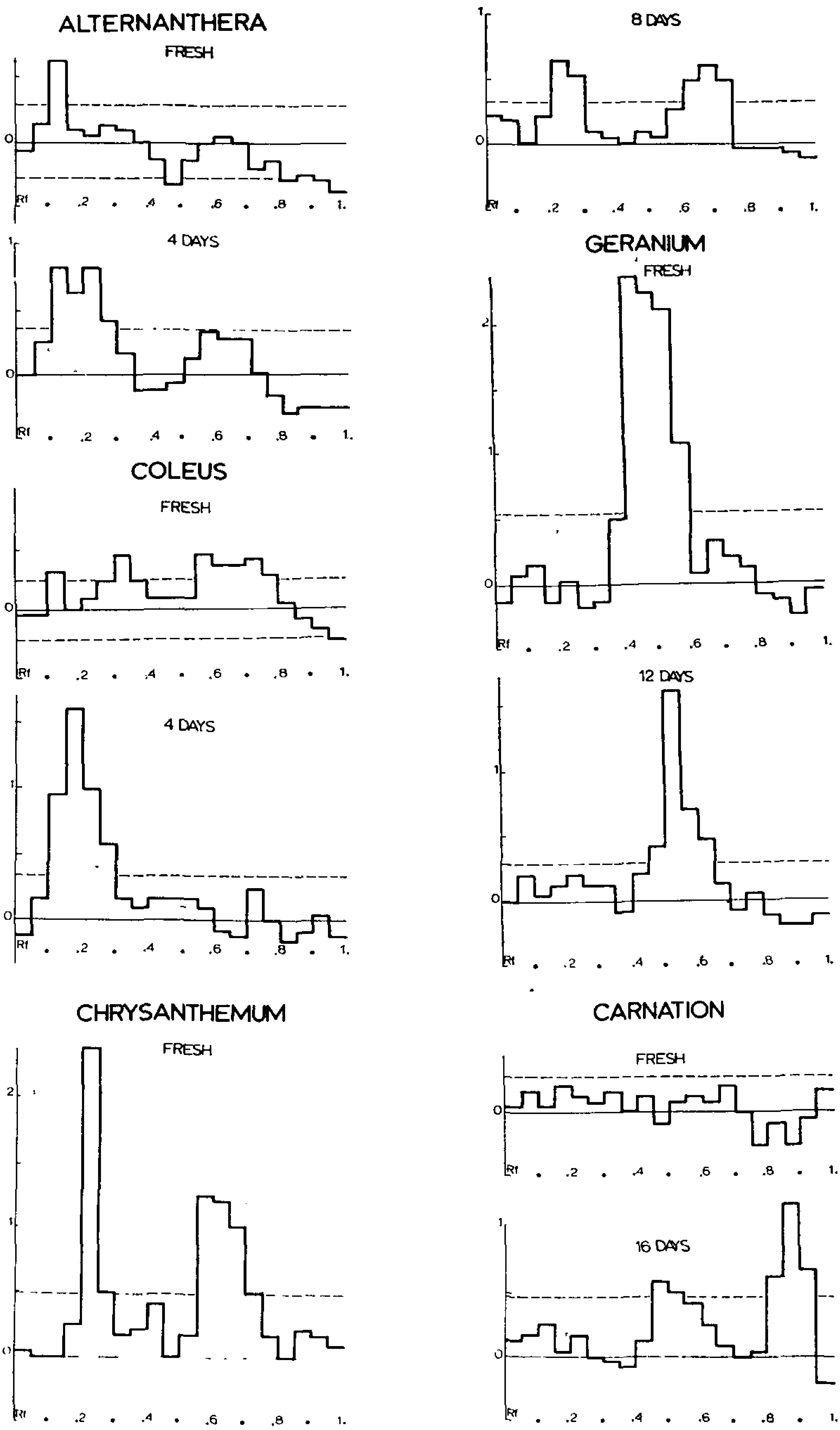

Plate 1. Histograms from bioassays of fresh cuttings and time of root emergence of alternanthera, coleus, chrysanthemum, geranium and carnation. Growth of coleoptile sections shown in mm, and significance at 5% levels indicated by dashed line

Uniform terminal cuttings were sampled at propagation and predetermined intervals of 1 to 4 days during rooting. The sampling of pecan differed since changes in auxins were determined during 5 weeks of dormant storage of hardwood cuttings at 7-day intervals.

The basal one-inch portion of the cuttings were lyophilized and extracted with methyl alcohol for 2 hours at temperatures below freezing. The extracts were purified (Nitsch, 1955) prior to separation by paper chromatography in a solvent system of isobutanol-methanol-water (80-5-15 v/v) (Nitsch, 1956). The chromatograms were cut to 20 equal 1 cm. sections and bioassayed by the Avena coleoptile test (Nitsch and Nitsch, 1956). Those procedures permitted determination of both acidic and neutral 'free' auxins in the bases of the cuttings at sampling time.

Selected data from the bioassays are shown in Plates I and II. The histograms illustrate auxin levels in fresh samples and when roots emerged in all species except pecan. Pecan bioassays were made from samples collected in November, February, and April. Comparisons are presented between auxin levels in fresh cuttings and after 5 weeks of dormant storage.

The histograms indicate qualitative and quantitative differences in auxins among the various species studied. Six auxins were tentatively identified by Rf location of growth peaks in the bioassay as A(0.05-0.20), B(0.20-0.35), C(0.40-0.60), D(0.55-0.75), E(0.70-0.85), and F(0.85-1.0). They closely parallel Rf values of indolepyruvic acid (1Pya), indoleacetic acid (IAA), indolebutyric acid (IBA), an unknown, indoleacetonitrile (IAN), and ethylindoleacetate (IAE) when chromatographed in the same solvent. Further identification attempts indicated that the substance tentatively identified as IBA in geranium probably was an unknown neutral precursor.

Quantitative bioassays showed either high levels of one or more auxins in fresh samples or a tendency to increase rapidly during rooting of alternanthera, coleus, chrysanthemum and geranium. Carnation and pyracantha cuttings initially had low auxin levels, but some accumulation occurred prior to or during root emergence. The levels of auxins in pecan were higher in November and April than in February with very little change during storage periods.

Qualitatively, the presence or accumulation of acidic auxins occurred in alternanthera, coleus and chrysanthemum, while the presence or accumulation of neutral auxins were more predominant in geranium, carnation and pyracantha.

Several indole auxins have been found in plant tissues. and several synthetic auxins have been shown to be capable of stimulating root initiation on stem cuttings. The precise effects of those substances are not known, but it is generally believed that their auxin activity may be due to conversion in plant tissue to IAA (Leopold, 1964) (Fawcett, 1961). The accumulation of a substance at the Rf of IAA was found in fairly high quantities

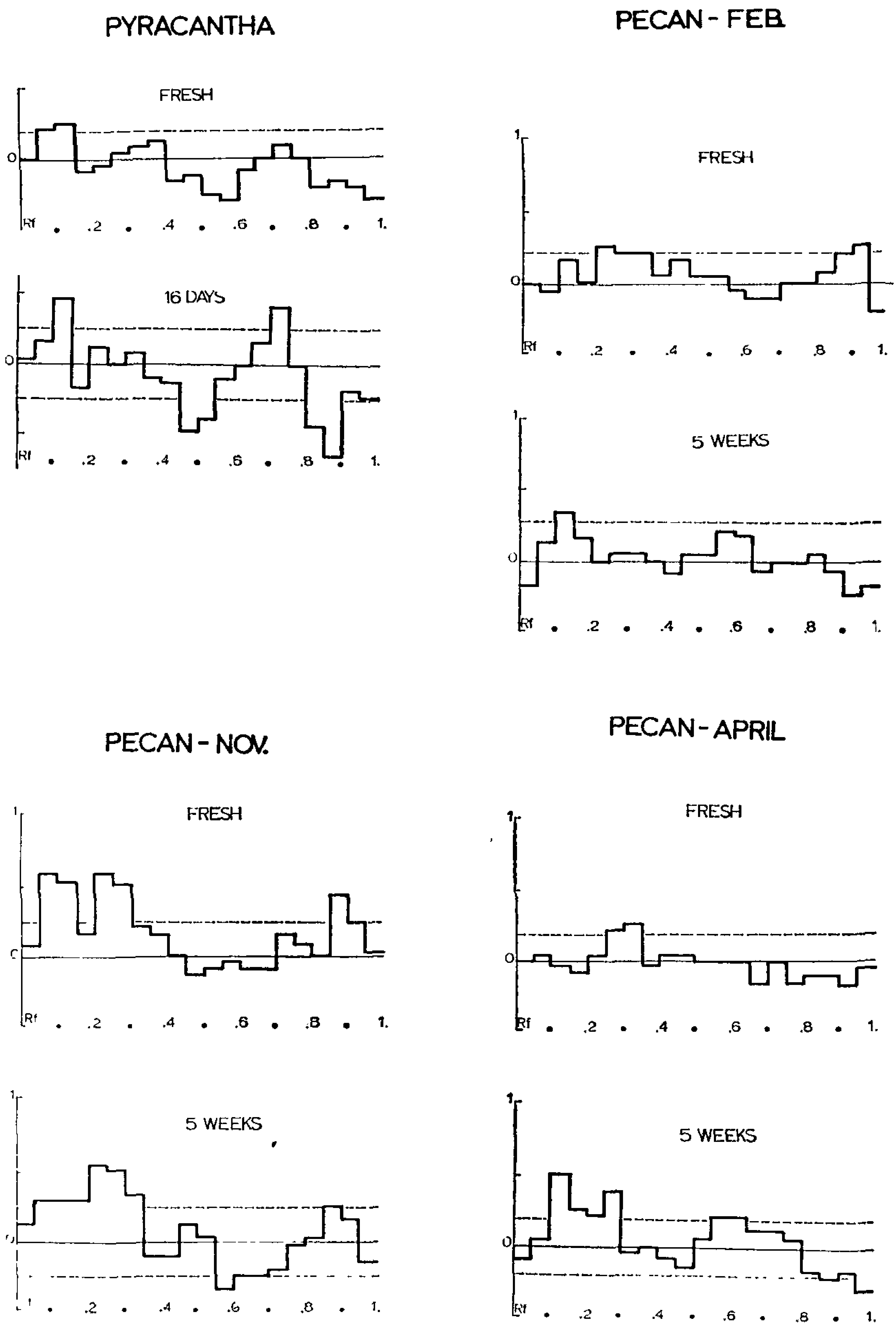

Plate 2: Histograms from bioassays of fresh cuttings and after five weeks of dormant storage of pecan taken in November, February and April. Growth of coleoptile sections shown in mm., and significance at 5% level indicated by dashed line.

in alternanthera, coleus and chrysanthemum, but it was inconsistent in geranium, carnation, and pyracantha. The inconsistent appearance in those species may be caused by slow conversion of neutral auxins to acidic types. Under such conditions, IAA could have been utilized in rooting as it was produced.

Although added root promoting substances have not been studied in these tests, geranium and carnation have been shown to respond to added auxins by producing more roots per cutting and rooting more rapidly (Hartmann and Kester, 1959). Similar beneficial responses were obtained in pyracantha when cuttings were selected in early spring and fall (Thimann and Behnke-Rogers, 1950). Alternanthera, coleus and chrysanthemum normally root so rapidly and profusely that added root promoting substances are of little consequence. Beneficial responses to added rooting stimulants with the species studied closely parallel the lack of or inconsistent accumulation of endogenous acidic auxins.

The nonrooting of pecan and the erratic rooting of pyracantha do not appear to be entirely related to lack of or low levels of auxins. Pyracantha and pecan have total auxin levels comparable with carnations, which indicates that substances other than auxins could be involved. Skoog and Tsui (1948) found a relationship between auxins and kinins in cell division and cell differentiation. Hess (1960, 1963) showed a correlation between the capacity of certain plants to root and the number of rooting cofactors present in the tissue. These findings also do not preclude the possibility of structural limitations.

In summary, the vigor and rapidly of rooting in the species studied paralleled the presence or accumulation of acidic auxins. The species that showed a delayed or inconsistent accumulation of acidic auxins are generally known to respond favorably to added rooting stimulant. Endogenous auxins did not appear to be the limiting factor in the erratic or nonrooting responses of the woody species studied.

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FRIDAY AFTERNOON SESSION

December 10, 1965

The session convened at 1:15 p.m. in the Cleveland Room, Sheraton-Cleveland Hotel. Mr. Thomas Pinney, Jr. was moderator.

MODERATOR PINNEY: Our first speaker this afternoon is Mr. Robert C. Simpson from Vincennes, Indiana.

CRABAPPLE PROPAGATION BY CUTTINGS, GRAFTING, AND BUDDING

ROBERT C. SIMPSON
Simpson Orchard Company, Inc.
Vincennes, Indiana

Cuttings

Propagation by cuttings is the preferred method only under certain conditions. Use of hardwood cuttings has generally given poor results. Softwood cuttings under mist have given satisfactory rooting with certain varieties. Where field space is limited and misting facilities already available this method may be desirable. It is suitable where understocks are not readily available or where propagation is decided upon after the season is too far advanced to secure and line out understocks. Also it is the best method should it be desired to grow certain selections on their own roots.

Disadvantages of this method are that a longer time is required to produce a tree suitable for field or landscape planting. It is generally less expensive to propagate in large quantities by budding or grafting. Little is known about the variation in rooting response of the large number of crabapple varieties being grown.

Grafting

Grafting methods have changed little over the years. Usually this method of propagation is utilized in order to give profitable employment to experienced help at a time when little other work is possible. Grafting is useful for production of small one year liners where larger trees are not desired, or where time is all important in producing crabapple plants and size is secondary.

Grafting permits economy in use of understocks if this is important. Straight root seedlings are used, the root is cut into several sections and each short section is used with a relatively long scion. This method has been used to secure own rooted scion selections. Scion rooting is hastened by a copper or other non-rusting band around the graft, just above the union. As the graft enlarges with growth the band progressively girdles the root stock, thus encouraging own rooting of the scion selection.

Grafting has the following disadvantages:

(1) A longer time is generally required to produce a tree the size of one produced by budding.
(2) Root systems of grafts are not as heavy or well branched as those from budded trees, and are a year younger on a one year graft than on a one year budded tree.
(3) The tops of one year grafted trees, grown on in the field for another year or two, generally are not as straight and well branched as a one year budded tree of the same size.
(4) There is an added danger of knot or gall infection at the graft union. Use of grafting tape with complete sealing of the cut surfaces has reduced occurrence of wound overgrowth and pathological galls.

Budding

Budding is generally the preferred method of propagation for the crabapples, as well as for fruit trees. Advantages are:

(1) Usually this is the simplest and easiest method.
(2) It can be the least costly operation. One experienced man with the help of two grade or highschool boys (or girls) should be able to bud at least 100 trees an hour. One is needed to clean away and wipe each tree, the other to tie the trees as budded.
(3) Much larger one or two year trees are possible from budding.
(4) It is possible to produce a better formed top and heavier rooted tree by budding. With grafting, a one year top is produced on a two year root system which has been retarded by the removal of the seedling top. With piece root grafts the seedling root system is greatly reduced. With budded trees, the understock is planted and grown a full season before being cut back to the bud the second spring.
(5) If scion wood is limited, a tree may be produced from each good bud whereas the normal graft requires a scion piece of at least three buds.

Consideration In Production

Certain considerations apply equally to budding or grafting although the following may apply primarily to budding.

First, understocks must be selected and ordered. Although commercial apple understocks are generally available, hopa and dolgo seedlings may be available. These are favored in the north central states becausse of their hardiness. Baccata seedlings are sometimes available, and occasionally zumi seedlings. Malling or Malling-Merton dwarfing understocks have sometimes been used.

Commercial apple seedlings are produced on the west coast. The seed is secured from the cider mills and usually consists of Jonathan and Delicious seed. This stock is carefully grown by firms who specialize in production of understocks. These seedlings are well grown and carefully graded, and are relatively uniform. The $\frac{1}{4}$ inch grade is better for budding stock, the No. 1 probably better for grafting. Branch rooted seedlings are superior for budding or whole root grafting. Straight root seedlings permit securing more than one graft per tree, although usually this is short sighted economy.

Hopa seedlings tend to be more variable in size and vigor. The large percentage of seedlings with red wood and bronze leaves may lead to mixtures where similar type varieties are being grown. Too often a shoot from the root-stock is mistaken for the scion variety.

Baccata seedlings also are quite variable in size and vigor and produce a less desirable root system characterized by fewer and larger roots tending to strong horizontal growth. For the three seasons used, the varieties on baccata understock made 12 to 14 inches more growth in height, on the average.

Dolgo seedlings are said to be satisfactory.

Zumi seedlings are seldom available. Crabapples tried on this stock were not noticeably different above ground. The root systems, however, were typically heavier than apple understocks, with many more fine roots, and a more horizontal orientation. The difference was so marked it was not difficult to distinguish trees on this root stock.

Malling or Malling-Merton understocks are for production of dwarf fruit trees. They have also been used to a limited extent for dwarfing crabapples. This would seem of questionable merit as many of the Asiatic species of crabapple serve as indicators for a variety of latent viruses. If these species or varieties of these species were grafted or budded onto virus infected understocks, the results would not be satisfactory. Virus has been rather wide spread in vegetatively produced clonal root stocks.

Treatment of seedlings prior to planting is important. Careful pruning will assure a better branched root system, with less breakage at digging time. Powdery mildew may be a serious problem on the seedlings during the first season as the apple is highly susceptible. Several sprays may be necessary for control of this one disease. The recommendation for control is to dip the seedling tops in dormant strength liquid lime sulfur, then include sulfur in the first two or three sprays. Later eradicant sprays require much more costly materials.

Seedlings for budding should be kept growing vigorously. Fertilizers to be effective should be applied prior to planting or very early in the first growing season.

A soil treatment of Dieldren or similar material for control of soil insects prior to planting may be of great value. Such treatment followed by BHC in the spray program, has eliminated woolly aphids as a problem. Furthermore, the control of soil insects has practically eliminated incidence of root knots, hairy root and root rots.

The budding process with crabapples is simple and resultant stands should be high. A few varieties have been more difficult. Among these are Dorothea, Katherine, Sargent and a few others. Baccata understocks have given better results with the first two varieties in some cases.

Best results normally are secured where scion wood is of such size and vigor that buds can be removed free of wood beneath the shield. This is done by making a rather deep cut beneath the bud, and a second cross cut just through the bark. The bud shield may be separated from the scion by a slight pinching action. This makes possible the union of cambium layers of stock and of the entire bud shield. Where a silver of wood is left beneath the bud, satisfactory union may or may not take place, depending upon the skill of the budder and the variety of crabapple.

Where bush form trees are desired or in the case of varieties giving poorer stands, double budding may be helpful. By budding a row normally and then rebudding, preferably on another day, setting the second bud on the opposite side of the tree, the stand can be improved.

Buds placed on the south side of the understock break dormancy earlier in the spring and thus have a longer growing season. Buds placed on the side toward prevailing winds, normally westerly, are less subject to separation from understock by wind and rain. Also they tend to produce a more upright main stem.

Removal of the seedling portion above the bud should be done just as the bud breaks dormancy. The cut should be made at a 45 degree angle 1/8 to 1/4 inch above the bud, with the bud at the high point of the cut. A few varieties are reluctant to break dormancy unless and until the top is cut back.

Proper attention to removal of shoots from the understock, staking, tipping, and early removal of lower scion side branches are all necessary for production of a well shaped tree. Some varieties do not respond to tipping and seldom can be induced to produce a branched tree until the second year. Response to tipping is strongly influenced by time of year, possibly a combination of photoperiod and temperature. In the latitude of southern Indiana it is possible to produce a shapely well branched crabapple from a bud in one growing season.

Under most conditions a better crabapple tree may be produced more quickly and at less cost by budding as compared with propagation by cutting or grafting.

MODERATOR PINNEY: If you have any questions put them in the question box for tonight. Thank you very much, Mr. Simpson. Our next speaker will talk to us on the rooting of broad leaved evergreens, primarily *Rhododendron* cultivars and species. Mr. Richard Vanderbilt.

ROOTING OF BROADLEAVED EVERGREENS, ESPECIALLY HYBRID RHODODENRONS AND SPECIES

RICHARD T. VANDERBILT
The Conard - Pyle Company
West Grove, Pennsylvania

The rooting of Broadleaved Evergreens covers so much territory that I find that I will only be able to cover the rooting of hybrid Rhododendrons and even there limit myself to the big leaved types. In many phases of rooting Rhododendrons I follow many of the practices put forth in these meetings and I here acknowledge my debt to those who contributed this information.

Before you can root a Rhododendron cuttings you must get the cutting. Where this cutting comes from and how it was treated before being cut determines not only your success in rooting or rotting it, but also what kind of plant it will make after it is rooted.

There is no real substitute for stock plants in Rhododendron production. If you grow enough plants until they are six or seven years old, you might get by without them. The fact remains that ideal conditions for plants in production do not yield ideal cutting material. Stock plants must be treated differently than those being grown for sale if optimum growth and bud set are to be maintained with the plants under production, and optimum rooting is to be experienced with the cuttings. The amount of nitrogen in the cutting at the time it is taken is the main key as to how it will root. I find plants that are visibly running out of gas are the ones that will yield cuttings with the most root ability. A cutting taken from one of those dark and lustrous beauties will take much longer to root if it ever does root. When the nitrogen is high in the cutting, it just won't root until the nitrogen is burned up. When nitrogen is excessive the bottom of the cutting will rot and very often the leaves will turn black and compost in the bench.

The care and feeding of stock plants becomes a problem since we want low nitrogen in the cutting when taken, but need enough nitrogen in the stock plants in the Spring to break into vigorous growth and produce cuttings of the size and quantities needed. The amount of nitrogen necessary to do this will depend on the conditions under which the stock plants are grown, the soil and the amount of shade. I used to feel that shade on stock plants was essential. Further experience has proven that this is not at all necessary with most hardy cultivars. A plant will need a decreasing amount of nitrogen as shade is increased to produce any given result in the plant. I hesitate to say just how much nitrogen should be applied to stock plants because of the tremendous variability in soils. If you assume that your soil is going to yield very little nitrogen on its own, then 40 pounds of actual nitrogen per acre applied in the ammonium form in March or early April would be ample for the plants growing in the ground. For stock plants growing in some sort of container it would not be quite enough, because of the tremendous leaching that goes on in the containers. I am coming to think that constant feeding at rapidly decreasing ratios as the season progresses might be suitable for stock plants in containers. The levels of phosporus, potassium, magnesium, calcium and available iron may be maintained rather high without hurting rooting.

The absolutely worst stock plant is a one-year old Rhododendron. As the plant gets older and proportionately larger it becomes more useable as a true stock plant. When one-year plants are used as a cutting source, the chain cutting syndrome sets in rapidly. The effect of chain cuttings was first noticed and pointed out by Guy Nearing. Chain cutting is repeatedly taking a cutting from a cutting. This produces crops with ever decreasing vigor. Leaf size and the overall size of the plants are reduced with each succeeding crop. The ultimate result is the exhaustion of the cultivar.

As we all know, small, slender, unbudded cuttings root very easily. I suggest that we not be deceived by this easy rooting. The important thing is how rapidly an unrooted cutting turns into a saleable, budded plant. The larger the caliber of the cutting the faster the rooted plants will develop. My suggestion then is to take the largest and fattest cuttings that are available. When there are enough large cuttings this means that no so-called ideal cuttings would be taken. I would further suggest that we pay no attention to flower buds and instead let's welcome them because they yield plants that do more branching at the first growth than those without. This heresy would be moderated only when the cultivar is very difficult. Dr. Dresselhuys would not be the best subject for these jumbo cuttings.

About six years ago I became disturbed about how we were rooting Rhododendrons. It is true that our overall percentage was in the high eighties and nineties, but the amount of sticking back required to get this percentage was excessive. To try to reduce this double work I laid out a series of hormone trials using all of the commonly available materials and a few uncommon materials in various combinations and in varying strengths.

Every batch of cuttings taken over the next three years had cuttings taken from it to try these 14 different materials. Gradually the information began to take shape. There emerged materials that were consistently safe, and were consistently producing heavy rooting, good attachment, and perhaps most important leveled the time required to root a whole batch of cuttings. In other words, markedly reducing the number needing to be stuck back. It was at this time that we were successful at rooting cuttings of the size usually considered to be too big. As you know, the first growth that a Rhododendron makes will root as will the second growth or the third. We know that if a plant makes two growths that each of the growths will root as separate cuttings. We wondered what would happen if the two growths were stuck as one cutting. Much to our astonishment these rooted as well as the single cuttings. The question arose whether this could be carried a step further. Could you get a first growth, then pinch it then get a branched growth on top of that and then root the whole shooting match as a sort of a branched little Rhododendron. We tried this and this, too, will root. The thing to watch out for here is that the leaves are thinned out enough so that they don't overlap each other to cause rotting.

The three hormone materials that were the most useful are:

1% I.B.A.	Examples of cultivators used on:
	Roseum Elegans
12½% Phygon	Catawbiense Grandiflorum
50 P.P.M. Boric Acid	
2% I.B.A.	America, Catawbiense Album
12½% Phygon	
50 P.P.M. Boric Acid	
2% I.B.A.	E. S. Rand and Dr. Dresselhuys
12½% Phygon	
50 P.P.M. Boric Acid	
.1% N.A.	
.25% 245 T.P.	

I.B.A. plus Phygon as reported earlier by Jim Wells produced a noticeable difference in quality of rooting. Boric Acid plus I.B.A. has much the same effect. I.B.A. plus Phygon and Boric Acid has an affect much greater than either combination alone. This is what Jim Wells likes to call the synergistic effect. One good everyday example of the synergistic effect is Irish Coffee.

The combination of ingredients not only effects the quality of rooting, that is the size and attachment of the roots, it has several other marked effects. Speed of rooting is leveled. In other words, more cuttings are ready to transplant at the time they are first lifted. It acts as a safener. It tends to overcome mistakes that could otherwise become troublesome such as degree of maturity or too much nitrogen. It also allows one to use much larger cuttings as I have already stated.

After cuttings are taken and treated, they are stuck in much the same manner as described by earlier speakers. I use the sand-peat medium 50 - 50. Each medium will find its supporters and I am sure that many others may be used in place of this. Depth of the medium in the bench is important. Eight inches is comfortable. A cutting only needs 3 or 4 inches of medium depth if the medium would stay in good shape. However, with the use of mist this soon becomes overly wet even with excellence drainage. It is here that the extra depth becomes useful. It acts as a cushion or a sponge. The bottom becomes rather soggy but out of harms reach so to speak.

The amount of mist used does not seem especially critical. The only thing to watch with the mist is that we don't use too much and get the medium too soggy.

As I see it, the time to take Rhododendron cuttings is September. Earlier cuttings have consistently been a flop with me and later cuttings hang around too long to fit into the follow-up program of late winter growing on.

Problems to look out for while the cuttings are in the bench are several. Leaf spotting is controlled very effectively by sprays of Parzate using two pounds per hundred gallons. Composting is from too much nitrogen in the cutting or from sticking the cuttings so close that the leaves overlap each other so that the washing effect of the mist is prevented. When you get bunchy root development where the roots do not grow out this is from the medium being so wet that air is excluded. When the medium is changed these roots will grow quite normally. Blackening and rotting of basal ends are from wetness or rather sogginess of the medium or from excessive nitrogen in the cutting. I might mention at this time that if Phygon is used in the hormone mixture it will stain the bottom of the cutting and the wounded sides a dark and dismal black. This is only a stain and the material has not killed the cuttings although it looks like it. It differs in appearance from a dead cutting black in that the unwounded portion of the cutting remains a normal green. I bring this up to forestall any heart attacks among the members trying Phygon. Another side effect of Phygon is that very often rooting will occur without callousing. When callousing does happen it seems to erupt from the cutting. In other words, callous does not form on the outside, but seems to emerge from within. Following the above procedure and maintaining bottom heat at 72 to 75 degrees, one should be able to root 85% to 90% of larger than average cuttings in 10 to 12 weeks.

CASE HOOGENDOORN: Do you find any difference, Dick, in cutting your leaves when you make the cuttings or by leaving on the full-grown leaf?

DICK VANDERBILT: If you can possibly leave the leaves, I think you'll get better rooting.

CASE HOOGENDOORN: Full leaf?

DICK VANDERBILT: Yes. But I think you're going to have to cut most of them to get a decent cutting because otherwise they will be too big.

CASE HOOGENDOORN: I know. I don't have enough greenhouse room. What do you do?

DICK VANDERBILT: Cut them.

CARL WILSON: Did you say that you used IBA and Boric acid? What did you find was the optimum of IBA and what was the optimum boric acid?

DICK VANDERBILT: The boric was consistent at 50 ppm; the IBA varied from 1 - 2% depending upon which cutting you wanted to root.

MODERATOR PINNEY: Our next speaker is Charley Hess from Purdue University.

ROOTING COFACTORS — IDENTIFICATION AND FUNCTIONS

CHARLES E. HESS
Department of Horticulture
Purdue University

The presence of root promoting substances in cuttings has been postulated since at least 1880 (4). The hypothesis is that when a cutting is taken, substances synthesized in the leaves and buds move down the stem, accumulate at the base of the cutting, and stimulate root initiation. The basis for this hypothesis can be demonstrated experimently by removing leaves, and/or buds, reducing leaf area, or by girdling the stem of a cutting. In each case the rooting response of the cutting will be reduced. Selim (5) has been shown in *Perilla* cuttings, the leaves contribute up to 78 precent of the rooting response, the buds contribute 15 percent and the stems, 7 percent. The fact that girdling the stem of a cutting below the leaves, but above the rooting medium, blocks rooting indicates not only the source of root promoting substances, but also that the substances are translocated in the phloem.

The presence of naturally occurring substances can also be demonstrated in grafting experiments (3). If a scion from an easy-to-root plant is grafted on a difficult-to-root cutting, the rooting of the latter can be improved. If the leaves of the scion are removed, or if the stem is girdled below the graft union, the promotive effect of the scion is lost.

Since girdling blocks the downward movement of root promoting substances, the technique can be used to enhance root initiation and also to provide information as to the kind of substances which are moving down the phloem. Root initiation can be enhanced by girdling a stem prior to taking a cutting. The longer the girdled stem remains on the plant, up to 34 days, before the cutting is taken, the better will be the improvement of the rooting response. This is because root promoting substances are accumulating in the tissue above the girdle.

The accumulation of substances in the tissue above the girdle can be shown by extracting the substances at several intervals after girdling (6, 7). The substance which accumulates in the largest amounts is sugar. Amino acids accumulate in the first five or ten days after girdling and then decline in concentration. As shown in Figure 1, rooting cofactor 4 accumulates in the tissue above the girdle of an easy-to-root, red variety of *Hibiscus rosa-sinensis* but not in the difficult-to-root variety, Wilson's White, or in the tissues below the girdle of either variety (7). As will be mentioned later, rooting cofactor 4 is a mixture of oxygenated terpenoid compounds (2).

Still another example of the accumulation of root promoting substances is shown in experiments by Cooper (1). Cooper worked with lemon cuttings which were treated with Indoleacetic acid (IAA). In some cases the base of the cutting was cut off after the IAA treatment, and in others, the cuttings were retreated after the base had been removed. The results are shown in Table I.

The control cuttings, treated with tap water, produced an average of 1.7 roots per cutting. When the cuttings were treated with IAA, they produced 12.6 roots per cutting. When the treated area at the base of the cutting was cut off, the average number of roots dropped to 4.9. It could be said that the de-

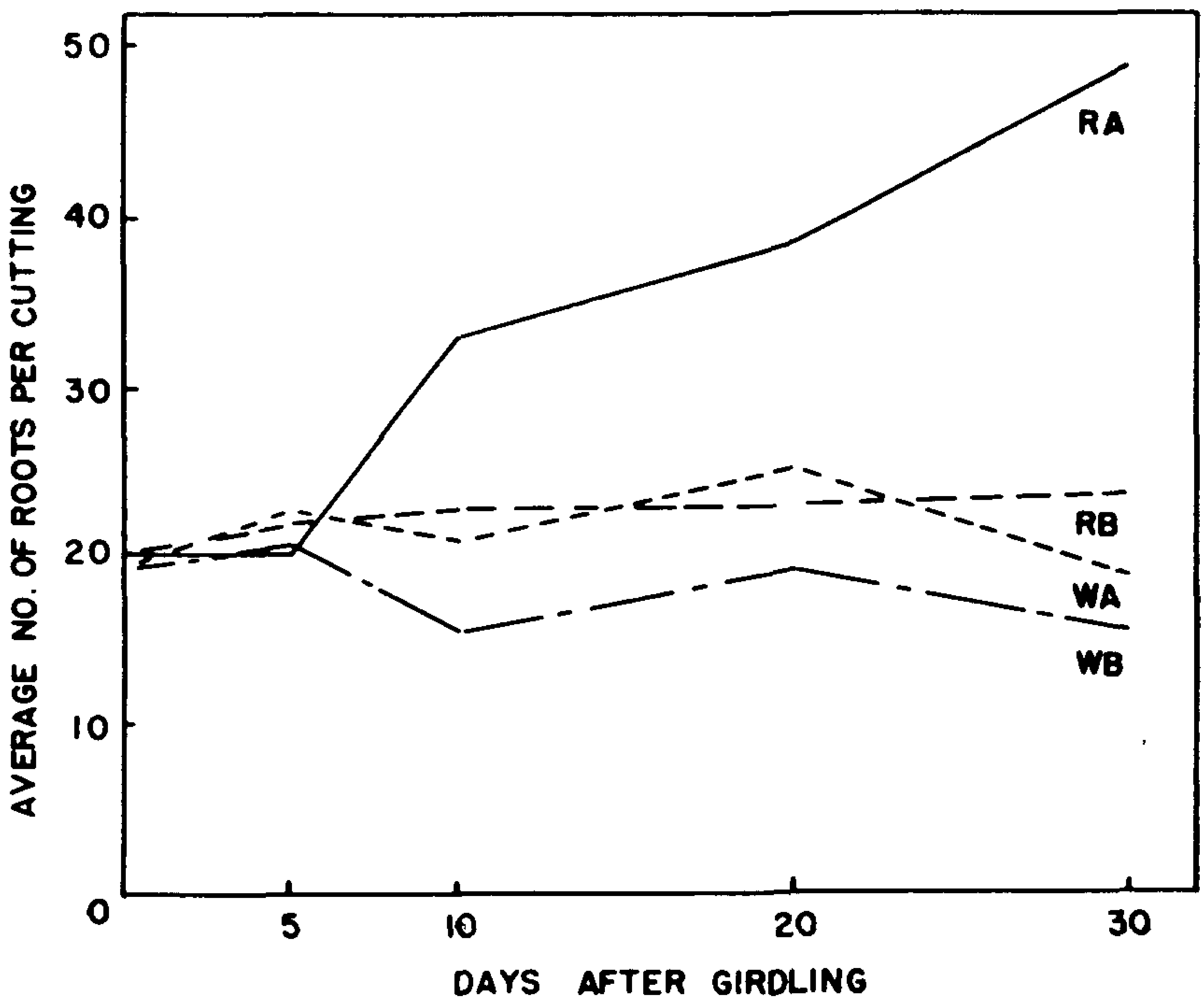


Figure 1. The accumulation of rooting cofactor 4 in girdled tissues RA — red Hibiscus easy to root), tissue *above* girdle RB — red Hibiscus, tissue *below* girdle. WA — Wilson's White Hibiscus (difficult to root), tissue *above* girdle. WB — Wilson's White Hibiscus, tissue *below* girdle.

Table 1 Interaction between indoleacetic acid and other naturallly occurring root promoting substances.

	Average Number of Roots per Cutting
Tap Water	1.7
Base treated*	12.6
Base treated and cut off	4.9
Base treated, cut off, cutting retreated*	4.8

*Treated — Fifteen hour soak in 0.17 mg/cc IAA.

crease was mainly due to the removal of the IAA which had been absorbed during the 15 hour soak. However, as shown in the last column, cuttings which had been treated, then had the treated area removed, and finally retreated only produced 4.8 roots. Even though the IAA was replenished, the cuttings were not able to initiate any more than 4.8 roots. The interpretation of the results is that a naturally occurring root promoting substance accumulated at the base of the cutting during the 15 hour soak in the IAA solution. When the base was removed, not only was the IAA removed but also other root promoting substances which had accumulated. Apparently these sub-

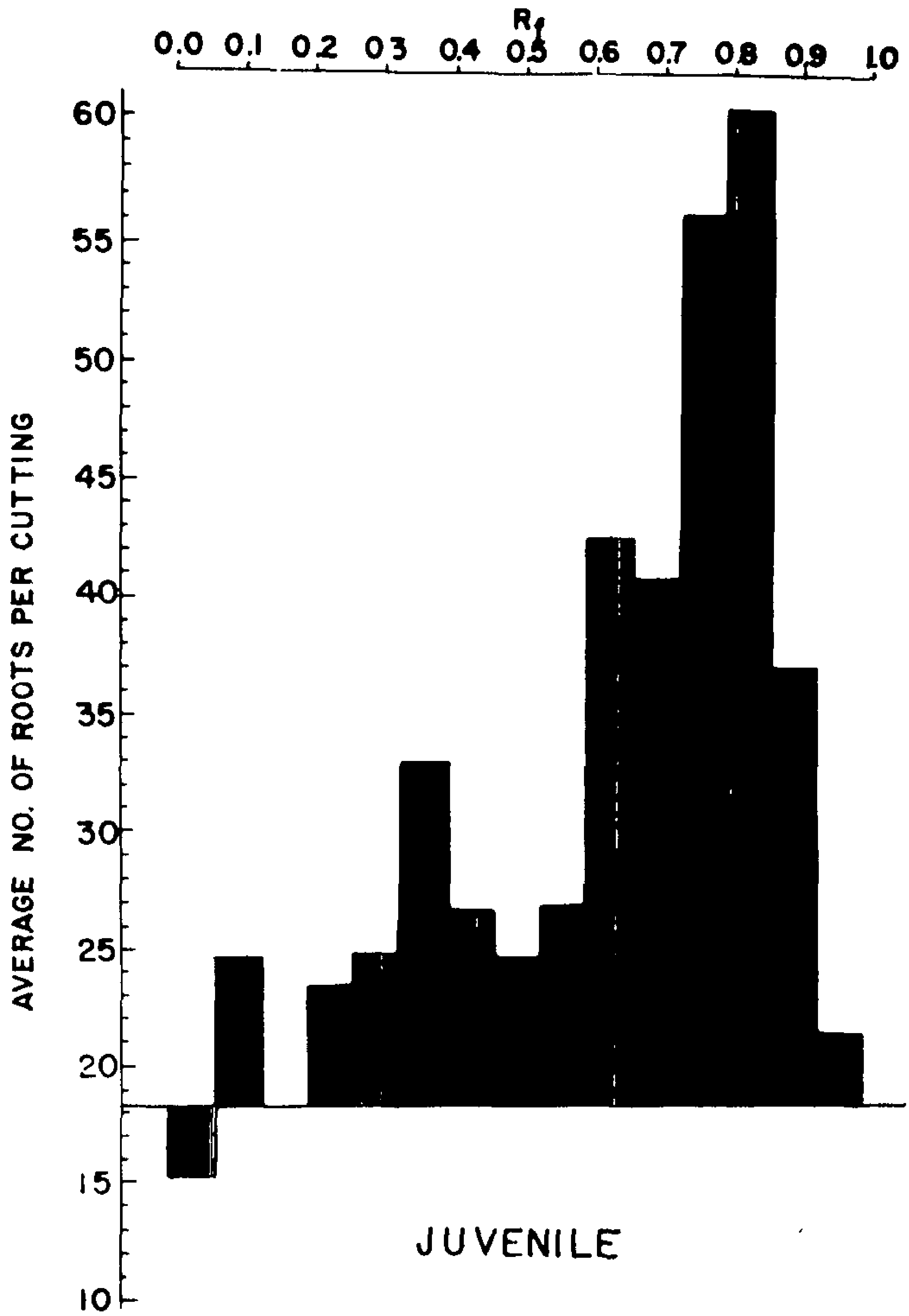


Figure 2 Histogram showing the biological activity in an extract of Juvenile *Hedera helix* Seventy-five mg of lyophilized tissue extracted with methanol and chromatographed with isopropanol and water (8 2, v/v) Bioassay. Mung bean rooting test

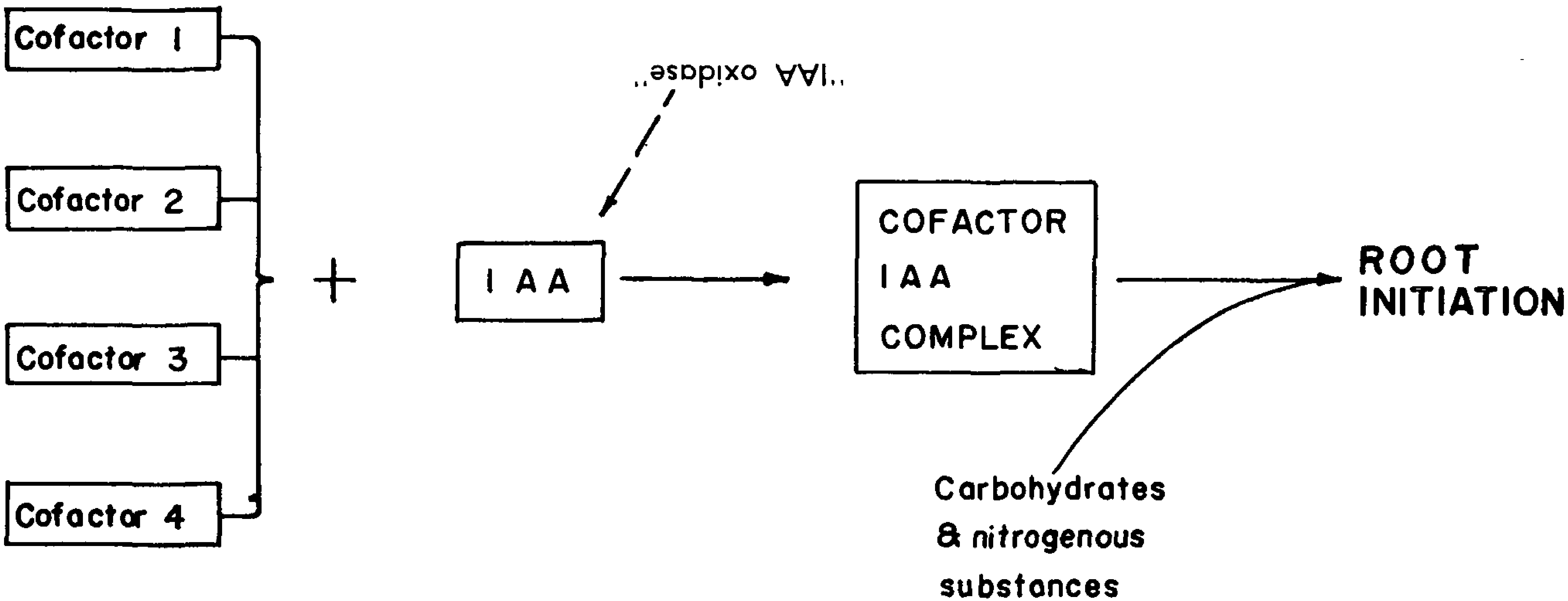
stances are synthesized slowly in lemon cuttings and the supply was depleted because a retreatment of the cuttings, after the base had been removed, did not increase the rooting response.

As has been previously described it is possible, to demonstrate the presence of root promoting substances in extracts of easy-to-root plants such as the juvenile form of English ivy, *Hedera helix* (2). As shown in Figure 2 the extract is partially purified by paper chromatography and the active, root promoting substances are located with the mung bean bioassay. There are four areas of activity and they are referred to as rooting cofactors 1, 2, 3, and 4, starting with rooting cofactor 1 closest to the origin.

By physical and chemical tests such as ultraviolet spectral analysis and functional group analysis, it has been determined that at least part of the biological activity in the area of rooting cofactor 3 can be attributed to the compound isochlorogenic acid. The subsance is a phenolic compound which has at least three isomers. By feeding cuttings a combination of isochlorogenic acid and IAA C^{14} (radioactive indoleacetic acid), it was possible to find that a large part of the root promoting activity of isochlorogenic acid and other phenolic compounds with similar orthodihydroxy structures is due to their ability to prevent the inactivaction of IAA by the IAA oxidizing system. Zenk (8) and others have found a similar relationship between IAA and phenolic compounds in *Avena* coleoptiles.

Rooting cofactor 4 is a group of oxygenated terpenoid compounds (2). These compounds appear to be the most active of all the naturally occurring root promoting substances. They react synergistically with indoleacetic acid, but it is not known as yet how they function in the cutting.

A hypothetical scheme of where the rooting cofactors fit into the process of root initiation is shown in Figure 3. From the standpoint of an easy-to-root cutting, all four rooting cofactors would be present, IAA would be present, and a sufficient supply of carbohydrates and nitrogenous materials would be available for energy and synthesis. If the cutting is difficult-to-root, it may lack IAA because of an active oxidizing system which destroys it before enough IAA can accumulate to stimulate root initiation. In this case a synthetic auxin such as Naphthalene acetic acid (NAA) could be used because the plant can not readily destroy this auxin. However, as is the case with many difficult-to-root cuttings, the synthetic auxin may have little or no effect. In this case it is believed that one or more of the rooting cofactors are missing. The degree of difficulty, which varies from variety to variety, is an expression of how many and/or how much of the rooting cofactors are missing. Theoretically, if all the cofactors could be supplied to a cutting and there were cells available to divide, the cuttings should become easy to root.



A HYPOTHETICAL SCHEME OF ADVENTITIOUS ROOT INITIATION

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MODERATOR PINNEY: Our next speaker is Dr. James Kelley from the University of Kentucky.

ROOTING OF CUTTINGS AS INFLUENCED BY THE PHOTOPERIOD OF THE STOCK PLANT

JAMES D. KELLEY
Department of Horticulture
University of Kentucky
Lexington, Kentucky

Photoperiodism is the phenomena in which the relative length of light and darkness influences the development of plants and animals. The influence of photoperiod on the development of plants was first recognized in 1923 (1). Since then the majority of plant physiologists have focused their attention on the flowering phenomena, however they were aware that photoperiod influenced the vegetative growth of many herbaceous and woody plants.

In more recent years the effect of photoperiod on woody plants has studied by Waxman (5) and others. It has been shown that if one divides a group of actively growing dogwoods (*Cornus florida* L.) into two groups and places one of them under long days of 15 hours or more and the other one under short days of 12 hours or less, one will observe that the plants under long days will continue to grow but those under short days will stop growth within 2 weeks. In other words, these plants become dormant.

Waxman (5) showed that when cuttings are taken from *Cornus florida* or *Weigela* plants growing under long days and rooted under various photoperiodic treatments, the number of roots produced per cutting was lower under short-day than under long-day treatments. Piringer (3) has reported that the rooting of holly and boxwood was favorably influenced when the

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Waxman (5) showed that when cuttings are taken from *Cornus florida* or *Weigela* plants growing under long days and rooted under various photoperiodic treatments, the number of roots produced per cutting was lower under short-day than under long-day treatments. Piringer (3) has reported that the rooting of holly and boxwood was favorably influenced when the short natural days of winter were lengthened with incandescent light. He extended photoperiod by interrupting the middle of the natural night with 3 hours of light. In general the long photoperiod or light interruption resulted in earlier and heavier rooting on both boxwood and holly.

It is well known that the cuttings of most species of plants root better at certain times of the year. The reason for this being environmental. One environment factor that is of particular interest is photoperiod or day length. The longest day of the year in the northern hemisphere is June 21 and after this date day length becomes increasingly less. For example here in Cleveland the longest day is 15 hours and 11 minutes on June 21 while the shortest day is 9 hours and 10 minutes on December 21. This is a net change in day length of about six hours. However, when we take cuttings from a plant at various seasons in order to study rooting response as influenced by photoperiod we have other environmental factors that influence the condition of the stock plant such as temperature, soil moisture, changes in stored food within the plant, etc.

We were interested in the effect of photoperiod only and what if any influence it would have on the stock plant. The purpose being to more clearly understand the role that it might have on stock plants and cuttings in the rooting bench.

Ilex crenata 'Hetzi' was the plant used in our work. Stock plants were grown in containers during the summer months and on July 26 all plants were given long days (18 hours). The supplemental light source was 100-watt incandescent lamps with reflectors spaced at 4-foot intervals 4 feet above the plants. On August 25 the plants were divided into 5 groups. One group was placed in a short day (10 hour) environment provided by using black shade cloth. Every 10th day thereafter an additional group was placed under the short day environment until 4 groups had received short days. On October 4 we had five groups of stock plants that had received 40, 30, 20, 10 and no short days. At this time cuttings were taken from plants in all treatments. The cuttings were then divided so that ½ the cuttings from each treatment could be rooted under short days (8 hours) and the other ½ under long days (16 hours). This resulted in 10 treatments. Cuttings were rooted in Perilte and under intermittent mist. Root-inducing chemicals were not used. In mid-December, 72 days after the cuttings were stuck they were removed from the rooting medium and the number of primary and secondary roots as well as the length of each primary root was determined.

The results of this work indicated that the stock plant as well as the cutting responded to photoperiod. Cuttings taken from plants receiving the greatest number of short days rooted best. Total root length was greater, more root were initiated, length of roots was increased and the number of secondary roots was doubled. Cuttings taken from stock plants receiving no short days rooted least (Table 1).

Table 1. Rooting response of *Ilex crenata* 'Hetzi' as influenced by photoperiodic treatment of the stock plants and cuttings.

No of short days received by stock plant	Cuttings Received Short Days (8 hrs)			
	Total length of roots/cutting[1]	No of roots initiated/ cutting	Av length of roots/cutting	No of secondary roots/cutting
0	4.5	4.4	1.01	6.9
10	5.4	4.7	1.14	9.4
20	5.4	4.9	1.12	9.1
30	7.0	5.5	1.24	12.8
40	7.4	5.6	1.30	13.7
	Cuttings Received Long Days (16 hrs)			
0	5.8	4.5	1.28	9.9
10	6.8	4.8	1.44	12.9
20	6.9	4.9	1.41	12.4
30	8.0	5.2	1.55	15.5
40	8.9	5.5	1.62	16.1
L.S.D. 5%	0.5	0.2	0.02	1.2
L.S.D. 1%	0.6	0.3	0.03	1.6

[1]Measured in cm

Differences Due to Daylength Cutting Received

L.S.D. 5%	1.1	NS	.23	2.0
L.S.D. 1%	2.5	NS	.31	NS

Cuttings rooted under long days produced more total root length and a greater number of secondary roots than those receiving short days. However, photoperiod received by the cutting did not affect the number of adventitious roots produced.

This work demonstrates the role that photoperiod might play in the seasonal variations found in rooting. At least it has been demonstrated in the case of *Ilex crenata.* It has been shown by others that the number of root primordia produced on cuttings is related to the level of plant auxins. The fact that increasing numbers of short days on the stock plant increased the number of roots formed as well as their growth suggests either the accumulation of certain inducing substances that accumulate to the greatest degree under shorter days or the possible destruction of natural rooting inhibitors when the plants receive short days. At present we are attempting to determine, by using Hess's bioassay method, the relationship in plant response and the presence of cofactors.

The effects of photoperiod on stock plants has been also shown in the case of *Populus canadensis* that had been exposed to 0, 4, 6 and 13 weeks of a 10 hour day. Our results differ in one important way. Roots initiated per cutting were less with increasing numbers of short days for *Populus*, for *Ilex* the reverse was true. It appears that with some plants conditions which tend to stimulate active growth inhibits rooting while with other conditions that tend to inhibit active growth stimulate rooting response.

In summarizing let me emphasize that day length of the stock plant of the cutting plays a role in rooting response. We cannot at this time by chemical analysis determine when a cutting is in an optimum condition, neither are we restricted to the old rule of thumb method. Great improvements can be made in propagating techniques without having a complete knowledge of how or what the plant does from a biochemical standpoint, but simply by recognizing that light, temperature, water and other environmental factors influence stock plants as well as cuttings. By using the limited knowledge of how they affect rooting we can improve rooting response. It very well may be that at some date in the near future it may be desirable to control growth of stock plants by regulating photoperiod and other environmental factors just as, today we partially control the rooting environment in order to obtain better rooting percentages and better root development.

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STEVE O'ROURKE: I believe that there is an item misunderstood, that is blossoms are born on the same stem as the leaves in early Spring. This would indicate that floral formation is on the short day of the preceding seasons. Now if these plants were grown under short days and floral initiation did not take place, does this mean that these cuttings were in a more vegetative state and that the flower-forming substance, if any, was depressed?

DR. KELLEY: Certainly. With short days, we certainly inhibit our induced vegetative growth. In other words, the plants that had never received any short days were the most vegetative, if you want to put it that way. They had the most vigorous growth.

STEVE O'ROURKE: Did you carry the stock plant on to see if they bloomed the following spring?

DR. KELLEY: No, we didn't. We just had too many.

RALPH SHUGERT: Dr. Kelley, have you ever done any work or read of any work in using light on an item such as *Juniperus Chinenis Pfitzeriana* which in my case roots slowly, poorly and I was wondering if light would promote 75% - 80% rooting in four months.

DR. KELLEY: You mean light on cuttings or on the stock plant?

RALPH SHUGERT: Light on cutting bench.

DR. KELLEY: It would be rather difficult. The only work I know of is some work at Illinois and they found that junipers rooted better under short days.

RALPH SHUGERT: This is the cuttings under short days or the stock plants?

DR. KELLEY: Cuttings. This was done several years ago.

VOICE: Did you have a check in regard to the evaporation and desiccation caused by your lights? In other words, was the moisture content of the plants that are shaded the same as moisture content in leaves of the ones that had additional light?

DR. KELLEY: We hope so. Shall we say, they all received the same treatment other than a variation in photoperiod.

DR. WAXMAN: Jim, we did some work with the lighting of stock plants and got the same results you described in working with poplar. Now I was wondering about the plants you're working with. Do they have to keep on growing or did they grow and then stop and remain dormant all summer?

DR. KELLY: No, Ilex continues to grow all summer. And we made them grow all summer by putting all stock plants initially under 18 hours so that we would be sure that they would grow.

DR. WAXMAN: So then couldn't it be that you were taking cuttings from plants of active growth, the ones which were receiving zero short days as compared with one that had stopped. Therefore that plant would have a greater food supply than the cuttings receiving zero short days and be in active growth.

DR. KELLEY: Yes, except that the only thing that was somewhat different is that we could get this response with just 10 days. In other words, a very short time. Of course, we can't say that you don't get any food build up in the ten days but this significant difference seemed to be more than you would expect in just these 10 short days.

DR. WAXMAN: How many more roots per cutting was that?

DR. KELLEY: About a ½ or ¾ roots per cutting. However, this was a significant difference in this case.

MODERATOR PINNEY: Dr. Makoto Kawase from the Morden Experimental Farm, Manitoba, Canada, will be our next speaker.

CENTRIFUGATION PROMOTES ROOTING OF SOFTWOOD CUTTINGS[1]

MAKOTO KAWASE
Experimental Farm, Research Branch
Canada Department of Agriculture
Morden, Manitoba, Canada

According to Cooper (1) and Went (4), the polar transport of auxin causes it to accumulate at the base of a cutting and the resulting auxin gradient causes a downward movement of rhizocaline towards the base of the cutting. Rhizocaline and auxin, thus accumulated at the base of the cutting, act together in root formation. This classical hypothesis suggested a search for some means of modifying the polar transport of auxin and rhizocaline in cuttings. Centrifugal force was applied to willow cuttings (*Salix alba* L.) which are easy rooters and it was found that centrifugation promotes rooting in this species. Although this new finding has already been published (2, 3), I would like to briefly review my work for you including results of a preliminary nature.

Centrifugation and Rooting

Leafless or leafy softwood cuttings were placed in a centrifuge tube with distilled water and centrifuged using an ordinary laboratory centrifuge. Centrifugal force was directed from the tip to the base of the cutting. The root-promoting effect of centrifugation increased not only depending on the increase of cen-

[1]Contribution No. 65, Morden Experimental Farm, Research Branch, Canada Department of Agriculture.

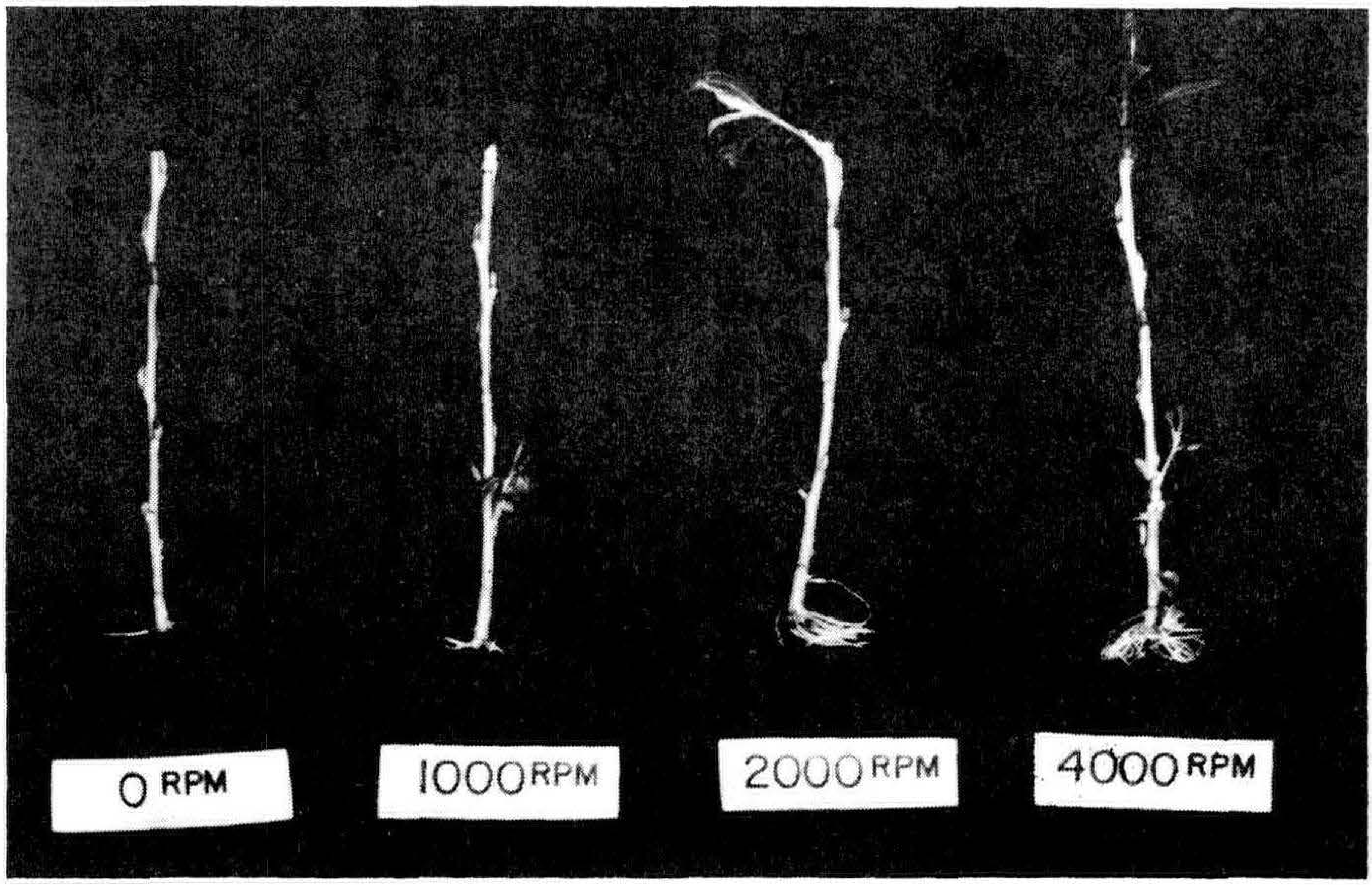

Figure 1. Effect of centrifugation on rooting of willow cuttings. Cuttings were centrifuged for one hour with speeds of 0, 1000, 2,000 and 4000 rpm or with gravitational forces of 0, 160, 640 and 2540 g.

trifugal force but also depending on the duration of centrifugation (Fig. 1 and Fig. 2).

Physiological Implication of Centrifugation

It was, however, found that the more the proximal ends were cut back after the centrifugation, the fewer the roots that were formed (Fig. 3). Willow cuttings were next centrifuged in the up-side-down position, i.e., the force was directed from the base to the tip of the cuttings. By this up-side-down method, rooting of the cuttings declined proportionally to the increased duration of centrifugation (Fig. 4).

What these results suggest is that some root-promoting substance was forced to move down towards the direction of the force. This idea was emphasized by a new finding. As mentioned earlier, cuttings were centrifuged in a centrifuge tube with distilled water. When the water or diffusate was tested after the centrifugation by mung bean rooting test, it showed a strong root-promoting effect. As seen in Fig. 5, root formation of centrifuged willow cuttings increased proportionally to the increasing gravitational force over the range between 0 to 2540 *g*. It is, however, most interesting that the root forming activity in the centrifugal diffusate as tested in the rooting of

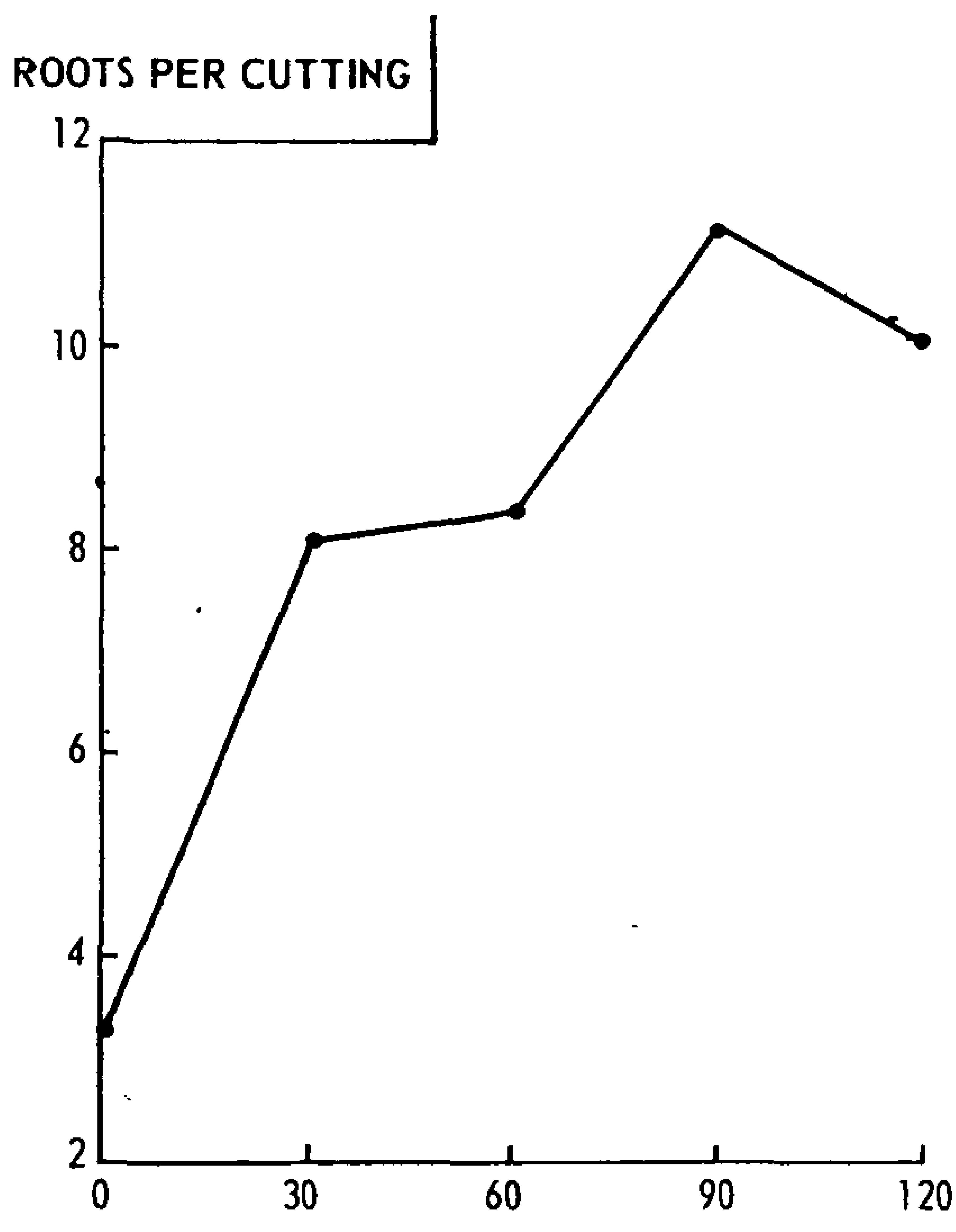

Figure 2. Duration of centrifugation and rooting in willow cuttings. Cuttings were centrifuged with a force of 640 *g* (Kawase, 1964).

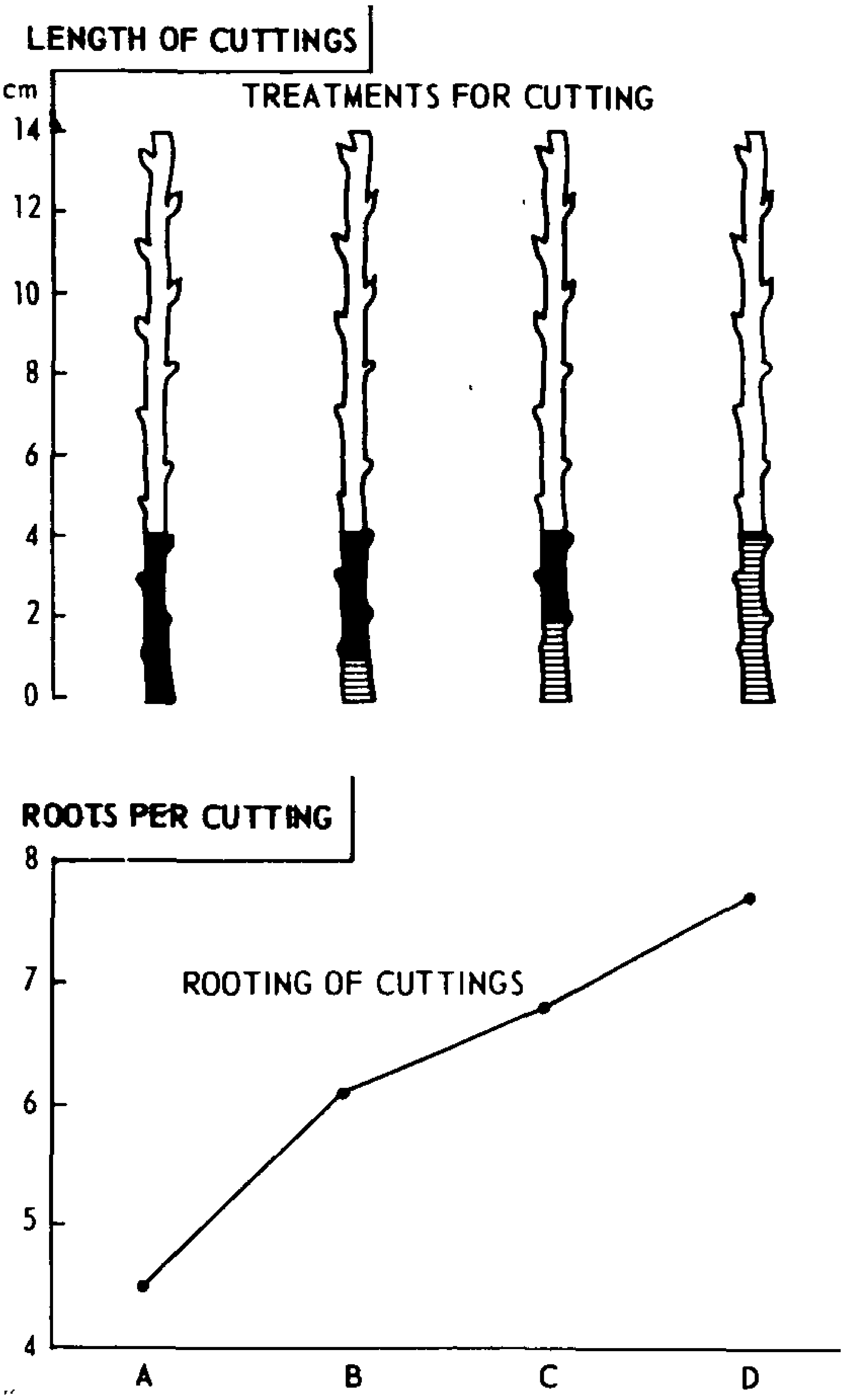

Figure 3 Effect of cutback on the rooting of centrifuged cuttings Cuttings were centrifuged for 1 hour with a force of 1090 g Shadowy and black parts of the cuttings represent parts which were cut back before and after the centrifugation (Drawn from Kawase, 1964).

mung bean cuttings also increased with the greater force of centrifugation within the range between 0 to 1940 g. The results clearly suggested that there was an accumulation of root-forming substance (or substances) at the proximal ends by the centrifugation and also that a part of it diffused into water.

Rooting Substances in Centrifugal Diffusate

Paper chromatographic study of the diffusate revealed that because of its immovability on the paper chromatograph with 80% isopropanol, the major root-promoting substance in the diffusate is not indoleacetic acid (Fig. 6). Paper chromatographic study also showed that the major root-promoting substance in the diffusate promoted mung bean rooting by itself

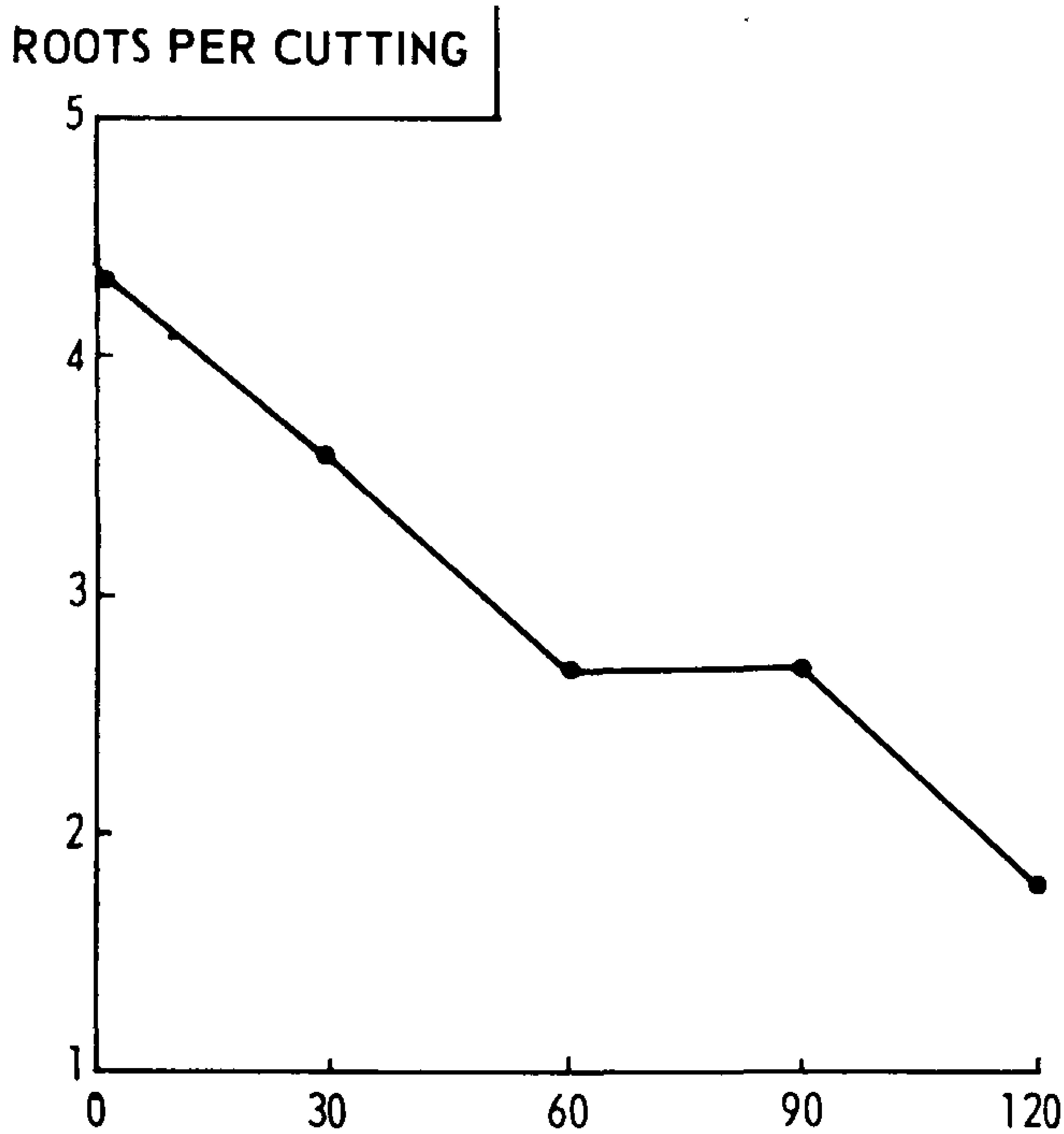

Figure 4 Effect of up-side-down centrifugation of willow cuttings on their rooting Centrifugal force of 640 g was directed from the base to the tip of the cuttings (Kawase, 1964)

and its effect was enhanced by the presence of indoleacetic acid (Fig. 6 and Fig. 7).

On the other hand, centrifuged cuttings which are supposed to contain a high level of the same rooting substance as seen in the diffusate, showed an interesting result when treated with indoleacetic acid. As seen in Fig. 8, the root-promoting effect of centrifugation was enhanced by the presence of indoleacetic acid. Rooting of centrifuged cuttings was also enhanced by etiolation treatment (Fig. 9). Etiolation treatment for the cuttings was recently found to delay the destruction or disappearance of indoleacetic acid in the cuttings (3).

It is noteworthy here that the diffusion method is one of ideal methods to extract rooting substances from cuttings because it enables one to extract the substances in the form in which they exist in the living plant tissue without any chemical treatment.

Conclusively, the rooting substance (or substances) in the diffusate is thought to be similar to rhizocaline, and it is proposed that centrifugation accelerates the transport of rhizocaline and thus the accumulation of rhizocaline at the proximal ends.

Future Application

Centrifugal root promotion is not limited to the specific species, *Salix alba* L. As far as I have studied, centrifugation promoted rooting of softwood cuttings in *Salix acutifolia, S. pentandra, S. fragilis, Viburnum dentatum* and *Populus alba*. More studies are needed before we find out how widely this centrifugation method can be recommended to the nursery industry. One point which has to be mentioned is that the centrifugation process can damage the leaves of cuttings. Thus a root-inhibitory effect instead of root-promoting effect was found in centrifuged *Philadelphus* and *Cornus* cuttings. My preliminary

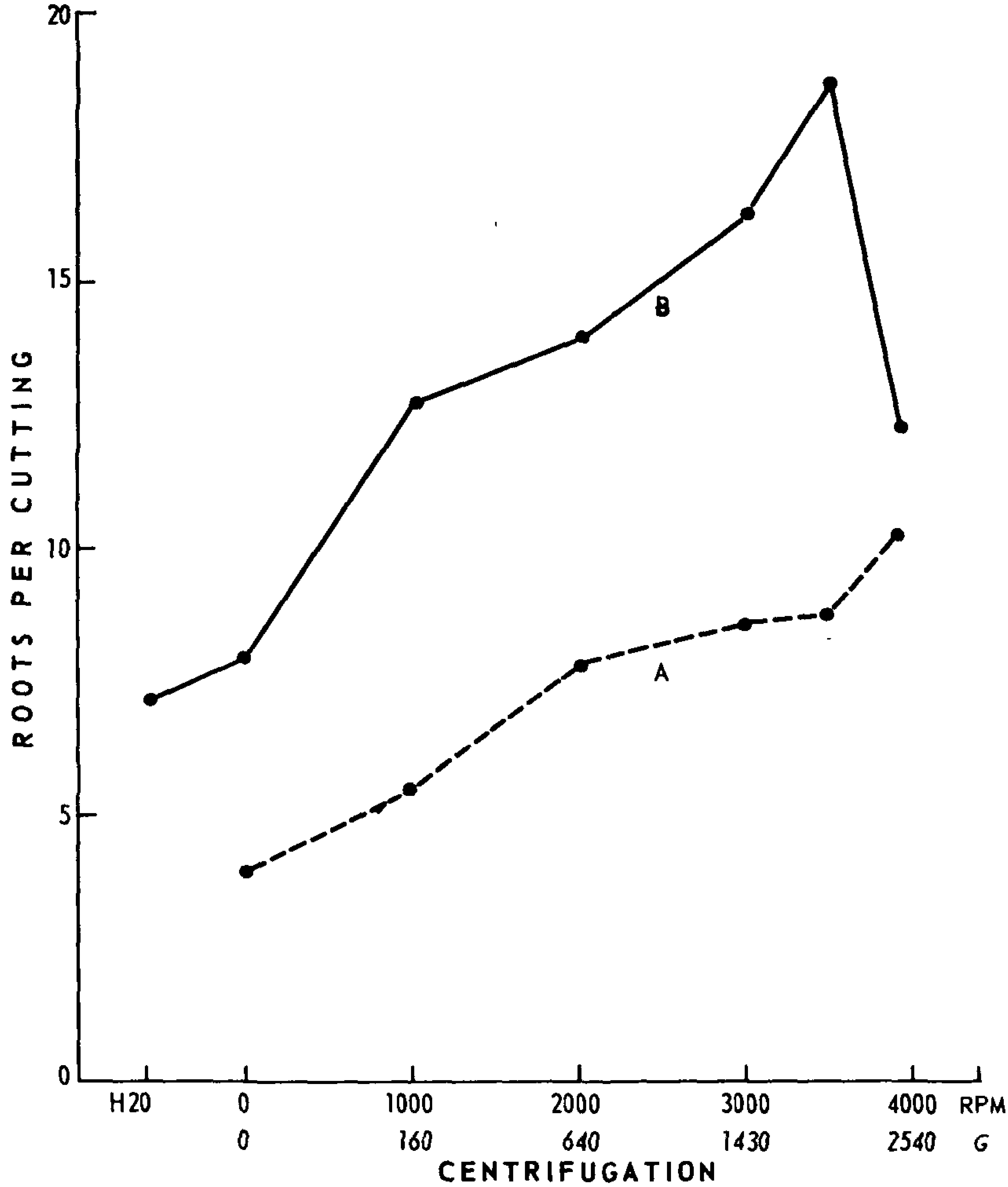

Figure 5. Effect of centrifugation on willow rooting (A), and the effect of the diffusate on mung bean rooting (B) Willow cuttings were centrifuged and their rooting was observed in distilled water (lower), while their centrifugal diffusates were assayed by mung bean cuttings (upper) (Kawase, 1964)

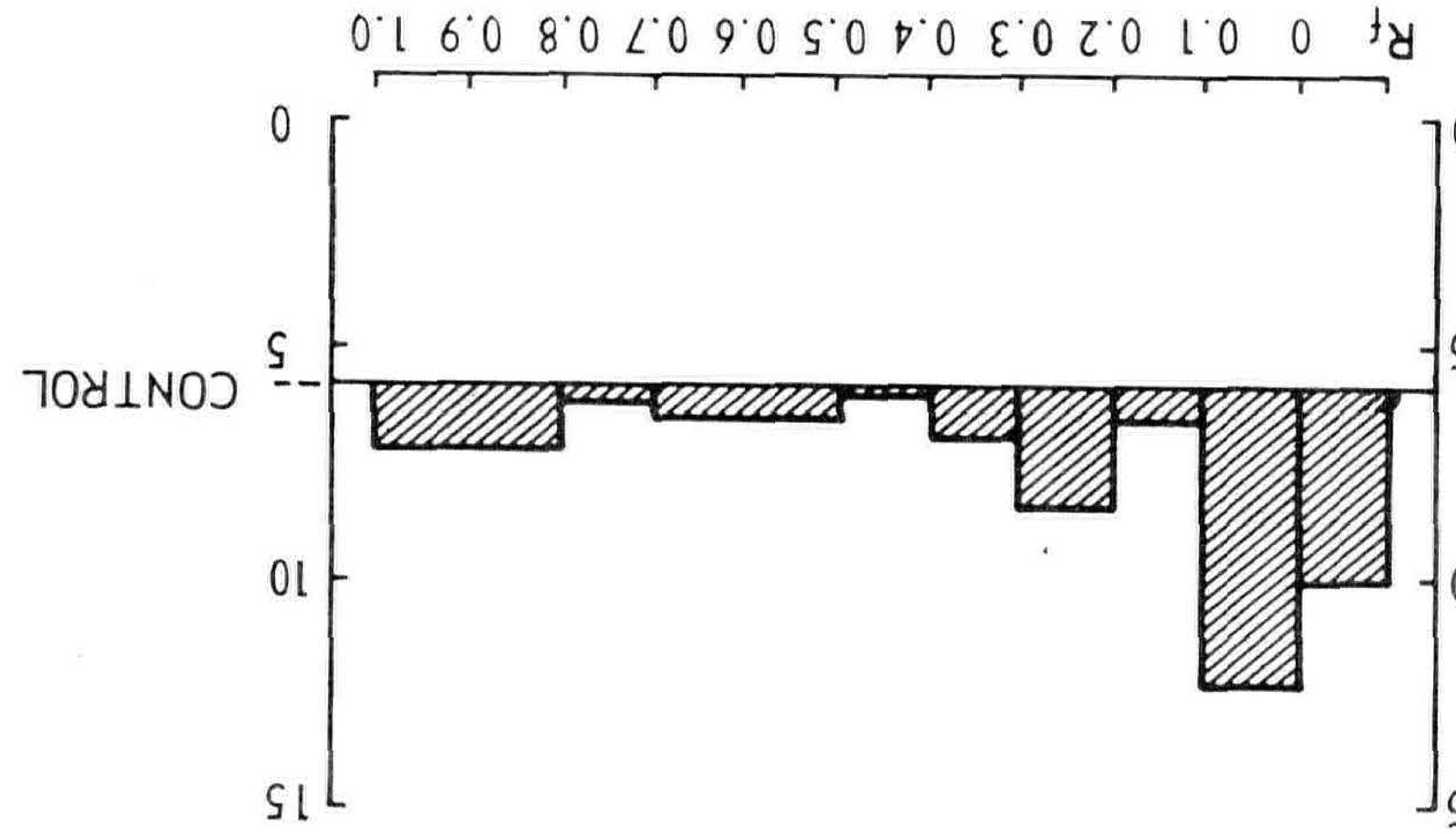

Figure 6. Histogram indicating the rooting substances of the centrifugal diffusate from 60 willow cuttings. Abscissa: Rf values in 80% isopropanol (v/v). Ordinate: No. of roots per mung bean cutting (Kawase, 1964)

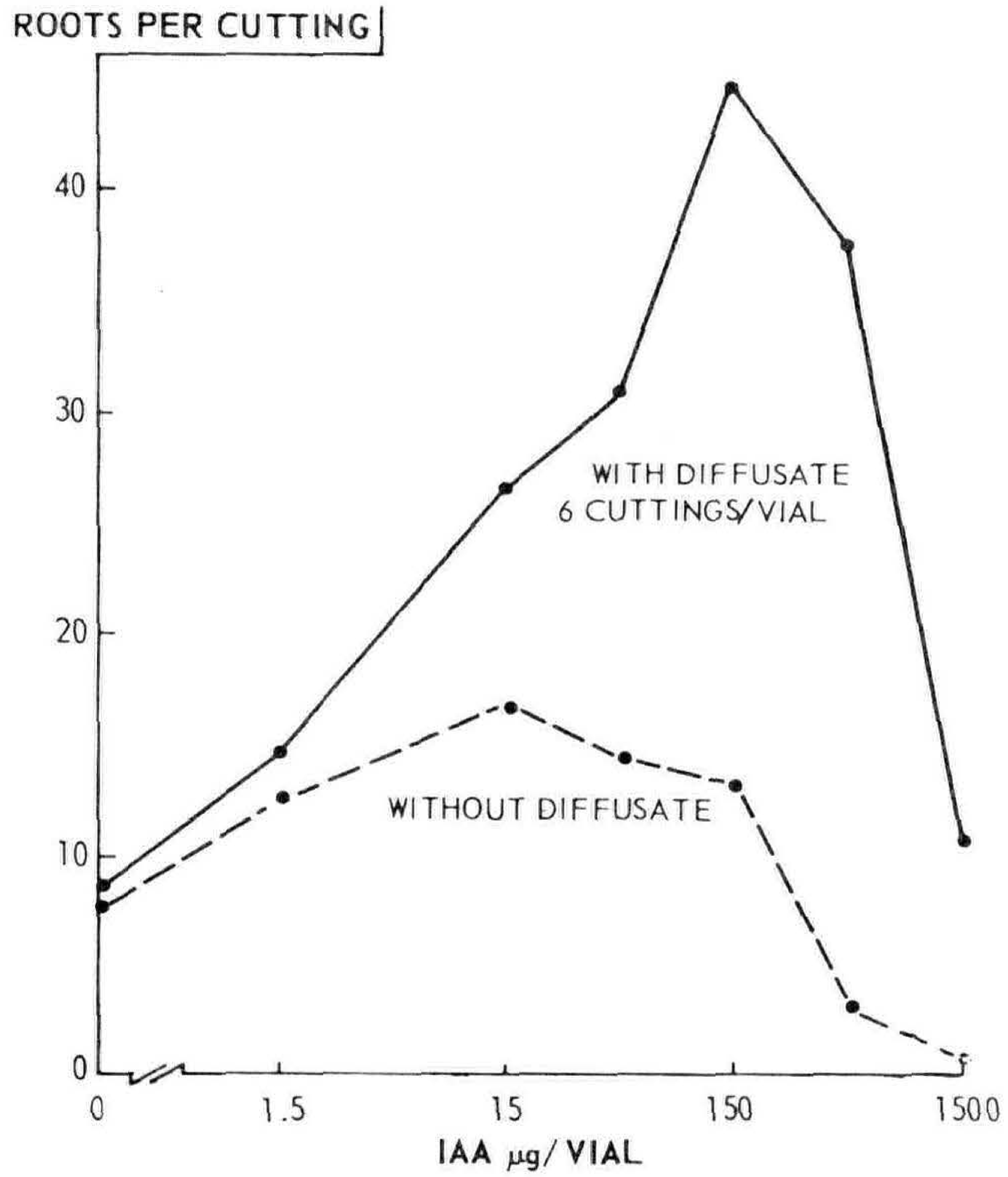

Figure 7. Synergistic effect of centrifugal diffusate and IAA on the rooting of mung bean cuttings (Kawase, 1964).

results show that many easy-to-root species apparently contain diffusible rooting substance(s). The root substance was shown to be effective also in cuttings such as *Euonymus obovata, Syringa pubescens* and *Cotoneaster lucida.* Therefore when more is known about the chemical nature of the substance, there will be a great interest in its future use to promote rooting.

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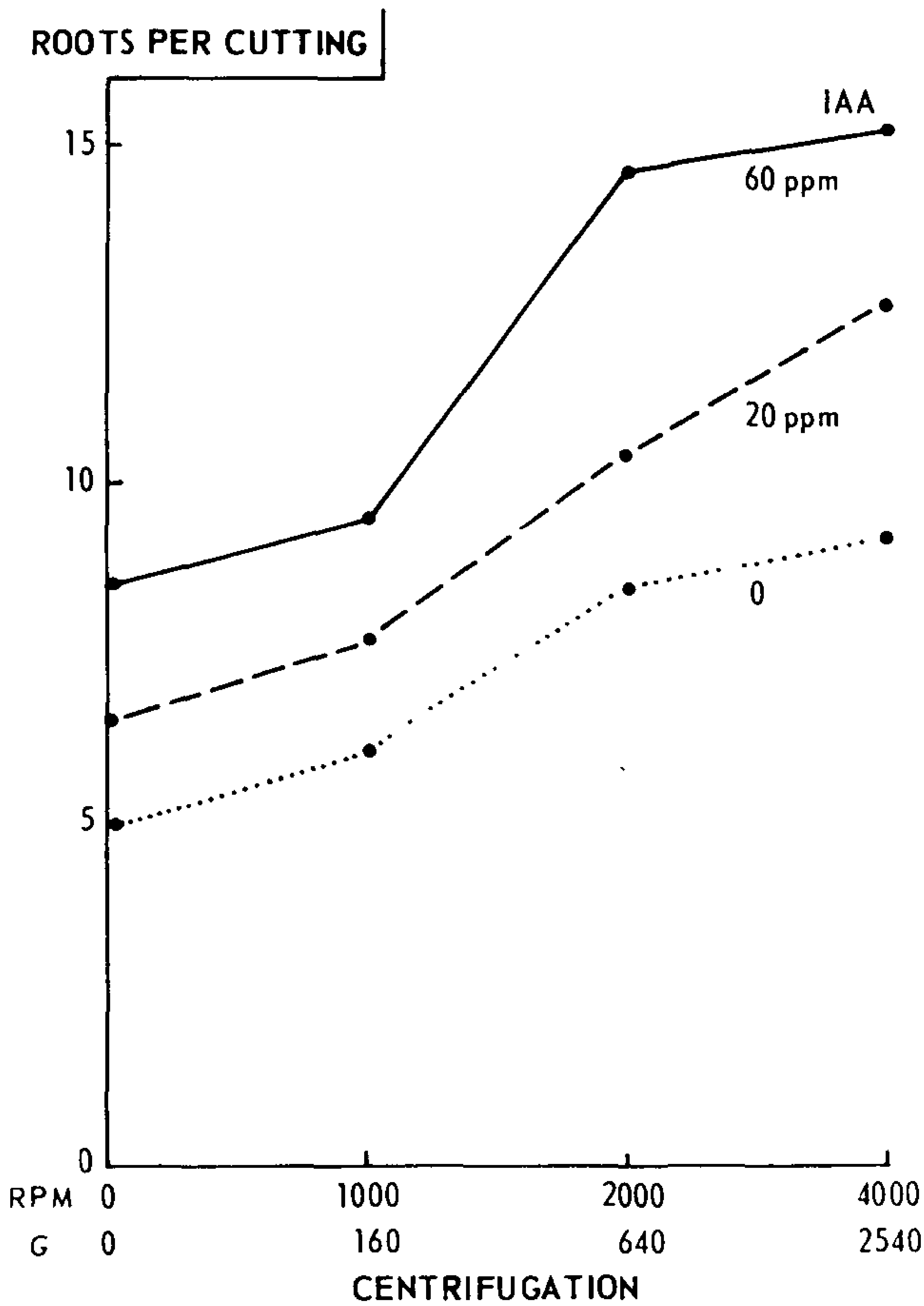

Figure 8 Combined effect of centrifugation and IAA on willow rooting After centrifugation willow cuttings were treated by IAA (Kawase, 1965).

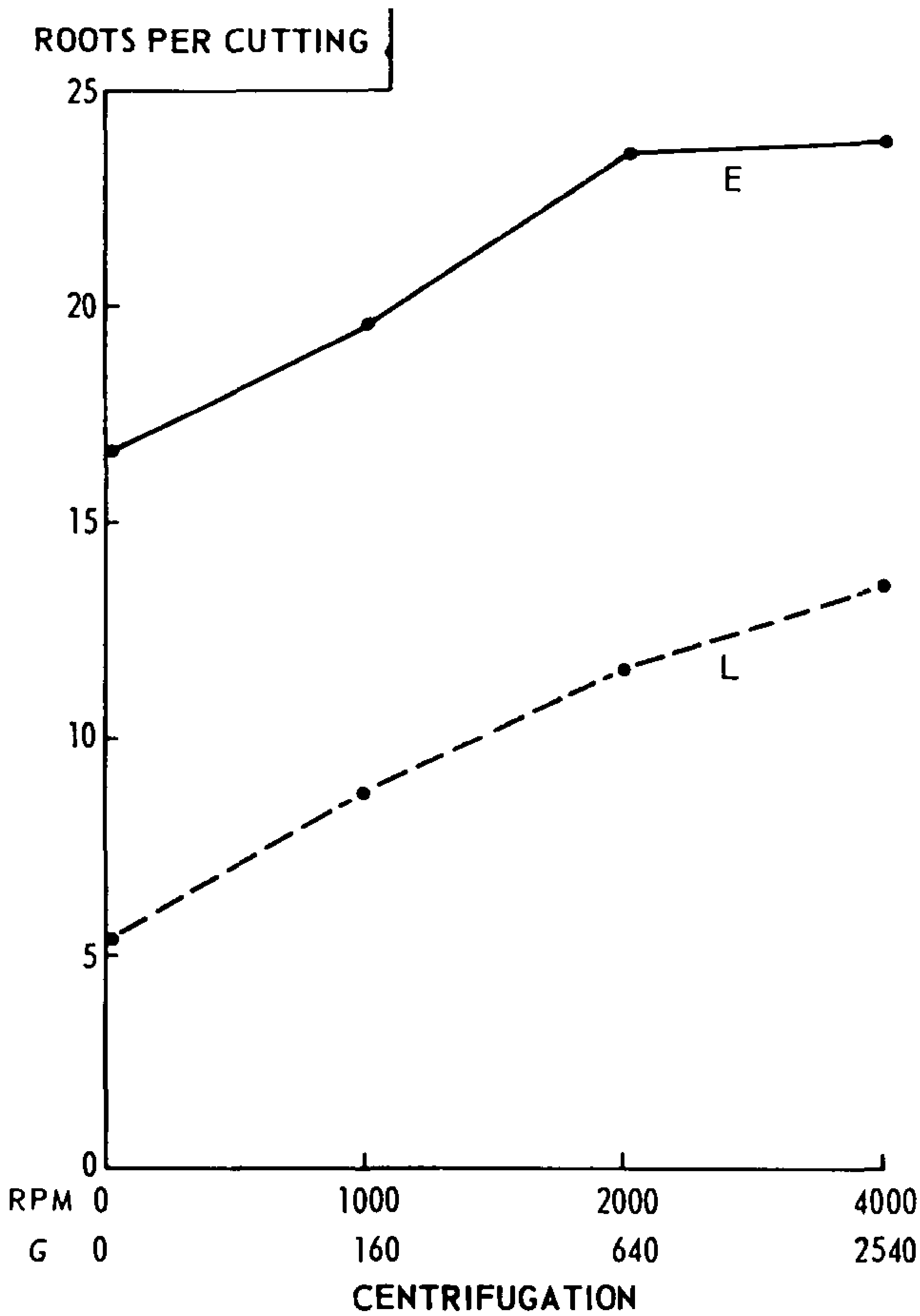

Figure 9 Combined effect of centrifugation and etiolation on rooting of willow cuttings. Centrifuged cuttings were etiolated (E) or not etiolated (L) (Kawase, 1965).

HOWARD STENSSON: Dr. Kawase, I just wondered if you tried the diffusate from the tips on the bases of the cuttings.

DR. KAWASE: I have tried upside down diffusion and it is as concentrated as the base. However, root formation at the base is retarded when the cuttings are centrifuged upside down.

HOWARD STENSSON: And a second question. Did you try the diffusate from one species on another species?

DR. KAWASE: Most species I have tested on the mung bean cutting test. I have extracted from willow and then retreated willow. It was most effective on the cuttings not previously centrifuged.

TREVOR SYKES: It's been known for a long time that willows root very easily or many of the willow species do because of the presence of primordial root initials. Have you found or examined the cuttings for any of these root initials?

DR. KAWASE: I cannot answer the question directly. However, I can say that the diffusate did promote rooting in mung bean cuttings as well as increase rooting in the willow cuttings. The mung bean cuttings have no performed root initials. So I know that it will promote root initiation as well as development of the initials.

VOICE: Did you observe any vascular cell tissue damage on your herbaceous material at 4000 rpm?

DR. KAWASE: Yes, this is sometimes a problem even with willow at the higher speeds.

DR. HESS: We could add another species here, Mokato, *Hedra helix* also works except that we get both 1 and 4 cofactors out from the diffusate.

DR. KAWASE: Yes, I understand that was reported in the last Proceedings.

DR. HESS: That was just straight diffusion but we've also used your centrifugation technique.

DR. KAWASE: Oh, you have used it.

DR. HESS: Yes, I think centrifugation is better because with diffusion over a period of time you have bacterial contamination, but by centrifuging just for an hour I think you get relatively pure materials without contamination.

MODERATOR PINNEY: The next subject, propagation of *Picea pungens glauca* will be given by Mr. Leonard Savella.

PROPAGATION OF PICEA PUNGENS GLAUCA CULTIVARS

LEONARD SAVELLA
Bald Hill Nurseries, Inc.
Pontiac, Rhode Island

The propagation of Blue Spruce from either seed, layering or grafting has been a practice for many years. It was believed that these were the only methods to reproduce this species commercially and make it profitable.

With the introduction of the mist system of propagation, the Spruces, like many of the other ornamentals that were reproduced in one of these three ways, have become easy to root from cuttings. The procedure is very much the same as most of the ornamentals propagated under mist, except that just a little more care should be taken in timing your cutting.

The following is a step by step method that we use at Bald Hill Nurseries, Inc. which has proven to be very successful:

An outdoor mist bed 6′ wide is prepared with a layer of peat moss 1½ - 2″ thick. Then a layer of sharp sand 6″ thick is put on top of the peat moss. The sand is then rolled with a roller filled with water for compaction. The sand is leveled off so that the surface area is as level as possible. The mist pipes are then placed on top of the bed and connected. Our system is examined the cuttings for any of these root initials?

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The bed is now ready to receive the cuttings. We go to our two stock plants of Koster Spruce and after carefully examining the new growth, we start to take the cuttings. I say careful examination because this is very, very, important. The cuttings are taken when the new growth is about 2″ to 4″ long and when the terminal buds of each cutting are just about to show or are just showing. If the cuttings do not show a bud, they can be taken because they will root and form buds. The location of the cutting will determine your percentage of success in rooting. Cuttings of the terminal growths are more difficult to root. The cuttings, usually six in number, on both sides and behind these lead shoots root more readily. Then if you look carefully beyond these cuttings toward the main truck and setting on top of the branch, you will notice cuttings of about ¾″ to 1″ long. These cuttings will root almost 100%.

The cuttings are cut just below the node but also making sure the husk covering the node is left with the cutting. *THIS IS MOST CRITICAL.* The cuttings are taken and are immediately dunked into a pail which is half full of water. The reason for this is that the cuttings are so very tender they may dry out unless you handle them this way. When we have taken about (300) cuttings. we then go to the mist bed where they are made ready for sticking. The cuttings are taken from the pail of water and shaken to remove the excess water. They are then dipped into #2 Hormodin powder and set in an empty seed flat, or any kind of flat container and covered with wet burlap to protect them from the wind and sun. Now they are ready for sticking. We take a metal straightedge and cut a line in the sand about 1½″ deep so that when you stick the cuttings they will go in easier and undamaged at the base. The cuttings are taken from under the wet burlap and stuck into the medium. We use a lath as a spacer. When the first row of cuttings are stuck, we tamp the lath gently to firm these cuttings. At the same time, the sand is cut on the front side of the lath to make ready for the next row. This procedure is followed until we have the desired amount of cuttings stuck.

The system is on and operating during the sticking so that the cuttings do not dry out. When we have finished, we water down the entire bed until it is thoroughly soaked. The mist clock is set at 30 seconds every 2 minutes and is set to go on (1) hour after sunrise and off (1½) hours before sunset. This must be progressed as the Summer days get longer. During the very hot and dry days of Summer, the beds should get a thorough drenching about once a month. On very cloudy or rainy days, the system should be shut down completely so as not to induce leaching. If leaching starts to show, the cuttings will become more difficult to root and many will just simply rot; therefore, this should be watched very closely.

By the middle to the end of September the cuttings should be ready to lift. They are lifted being very careful in the process, not to break any of the roots for they are *extremely tender* and *brittle.* Those that are rooted are transplanted in flats containing a mixture of ½ peat and ½ sand. They are planted 54 and 63 to a flat. When flatting the cuttings a hole is made with a peg so that the roots can be placed in this hole. This will eliminate much of the root "break-off" when transplanting. Also when the cuttings are pressed in, they must be pressed very gently. Let the watering do most of the packing.

Many of the cuttings that die in the flats, die because the roots were broken off in the transplanting. When the flats have been filled, they are brought into the greenhouse and placed on the benches. They stay there for about 4 - 5 weeks during which time they have made new roots and are now ready for hardening. They are put in beds where sides and shades are placed over them. We are very careful in making sure they get proper watering during this period. Before the real cold weather sets in, we cover these beds with sash and shades. This protection brings them through the Winter with light losses due to frost heaving and cold. On warm days during the Winter, we open the sash slightly to air the cuttings and at night they are closed. When Spring arrives. we take the sash off leaving the shades on and the plants are watered and cared for in these beds for 2 years. After this time, the cuttings have formed very good root systems and can now be planted in beds for further growth or can be field lined, depending upon their size.

We have been rooting Blue Spruce for 4 years and they show great promise. The plants are full and have many buds. They show a leader early and seem not to need staking when field lined. I would say that many more Propagators should adopt this method.

VOICE: Sometimes in grafting we experienced that the terminal bud doesn't come out and one of the lateral buds must be able to take the lead. Is this true with cuttings also or does the terminal bud grow out?

LEONARD SAVELLA: The terminal buds grow out because actually it's the one bud that forms first and that's the one that takes over.

JIM WELLS: Have you tried any other form of the spruces and have you tried any different misting periods?

LEONARD SAVELLA: No, I haven't. This whole thing was done accidentally. We were grafting in the wintertime and when we were cutting off some of these lateral shoots some of them looked so really nice that it seemed a shame that there were no roots on them. So I stuck them in the bench in some peat and, low and behold, some of them did root. I said if they can root there, they may be able to root outdoors. So the next year we tried it and I was just flabbergasted with the results. So that's what we did and we've been doing it every since.

VINCE BAILEY: I noticed in the pictures a few unrooted cuttings. Do you restick them?

LEONARD SAVELLA: Yes. If you restick unrooted cuttings indoors with heat those that are good will root very fast, probably in 2 weeks. And if you look in the back of the room, the one with the longest roots is the one that was restuck.

RALPH SHUGERT: Do you have cost figures on the three year cutting and grafts of the spruce?

LEONARD SAVELLA: No, like everybody else, I just do it. I don't know how much it costs me.

E. STROOMBEEK: I have two questions. Have you taken cuttings from different stock plants and where did the stock plants originate?

LEONARD SAVELLA: The stock plants were bought from Case Hoogendoorn. They are true Kosters. We have tried other varieties and we find Moerheim more difficult and the Hoopsi true to its name, it's tough.

BRUCE BRIGGS: Did you try some with pulling off and leaving the heal rather than cutting them off?

LEONARD SAVELLA: Yes, we tried pulling them, but we had better results with cutting them. It seemed that the right time to take them is just when the pulling stage is past.

BRUCE BRIGGS: We know that spruces root better when they have lots of free air. Can you root the same way inside the greenhouse having it completely open?

LEONARD SAVELLA: There again, I never tried it out, but getting the 85% outdoors, I thought I'd leave well enough alone.

PETER VERMEULEN: Did you find any difference on the position on the stock plant or between the lower cuttings and cuttings higher on the plant?

LEONARD SAVELLA: That's a good question, Pete. We took cuttings as far as we could reach.

HANS HESS: Was this a continual mist that you had on these cuttings or was it intermittent mist?

LEONARD SAVELLA: Intermittent. Here again, I never took the trouble of timing these things. I just put the mist on and when I thought it was enough I left them alone. Maybe if I figured this thing out, they wouldn't root.

MODERATOR PINNEY: Next, we shall learn about cell culture and plant propagation from Dr. John Mahlstede.

CELL CULTURE AND PLANT PROPAGATION

J. P. MAHLSTEDE[1], F. C. LADD[2], AND J. PELTIER[3]
Iowa State University

Plant propagation, defined simply as the multiplication of plants by either sexual or asexual means involves the use of

[1]Professor of Horticulture, Iowa State University, [2] Sister, Mount St Clare Cllege, Clinton; Iowa, [3]Technician, Iowa State University, Ames, Iowa

year we tried it and I was just flabbergasted with the results. So that's what we did and we've been doing it every since.

VINCE BAILEY: I noticed in the pictures a few unrooted cuttings. Do you restick them?

LEONARD SAVELLA: Yes. If you restick unrooted cuttings indoors with heat those that are good will root very fast, probably in 2 weeks. And if you look in the back of the room, the one with the longest roots is the one that was restuck.

RALPH SHUGERT: Do you have cost figures on the three year cutting and grafts of the spruce?

LEONARD SAVELLA: No, like everybody else, I just do it. I don't know how much it costs me.

E. STROOMBEEK: I have two questions. Have you taken cuttings from different stock plants and where did the stock plants originate?

LEONARD SAVELLA: The stock plants were bought from Case Hoogendoorn. They are true Kosters. We have tried other varieties and we find Moerheim more difficult and the Hoopsi true to its name, it's tough.

BRUCE BRIGGS: Did you try some with pulling off and leaving the heal rather than cutting them off?

LEONARD SAVELLA: Yes, we tried pulling them, but we had better results with cutting them. It seemed that the right time to take them is just when the pulling stage is past.

BRUCE BRIGGS: We know that spruces root better when they have lots of free air. Can you root the same way inside the greenhouse having it completely open?

LEONARD SAVELLA: There again, I never tried it out, but getting the 85% outdoors, I thought I'd leave well enough alone.

PETER VERMEULEN: Did you find any difference on the position on the stock plant or between the lower cuttings and cuttings higher on the plant?

LEONARD SAVELLA: That's a good question, Pete. We took cuttings as far as we could reach.

HANS HESS: Was this a continual mist that you had on these cuttings or was it intermittent mist?

LEONARD SAVELLA: Intermittent. Here again, I never took the trouble of timing these things. I just put the mist on and when I thought it was enough I left them alone. Maybe if I figured this thing out, they wouldn't root.

MODERATOR PINNEY: Next, we shall learn about cell culture and plant propagation from Dr. John Mahlstede.

CELL CULTURE AND PLANT PROPAGATION

J. P. MAHLSTEDE[1], F. C. LADD[2], AND J. PELTIER[3]
Iowa State University

Plant propagation, defined simply as the multiplication of plants by either sexual or asexual means involves the use of

[1]Professor of Horticulture, Iowa State University, [2] Sister, Mount St Clare Cllege, Clinton; Iowa, [3]Technician, Iowa State University, Ames, Iowa

many and diverse techniques which you as plant propagators are quite familiar. The asexual propagation system that you use to supply that plant part with the missing organ or organs has as its basis the satisfaction of certain basic physiological processes founded on plant biochemistry and related to plant anatomy. There are many challenging and fascinating problems in plant reproduction. They are as diverse and intricate as the numerous enzymes, amino acids, proteins and auxins that control plant growth and development. Answers to these questions come slowly, and new break-throughs often represent the integration of many accumulated facts that are put together into a workable and sensible hypothesis. These are then assimilated by the resourceful horticulturist and applied directly to the solution of some propagation problem.

In 1963, Wetherell (2), of the University of Connecticut, described a system for growing whole plants from single cells. While the idea was not new and had been previously demonstrated by Steward (1), of Cornell University, the fact that vegetative cells of the type contained in the tissue systems of the cuttings you propagate, could be manipulated through a series of embryogenetic steps which approached that of the fertilized zygote of sexual propagation, was a breakthrough. By using a defined growing medium, callus tissue could be broken apart into single cells, and each single cell be induced to divide, differentiate and to eventually form an intact plant. The use of 2,4-D and adenine stimulated callusing. Kinetin substituted for adenine induced specialization and establishment of the familiar tissues systems and the formation of organs. Removal of the auxin 2,4-D stimulated embryo formation and the addition of coconut milk provided the impetus of after ripening and permitted the embryo to develop into a normal plant.

The technique appears simple, and it is for carrot. It is not simple for many of the types of plants which nurserymen grow and propagate.

We might pause a moment to reflect on the application of this technique to the problems that we have in propagation. The technique of tissue culture provides a tool by which we can study the effects of auxins and related balance systems on cell differentiation, growth and development. By providing precise conditions of environment, the effects of pH, aeration and many other conditions of the mirco-environment can be critically studied as they are related to the propagation techniques that we now apply grossly. As information is gathered, the propagator will become more deeply involved with refinements in the propagative skills and management practices he now employs. Propagation will be truly a science.

This trend has been evident since the founding of this Society. The development of mist propagation and the refinements and ingenuity applied to the regulative devices sequencing the application of water to best meet the physiological requirements of the cutting as well as the use of a form of tissue culture to index and develop pathogen-free plant material are other indications of the rapid progress which is taking place in the science of plant propagation. They further illustrate the importance of science to the plant propagator.

At Iowa State University we have been experimenting with the techniques of plant tissue culture for a period of four years. Cultures of carrot tissue were first used according to the procedures developed by Steward and Mapes. Chrysanthemum, geranium and Kolkwitzia are the plants currently under study in our laboratory. Our objectives, together with studying differentiation in these cell cultures are those of breeding and the development of new clones and cultivars.

Using *Kolkwitzia amabilis,* the common beauty bush, as an example, let me describe briefly our approach to the application of this technique. As you know, *Kolkwitzia amabilis,* and the variety *K. a. rosea* are the only forms in this genus. Any variation from these two would, in fact, represent a new clone.

In the spring of 1965, developing ovaries were collected from established plants at regular intervals. Developing embryos were then excised and cultured on a Marashige-Skoog medium with and without the addition of 2.5 mg/liter IAA, .2 mg/liter kinetin and 100mg/liter of yeast extract. When a solid medium was required, nine grams of agar was added to the basal medium. In one series of experiments the MS medium was further modified by the substitution of arginine and lysine for glycine, each alone as well as 1:4 and 4:1 proportions, all in equimolar concentrations to glycine.

Embryos were then cultured and segments of root, hypocotyl and epicotyl transferred to separate culture tubes and callused. The developing callus mass was then broken into single cells (which is the only way in which mutations can be cloned) by the use of a chelating agent, Fe EDTA (ethylendiamine tetraacetic acid .01-.02 per cent). This chemical reduced the binding calcium of the middle lamella between cells. Separation was further activated by the use of magnetic stirrers and sterile Bellco flasks. These single cells were then transferred to a MS medium with IAA, kinetin and tyrosine. The individual study with lysine and arginine indicated that there was an optimum balance of these two amino acids as they affected the growth of the callus. Both ratios gave higher dry weights than either alone or glycine alone. From this it was obvious that each callus type may require its own organic nitrogen source, which can only be determined by trial and error.

By further subjecting these single cells to chemical mutagens, we hope, in the not-too-distant future to give to the nursery and arboretum inventory a whole new complex of *Kolwitzia* cutlivars . . . through a system of micro-propagation, a technique off the drawing boards of fantasy, but one that we hope will serve to further the science and practice of plant propagation . . . and a better living through plants.

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2. Wetherell, D. F. 1963. Growing Whole Plants from Individual Cells ,Proc. International Plant Popagators' Society 13:176-181.

HAROLD EPSTEIN: The meristem culture technique is already in use for orchids such as the desirable plants that everybody wants like the bright red cattleya and things like that and selling them as young plants for $7.50 and $8.50 apiece. Unfortunately, most of this is being done in France and the plants are exported to the rest of the world. France at this moment seems to have the production monopoly on meristem culture of orchids. So it's beyond the experimental stage.

DR. MAHLSTEDE: This is correct, but there is basically one difference between meristem culture and the type of technique that I discussed. We're getting down to the individual cell rather than a group of cells. And it's the process of differentiation that forms the apical meristem or root meristem that is already formed in the segment of the tissue that you have mentioned. It's essentially the same type of thing with the basic difference being the number of cells and the organization of the cells you start with.

DR. STOLTZ: Just a follow up on what you have said, John. We are also doing this type of work with orchids at the University of Kentucky. It does, of course, have the very basic difference that you pointed out.

JIM WELLS: John, have you been able to grow the single cells to complete plants yet?

DR. MAHLSTEDE: I was afraid you'd ask that, Jim. No we haven't. We have with carrot and with *Chrysanthemum* but not with the *Kolkwitzia*. In the past they have been using an agitated culture in which they take the Erlenmeyers and put them in a gently swishing solution. The single cells then are forced apart and land on the edge of the glass at the juncture of the back and forward movement, and from there they grow and develop. We've used flasks with a magnetic stirrer and this gently rotates — there is no violent action and then by the use of ETA the cells are gently split apart. And, of course, it's interesting how these cells develop when taken out of the framework of an entire plant part. And of course, we're doing exactly the same type in our propagation techniques. You and I, when we stick a cutting, try to provide an environment for it to grow. We are doing exactly the same type of thing on defined media using some of the results that Charlie has and some of the products he is using specifically in tissue culture and I'm sure that Len back here is doing the same thing. In other words it's a refined mirco-technique that I'm sure will have application in the future.

DICK STADTHERR: Have you irradiated any of these cells as yet?

DR. MAHLSTEDE: We've irradicated them, but we haven't set up this dosage yet. As you might imagine that it is pretty sensitive at this time. We've killed everything we've treated so far.

VOICE: Have you been able to find any chromosomes yet in these cells?

DR. MAHLSTEDE: Yes, but of course, with *Kolkwitzia* they are dfficult to find.

JIM ILGENFRITZ: John, do you have any data on the number of generations or divisions or the length of time before we begin to get differentiation from a single call?

DR. MAHLSTEDE: We haven't determined the exact number of divisions but certainly there are a great number of them.

MODERATOR TOM PINNEY: At this point we have asked five Canadian Nurserymen to discuss propagation of difficult, unusual and rare plants. At this time it gives me real pleasure to introduce the first of these gentlemen whom all of you I am sure know, Mr. Ray Halward of the Royal Botanical Gardens.

PROPAGATION OF DIFFICULT, UNUSUAL AND RARE PLANTS

RAY E. HALWARD
Royal Botanical Gardens
Hamilton, Ontario, Canada

The plants included in this article are not necessarily difficult to root, but certainly could be classified as unusual, especially in our area. The *Davidia* or Dove Tree has been mentioned in previous papers. In 1958, Miss Mary Milton, former propagator of the Morris Arboretum, related its performance in the Philadlephia area. In 1960, Alfred Fordham, explained the best treatment for seed germination. My interest in *Davidia* was aroused in 1960, when I observed a 30′ specimen growing in Hamilton. It was imported in 1935 a 6′ plant from Daisy Hill Nurseries, Neury, Northern Ireland, and given some protection with evergreen boughs for four years. In 1947 it flowered for the first time, and has flowered every year since that time. I tried rooting softwood cuttings on two occasions and was unsuccessful. In the meantime, seed I had received from Denmark and the Arnold Arboretum in 1960, had germinated and were doing quite well, in an acid medium under lath house conditions. On July 14th this year I took the cuttings from the seedling plants which were over six feet high. The cuttings were six inches long and the large leaves were reduced in size. They were dipped in a mixture of one half Captan 50 W and one half Seradix No. 3 and they were put in boxes with a mixture of four sand and one peat, and put under intermittent mist with bottom heat supplied by a cable set at 70°.

In the first lot of 22 cuttings from the Danish source, only six were rooted by October 31st. In the second lot of all cuttings from the Arnold Arboretum's seedlings, five of which had

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In the first lot of 22 cuttings from the Danish source, only six were rooted by October 31st. In the second lot of all cuttings from the Arnold Arboretum's seedlings, five of which had been wounded lightly, eight were well rooted by October 31st. It was obvious that wounding had aided considerably in the root formation.

Other plants which I have had success in rooting under exactly the same conditions as for *Davidia* are listed below, and may act as a guide for someone wishing to propagate the same species.

Date	Name	No Cuttings	Hormone Used	Transplanted Date	No Rooted
7/20/61	*Acer tegmentosum*	84	Seradix #3	Sept. 27	50
7/22/60	*Acer carpinifolium*	15	Seradix #3	Oct. 7	11
7/20/61	*Corylopsis sinensis*	50	Seradix #1	Sept. 22	48
7/13/60	*Halesia monticola*	50	Seradix #1	Oct. 7	35
7/13/60	*Pterostyrax hispida*	24	Seradix #1	Oct. 6	16
5/30/62	*Parrotia persica*	5	Seradix #3	Aug. 27	5
7/8/65	*Prunus Maackii*	10	½ Seradix #3 ½ Captan 50W	Sept 28	7
7/19/65	*Stewartia Pseudocamellia*	44	½ Seradix #3 ½ Captan 50W	Sept. 29	40

PROPAGATION FROM CUTTINGS OF PICEA PUNGENS 'GLAUCA GIOBOSA'

JENS PEDERSEN
Rose Arbor Nurseries
Oakville, Ontario, Canada

We have propagated this dwarf blue spruce from cuttings in cold frames in the shadehouse for the last few years with fairly good results. We take the cuttings about June 20th with a good heel, this is important. We do not strip the needles off. We put the cuttings in flats as we find this is an easy way to move them. It takes 18 months to get a good root before transplanting by the first fall. We leave them in the cold frames for the winter and about June the following summer, we take them outside in the shadehouse. As our medium has very little nutrients, if any, we use some fertilizer at this time.

The following spring we plant them out in beds with 40% shade. Our medium is 50% sharp sand and 50% perlite or similar material. Be very careful not to over water. Our catch is about 65 to 75% and we use the same method for all dwarf spruce.

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WINTER ROOTING OF EVERGREEN CUTTNGS IN COLD FRAMES

PETER R. NIELSEN
Robert Nielsen and Son Nurseries, Ltd.
Oakville, Ontario, Canada

This method may not be considered too unusual and it is definitely not a new method but being such a simple and inexpensive method, it may prove to be of some interest to certain propagators attending this meeting.

My Dad first saw it used a few years ago here in Lake County, Ohio and thought then that it would be an ideal system for us. Not having a propagation house and being financially unable to construct one and running a business which included landscaping and the operation of a Garden Centre as well as regular nursery operations, time was always short, good help was always scarce and money even scarcer. Thus we decided this would be an ideal method for us to adopt.

The evergreen cuttings were taken and made in the winter as soon as we were able to get at it, which was usually in late February. When we had made enough cuttings to fill three or four frames, we would set the frames up out in the shadehouse right on the frozen ground. (This really made them cold frames). Sand was put in the frames and the cuttings stuck immediately. A mild day was usually chosen to do this. We have used both glass sashes and poly covered sash with equal success. A reed mat was immediately rolled over the frames and we then proceeded to completely neglect them until about early April when the reed mats were removed and replaced with 40% lathe shade.

Again they were shamefully ignored and neglected, until towards the end of May, when more time was available and we suddenly remembered we had them and gave them a drink. Here the similarity between the plant and the propagator is quite evident — both perk up considerably with a little drink. At this stage rooting was apparent. Watering continued and gradually the hardening-off process began. The rooted cuttings were left to winter in the frames and set out in beds the following June.

Straight sand was the only medium we ever used. No insecticidal or fungicidal treatment was given to either the cuttings or the medium and no hormones were ever used during the six or seven years we have been employing this method. Periodically when the notion hit us, we applied a solution of 20-20-20 fertilizer to the rooted cuttings.

Now this method is only good for easy to root types. We have rooted the following with excellent results — Juniperus pfitzeriana, pfitzeriana aurea & pfitzeriana compacta — Juniperus sabina, sabina hicksi, sabina Blue Danube and sabina tamariscifolia — Juniperus horizontalis plumosa and Juniperus hetzi.

This may appear to be a rather hap-hazardly run system. Well, it is — but, it certainly helped us to increase our evergreen stock, took very little of our time and the costs were minor.

I might add that we are presently engaged in constructing a glass propagating house and boiler room workshop and if all goes well, we will be able to plant our cuttings inside this year.

CORYLUS AND CORNUS FROM CUTTINGS

JOERG LEISS
Sheridan Nurseries, Limited
Oakville, Ontario, Canada

This paper represents some of the trials conducted at Sheridan Nurseries over the last two years, 1964 and 1965. The trials were to find a way to root such plants from cuttings which were previously propagated by all other means but cuttings. It was our thinking that for instance if a layer would root why not a cutting, which would be much quicker made and also give a much greater yield per plant and would do away with large stool blocks. On grafting, the raising of understocks and subsequent sucker growth from this understock could be eliminated.

Corylus maxima atropurpurea was our first trial and in 1964 100 4 - 6 inch tip cuttings were made after the first flush of growth had hardened. This would be in the middle of July in our region. Half the cuttings were treated with Seradix #2, the other half with Seradix 3# (Seradix is both in content and formulation similar to Hormodin).

The cuttings were placed in a greenhouse bench under intermittent mist controlled by time clock. The medium was sand of a coarseness known as concrete sand. Cuttings were inspected after five weeks and the following observations were made: —

Small cuttings had excessive callus in both treatments and were also swollen as far as dipped. No rooting on either. There was a good portion of rooted cuttings in the #3 treatment while only few cuttings were rooted with #2 treatment. Especially heavier cuttings showed no sign of rooting.

We also stuck at this time cuttings of *Cornus mas aurea*, treated with #3 Seradix, into the same medium and mist system. No roots were found at the end of eight weeks when cuttings were taken up.

Rooted *Corylus* cuttings were heeled in a cold frame, but all were dead by Spring 1965.

After these experiences the following changes were made in 1965: — Only heavy tip and shoot cuttings were made of *Corylus max. atropurpurea, Corylus avellana aurea* and *Corylus avellana contorta*. Rooting was over 50% and to prevent winter death, cuttings were either potted or planted out direct into beds. The plants showed quite a good root development in the bed which was much better than the potted plants. Hormone green stock, took very little of our time and the costs were minor.

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1) treatment with Chloromone 100%.
2) quick dip in 2% indolebutyric acid (IBA in 50 grams alcohol in 450 grams water)
3) treatment with a liquid dip 15 minutes in 1.5% indolebutyric acid solution diluted in equal parts of water as above (2).

Rooting commenced in three weeks and roots showed all along the portion inserted in the medium. Our best results were with Chloromone and quick dip 2%; up to 75% heavy rooting was obtained with both treatments.

To mention but a few of other plants where partial rooting was obtained: —

Acer saccharum erectum
Acer rubrum "Armstrong"
Davidia involucrata
Hydrangea petiolaris

MODERATOR TOM PINNEY: We now have time for some questions from the last five papers.

AL LOWENFELS: I would like to ask how you got the *Davidia* seed to grow because last winter at the meeting one of our members gave me some seed and neither he nor I could get them to grow. Can you tell us how you grow your seed?

RAY HALWARD: These seeds I received from the Arnold Arboretum and I don't think they had any previous treatment. We have a black muck which is very acid in nature. I don't know whether the seeds are coming through this year, but I known quite definitely we didn't give them any treatment. They come through quite frequently, although they are slow in germinating when we sow them in the fall of the year as soon as we get the seed.

PETER VERMEULEN: We got some seeds from Hal too and we've been using the hot - cold treatment with good success — forty days hot. We take our *Davidia* seeds and put them in a plastic bag with damp German peat moss and put them in the green house with a 60 - 75 or 80° F. night and day and then 40 days in the ice box at about 40° F. and then again outside. Then we start watching for germination.

TOM PINNEY: When do they germinate?

PETER VERMEULEN: This will vary, sometimes it might be 25 - 30 days after they are out the second time in the heat. They will develop over a period sometimes it may be 2 - 3 weeks.

RAY HALWARD: I started the heat treatment during May and June in the cold frame. They don't show any roots until July. I don't give them any other treatment and they seem to be quite happy.

BILL FLEMER: I would like to ask Ray Halward how those *Davidia* cuttings grow up. I know we rooted many cuttings but they don't grow very vigorously as compared to seedlings.

RAY HALWARD: I'll tell you next year.

CASE HOOGENDOORN: Ray, you're talking about difficult to root things. Did you ever try to root *Acer griseum?*

RAY HALWARD: Two years ago I took cuttings of *Acer griseum* from five year old plants. We took them about the end of May and they rooted very quickly. I think you'll find this was also written up in one of the quarterly bulletins.

CASE HOOGENDOORN: Did you use any hormone?

RAY HALWARD: Sephadex #3 I believe. I'd have to check back. It might have been Rootone but I don't think it was.

GERALD VERKADE: When Mr. Peterson took the spruce cuttings in April or March, did you check in September to see if any of them were rooted?

JOERG LEISS: Yes, I think Mr. Peterson mentioned that he spot removed cuttings in September or even August. We are using the same procedure and are getting roots by August. It takes generally about ten weeks. I feel that timing isn't very essential as long as you can provide those 10 long weeks you get roots on just about every spruce you can name.

CASE HOOGENDOORN: You said you rooted *Acer griseum.* Do you still have them or do you lose them after you took them out of the medium or did you loose them after the first winter?

RAY HALWARD: As a matter of fact, Case, we still have them. We don't lift them out of the medium.

FRIDAY EVENING SESSION

December 10, 1965

PLANT PROPAGATORS' QUESTION BOX

The Friday evening session convened at 8:00 p.m. in the Cleveland Room. Mr. Gerald Verkade was moderator.

MODERATOR VERKADE: Have any growers rooted directly in the new plastsic flats or cube flats in which individual plastic pots are formed into a single flat? Also, after rooting and hardening off, have the liners been put into the field?

PETER VERMEULEN: This is getting to be a rather common process as we discussed here at the mist symposium. There are quite a few people, comparatively speaking, rooting directly in the pot and then going directly to the field. We've done quite a bit of this and I'm sure others have, too. There is no particular disadvantage or difference in going from the pot to the field with a plant whether it be potted in the pot subsequent to rooting or rooted directly in a pot. I don't quite understand the question.

ANDREW ADAM: What I was trying to get across are these new cube-type trays which are being used for rooting of a plant or liner under the mist, hardened off and taken directly to the field eliminating the process of going from bench to the pot and then to the field?

PETER VERMEULEN: There is a tray similar to the one you are referring to put out by Vaughn called "multi pot". And it comes in various sizes such as 1¾ inch square.

JOERG LEISS: This thing Mr. Adams is referring to is a tray made out of plastic just the same as a flat. It is molded in one piece.

PETER VERMEULEN: Well, essentially it's just a matter of form, is it not? Is it not just a plastic flat that is compartmentalized?

JOERG LEISS: No, not exactly.

MODERATOR VERKADE: I would like to know a recommended disinfectant for cleaning greenhouses, flats, tools, etc.

VOICE: Chlorox.

GERALD VERKADE: It also says here — when do you change your medium for placing the next crop?

ROBERT DEWILDE: There is a phenyl mercury product that you buy that's a hospital disinfectant. It's quite satisfactory for killing all types of fungus and bacterial organisms. I cannot remember the name of it precisely, but it was purchased from Geigy Co.

VOICE: It will also kill some plants.

LINCOLN PEARSON: There is a material that is on the market labeled as LF-10 which can be used even on the naked hands, although I prefer to wear gloves and can be used as a germicide, bacteriocide, and fungicide and is being used in the geranium industry and in their culturing processes. And this is much ahead of Chlorox and formaldehyde.

MODERATOR VERKADE: Is it toxic to plants also?

LINCOLN PEARSON: No, we dip pots in it; we dip plants in it and where other products kill, this does not. What they do is mix up a barrel of the material in a 55 gallon drum and soak things in it for a period of 20 minutes and take them out and let them air dry and then immediately plant.

ALBERT WILL: In Florida quite a number of nurserymen are using this LF-10 product and quite successfully. It has no phyto-toxicity. That is you can sterilize pots or clean the benches or walls or anything like that.

MODERATOR VERKADE: Where can I obtain a #6 Bard Parker blade holder and blades as recommended in a paper last year? Any surgical or scientific supply company such as Fisher Scientific Company, of Chicago.

DONALD CATION: That was my question and the catalogs of this Bard Parker don't have a #6 blade that was recommended. They have a number 2 and 3.

JOHN ROLLER: Those blades can be purchased in your local drug store.

MODERATOR VERKADE: What is considered the best growing medium for Taxus in containers?

BOB DEWILDE: We gave it up. We tried a great number of things; peat and perlite, sand, peat, and sand and peat mixtures. We could not grow them as well in containers — one of the few plants we could not grow as well in containers, as you can in the field.

MODERATOR VERKADE: Well, who is growing them in containers? There should be somebody in this room.

HARRISON FLINT: They aren't growing perfectly for us but we are at least growing them. Bob. We do grow them in our experimental program; ⅓ perlite, ⅓ peat, ⅓ sandy loam. With the right additives and careful watering we experience no problem. Not necessarily growing as well as then do outdoors, but we have reasons for wanting to do it this way.

BRUCE BRIGGS: Actually we grow Taxus in quite a few forms in containers and we can grow them twice as fast in containers as we can out in the field. And we use pretty much 100% bark mix supplemented with a lot of organics.

VOICE: 100% bark mix? What kind of bark is that?

BRUCE BRIGGS: Actually we are not too particular about the kind of bark but the bark we have is hemlock. We prefer hemlock because it has no splinters. I presume fir would be just as good. Now you probably don't have either one of these two; the main thing we want is a very light fluffy mix that the water will go through very rapidly. We have used a compost of sawdust which we have sometimes as a mix. It is made up of soil, sand, and ⅔ sawdust decomposed with ingredients put in for a period of maybe 6 months to neutralize the loss of nitrogen and it works just as well as the other mixes.

DR. PRIDHAM: We have had the same experience as Harrison Flint with the exception that we try to take our Taxus cuttings with a base of 1 year or 2 year wood that was mentined earlier today. We take those in November or December, carry them on to the Spring and move them into plastic containers, using the same mix as Harrison mentioned — ⅓ each peat, vermiculite and soil. In September they're ready for planting. We do pick up a good deal of root growth during the summer so that we have very little in the way of loss in September and October.

MODERATOR VERKADE: Can anybody identify the nozzle we saw in use at Yoder Brothers?

DR. HESS: They had it specially made for them and they called it a Boston nozzle.

VOICE: I don't know whether it's made in Boston or not but it looks like a "Mister 100". They said they were going to give us the address and we never did get it.

MODERATOR VERKADE: Do we have a policy prohibiting commercial propagating equipment at our meetings?

No, we haven't. We had a whole panel on equipment in the round table discussions. There's no policy against any equipment used in propagation.

PETER VERMEULEN: Well, there's a policy against commercializing, because it might lead to an embarassing situation. If the product is relatively new and hasn't been exposed to the Society before and it has potential benefit, then it should be shown, such as Laursen's nozzle. But we have to be careful in that we don't allow any commercialism in the Society.

MODERATOR VERKADE: How long are the scions of budwood immersed in water prior to budding?

BOB SIMPSON: From 2 - 3 hours to maybe 24 or 48 hours. For example, from Saturday afternoon to Monday morning. *They go into refrigerated storage.*

GERALD VERKADE: You let them soak all the way from Saturday to Monday?

BOB SIMPSON: Yes. We let them soak sometimes from 2 - 3 days sitting at temperatures of about 35° F.

PRESIDENT BAILEY: In regard to the question and answer that was proposed, we've budded quite a few ornamental crabs and I assume that is what is referred to in the question. We also feel that the buds should be submerged in water to keep the budwood moist and we have no trouble taking the bud away from the inner part of the stem.

BOB SIMPSON: When you talk about de-wooding, do you cut the bud and then pull the wood out, or do you take the bud off leaving the wood on the stick?

PRESIDENT BAILEY: We leave the wood on the stick. They are carried in a very moist container. We have boxes that each budder carries with him lined with burlap or cloth. When he cuts a bud, he cuts from the bottom up and makes the cross cut on the top being careful not to cut through the wood on the top.

Then he picks the bud off and leaves the wood on the stick.

BOB SIMPSON: We had many cases where scions wouldn't do that so we started keeping them in water. It works so well and it's so simple that we have them just carry a bucket full of sticks out into the field.

HARRY HOPPERTON: Everyone has their own process here of handling these, but that bucket can get awfully heavy carrying it along the row all day long. We take a wet burlap bag and wrap our scions, maybe 50 sticks, and tie it around our waist rather than carry that heavy bucket.

DR. NELSON: Maybe this is not a firm rule and certainly we have broken it a few times, but with all the work at Ottawa it has been shown quite clearly that de-wooding is not essential at all. As a matter of fact in some cases we have had greater success with the wood in the bud rather than without the wood.

MODERATOR VERKADE: What are the directions for rooting *Cercis canadensis*? They want to know what time to take it, what hormone to use and what rooting medium to use.

HAROLD DAVIDSON: This past year we had an opportunity to try rooting *Cercis canadensis*. A very large branch of *Cercis* broke on campus and while doing some other rooting experiments, I just took a series of cuttings from the *Cercis*, softwood cuttings, and put them in a mist house where we did not have bottom heat. The temperatures ran about 65° F. We got about zero rooting. Where we maintained a temperature of about 75° F. we got about 90%. We used Hormodin #2.

VOICE: We have been quite successful with outdoor rooting just as soon as the leaves have reached their full size. The stem is still quite soft. This outside without any bottom heat.

MODERATOR VERKADE: Has anyone been working with *Euonymus vegetus* standards? What is the procedure? How does grafting compare with budding?

JOERG LEISS: We use *Euonymus europaeus* as an understock. We cut it back after the second year, and shoot it up into a whip. We either double bud in the summer or graft in the winter or until early Spring with defoliated plants with good success.

MODERATOR VERKADE: What, if anything, is being done with fogging systems?

PERCY EVERETT: I'm the one who asked that question. I have been trying to find something out about fogging systems because we have one in our small nursery operation. I know the Monrovia Nursery has one in Azusa, California. We've had pretty good success with it. The reason we installed it was because we had rather a high mineral content in our water and many of the plants that we propagate had a lot of hairs on the leaves and they were slower to propagate. They collect quite a bit of this mineral, calcium, and after they're rooted and we begin to wean them off — the leaves will drop. Oftentimes even the buds will be so covered with this material that they won't leaf out. So along with the intermittent mist we have installed this high pressure fogging system. All it is four jets that are above the intermittent mist and we can regulate these as much as we want. With the low pressure water and high pressure air it pulls out the water into a fog. On cooler days it's just exactly like a fog. We can maintain a high percentage of humidity without using much intermittent mist. Oftentimes we can bring things in from the field or from the wild as bare root plants and establish them very well with the use of this system. Also, we have some plants that drop their leaves immediately or within a few days or a week after growing under intermittent mist. You'll have to take them out of that mist and put them up in the individual pots and just root them with fogging. I was wondering if there was any other work being done anyplace else?

DR. NELSON: Sir, are you talking about a centrifugal system or an air pressure system?

PERCY EVERETT: Air pressure.

PRESIDENT BAILEY: We have used a humidification system and from the comments I suspect our system is about what you're talking about. We carry some clones in storage at 96% humidity — it looks like it's pretty foggy in some of these rooms. In the propagation house we don't carry that high a humidity. However, we find this humidification system is a great benefit in the greenhouses for propagation. It is uniform at least.

MODERATOR VERKADE: I think this would be a good subject for next year.

CASE HOOGENDOORN: Is that what they call a Swiss humidifier?

PERCY EVERETT: I don't know if it's Swiss or not. We had it installed by a local greenhouse company. It has a little tank about 12 inches square. It is rectangular and probably doesn't have more than a couple or 3 gallons of water in it. It is kept full all the time by a regulating valve. Then outside the greenhouse we have a 7 horsepower compressor and every so often according to the clock — the way it's set — that compressor will come on and the needle will go up to 60 to 70 pounds. The fogging system will shoot a stream of 4 jets from each one of their heads.

DR. PRIDHAM: I think at one time we had one of these at Cornell and it's called a Binks Humidification system.

DR. SYNDER: The 1954 Proceedings contained a very good articles on humidification by Vince Bailey.

MODERATOR VERKADE: This one is to Dick Vanderbilt. Have you used peanut hulls on your cans of rhododendrons as a mulch?

DICK VANDERBILT: No.

MODERATOR VERKADE: Any herbicides on your rhododendrons in cans?

DICK VANDERBILT: No.

MODERATOR VERKADE: How do you keep them clean?

DICK VANDERBILT: We just pull the weeds out.

MODERATOR VERKADE: I understand that Mert Congdon has used Treflon on the entire nursery. Has any stock been affected adversely?

MERTON CONGDON: It's not quite true that we use it on the entire nursery, certainly not on seed beds and so forth. But we did use it on an excess of 100 acres, I would say closer to 200 acres, with a wide range of material and no adverse results at all. And we did have check plots, too.

MODERATOR VERKADE: Any other growers have experience?

BOB DEWILDE: This past spring we applied two quarts per acre and then stuck hardwood privet cuttings in it. The material was incorporated immediately in the soil after it was applied. We had absolutely no effect upon the rooting — they all rooted very well and we only had to hoe the block as a skip hoe job once during the season.

MODERATOR VERKADE: What effect does a weed killer have upon cuttings taken from treated plants?

KLAAS VAN HOF: We use simazine as a direct spray over yews, arborvitae, and junipers. We have taken cuttings not immediately, but maybe a week or ten days after with no apparent effect.

PRESIDENT BAILEY: We've used simazine at 1.5 pounds per acre active ingredients on scion blocks. We have found no adverse effects in either conifers or deciduous material.

MODERATOR VERKADE: The manufacturer of Casaron has been cautioning against its use on Japanese hollies especially on light soils. We have been told that the manufacturer has now withdrawn this warning this Fall. Does anybody know anything about this?

DAVE PATERSON: We used it last year about this time to clear up a mixed plot that was fairly heavily infected with quack grass and there happened to be *Ilex* in this particular area. We used it at the rate of 150 pounds per acre. I think now they've moved that up to 200 pounds per acre. We found no damage to the *Ilex*.

BRUCE BRIGGS: West Washington Experiment Station has used it over 3 years on trial plots with *Ilex convexa* at the rates of four pounds actual and eight pounds actual and they also used other herbicides along with it. He did get a little discoloring — the very end of the leaf turned a little bit yellow. On the whole, at the end of the season, the growth compared to the check was just as good on Casaron as it was with the others. As I said we did have a little difficulty with the foliage at the time of application.

JIM WELLS: We've been using Casaron for a couple of years now, and this last summer we used it on azaleas and rhododendrons up to 350 pounds per acre of the 4% granular. No damage, whatsoever. Just weed control.

RICHARD STADTHERR: We have used it on *Ilex crenata convexa* and we do get damage. This is especially true on the real sandy soils in contrast to planting soil. In the mountains this is not true with the heavier soil where you get more clay content. But we get a regular chlorosis, and actually some of the plants have been killed. This is at three pounds active material per acre.

DR. PRIDHAM: We have worked with Casaron for quite a while in comparison with a number of other herbicides. Casaron will control artemisia, quack grass, bind weed, nut grass, Canada thistle, horse tails and I don't know how many other weeds. This group is characterized by underground stems. So I think you can bring this fact down to horticultural plants with underground stems and with them I think there ought to be trouble. However, now is the hour. It is December 10th. Casaron put down at this time of year will take care of these perennial weeds listed here and, you don't have to work it into the soil. As a matter of fact I think it's better if it is used only on the soil surface and in granular form. Mr. Wells, I think said something in the neighborhood of 300 pounds granular, this is 4% active material and therefore 12 pounds Casaron in the 300 pounds. This is more than we have found necessary to deal with the artemisia, quack grass, and these other weeds. Probably in the neighborhood of 7 pounds or 7½ pounds of active chemical is all that's really needed. Five pounds will do a pretty good job on these weeds. They'll be places where for some reason you can't get a complete kill. Ten pounds is the rate we started out with, and with these perennial weeds in among stock such as *Ilex*, rhododendrons, Taxus, and the normal run of narrow leaved evergreens. it has given consistently good results over the last five years. We had a paper in Northeastern Weed Control Conference last year indicating that soil samples after five years with repeated treatments of Casaron showed no indication of Casaron being present. What we use is a soil sample and grow ordinary garden beans in it. Usually, if Casaron is present, the beans may grow with a bit more red color in the hypocotyl than you might usually expect to find. If you add fertilizer it usually greens up and the plant is all right. If there's any serious quantity of Casaron present, usually the bean root as it first emerges begins to decay. If this is the situation, then it might be worthwhile not to use that soil for immediate planting of nursery crops particularly those that have soft fleshy roots or stems. Under field conditions with 10 pounds per acre of Casaron, we have planted garden flowers and things of that sort in the spring after a fall application. That is just a little background in terms of the few serious weeds that this particular chemical is doing a better job than the simazine. Simazine does a good job on quack grass but not quite as good on the artemisia. It seems to make the bind weed grow, encourages the nut grass, and the horse tail still seems to grow when we treated with simazine. So as I say this is a useful thing from that point of view. In comparison with the spring treatment of weeds, I don't think that Casaron needs to be used at anything like the 10 pound rate. You chop it down to four pounds or two pounds. The other material that I think should be mentioned here is amizine. This is a combination of amino triazol and simazine. It does almost the same job that the Casaron will do, either used as a spray this time of the year or used during the growing season.

CARL KLEHM: Do I understand that if it's applied in the fall or winter you should not transplant during the spring for hollies?

MODERATOR VERKADE: Yes, that's the way I took it. Dr. Whatley, what is the pH of the vermiculite and the perlite used in your experiments?

DR. WHATLEY: The pH of the vermiculite was 6.0 and the perlite was 7.2.

MODERATOR VERKADE: Have there been cases where natural plant extracts have improved the rooting of cuttings?

DR. HESS: That's a loaded question. There is a product that is well known; it is called chloromone. It is supposedly a natural plant extract, extracted by the "2 x 4 method" as best we could find out. It is supposed to be extracted from alfalfa. We did check it out one time and it does have a high concentration of naphthalene acetic acid in it. It may also have some other materials in it that we haven't been able to identify. I know Dick Vanderbilt tried using the same concentration of naphthalene acetic acid that we estimated Chloromone contained, and he felt that he had better results using Chloromone. This may indicate that maybe it does have something else in it. Other than that as far as commercial products are concerned, I don't know of any natural plant extracts that have been used. There is one other case, however, also rather notorious. A number of years ago a man was offering for sale a method to produce rooted blue spruce cuttings. It was supposedly an extract of Norway spruce seedlings, and I don't know if anyone has had good results with this extract after paying their $50.00. The trouble with natural plant extracts is that the total extract is likely to contain inhibitors as well as promoters. Until you get the extract refined, and purify the substances you want, you're liable to have more trouble than positive results.

DICK CROSS: I tried this spruce formula that Charley Hess just mentioned. I obtained the procedure from a gentlemen at a Garden Club meeting held a few years ago. I wasn't successful with it. This solution was made up of bark of spruces put into liquid solution. The cuttings were supposed to be dipped into it. I followed his directions implicitly, but they didn't produce results. There is a variation in the climatic conditions and that may have been the reason it wasn't successful.

MODERATOR VERKADE: Have continuous or repeated hormone treatments been used during rooting and compared with a single treatment?

JIM WELLS: We have done this continuously for years and I think it's a sign of failure. When we lifted the cuttings —

any that have rooted, of course, move on. Any that are just likely to be rooted are set back to root better and any that are not rooted at all are recut and retreated. This in theory should not be necessary. If you have a good batch of cuttings that are getting along well, they will all root, or very nearly all of them. You're way ahead to throw those cuttings away rather than re-sticking again and then start with another batch.

HOY GRIGSBY: The University of Arkansas put out a folder on the rooting of cypress trees which they got good results treating with 20 ppm, sticking them and after 45 days retreating them with 500 ppm. I tried the same thing on pine and without any positive results.

MODERATOR VERKADE: *Cryptomera* — can they be rooted from cuttings? If so, describe timing, hormones, etc.

DICK VANDERBILT: We have been fairly successful in rooting quite a few clones particularly the dwarf ones of *Cryptomera*. We root them usually in December to mid-January in a medium of sand and use Hormodin #3.

AL LOWENFELS: I just wanted to know if anyone has been able to root that subject. I haven't had good success.

CASE HOOGENDOORN: Which variety?

AL LOWENFELS: I don't know, it's just *Cryptomera*.

CASE HOOGENDOORN: The only one that we've been able to root is the *Cryptomera japonica* which is the seedling that we use as an understock. But when you try Lobbii, then you have a problem. We have never rooted them yet.

DICK VANDERBILT: We rooted that Lobbii compacta once. We took a graduated set of cuttings from very small to something unbelievable — 2 feet tall and 3/4 or a 1/2 inch thick. The only ones that rooted were these 2 feet tall things; they rooted very nicely. We planted them out; they grew much more slowly than grafted plants. I never tried it again.

CARL ORNDORF: I have rooted *Cryptomera japonica compacta*, the cuttings being taken in the latter part of July. We get about 70 - 90% of them. I have also rooted quite a few of *Cryptomera Lobbii compacta* in the greenhouse; 40 - 50% is about all we get. It's just not consistent.

MODERATOR VERKADE: What hormone, what time, etc.?

CARL ORNDORF: We took the cuttings in the latter part of July and used intermittent mist in the greenhouse. We used perlite for the medium and no hormone treatment.

JOHN VERMEULEN: We should ask the Western members to put out a paper on rooting *Cryptomera*. They root a number of varieties which grow into very nice plants. We buy a number of rooted cuttings from the West coast.

MODERATOR VERKADE: Should one strip needles from evergreen cuttings before inserting in rooting medium? Maybe I can answer that. I believe you have to strip *Taxus* so that the rotting does not get ahead of the rooting. However, I saw today that not stripping the needles on spruces works very well.

BILL CURTIS: In the northwest we used to strip the cuttings such as *Picea albertiana* and your dwarf spruce — the low-growning ones, but we found that this was not necessary. And we don't have too much trouble with rot. I visited Mitch's Nursery near Aurora, and he was putting out Albertas, heel cuttings in July and just before I left to come out here he was potting them up. He took a heel cutting and just took the end of the heel off and put the cuttings in sand with bottom heat and no mist and no hormone treatment.

MODERATOR VERKADE: This question is for Dick Vanderbilt. Do you expose rooted *Rhododendron* cuttings to long day treatment before canning?

DICK VANDERBILT: Yes, after they're rooted and transplanted they are then chilled for a period of 20 days under 40°F. After the 20 day cool period, the heat is raised to 70 degrees and then they are lighted.

MODERATOR VERKADE: Mr. Savella, how old are the blue spruce you have grown from cuttings?

LEONARD SAVELLA: The oldest plants we have are four years old and one of them is in the back of the room.

MODERATOR VERKADE: There is another part to the question and I think you may have answered it this afternoon and that is, do they grow straight?

LEONARD SAVELLA: There again, I can only tell you to look in the back of the room. They seem to be growing straighter than the grafts.

MODERATOR VERKADE: How may an adult clone be reverted to the juvenile condition for propagative purposes?

DR. HESS: Actually there are a number of ways. Commercially a stool bed may be used. The reason the stool bed works, for example, with the Malling apple stock, is that the plant is kept cut back and shoots develop from the base. Juvenility is retained at the base of a plant, and if you can get shoots to develop from the base, they are usually juvenile. Sometimes these are seen as water sprouts from mature trees. Another technique that has been successful with the mature form of English ivy has been the application of gibberellic acid. I don't know whether this is applicable to other plants. Another way of obtaining juvenile shoots from mature plants is seen in the English holly — *Ilex aquifolium.* You can find growing on the trunk of mature trees, small bubbles of tissue called spheroblasts. These may be broken off and planted as seeds. They will form a plant which will be juvenile. Stoutemeyer at the University of California, has been able to induce spheroblast formation in apple shoots by continuously removing the vegetative buds. The shoots which develop from the spheroblast are juvenile. The best commercial technique, however, is severe pruning to induce shoot development from the base of the plant.

DR. NELSON: Another example is to take the bud from a mature plant such as MacIntosh apple and bud it onto the base of a juvenile seedling such as robusta 5. You will obtain a juvnile form of the MacIntosh.

DR. HESS: There is another specialized example in the case of the nucellular seedlings of citurs. These seedlings develop from tissues within the seed but not the embryo. They have the exact genetic makeup as the mother plant. These plants are highly juvenile.

VOICE: Mangos and avocados also have a high proportion of nucellular seedlings.

MODERATOR VERKADE: What is your procedure in rooting of blue spruce cuttings?

PETER ORUM: We take a cutting in the beginning of July, the first week in July, and we dip them in hot water mixed with Hormodin, Hormodin 3 powder. The water is 120° F. and leave them in there for half an hour and stick them outside with mist and no shade.

VOICE: Do you use heel cuttings or is the cutting stripped?

PETER ORUM: No, we just use a plain cutting — no heel cutting.

VOICE: What is the concentration of the Hormodin in the water?

PETER ORUM: I can't give you that exactly now.

MODERATOR VERKADE: Could I have some information on the propagation of *Yucca glauca?*

JOERG LEISS: You can propagate them from seed from Northern and Southern Italy.

HUGH STEAVENSON: You can raise a dandy liner from seed in one year

MODERATOR VERKADE: What is DMSO?

VOICE: It is a by-product of the paper industry and is called Dimethyl sulfoxide. It is manufactured by the Crown-Zellarbach on the West Coast. We have used it on the rooting of rhododendrons and the results have been less than desirable.

PETER VERMEULEN: I have some literature here on DMSO. The compound has the ability of enhancing the penetration of chemicals into plant tissues and may have some potential for getting plant growth promoters and retardents into plants more efficiently.

JAMES WELLS: We have obtained some DMSO from Crown-Zellarbach, but we are not about to use it. We have been told there may be dangerous side-effects such as affecting the eyes. It has an extraordinary penetrating effect; if you put it on your skin, within a few moments you can taste garlic in your mouth. Our purpose in getting it, and I still think it's a good idea, was to use it as a carrier with some of the newer fungicides to try and control rhododendron wilt.

DR. STOLTZ: I know of some work with DMSO on orchids in an attempt to use a smaller concentration of IAA or IBA and obtain maximum effect. There was no promotive effect at all and by itself it had a slight retarding effect upon root initiation.

JAMES FLEMING: There is one use that has not been mentioned, and I've seen reports of it in European literature. They stated it would stimulate seed germination and suggested that water penetration might be more rapid.

PETER VERMEULEN: Treating *Pyrus* seed with 50 - 100 ppm of DMSO in water stimulated germination and shortened the chill requirement. Other seeds with chill requirements are now being studied. It has also been shown that virus infections of fruit trees such as stony pit in pear and leaf mosaic in peach appear to be controlled or retarded by DMSO application.

MODERATOR VERKADE: Ralph Shugert, is the 100 pounds of Juniper seed you sow clean or in the berry?

RALPH SHUGERT: Yes, it is clean.

MODERATOR VERKADE: Do you spray more than once a week in very wet weather?

RALPH SHUGERT: That's a good question, Jerry. No, I set up this weekly spray program and don't miss a week from when we start till frost. By never missing a week I believe I obtain as good a control as I can get and still keep the cost reasonably in bounds. We can't afford to spray after every rain. For example, in Nebraska we have in the month of September, 17.3 inches of rain which meant of the 30 days of September, I believe rainfall was recorded on 23 days.

MODERATOR VERKADE: Dr. Waxman, was any bud breaking or top growth apparent prior to rooting on blueberry cuttings under light?

DR. WAXMAN: No, usually you see rooting first and then bud break on top.

MODERATOR VERKADE: Jim Wells, what do you think of air as a rooting medium for cuttings?

JIM WELLS: I should really give this question to Dr. Chadwick; he is the expert on mediums. However, I would say that if we had all factors under control, I don't see any reason why we couldn't use air as a medium.

DR. HESS: I disagree with you, Jim, in that you may get a side effect from the medium which you wouldn't get from the air. In a medium the bottom part of the cutting would be in darkness and therefore b l a n c h e d or etiolated. As you well know, etiolation has an excellent stimulatory effect upon rootinig.

JIM WELLS: You're right, Charley, absolutely right, but yet I feel that when we have complete control of our cuttings including water loss I feel we can get rooting of a wide range of materials right in the air. For example, this year we have had excellent rooting of rhododendrons and in a few cases cuttings which have been left on the top of the bench have sent roots out of the wound which curved down and found their own way into the medium. Now of course, all things were just right.

ALBERT WILL: I had some experience down in Ft. Lauderdale, Florida with *Ficus*. I had a bunch of 18 inch *Ficus* cuttings which I didn't have time to stick and I just threw them under the bench to keep moist. Although this selection was fairly difficult to root, when I went back to them four weeks later they already had four inch roots on them. I potted them up and they are doing beautifully.

BRUCE BRIGGS: We have been doing some rooting of cuttings suspended in air and I'll have to report that they root faster in the air than in the medium. We used an enclosed chamber and the cuttings were stick through a black poly sheet and sprayed the base of the cuttings with warm water. The base of the cuttings was enclosed but the top was open. [*Editor's Note*: In this case you would still have the benefit of blanching or etiolation of the base.] In this set up this summer Japanese maple cuttings rooted in 10 days and that was much faster than similar cuttings in the medium. Clematis gave up similar results.

JIM WELLS: Did you use a clear plastic or a white plastic?

BRUCE BRIGGS: When we started out, we thought we needed the light so we started with clear plastic using *Daphne Cneorum* and azaleas. Now this didn't get started until Christmas. The Daphne didn't root for six weeks and the azaleas didn't root for three months and so we discarded the whole thing. Then along toward the spring, we tried the whole thing over again. But this time we used black poly. When we used black poly, the *Daphne* cuttings rooted in about 20 days as compared with 30 in the summer and so from now on we are using black poly.

MODERATOR VERKADE: What type of paint is best for use on polyethylene for shading during the winter and what type of thinner is safe to use with this plastic?

KLAAS VAN HOF: I use a rubber base paint and I thin it down with water about 1:5. I take a one gallon can of rubber base paint and add four gallons of water and spray it on.

PETER VERMEULEN: We use "solar shade". This is a compound on the market for shading purposes. I can't give you the exact dilutions at the moment. But it's a little more expensive than the rubber base paint.

MODERATOR VERKADE: How do you patch holes in plastic greenhouses? I noticed some patches over at Yoder Brothers.

PETER VERMEULEN: I have some of that material; it is called "miracle tape". We're not satisfied with this material; however, we did purchase some material in a hardware store called "contact" and it was still in place when we took the plastic off this past spring.

RALPH SHUGERT: If you will write Minnesota Mining, they have several tapes manufactured especially for polyethylene.

JIM KYLE: We had a little trouble putting this tape on in the winter time because of frost on the inside of the plastic house and we found that a woman's hair dryer did an excellent job of heating the plastic up, making the patch stick and almost welding them together.

MODERATOR VERKADE: Dr. Cannon, have you experimented with rooting *Rhododendron carolinianum* using a hormone-talc dip?

DR. CANNON: Yes, we used Hormodin #3 with good success.

MODERATOR VERKADE: Has anyone further experience in trying to increase plant hardiness through the use of Decenylsuccinic acid as described by Dr. C. J. Weiser of Minnesota?

DR. MECKLENBURG: I tried it on a variety of plants at Michigan State with no success at all.

MODERATOR VERKADE: What are the possibilities that government may consider entering the production of nursery stock to supply the needs of the President's National Beautification Program?

PRESIDENT BAILEY: I think this Society has a great stake in that very problem. As I said in my opening remarks, one of the problems is likely to be a shortage of plant materials as this highway beautification program moves forward. I can foresee the calling for bids in various states or areas and not being able to get any bids. What will be their answer if they want it in the next week? "We'll have to have federal nurseries." And as nurserymen and plant propagators we could not say a thing. If we can't furnish the stock, they'll say they've got to have it. I think the shortage of plant materials is a more serious problem than over production from the plant propagators standpoint.

RAY BRUSH: This is a very real problem. We as an industry need to at all times maintain the best possible liaison with your state and federal agencies that will be working in the beautification program. Now, part of this problem is a lack of their understanding of our industry and its problem. It is up to us to make these contacts and to see to it that they understand the problem. Some of the things that have happened in the past couple of weeks leads us to believe that they are beginning to comprehend the problem of this industry in producing the masses of material they are thinking they will want. So we are in hopes if we can get to these people, that they will be reasonable with us. I think those people we contacted so far are most cooperative, and they are understanding. They are sincere in wanting to accomplish these goals as set forth. So, we as an industry have an obligation to establish and maintain contacts and I think we can come out of this much better and do a wonderful job both for our Society and for our own industry.

HUGH STEAVENSON: I have been on both sides of the fence, being employed by the government for a decade or so. And I do know this, that many government agencies now are aware of this problem, and see an opportunity to expand their bailiwick so to speak, I don't know why, but government agencies love to have nurseries. It seems to be popular amongst people and whenever they have an excuse to do so, they will take hold of it. There is no question that the people here in this room and the industry we represent can do a much better job of producing this material as required, more quickly and expediently than any government agency could do. It's obvious that we can do a far better job and that not only the agencies, but our representatives in Congress must be constantly aware of this.

We must be darn sure our congressmen and senators are fully cognizant of that, and we must insist that they not permit agencies to set up government nurseries to produce nursery stock. Obviously, we have the facilities, we have the land, the equipment, we have the know how which the agencies would have to acquire. So we certainly could do a far better job and get the job done more effectively. But it's ridiculous for an agency to call for something that we have no idea in the world they wanted, and they must understand we must get advance notice before it's going to be needed so the program can be orderly carried out. Also the members in Congress must know this, so they do not appropriate funds for any agency to set up federal nurseries. That's a political problem we have, if we are alert I'm sure we can help.

RAY BRUSH: May I add one other comment on alerting and knowing what we have. I question whether the nursery industry itself knows as a whole, what we have available at any time. Now one of the problems that is going to be with us for some time, is the location and availability of plant materials. I think the area of the country that probably has come the fastest in this area is in the Eastern Region where we built expressways, and have the housing agencies, the highway contractors, landscape architects, landscape contractors. These people are maintaining membership in LMIS, landscape materials information service. This type of service is set up in other regions of the country. We feel that it should be, but it may be that in some other areas of the country it should be set up on a different basis. This I do not know. But it is something that certainly should be explored and considered in other sections of the country. In this way all of these different groups that are interested in the use of plant material, will at all times as near as possible know what is available and where it is available.

JOHN VERMEULEN: I think we are trying to do something that is no business of our organization whatsoever. We all have a state organization. Our state organizations are alert to those things and they have written about them in the papers. We have a wonderful American organization which is willing and has been taking care of the thing you people mentioned. It is none of our business at all. We are propagators, not sellers.

MODERATOR VERKADE: With plants which produce leggy growth would it not be beneficial to light them from the side or the bottom?

DR. HESS: Sid mentioned in his discussion that when plants were grown under continuous light they do tend to get "leggy". He recommended that you give them a rest with short days, next, give them a cold treatment and then long days again to stimulate lateral bud development and growth. Lighting from the side vs. lighting from the top would not be any different as far as inducing lateral bud growth is concerned.

MODERATOR VERKADE: What is a propagator?

JIM WELLS: I'm not going to even attempt to answer that question, but I will refer you to the first Proceedings of this Society and first Proceedings of the Western group in which that was fully covered. There is a little item I would like to bring in here; it's part of the mist symposium and it's in the current issue of the *Royal Horticultural Society Journal.* It was written by a man named Hannibal in California and is entitled: The Sprouting of Seeds on Brass Sieve Screens.

The various methods tried in sprouting seed are almost legion, but basically the problem is to provide sufficient moisture at germination temperature without promoting damping off. This may sound elementary in areas where the natural humidity is high, but in dry climates a high humidity is an immediate invitation for every spore of fungus to become active and seed mortality can be a very serious problem.

Some twenty years back the use of live sphagnum moss was suggested as a planting medium for *Lilium* and *Hippeastrum.* It was effective but had definite limitations. Vermiculite, exploded perlite granules, quartz sand, fine glass beads of the "Scotch-lite" variety and other sterile sprouting mediums have all been tried, and of all the materials tested the perlite granules in a sealed plastic container was one of the best. Recently the Auckland Lily Society of New Zealand suggested the trick of floating seed on water to have it sprout, and the results have been rather startling. But several annoying things occurred for the writer, in a half-dozen instances the water became stained and made a good paramecium culture, and in another glass he found a good crop of mosquito larvae.

Recently the writer had picked up some used laboratory screens with the thought of using these to winnow seed. Several of these units had 100 to 200 mesh brass wire screening such as used to sieve out fine clays or flour. What would be the result of using these sieves to retain seed while exposing it to a slow drip? This has now been tried quite thoroughly and the results have exceeded our fondest hopes when the screens were stacked one above the other in a manner such that the water could trickle down from one deck to the other. Practically 100 per cent germination is possible, starting with *Pinus* seed in late winter and terminating with *Zephyranthes, Hippeastrum,* and Australian Wattle during the mid summer. Most seed can be left upon the screens until the primary leaves have developed, then picked off and planted in a satisfactory planting material. Trace of copper may be present as no difficulty with damp off or decay has been encountered on the screens, and as long as the tap maintains a slow drip there is no problem in trying to retain a high humidity level throughout the stack.

The only seed giving difficulty thus far has been *Callistemon* and this was due to it being so fine that it passed through a 100 mesh screen. Possibly this seed could have been suspended on a piece of filter paper, but in this instance some of it was floated on water in a watch crystal and the bulk of it sprouted in six days. Even that which sank sprouted as readily.

Initially there was some speculation whether brass or copper enhanced the aeration of the tap water by catalytic action creating conditions comparable to rain water, but it was soon learned that many seeds contain strong growth inhibitors which have to be leached out by water before germination can proceed. In fact the success of embryo culture depends partially upon the removal of the endosperm which contains such growth inhibitors. Perhaps the old gardener who insists that there is nothing better than a good gentle rain to sprout seed never heard of the technical reasons, but it is plausible that the wetted surface areas on the screen both enhance aeration and leaching of the enzymes as germination is good. The arrangement is so simple and yet so natural that we wonder why it hasn't been suggested previously. [*Editor's Note*: The author of the above article was L. S. Hannibal, Fairoaks, California.]

SATURDAY MORNING SESSION

December 11, 1965

The Saturday morning session began with the annual business meeting at 8:30 a.m. in the Cleveland Room. The minutes of the meeting are recorded elsewhere in the Proceedings. At 10:30 a.m. a panel discussion of 'Concerns and Practices in Cutting Selection' was conducted. Mr. James S. Wells served as moderator.

INTRODUCTION

JAMES S. WELLS
James S. Wells Nursery
Red Bank, New Jersey

In preparation for this meeting I spent a few quiet evenings, last month, reading through the Proceedings of the meeting in Rochester. I did this, of course, with particular interest because, unfortunately, I was not able to attend. But I do this every year and what never ceases to amaze me is the mass of information which is poured forth at these meetings. As one contemplates the whole picture, it is surely clear that the work of the plant propagator has become a science as well as an art, and in the operations of our Society we see a unique blending of these two facets of human behavior.

As I read, I was collecting my thoughts for this introduction and I believe that one of the most clear aspects which comes to the top of this mass of information is the greatly increased efficiency in propagating techniques which we have acquired over the past twenty years, especially in the propagation of a much wider range of plants, from cuttings.

I was thinking back to the training which I received as a young man on my father's nursery. It was considered essential that we take the most meticulous care of every operation involved in our work. Some of the things which were required make strange reading, now. For instance, it was almost mandatory that we use "good sharp sand." But what was meant by this was never defined. When the truckload of sand was delivered from the source we knew to be the best, the propagator would go out and feel a little between his fingers and then would repeat the magic formula, "good sharp sand." We were required to fill pans with this sand, or any rooting medium, and to pound it firmly to be sure it was really hard before the cuttings were inserted.

The cuttings themselves were carefully cut and graded to a uniform and quite minute size. Once they were inserted, watering was carried out by hand, using a watering can rather than a hose, and with water from a tank which had been carefully brought up to greenhouse temperature. These and many similar procedures were considered essential to success, and successful we were, to a degree.

But the ease and relative simplicity with which we now propagate vast quantities of plant material under a mist system, or by the Phytotektor method, or perhaps using the Burlap Cloud, makes us realize that we have both simplified our systems and adopted new ideas and techniques which have immeasurably increased our efficiency. This increased efficiency has been due, in no small measure, to an increased understanding of how plants work. We have examined most of the internal and external factors which affect the development of the plant material and have determined, with some degree of accuracy, the optimum conditions for reproduction.

This Panel has been assembled with the thought of considering the four facets which can combine to achieve first class production. We hope to show how these facets react, one with the other, and properly combined, produce a substantial propagating force which can enable us to root, from cuttings, many plants which might previously have been considered difficult.

We have somewhat arbitrarily limited our speakers to five minutes in the hope that they will reduce their comments to pithy and pungent sentences which will arouse your interest and perhaps your disagreement. We want to leave plenty of time for you to exercise your prerogative to speak.

Our first speaker will be Merton L. Congdon.

TIMING AND ITS RELATION TO CUTTING SELECTION

MERTON CONGDON
Congdon's Wholesale Nurseries
North Collins, New York

I feel most fortunate in having the subject of "Timing" assigned to me because I believe in the past I have devoted as much to timing as to any other problem in propagation. Certainly, we have led off this discussion with the proper topic. If we do not select our cuttings at the right time there is not much point in continuing the discussion because we are not going to have any cuttings to discuss, at least in the more difficult subjects. In the easier subjects we are going to be laboring under unnecessary difficulties.

I should tell you that my experience is limited mostly to a wide range of deciduous shrubs and a few of the easy broadleafs. Also, it is entirely to outside bed work either with conventional sash or intermittent mist. So you see when this discussion turns to such items as Evergreens, Rhododendrons and Azaleas or to elaborate glass-house installation, I am entirely out of my realm. My observations, however, are that a lot of effort has been put into elaborate installations to try to bend the ways of nature to the will of the propagator when in many cases, a more desirable result may be obtained in working more closely *with* lar procedures were considered essential to success, and successful we were, to a degree.

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Now back to the subject at hand, "Timing". Anyone who has tried rooting French Lilac from softwoods soon learns that this is one of the first groups to select if you are working under outdoor conditions. In our latitude each day further into June only multiplies our problems in rooting *Syringa*. Taken late in May they not only may be rooted, but they may be taken to the field later in the summer and become very well established.

In western New York we are blessed with a long period of mild weather in the Fall and the first killing frost is generally not experienced until late October. For that reason a whole range of material is rooted and taken to the field without potting. We must, however, draw a deadline of about August 10th for transplanting to the field in order for the stock to become well established. To transplant too late will only lead to susceptibility to winter injury or to heaving out due to alternate freezing and thawing. It only follows then that these cuttings must be selected in early June in order for them to become well enough established to stand field conditions within eight or nine weeks. Timing then is the answer to a successful chain of procedure that often produces material in salable sizes in only a year and a half of field growing.

Poor timing often produces odd results. *Kolkwitzia amabilis* is one of the old time shrubs that no longer should be grown from seed as there has been at least one selection made that is a worthwhile improvement. Take *Kolkwitzia* any time after Mid-June and all you will get is a callous as large as a marble on those little, slender cuttings. Taken in late May or early June and they will root normally.

While I have mentioned a couple items that are rather inflexible in their requirements as to when they should be taken, I should also mention that the advent of intermitent mist propagation has allowed a great flexibility in timing with many varieties in comparison to the comparatively tight schedule required in cold frame or greenhouse methods.

Most experienced propagators use little aids to help them in their timing. They know that the calendar is not the answer because weather conditions vary greatly between seasons and it is the condition of the wood that matters and not the date. Anyone rooting the whole range of *Spirea* should know that they should be taken when wild blackberries are in bloom. This is an old propagators' trick and I have never seen it fail. Of course, the test of having the cutting bend neatly between the fingers — neither snapping because of being too immature nor breaking because of being too mature — is so fundamental that it should need no further discussion here. Time and again we read in the old propagators manuals the term, "firming at the base."

While I assume that this group is mainly interested in softwood cuttings, I have devoted most of my time to this subject. However, if we were to consider timing as it applies to hardwood cuttings we would open up another whole range of discussion. One brief comment, however, concerning hardwoods — it is generally better to time the gathering as early in the Fall as the wood is mature, rather than to wait until the rigors of winter have had their effects. Certainly, in practically all cases, wood should be gathered before sap flow begins in the Spring.

To sum up, I wish to emphasize that one should devote a great deal of time to the study of "Timing" as it effects the potential success of propagation, no matter what subject he is working. Correct timing eases the task and produces better results.

MODERATOR JIM WELLS: Timing is one of the few procedures which we carry out in which the real skill of the propagator is called into full force. I would like to call next Mr. Dick Fillmore who will discuss the position of the cutting on the plant.

POSITION IN CUTTING SELECTION

RICHARD H. FILLMORE
Sarah P. Duke Gardens
Duke University
Durham, North Carolina

The position of the cutting in relation to the entire plant is always a consideration in the successful rooting of cuttings. This position may not only affect their potential ability to root but also the configuration and stature of the resulting plants.

Terminal tip cuttings are necessary for the development of properly shaped plants of certain clones of *Taxus spp.* In other instances, such as *Thuja spp.*, where apical dominance is apparently equally pronounced, normally shaped plants may arise regardless of the position from which cuttings are taken and cuttings from all positions may root with equal ease.

Success in rooting *Ulmus carpinifolia* cult. "Christine Buisman" is apparently almost absolutely dependent on the position from which the cuttings are taken.

If root cuttings are made in spring at almost the time when Norway maple blooms in the same area, they will form both roots and shoots concurrently. There will generally be several course, the test of having the cutting bend neatly between the fingers — neither snapping because of being too immature nor breaking because of being too mature — is so fundamental that it should need no further discussion here. Time and again we read in the old propagators manuals the term, "firming at the base."

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If root cuttings are made in spring at almost the time when Norway maple blooms in the same area, they will form both roots and shoots concurrently. There will generally be several shoots per root cutting. If these shoots are removed and treated as stem cuttings, they will also root satisfactorily.

If the tree trunks were pruned during the previous season, the short shoots which arise around these wounds will also root well. Apparently comparable short shoots taken from the main mass of the tree at the same time and placed in the same conditions will not root in reasonable percentages.

The author wishes to acknowledge the helpful advice of fellow-member Mr. Ralph Crawford concerning the propagation of the Christine Buisman elm.

MODERATOR JIM WELLS: Thank you very much, Dick. I would next like to call on Mr. James Kelley to discuss nutrition.

ROLE OF STOCK PLANT NUTRITION ON ROOTING RESPONSE OF CUTTINGS

JAMES D. KELLEY
Department of Horticulture
University of Kentucky
Lexington, Kentucky

As we have just heard, many factors influence the rooting response of cuttings. Today, considerable evidence indicates that the nutrition of the stock plants exerts a strong influence on root initiation and development. This is particularly true in the case of nitrogen, and more recent findings indicate that zinc and boron also may play a role in rooting.

Kraus and Kraybill (8) as early as 1918 demonstrated the effect of the carbohydrate-nitrogen ratio on rooting of tomatoes. Cuttings high in carbohydrates but low in nitrogen produced many roots but weak shoots, whereas those high in carbohydrates and higher in nitrogen produced fewer roots but stronger shoots. Cuttings made from succulent stems, very low in carbohydrates but high in nitrogen, all decayed without producing shoots or roots. Subsequent experiments by others have shown that a high ratio of carbohydrates to nitrogen favor rooting (3, 13, 15) in tomatoes and grapes.

Winkler (19) showed that grape cuttings highest in starch rooted better than cuttings with a low starch content. More recent work (1, 4, 9) has re-emphasized the importance of a favorable carbohydrate-nitrogen balance using geraniums, azaleas, and roses as examples.

This favorable carbohydrate-nitrogen ratio in a cutting is regulated primarily by two things: 1) the amount of nitrogen applied to the plant, and 2) the stage of development of the current season's growth.

The commercial propagator achieves this condition by 1) reducing the nitrogen supply to the stock plant in order to allow carbohydrate accumulation, 2) allowing plants to have full sunlight in order that photosynthesis may be maximum, 3) by withholding water, and 4) by a combination of the above.

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Stems low in carbohydrates and high in nitrogen content are soft and flexible whereas those high in carbohydrates are firm and stiff. This is related back to time of taking the cutting. Knight (7) noted that firm cuttings which had ceased growth were much superior to actively growing shoots and attributed better rooting to a higher carbohydrate content.

The effect of zinc and boron on root initiation has also been studied. Samish (12) found that the tryptophan content of grape cuttings increased after fertilization with zinc, and he has suggested that increased auxin production from accumulated tryptophan may explain the beneficial effects of zinc applications since zinc is required for tryptophan production which in turn is required for the production of IAA. Tackett (17) showed that chrysanthemum cuttings containing less than 35 parts per million boron did not root as well as cutting containing greater amounts of boron. To date, little information is available concerning the effect of trace elements on rooting, but the effect of nitrogen on root initiation and root growth cannot be overlooked.

Even though we are well aware of the importance of the carbohydrate-nitrogen ratio, a quantitative measure of its relationship to rooting has not been worked out. In other words, the optimum ratio for maximum rooting is unknown. Researchers have shown limited interest in this area and, until they do, we will all continue to take cutting based on firmness of stems which is believed to be associated with a desirable carbohydrate-nitrogen ratio.

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MODERATOR JAMES WELLS: It's a wonder someone hasn't borne down on this problem yet. It is a wide open field for someone. The last and by no means the least, but in my opinion the most difficult subject for our panel to cope with, is weather. And Al Fordham of the Arnold Arboretum is going to do that.

WEATHER AS IT CONCERNS THE PRACTICE OF CUTTING SELECTION

ALFRED J. FORDHAM
Arnold Arboretum of Harvard University
Jamaica Plain, Massachusetts

Although the literature abounds with information regarding cuttings, few references are directly concerned with the relationship of weather to cutting selection and these are usually generalized or sketchy. Weather and the seasons, or timing, are difficult to separate in this context and many of the references give approximate dates with qualifying remarks such as, "depending on the season", or, "varying with the weather".

Two references dealing with the collection of lilac cuttings recommend that cutting wood be taken when the blooms first begin to open (1), and just as the terminal buds are formed (2). The dependence of these development stages upon the weather is shown by the lilac flowering dates at the Arnold Arboretum which reveal that propagators in the Boston area, using these stages as guides, would find variance up to three weeks in different years depending on the weather.

Bos (3) observed that warm days in early spring led to a start in growth on his stock plants of *Philadelphus coronarius aureus* which were later damaged by periods of cold rain or light frost. Cuttings made after this damage led to a 50% propagational loss no matter how carefully they were handled. He recommended that such stock plants be protected.

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Zorg (4) in discussing Juniper cuttings pointed out the difficulty of selecting the time when cuttings were in proper condition. It was self-evident that weather had a great influence on cutting material, for during periods of heat and drought plants would cease growing and ripen off, while during seasons of well spaced rain and favorable temperatures the ripening would take place at a later time.

Leach (5) states that it is not the time of year which is important but the condition of the plant tissues as they mature under the influence of rainfall, temperature and their inherent constitutions. This factor has been the origin of endless controversy in the propagation of Rhododendrons. For the occasional year when an exceptionally hot, dry summer hastens the maturity of the tissue or an unusually warm moist autumn delays it, the period when cuttings are taken should be advanced or postponed according to the condition of the plants.

He also recommends that if there has been drought, it will pay to irrigate the stock plants the day before the cuttings are taken. Furthermore it is a good practice to remove the clippings in the early morning, or on an overcast day, so that none of their turgidity will be lost.

Wells (6) has drawn attention to the fact that weather and the season are related and have to be considered together. A wet spring and lack of sunshine will delay maturity and keep young plants in a soft condition so that the collection of cuttings may have to be put back two or three weeks. In a hot dry spring, the converse is true.

He says weather is also important for cuttings which are taken in a condition of relatively inactive growth. There are well authenticated results which show that most hardwood cuttings of conifers, taxus, etc., root more readily after they have been subjected to one good stinging frost. Similarly, (7) the varieties of juniper which can be propagated from cuttings give the best percentages only after the stock plants have been subjected to some hard frosts. This usually means that we do not take cuttings of this kind until December or January.

There has been much controversy concerning the collection of propagating material in cold weather, I would like to say that on a number of occasions when there was no choice, we, at the Arnold Arboretum, have gathered cuttings and scions during periods of extreme cold. Detrimental effects in the ensuing propagants have never been noticed. Perhaps the shrunken appearance of some frozen propagating wood, together with the fact that it may have been winter-injured, led to the opinion that it is unfit. However, we do follow a procedure with frozen cuttings and scions. On returning to the greenhouse they are sealed in polyethylene plastic bags and placed in a 40° F. refrigerator to thaw slowly. After a day or two of such treatment the wood resumes a normal appearance and is ready for use.

Those who are dismayed by the unkind manner in which weather may deal with their propagating material should ponder the plight of Dr. Richard H. Washburn (8) our fellow member from Palmer, Alaska. He reports some of his weather problems as follows: Even with the hardiest woody materials more problems are found in winters of heavy snowfall than in mild ones with practically no snow. When the snows pile up in the mountains the moose descend to the valleys and eat the terminals on many of the well-adapted shrubs and trees. But they seldom prune in a desirable manner; they may stand up on their hind legs and break down the centers of tall trees just to get the tender terminal growth. Unfortunately, last winter the mice were active under the snow, so that some six-foot trees were entirely debarked from ground level to the tips of their branches. Porcupines seem to confine their feeding to raspberry canes. These hazards associated with weather appear to have solved Dick Washburn's problem, for it would seem that after some winters he has no cuttings left to be concerned about.

Getting back to the topic of this paper, the effects of weather and climate, one may conclude with the thought that plant propagation, in this aspect, is more an art than a science. For a propagator must rely on his own skill and judgment based on a true understanding of the plant's condition.

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MODERATOR JAMES WELLS: Thank you very much, Al. There was a fifth item on this program entitled "etc," by James Wells. I just meant to try and pull this together briefly and turn it over to you for discussion. Obviously timing is of extreme importance and we have a number of well documented articles on this — Sid Waxman's article on Japanese umbrella pine, *Larix,* and deciduous azaleas. The position is important as to the type of plant produced. All of us are aware of the fact that you take terminal cuttings to get *Taxus capitata* and you get spreaders if you take cuttings from the side of the plant. The same is true on cuttings of the Norfolk Island Pine, *Araucaria* — you have to take terminal shoots in order to get a symetrical plant. Juvenility hasn't been mentioned, but the physiological age of the cutting is important — cuttings from cuttings and the type of cutting you would take say from a Juniper *excelsa stricta* with the sphearoblasts on the stems, these are cuttings from the base of the plant rather than from higher up. I think the weather is one of the most difficult things to consider, to be precise about, because it effects the condition of the wood very much and it brings into full force the skill and judgment of the propagator. The water content of the soil and the temperature of the soil affect soil bacterial and the release of nutrients and that affects the balance of the carbon-nitrogen ratio, whatever that is, or it affects the squeeze-ability of the cuttings which I do understand a little. The affect of frost on cutting wood and preconditioning — incidentally in regard to taking cuttings at very low temperatures — when I was out in the midwest, just for fun one day at Jack Hill's I took some Taxus cuttings at 15 below zero and walked straight in and stuck them in a bench of 75° F. And they rooted beautifully. On nutrition, I was very surprised to learn that so little was known about it — only one other thought, we have found, in rooting rhododendrons that a very high calcium level seems to be desirable. Now when I say fairly I don't really know what I'm talking about. The tests probably should indicate a level of calcium of 1000 or 1200 lbs. to the acre. Also, you can get better results if you apply the calcium in the form of gypsum which will not effect pH but which will increase the available calcium to the plant. We haven't considered any of the techniques, which we have considered in detail these last four days; mediums, which I consider to be very important, inspite of Dr. Chadwick's disapproval, I feel there is an absolute void or vacuum of knowledge of the effect of mediums and it was high lighted by the work of the fellows in the state of Washington who are rooting cuttings in the air. I didn't touch on wounding — that's been covered pretty thoroughly I think. There are a few other subjects that should at least be brought into our general thinking on this whole problem — the care of stock plants, the time to gather the cuttings, the condition of the cuttings on the stock block, and whether we should water stock plants before taking cuttings and so on, the care of cuttings while they are being processed — here is something I feel a lot of people fail miserably on, light intensity and I think we have learned a great deal at this meeting on that. So much for the "etc" and now I welcome discussion, comments, and questions from the floor.

JOHN ROLLER: Did I understand Al to say that it was desirable to have frost on *Juniper* cuttings before they are taken?

MODERATOR JAMES WELLS: I think it is desirable and I think you get better rooting from cuttings taken from stock plants after they have been subjected to 2 or 3 frosts. Am I right, Al?

AL FORDHAM: Well this is what is said in your book.

MODERATOR JAMES WELLS: If that's so I substantiate this in that the work we had done at Dundee seemed to indicate this, John.

JOHN ROLLER: Then how do you account for the high percentages of some of the field stuff in late summer or September in the Southern states? Pfitzer juniper for instance.

MODERATOR JAMES WELLS: I think that the answer to that is because they are taking older wood. More mature wood. We are talking, I think, about frost effects upon current season's growth.

BILL FLEMER: These field cuttings remain through the winter in the ground and get their cold there. They are not rooted by the time winter comes along.

JOHN ROLLER: Some are rooted before the winter.

HANS HESS: I hate to dispute your theory, but we make a lot of *Juniper* cuttings in the summer time. They do fine in the open mist in full sun light. They haven't had any frosts on them.

MODERATOR JAMES WELLS: I can see it's time I brought out a revised edition of my book.

BILL CURTIS: I would say the majority of *Juniper* cuttings taken in California, from plants grown in California never even know what a frost is. And they have real good rooting. Thousands and thousands of them all rooted in the summer time, potted, and chances are by next spring they are saleable plants. They never have a frost on them.

CASE HOOGENDOORN: Will they live in the East?

PETER VERMEULEN: We have had a chance to compare this. For the past several years, we have been sticking *Juniper* cuttings in the rooting-growing medium in the summer. We have found that the *J. chinensis* varieties tend to root rather poorly. We did get a very high take the first time we tried them. This year we tested 250 each of the various *J. chinensis* varieties we grow and compared them with the *J. squamata* varieties and the *J. horizontalis* varieties. We found that the *J. chinensis* rooted very poorly whereas the others rooted very highly. I would also like to make a comment, in view of the papers that were presented at this meeting on the rooting-growing media, I would consider your remark that there is an absolute void on this subject to be rather challenging.

MODERATOR JAMES WELLS: I seem to be challenged in all directions!

VOICE: I have worked in the New York Botanical Garden, propagating woody plants and I found that the tighter I packed the sand [rooting medium] the better were the rooting results.

MODERATOR JAMES WELLS: In defense of myself, I would like to come back to a quote somebody made that we have to treat each plant as an individual. I really do think we are dealing here with specifics about particular plants. The generalities which were stated in my book and quoted by Al seem to hold true for a broad spectrum of plants we grew while I was in Dundee. That is, if we stuck cuttings of *Junipers* prior to Christmas or prior to a hard frost, we would get rooting, but we would not get the quality of rooting and the percentage of rooting which we would get if we waited until later.

HARVEY GRAY: Jim Wells, could you or some other member of your panel give me a little guidance on this, which I will briefly state. Many years ago, when I got into the subject of propagating plants, I visited many English gardeners and superintendents of estates and I was aware of the fact that they and their difficult plants to root such as for an illustration, flowering guince, were done in very late winter, brought into the greenhouse, caused to develop soft growth, and it was with this according to them, they got their best rooting of these cuttings or in many instances cuttings rooted where they were never able to root them otherwise. Now, is there any explanation of this point. I know it is a fact, I have practiced it, it works, now is there an explanation?

MODERATOR JAMES WELLS: I don't know the explanation, do you Dick?

DICK FILLMORE: I have no explanation, but I will mention a few things which are obvious. When one compares the outdoor and the indoor climatic condition, that is out of doors versus a greenhouse, one finds right away that ultra-violet and some other qualities of light do not come through the glass used on those greenhouses and propagating structures. That's number one, there is a different quality of light. There is generally a lower intensity of light. There is generally a higher night temperature and less difference between day and night and extremes of temperature in a greenhouse. In the greenhouse there is likely to be, even from the workman's breath, a significantly higher level of carbon dioxide. There is also likely to be in the greenhouse some little bits of combustion products or from a man smoking a cigarette adding a little ethylene. And don't think plants aren't sensitive, they are. Now I would like to see an analysis in the same area of these various factors within a greenhouse and without a greenhouse at the same season and make some more definite determination of this sort of thing.

MERTON CONGDON: In addition to what has been said here, I think there is a whole range of plants whose cuttings should be taken when they are in a flush of growth. And this, of course, is what I hear mentioned under timing. Now, *Philadelphus aureus,* is a perfect example. Many members have had trouble with this plant. I can't say at the beginning of the year when I'm going to make my *Philadelphus aureus* cuttings in June or July or possibly even August, due to the fact that I want to catch them in that flush of growth when I can get the soft, long cuttings that I desire. And I think perhaps in the *Chaenomeles* that this is one of the plants that fall into this category also.

MODERATOR JAMES WELLS: Incidentally on the *Chaenomeles* the treatment with the 1% potassium salt of IBA is almost specific for it.

BRUCE BRIGGS: Just to confuse the issue a little bit more, a couple of questions, maybe someone could answer. We have at times secured in Southern California "Tams" [*Juniperus Sabina tamariscifolia*] lining out stock in August for long runners. We have taken these cuttings off, put them into the medium and in less than a month they have rooted readily. The temperature may be 80 - 90° F. The same thing, we've seen *Rhododendron,* not with us but with many others, commercial growers, they have taken cuttings from Southern California brought them

North and they're much superior to anything we can take off, they root much better, much faster than our cuttings. *Camellia* cuttings taken off under the same conditions in California brought North, put in our greenhouses root and are much superior to anything that we can grow. Also going back to the work with "Tams", the most peculiar thing is that those cuttings taken off in California, when stuck in California did not root as good as under our conditions. The same was true for *Rhododendron* and *Camellia*.

VOICE: It must be the smog.

MODERATOR JIM WELLS: I would suggest to future program chairman that more time be allotted for discussion. I wish to thank the panel very much for their participation.

PETER VERMEULEN: I would like to introduce the moderator for the next portion of the program, Mr. Michael Johnson.

MODERATOR JOHNSON: Each round table moderator will be allowed six minutes to summarize what went on in about an hour or an hour and a half of discussion. Our first moderator is John B. Hill.

AUTOMATION AND/OR MECHANIZATION IN PROPAGATION NEW TOOLS, PRACTICES AND TECHNIQUES

JOHN B. HILL, *Moderator*
THOMAS WHEELDON, *Recorder*

I believe that I can sum this up rather quickly by saying that the consensus indicated at the conclusion of our round table was that actually there were precious few new tools, new in the strict sense of the word. The solution to our problems lay not so much in sitting back and waiting for a latter day Cyrus McCormick to develop for us sophisticated complicated equipment to aid us in propagation or field culture, but rather to adopt the equipment we do have to do the best possible job. I define a machine as any tool we use — very simple tools such as knife or a relatively complicated piece of machinery such as the device for measuring the average CO_2 content of the air in a propagation house as we saw at Wooster. I'm not sure that as practical propagators we need be concerned nearly so much with the acquisition of complicated sophisticated equipment as we do better utilization of the tools we already possess. A very quick study of the understandable desires and needs to mechanize the propagation part of any nursery operation, let alone the field or container operation leads to the following thoughts. Quickly, to bring this around to one hang up point, that is in common with all food and fiber agriculture, we nurserymen are denied the single principle which Henry Ford is given credit for developing, and that is the very simple thing of bringing the work to the worker. It is impossible to put a propagation bench on an assembly line, and let the workers sit at one place and have the work pass in an orderly way. The same applies to any field

North and they're much superior to anything we can take off, they root much better, much faster than our cuttings. *Camellia* cuttings taken off under the same conditions in California brought North, put in our greenhouses root and are much superior to anything that we can grow. Also going back to the work with "Tams", the most peculiar thing is that those cuttings taken off in California, when stuck in California did not root as good as under our conditions. The same was true for *Rhododendron* and *Camellia*.

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But there are also very good reasons for having machines and it must not be construed that the censensus around the round table was that machines have no value. Obviously, very clearly, we have to continue to search for and look for machines that will do the job better for us. After all it is impossible to put a dollar value on being able, for example, to get all that B + B dug on the first week of the digging season, it would be possible to lean back and solicit further orders. As it is most of the time, I am sure, we are guaging how many plants we must dig, what labor force we can effectively focus, and that isn't just in terms in numbers of people, it's numbers of people that can be adequately supervised, against the time element envolved. Until finally sometime through the middle part of the season we are bound to get that once a year phone call "ship it" or "cancel it." All of us then are seriously looking for a machine that can accomplish the job. It saves us the necessity of facing that issue. I'd like to conclude here quickly — there was no consensus at our table as to how to guage the price of a machine — and say yes, I can afford this or I can not afford it. Looking around for industrial standards I found that there was almost no standard.

Just for the sake of discussion I said that any machine to be worth purchasing must save its price and its cost of operation in terms of labor or personal relations, whatever you want, with in the first season or first year of operation, whichever is less.

MODERATOR JOHNSON: Our second round table discussion was moderated by Bob DeWilde.

WEED CONTROL IN POTTING SOILS, SEED FLATS, BEDS, AND FRAMES

ROBERT C. DEWILDE, *Moderator*
FREDERICK O. LANPHEAR, *Recorder*

Today each nurseryman realizes the economic importance of developing a weed control program for potting soils, seed flats, beds, fields, and frames. Properly executed control programs will reduce production costs, improve quality, as well as increase the number of saleable plants per acre. We apply the epithet "weed" to those unwanted plants which compete with our ornamental plants for water and nutrition.

Essentially there are three ways of controlling weeds:

(a) Mechanical Control achieved by the use of tools from cultivators, rototillers, flame throwers, and compressed air through the expert use of the hand.

(b) Physical Control through the use of mulches or physical barriers which prevent weed growth.

(c) Selective Chemical weed control through the use of chemicals which kill specific weeds without injury to the ornamental crop.

With regard to physical control of weeds, this was the technique used to obtain three year weed control in container grown stock. A black plastic circular disc of two, or four mil polyethelene was cut with a slit to the middle. The disc is placed on the pot so it fits around the base of the plant and extends to the edge of the pot. A little sand is then placed on the polyethylene disc to hold it in place. Only a scattering of easily pulled weeds may appear around the edge of the container during a three year period. The polyethelene disc does not interfere with watering. In practice the disc will reduce the frequency of watering by 50% in some cases.

Numerous mulches were discussed and a list of some of the types discussed appear below. All the mulches listed seemed to have some drawback, but many are used as they are usually cheap to purchase if locally available, authough expensive to apply, and they will control weeds particularly if used or mixed with a weed control chemical. Mulches may of course provide some additional benefits by preventing soil erosion, aiding moisture retention, and supplementing the nutrient supply.

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(b) Physical Control through the use of mulches or physical barriers which prevent weed growth.

(c) Selective Chemical weed control through the use of chemicals which kill specific weeds without injury to the ornamental crop.

With regard to physical control of weeds, this was the technique used to obtain three year weed control in container grown stock. A black plastic circular disc of two, or four mil polyethelene was cut with a slit to the middle. The disc is placed on the pot so it fits around the base of the plant and extends to the edge of the pot. A little sand is then placed on the polyethylene disc to hold it in place. Only a scattering of easily pulled weeds may appear around the edge of the container during a three year period. The polyethelene disc does not interfere with watering. In practice the disc will reduce the frequency of watering by 50% in some cases.

Numerous mulches were discussed and a list of some of the types discussed appear below. All the mulches listed seemed to have some drawback, but many are used as they are usually cheap to purchase if locally available, authough expensive to apply, and they will control weeds particularly if used or mixed with a weed control chemical. Mulches may of course provide some additional benefits by preventing soil erosion, aiding moisture retention, and supplementing the nutrient supply.

Mulches Used For Weed Control

Woodchips (stockpiled for 1 year prior to using)	Peatnut Hulls (possibility of nematodes-sterilize)
Sugar Cane (relatively expensive)	Crushed Corn Cobs
Cocoa Hulls (fungus and other problems)	Swamp Marsh Grass (locally available-problem in digging)
Pine Needles (fire hazard, difficult-to-handle)	Licorice Roots (mushroom flies, high pH)
Pecan Shells (dfificult-to-handle due to sharp edges)	Spent Mushroom Soil
Buckwheat Hulls) (difficult to obtain)	Redwood or Pine Bark

Selective chemical weed control is a relatively new science that is being expanded every day. New and often better chemicals are appearing as fast or faster than they can be tested for nursery use.

The activity of these chemicals and the resultant degree of weed control obtained is dependent upon a number of factors such as soil type, soil moisture, soil organic matter, soil and air temperature, humidity, wind movement during application, form of the active chemical (wettable powder, granular, liquid), condition of cultivation, incorporation requirements, types of weeds to be controlled, and the age and variety of ornamental plant upon which the chemical is being used. It can be easily shown that results will vary according to local conditions. It cannot be stressed too strongly that each operator must test chemicals to be used before applying them on a wide basis. Detailed records of all weed control work should be maintained and the manufacturer's recommendations should be closely adhered to. A good program usually starts with healthy weed free plants and with clean potting soil through the use of steam sterilization or chemical soil fumigation with materials as Vapam, methyl bromide, and Dowfume.

This discussion group compiled a list of thirty-eight weeds that are problems in our nursery operations and a list of over thirty chemicals currently in use to control them. In general discussion the factor of "time of application" was found to be quite important. Fall treatments often have practical value and increased effectiveness from several standpoints.

(a) Low evaporation of volatile chemicals when the temperature is cool.

(b) Lower bacterial activity that usually cause chemical degradation.

(c) Fits well into late fall or winter nursery work schedules.

Time of application is also very important with regard to the type of weed you want to control. Some chemicals work quite well when applied on snow in middle of winter, but avoid hard frozen ground where the wind will blow granular materials into small pockets of concentration.

Considerable discussion followed concerning the possible residual problem of Simazine. The low cost, broad spectrum control of this chemical has made it the most popular chemical in the nursery today, but there was concern about residual effects. This problem can be somewhat minimized or checked upon by some of the following considerations.

(a) Use of combination chemicals to reduce the level of simazine as well as to control some weeds that are not controlled by simazine. One such chemical combination is amizine.
(b) Use a charcoal slurry to dip roots of simazine sensitive plants. Or apply charcoal directly in the soil prior to seeding.
(c) Decrease the amount of active simazine each year it is applied to the same piece of ground.
(d) Use corn or high organic cover crop rest periods between crops when simazine has been applied for several years.
(e) Oats may be used as an indicator plant since they are very sensitive to low levels of residual simazine.

Other materials such as Diphenamid, Casaron, and Trifloralin were discussed and since there was considerable interest in a number of other chemicals, your moderator asked Dr. A. M. S. Pridham, Dr. Chico Hiramaki, and several others to continue comments on these chemicals.

Many thanks to Dr. Fred Lanphear for his assistance as recorder.

GENERAL COMMENTS ON HERBICIDES

Amizine

post-emergence herbicide - good in large shaped tree plantings where cultivation is difficult Dormant application safer. Applied to established plants only, not on simazine sensitive plants.

Amitrole

post-emergence herbicide - used as spot treatment for perennial weeds Good for poison for ivy control - do not use on nursery plants Never ap-applied at high rates - toxicity remains in the soil for several months

Allyl Alcohol

Used as a soil drench but not as effective as fumigation.

Atrazine

pre-emergence and post-emergence - somewhat risky to use in nursery stock due to great solubility.

Casoron

pre-emergence herbicide - Safe on most general nursery stock Granular material best applied in late fall application. Effective against hard to control perennial weeds such as Wild Chrysanthemum, quack grass, and nutgrass if applied at higher rates. If applied during period of high temperature it should be watered in or incorporated. Short residual life not usually more than 1 growing season

CIPC

Fairly good for general nursery use due to safety factor Limited period of weed control Apply in spring or when it is moist

Chloropicrin

preplanting fumigant

Diphenamid

pre-emergence herbicide Safe on almost all nursery plants Fairly long lasting control but has limited effectiveness on certain broad-leaf weeds. Can be applied at any time of the year.

Dacthal

Very good for spring and summer use Limited residual affect. Short period of weed control

Diuron

Very good control if applied during spring or summer Somewhat selective as to weeds it will kill Also slightly risky to use particularly with broadleaf evergreens

Dalapon

Good quack grass control when used 3 months to 1 year before planting. Post-emergence herbicide. Do not apply on nursery stock

Diquat

Contact herbicide with similar properties to paraquat The latter being preferred

Dinitro

Post-emergence herbicide - Good contact herbicide. Useful in fall or early spring.

Eptam

Pre-emergence herbicide Must be incorporated into soil and can be used as a pre-planting application. Bare root cuttings may need some protection, but potted liners can be safely used in treated soil.

Mylone

pre-planting sterilization - granular material not as effective as other sterilants.

Methyl Bromide

Very good pre-plant sterilization procedure. Requires air tight cover Depending upon dosage, it will control diseases as well as weeds.

Paraquat

Excellent contact herbicide and foliage killer. Useful around dormant nursery stock.

Stoddard Solvent

Post-emergence herbicide. Good contact herbicide but must kept off nursery stock foliage. May be used between beds.

Sesone

Pre-emergence herbicide - short lasting May be useful on seedling weeds.

Sodium Arsenite

Too risky to use. Other contact herbicides are more generally acceptable

Simazine

Pre-emergent herbicide. Very good particularly on narrow leaf evergreens. It is somewhat risky to use on many broadleaf evergreens and certain deciduous species Long residual activity which tends to create accumulation with repeated usage. Not effective in controlling crab grass In general, do not use on lilacs, privet, euonymous, honeysuckles or azaleas.

Telvar

Pre-emergent herbicide - Similar to Diuron but more risky to use. Many narrow leaf evergreens and larger deciduous plants are tolerant.

Vapam

A good pre-plant sterilant - incorporate into soil using water and preferably a plastic sheeting as a seal.

Vernam

A pre-plant herbicide similar to EPTC. Must be incorporated into soil.

Treflan

Pre-emergent herbicide or as preplant treatment when incorporated into soil. Most nursery species appear to be tolerant. Some broadleaf weeds may not be controlled.

2,4-D

Low volatile ester or amide form for spot treatment of field fine weed. Do not apply to foliage of nursery species. Can be used for brush and broadleaf weed control in non-crop areas. Preferably in combination with 2,4,5-T.

2,4,5-T

Similar to 2,4-D. Somewhat better when used for brush control. Do not use on nursery species.

LIST OF NURSERY WEEDS COMPILED IN ROUND TABLE DISCUSSION

Carpetweed	Nightshade	Wild Garlic	Saw thistle
Chickweed	Pigweed	Wild Artichoke	Wild Oats
Blue Grasses	Plantain	Horsetail	Witch grass
Canada thistle	Purslane	Dollar Weed	Nutgrass
Chrysanthemum weed	Quackgrass	Horse nettle	Dock
Crab grass	Oxalis	Dodder	Poison Ivy
Dandelion	Johnson Grass	Quickweed	Bind weed
Foxtail	Burmuda Grass	Pursley	Morning Glory
Lambsquarters	Milkweed	Ragweed	
Mustard	Spurge	Smartweed	

MODERATOR JOHNSON: We will now go on to the third round table with Harrison Flint.

WINTER HARDINESS OF NEWLY POTTED AND CONTAINER MATERIAL, PREPARATION FOR AND PROTECTION IN STORAGE

HARRISON L. FLINT, *Moderator*
RALPH SHUGERT, *Recorder*

Concern for winter hardiness of plant material is shared by all of us in the temperate zone, even though we may be concerned with different degrees of hardiness and different plants. Hardiness is certainly enough of a problem in a field production — but it's even more serious in overwintering young pot-grown plants.

With this introduction, discussion commenced:

Several overwintering problems with specific plants were brought up. It was pointed out that failure to overwinter *Cornus elegantissima,* so-called, has been observed, apparently because of too much cold in some cases and too little cold for breaking dormancy in others. Hardening of young plants is accomplished by some growers by withholding water. The need for a considerable exposure to temperatures around 40°F. or below for breaking internal dormancy was reviewed.

A variety of methods have been used by members of the group for storing young propagated stock:

Pit storage has been used successfully at the University of Rhode Island. Rooted cuttings are placed in tight polyethylene bags. These are imbedded in perlite in a pit in the ground. Results in one year compared favorably with those from refrigerated storage.

Several persons described plastic structures used for overwintering young plants. These ranged from relatively small quonset-type or A-frame structures to full-size greenhouses. Some used heaters during cold weather — others did not — depending upon the location and the nature of the plants being protected.

The point was made that propagators can't afford to give plants *minimum* protection — only maximum protection is truly economical when plant losses are considered.

Further discussion centered on the need for ventilation in plastic structures and ways of accomplishing it. Methods in use among members varied from simply lifting a flap of plastic on a frame to thermostatically-controlled exhaust fan ventilation. There was good agreement on the need for ventilation in spring but some disagreement as to whether ventilation is necessary during warm periods in winter, probably due to differences in experience in different locations. Some growers use shade over plastic structures — some do not — some use shade only in spring.

Nurserymen in several areas including northern Ohio, are storing stock in opaque buildings such as polyethylene-lined barns, with good results.

Burlap shades over plants are giving good results in Oregon. Burlap shades are also being used experimentally at the

University of Minnesota. Also at that institution, sticky coatings are being applied to Rhododendron leaves and then flocking material is stuck to them to insulate them from rapid temperature changes.

Rooted cuttings are being carried overwinter in refrigerated storage in Rhode Island with good results. Growers in other areas are keeping shrub lining-out stock and scions for spring budding and grafting in refrigerated storage. Storage temperatures commonly run in the mid 30's. The point was made that rooted cuttings potted and stored in sash houses get a head start in the spring over cuttings stored bare-root in refrigerators.

Discussion then centered upon special treatments used with problem species such as *Cornus florida rubra, Viburnum carlesi,* and deciduous azaleas, to help overwinter survival. Several growers stressed the importance of propagating early in the summer to allow time for new top growth in the same season. Some use lights to increase the daylength and force new growth, as recommended by Sid Waxman. Others suggested that leaving the root system undisturbed in the rooting medium over winter will accomplish the same thing, at least for some plants such as deciduous azaleas.

The last question raised probably could have sustained the discussion for another hour or two. The moderator was grateful that it came near the end of the allotted time. The question is a familiar one — "Are plants obtained from warmer areas likely to be less able to winter-harden than similar plants grown in colder areas?" Conrad Weiser was asked for a professional opinion and replied, in essence, that the ability to winter-harden is a genetic charactristic, not one determined by environment.

MODERATOR JOHNSON: I am sure there are comments on this report.

HANS HESS: I would like to make this comment. Seedlings of various plants grown by nurserymen including sweet gum, *Albizzia,* and many others, which are grown from seed gathered from northern sources without a question will be hardier particularly in the younger stages than those from seed from southern sources. I believe Bill Flemer will bear this out.

HARRISON FLINT: Are you assuming, Hans, that such sources would be very genetically?

HANS HESS: It has nothing to do with genetics, it's a matter of sources — from areas of colder temperatures seeds of sweet gum, red bud and bayberry are far hardier especially in the first and second year.

DR. HESS: Hans is right about the hardiness being better from northern seed, but I do believe this is due to genetic variability. The plant will look like a sweet gum plant but there are subtle genetic variations which affect hardiness. As a result of natural selection, they are more hardy and the southern grown plants have evolved with less hardiness.

JOERG LEISS: I would say that if you took a red maple from Northern Canada and propagated it in Texas and brought it back to Canada it would be just as hardy as it was before. It is more or less the source of the seed which determines the hardiness. If it is genetically hardy, it stays hardy no matter where you propagate it.

MODERATOR JOHNSON: The report of the fourth round table discussion will be given by William Flemer.

ROOTING CHEMICALS, LIQUID VS. POWDER, USE, ETC. AND ROOTING MEDIA, NATURAL, ARTIFICIAL, ADDITIVES, ETC.

WILLIAM FLEMER, III, *Moderator*
JAMES D. KELLEY, *Recorder*

Various methods of hormone application used were tabulated as follows:

Soak Treatment — 11 participants
Quick Dip — 9 participants
Talc Treatment — 24 participants

Soak Treatment — Reports of 18 hour soak, cuttings were bundled with rubber bands during soaking in idolebutyric acid solutions. Such solutions were usuable for two days before discarding was necessary.

Hormones in general were not found to be useful for improving rooting of hard wood cuttings. There were two exceptions reported in which deciduous hard wood cuttings of *Berberis thunbergi* Crimson Pygmy in which hormone soak in IBA greatly increased rooting percentages. A Dutch paper was also cited which indicated that *Laburnum vossi* hard wood cuttings rooted better with hormone treatments.

David Leach observed that: "Theoretically the activity of any hormone should double with every 10°C temperature increase but this does not appear to be strictly so." Comments from the floor bore out this contention of increased activity was true, and instances were cited in which increased heat caused stem burning of cuttings from excess hormone activity. Martin Van Hof reported using weaker hormones for summer than for winter Juniper cuttings.

Jim Wells reported no decrease in the activity of stored hormones but others had experienced a decline in effectiveness during the shelf life of the materials. All agreed light was harmful to hormones.

Leach reported on rooting Exbury, Knaphill, and Ilam hybrid deciduous azaleas and generalized that yellow hybrids required a weaker hormone concentration than orange or red clones. He also reported a wide difference in the use of clonal stock. Cecile for example roots very easily and some of the Ilam varieties are very difficult.

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It was generally agreed that hormone powder was absorbed only through the cut surfaces of the cutting and that excesses applied should be tapped off before inserting the cutting into the medium.

For the general run of deciduous soft wood shrub cuttings, most propagators used straight sand as a rooting medium. Joerg Leiss reported best success using a layer of peat with a layer of sand over the peat in which the cuttings were actually stuck. The control of moisture was improved, and after rooting has taken place and the roots have grown down into the peat, growth and root mass are greatly improved. Martin Van Hof reported excellent rooting in beds of carefully prepared soil, covered with a plastic tent.

Nobody reported using Vermiculite or expanded mica at the present time.

One man reported using calcined clay for rooting cuttings, but others felt that it had no discernable advantages.

It was generally agreed that sphagnum peat was in all cases greatly superior to sedge peat or "peat humus" for rooting cuttings. Dutch, German and Canadian sphagnum peats were used.

Shredded sphagnum moss was reported to give good results in rooting Viburnums but was too expensive for extensive use. Also it was difficult to separate rooted cuttings upon removal from the sphagnum moss.

Two disadvantages of Perlite were:

1. It was abrasive to the lungs of the workers when it was being benched and moistsened.
2. It gave a fleshy and very brittle root system which fractured badly when the cuttings were removed and handdled.

A member from Florida wondered why more propagators do not stick cuttings directly in pots and root them there. Reasons for the rarity of this practice are that it ties up too much space, especially heated space in winter which is at a great premium. Also if a poor stand occurs, all the expense of potting and the space usesd has been wasted. For very slow rooting crops, space would be tied up for too long a period. Peter Vermeulen said that he rooted quite a list of ordinarily considered "difficult" items by this method of sticking unrooted cuttings directly in pots of a peat, perlite, styrafoam, and sand mix.

Several growers reported good results with a 50% peat and 50% perlite mixture used for Juniper and other coniferous cuttings stuck on a greenhouse bench. Its advantages are good moisture retention coupled with very rapid drainage.

Two cases were cited in which dry slow release fertilizers were mixed in the rooting medium with success. One was for blueberry propagation and the other was in California in which Osmocote, plastic coated fertilizer 20-16-14 was mixed in the rooting medium for a wide range of ornamentals.

In summation, the concensus of the members present was that the best rooting medium should combine a maximum of aeration with sufficient retention of moisture to maintain cutting turgor.

MODERATOR JOHNSON: The summary of the fifth round table discussion will be given by David B. Paterson.

SELECTION, TESTING AND INTRODUCTION OF NEW PLANTS AND TEST GARDENS AND ARBORETA AS THEY RELATE TO PLANT PROPAGATION

DAVID B. PATERSON, *Moderator*
OLIVER D. DILLER, *Recorder*

The moderator started off by briefly describing the joint Longwood Gardens—USDA Plant Exploration Program which has sponsored 8 expeditions since 1956 and is planning one to Korea in 1966.

The word "new" as applied to plants was re-defined to include not only new-born (for example brand new hybrids or selections) but plants that are new to a particular area, for example, Azaleas are now being grown in St. Louis where it was said it couldn't be done. They are new plants.

The New Crops Program at the University of Minnesota Arboretum has been testing potential ornamentals for about ten years and about 150 introductions have been made. Many of these are examples of little known plants that have been buried in collections for years and are now available to the nursery trade. In Minnesota there has been a fine relationship between University and nurserymen. The nurserymen help support to research section. A seven man committee meets twice a year with the University Arboretum staff and helps to decide whether a new plant is worthy of introduction. An introduction date is set and budwood given to nurserymen. A fee is paid to the Research Committee. The plants are not patented.

It was pointed out that some time ago the AABGA published a list of names of Arboreta willing to participate in a plant testing program. American Nursery Association showed interest in the idea but nurserymen have not participated. Effort is being made now to revive this program.

Test gardens in various parts of Europe were described. At least one or two are run by an association of nurserymen who establish and maintain the collections. This not only tests new varieties and shows what is available but provides an opportunity to check nomenclature. Old private estates are good sources of unusual material but must be taken advantage of right away as many are being disbanded.

It was pointed out that one source of "new" plants was American natives — many of which have to be imported from England.

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It was felt by some that distribution of plants could be done in a more organized way.

Several suggestions as to a central clearing agency or an organization to diseminate information as to what was available and where.

This could be done by an organization of Arboreta, it could be done by nursery growers, it could be done by plant societies such as being done by the Iris Society. It was generally agreed that a terrific amount of work was involved, and that no one would make any money doing it — probably quite the contrary.

The greatest problem that exists between the nurseryman and the Arboreta is one of poor communications. While a clearing house system could probably facilitate the spread of information as to what plants are available, the individual nurseryman will probably always have to take the initiative if he wants to find new and unusual plants.

It was expressed that plant taxonomy should be an important interest of the plant propagator and this society could do much to further interest and better understanding of this important subject.

[*Editor's Note*: Mr. Paterson expressed thanks to Joe McDaniel who helped record the discussion.]

THE PHYSIOLOGY OF GRAFTING

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The art of grafting two plants together is probably as old as civilization. Our ancestors undoubtedly learned it after observing natural grafts in the tops or roots of forest trees and vines. The basic reason for grafting is to propagate clones which do not readily produce adventitious roots on cuttings. It is also important as a means of changing plant form or to take advantage of special rootstocks and interstocks.

Stem Structure and Function

In order to intelligently discuss grafting physiology, some understanding of the structure of a stem and the function of some of its main parts is required. A summary of the essential functions, the locations and the cell types involved is given in Table 1 and illustrated in Figures 1 and 2.

Growth and Healing

The grafting operation mostly concerns those parts that make up the *vascular cylinder* — (a) the cambium layer and the functioning (b) xylem and (c) phloem, which immediately adjoin it. In the spring of the year, the cells in the cambium layer are activated by some stimulus from the opening buds. Side walls of the cells become thin and division occurs. As a result, the bark becomes loose and easily separated from the wood. It is said that the "bark is slipping." New cells developed from the dividing cambium gradually change into the specialized cells that make up the stem. Xylem cells are produced on the inside; phloem cells are produced on the outside. The activation of the cambium takes place in a wave from the top of the plant down and may not be complete until several weeks have passed. Once the cambium is activated, the cells will continue to divide until such time as the plant goes dormant in the fall or is inhibited from growing by adverse environmental conditions, such as lack of water or defoliation.

When a plant is wounded, there is a somewhat different chain of events in the healing of this wound. This is what occurs in the grafting process. The basic difference between healing a wound, such as a pruning cut, and graft healing is that a scion from another plant is inserted into the stock with the expectation that the two parts will heal together.

Phases of Graft Union Formation

The formation of a graft union can be discussed in terms of the separate problems that must be solved in order to have a successful graft combination.

I. The plant has to be able to heal the wound that was created when the graft was made.
   a. Exposed living cells (ray cells, cambium and its im-

Table 1. Important parts of stems of woody perennials of significance in grafting.

Function	Location	Cell types involved
Plant support and strength	Woody portion of the stem Includes the "old" xylem. Also "old" phloem in the bark	Elongated, narow cells (fibers) or shorter, rounded (*schlereids*); both dead; thick walls.
External protection from drying out and adverse environment factors	Outermost corky layer of bark (*periderm*)	*Cork cells* - dead, rounded cells with deposits of lignin and suberin in walls. *Cork cambium layer* - layer of living cells that produces the cork cells.
Water conduction	Outer layer of wood "New" *xylem*	Vessels. Long, barrel shaped, dead cells with thick walls and perforations in end and side walls *Tracheids* narrower, dead cells
Food conduction (translocation)	Inner layer of the bark "New" *phloem*	*Sieve cells* - special elongated cells, contain protoplasm with special openings on the end (sieve plates); associated with vertical distribution of organic materials. *Companion cells* - living cells adjacent to sieve cells; function uncertain. *Ray cells* - living cells that provide some horizontal distribution
Food storage and deposition of organic materials	Deposited in inner layer of bark (*phloem*) and outer layer of wood (*xylem*)	*Ray cells* - laterally distributed living cells of both phloem and xylem (see above). *Xylem and phloem parenchyma* - rounded, living cells that may show starch deposits.
Growth and production of new tissue	*Cambium* layer	*Cambium initials* - single layers of cells that divide to initiate growth *Immature* xylem and phloem cells and ray cells.

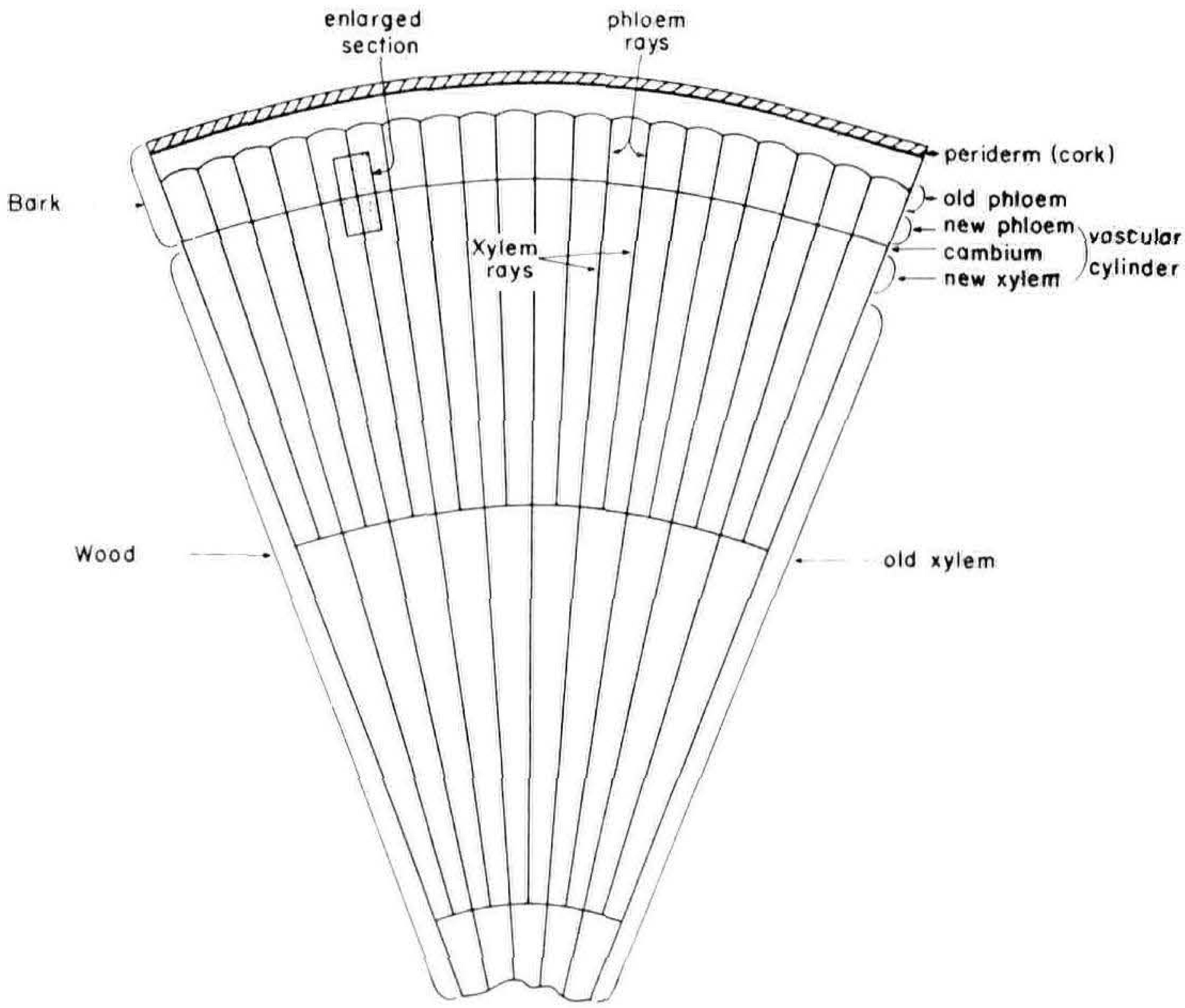

Fig. 1. Cross-section of woody stem shows parts important in grafting. Redrawn from Esau, K. Plant Anatomy. N.Y.: Wiley. 1953.

mediate derivatives) that are damaged turn brown and die (Fig. 3). This layer may be several cells deep, depending upon the length of exposure and particular drying factors. A plate of dry, necrotic tissue is produced over the cut surface (13).

b. Living cells, including ray cells and young xylem and phloem, below the necrotic surface begin to divide and to produce large, rounded parenchyma cells. The mass of white, solid tissue composed of these cells is known as *callus* tissue. It is produced on wounded stems, bases of cuttings and can be grown in an artificial media as tissue culture. The ability of the stock and scion to produce callus is the *first* prerequisite for a successful graft union.

c. Exposed dead cells (tracheids, vessels) are sealed off with a deposit of gum (1). The ability and speed of gum formation can be important. In one study, it was shown that apple (which is easily grafted) had the ability to plug and seal off the vessels quickly, whereas the more difficult-to-graft black walnut was much slower and desiccation was a problem (10).

d. Formation of a periderm or cork layer on the outside of the wounded area.

A. *Factors affecting callus formation*

a. *Genetic constitution.* Some varieties and some species are poor callus producers. In some cases this is evidently related to grafting difficulties. Slow callus producing plants can be sometimes combined by approach grafting, keeping both stock and scion on their own roots until the union heals.

b. *Supply of endogenous hormones and growth substances.* Callus formation is a function of at least two kinds of growth substances: auxins and kinins. Treatment of cuttings with growth regulators of the

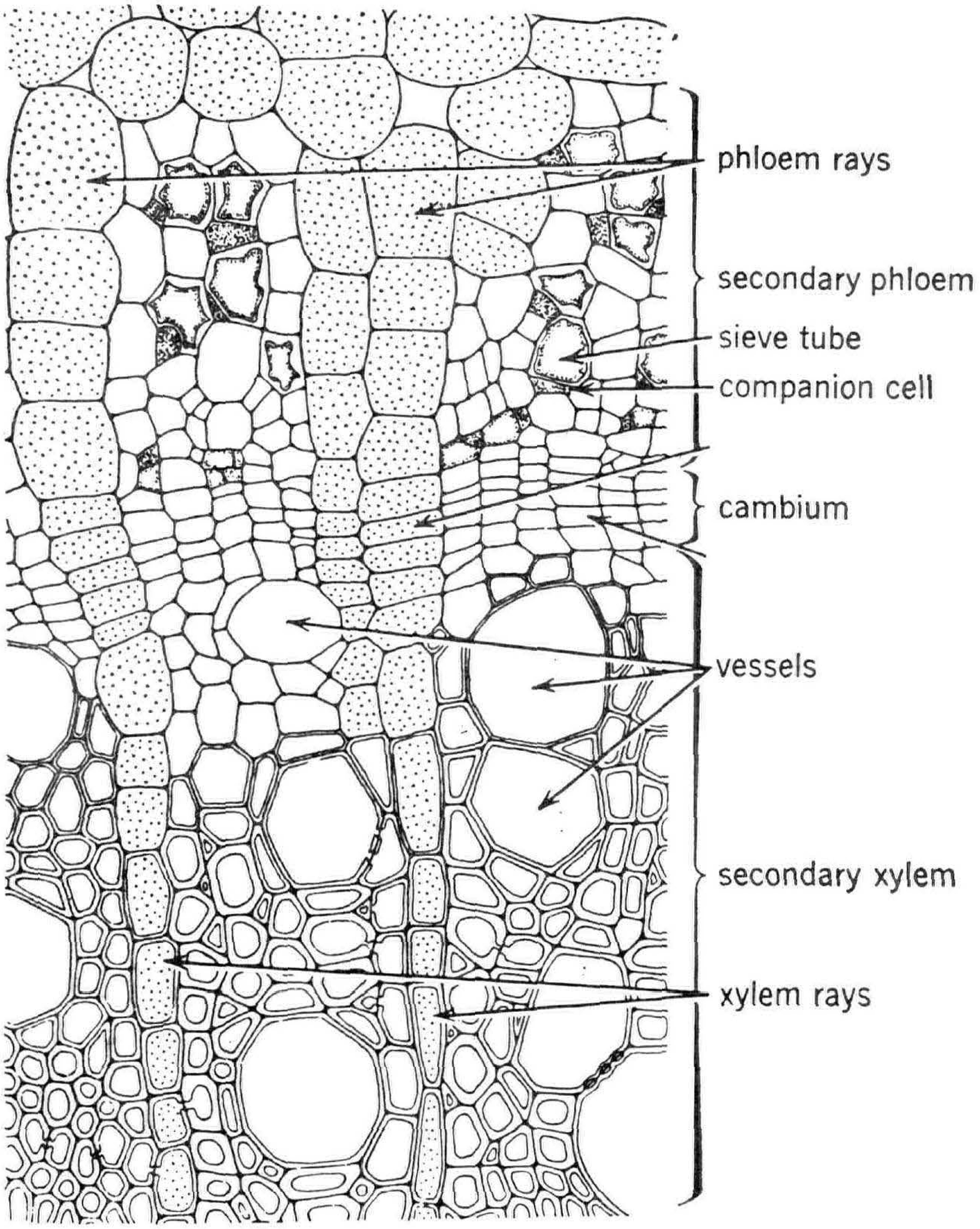

Fig. 2. Enlarged section from Fig. 1 showing details of cells at the vascular cylinder important in grafting healing. Redrawn from Esau, K. Plant Anatomy. New York: Wiley. 1953.

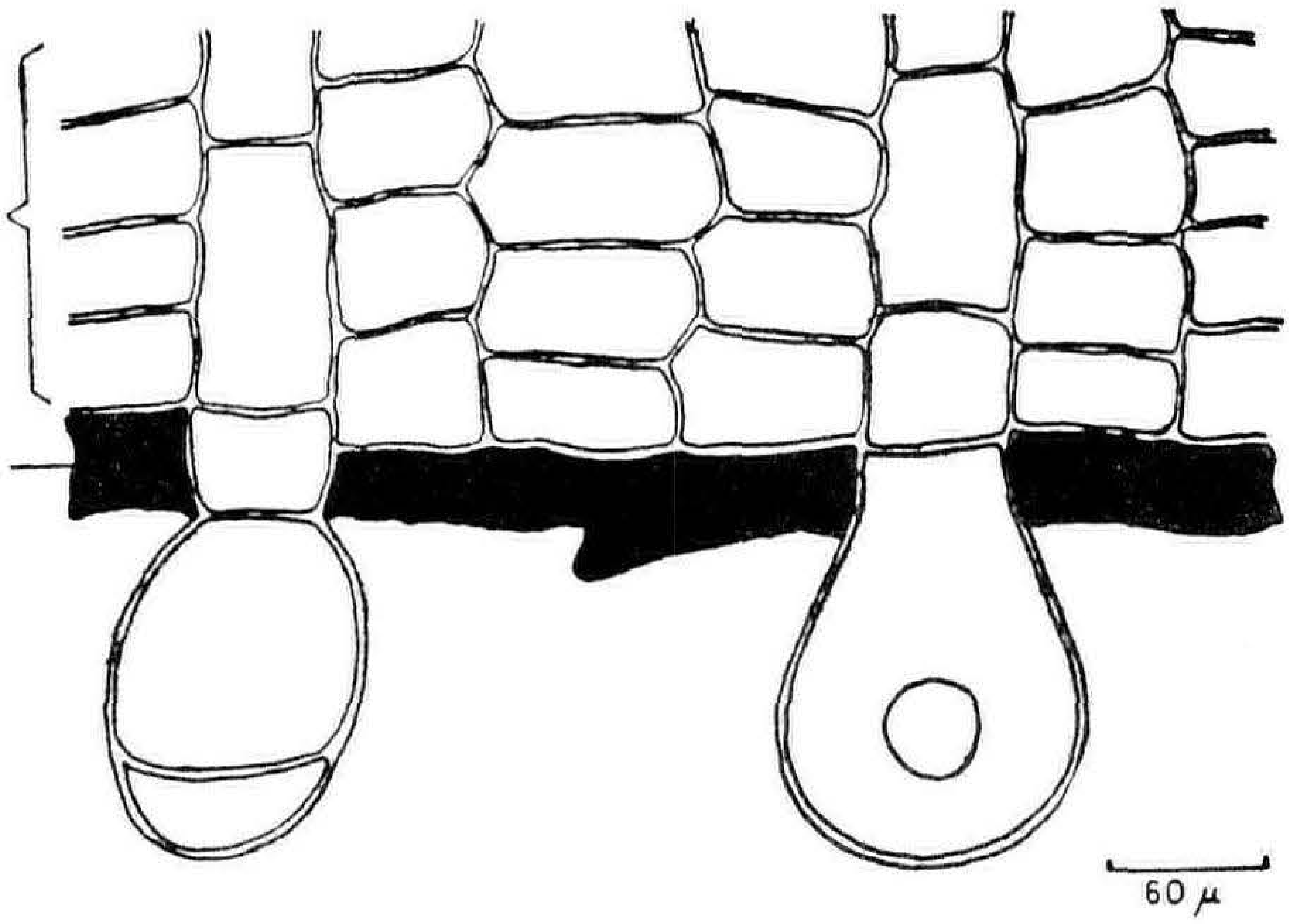

Fig. 3. Isolation layer from damaged cells at surface of wound and production of new callus cells from the rays. From Thiel (13).

auxin-type (IAA, NAA, IBA) stimulate callus formation. If one takes a piece of stem (without buds) or root or other plant organ and grows it without NAA or some other similar substance, some species will produce callus; others will not. If one takes a piece of callus and tries to keep it alive in artificial media by continual retransfers to new media, it will not survive without auxin (except in certain specific cases).

Kinin-like substances, such as kinetin, which are known as cell-division factors, also play a role in callus formation. For example, almond stems collected in winter respond to kinetin slightly but respond strongly to NAA (5). For continued maintenance of almond tissue in culture, kinetin is essential and certain other substances, e.g., thiamin (vitamin B_1) may be helpful.

A number of years ago Skoog (11) showed that relative amounts of IAA and adenine (a kinetin-related compound) would control the type of growth on tobacco pith culture.

- high or intermediate auxin plus high or intermediate adenine = callus
- high auxin plus low adenine = roots
- low auxin plus high adenine = shoots

The application of various externally-applied growth substances in grafting operations has not shown consistent practical benefit (4). Some experimenters have reported beneficial results; most do not. It seems that other factors, such as time of year, proper scionwood, correct technique, etc., are more important factors than supplying external growth regulating chemicals.

c. *Time of year and stage of development.* Callus proliferation varies with time of year. Sussex and Clutter (12) took pieces of stem every six weeks and determined callus formation at different times. It

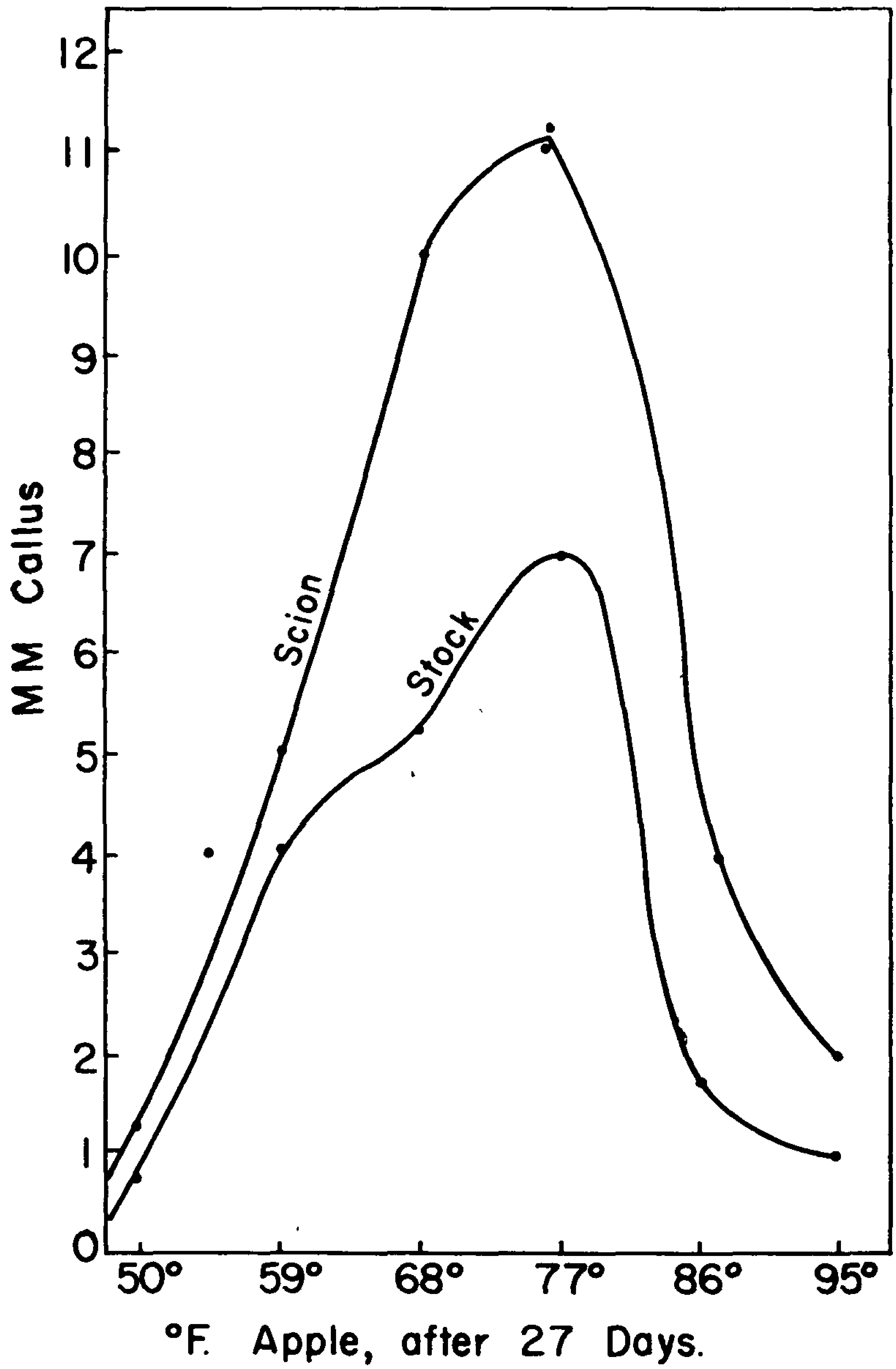

Fig. 4. Effect of storage temperature on callusing of apple scions. From Shippy (9).

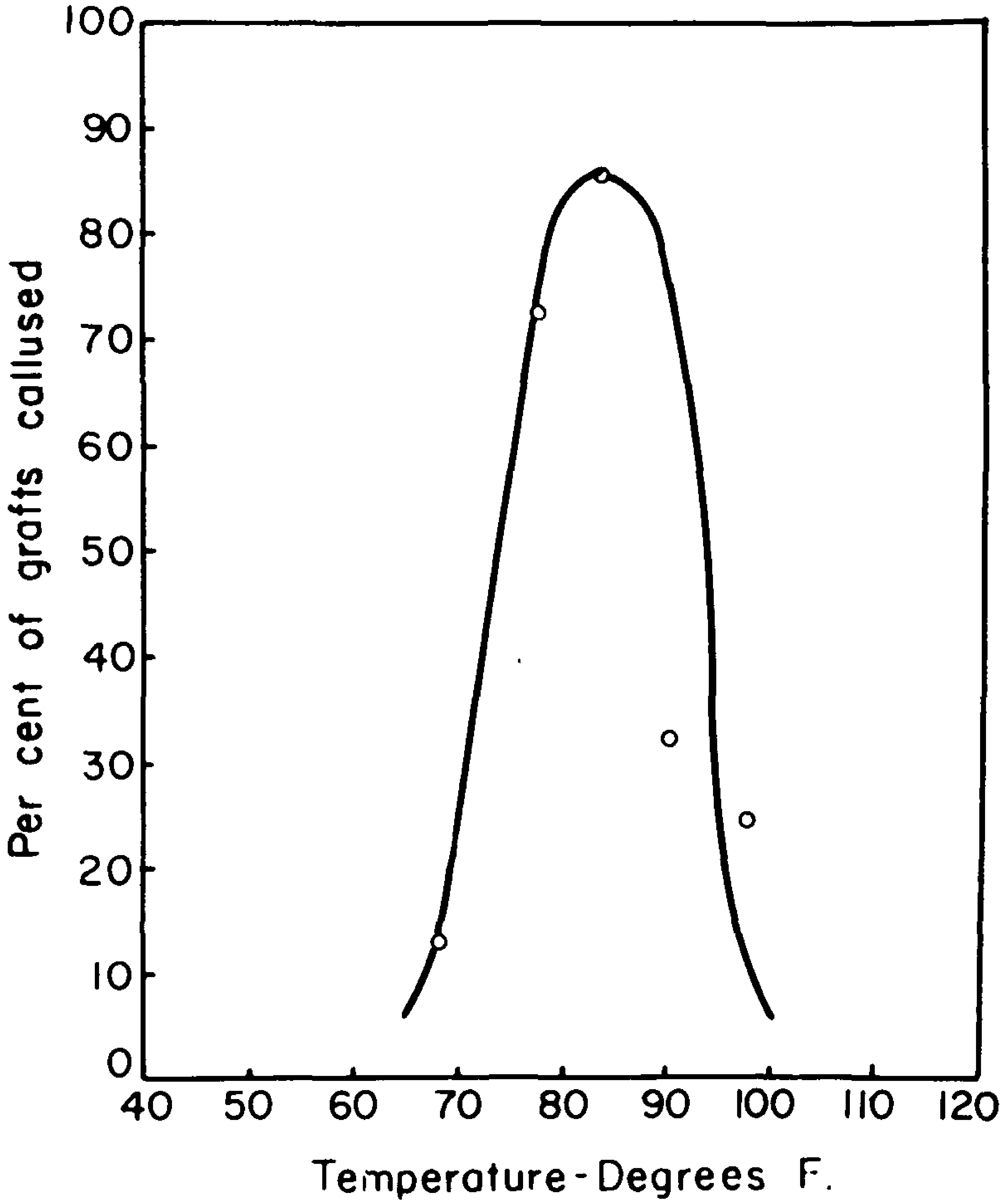

Fig. 5 Effect of storage temperature on callusing of black walnut grafts. From Sitton (10).

was greatest in spring when new growth occurred, decreased gradually into fall and winter. It increased again several months before bud break even though buds were dormant.

In some plants grafting must be done during the time of year the plants are in active growth. Budding operations and bark grafting require that bark be slipping. Side grafting of junipers is done when the plants are in active growth.

d. *Temperature.* Warm temperatures promote callus formation; cool temperatures reduce or inhibit it; high temperatures may be injurious or result in too much soft callus which is easily injured.

Figures 4 and 5 compare the effect of temperature on callusing of apple and black walnut. Apple is less sensitive to temperature than walnut. where the range of effective temperature is narrow.

e. *Moisture.* High humidity is essential for callus formation. Holding cut potato tubers, for instance, under somewhat dry conditions results in the formation of a periderm and deposits of suberin which seal over the wound; high moisture suppresses suberization and induces callus formation (2).

Probably the same thing is involved in a graft. High humidity of near saturation, and even free water deposit is conducive to high callus formation (Fig. 6). This is why it is essential to enclose the graft wound to keep it from drying out.

f. *Aeration* is important and different species vary in their response to the oxygen supply. Some reduction in aeration is permissible, at least in some species (Fig. 7).

g. *Polarity* is also important. Callus develops mostly at the base of cuttings or scions. This is related to the downward movements of auxins and other substances in the stem.

A scion placed upside down will usually fail to unite although a single inserted bud will reorient itself and grow to produce wide-angled branches.

An inverted bridge graft or bark strip may heal in place but does not grow normally. The latter has been used to some extent to produce dwarfing.

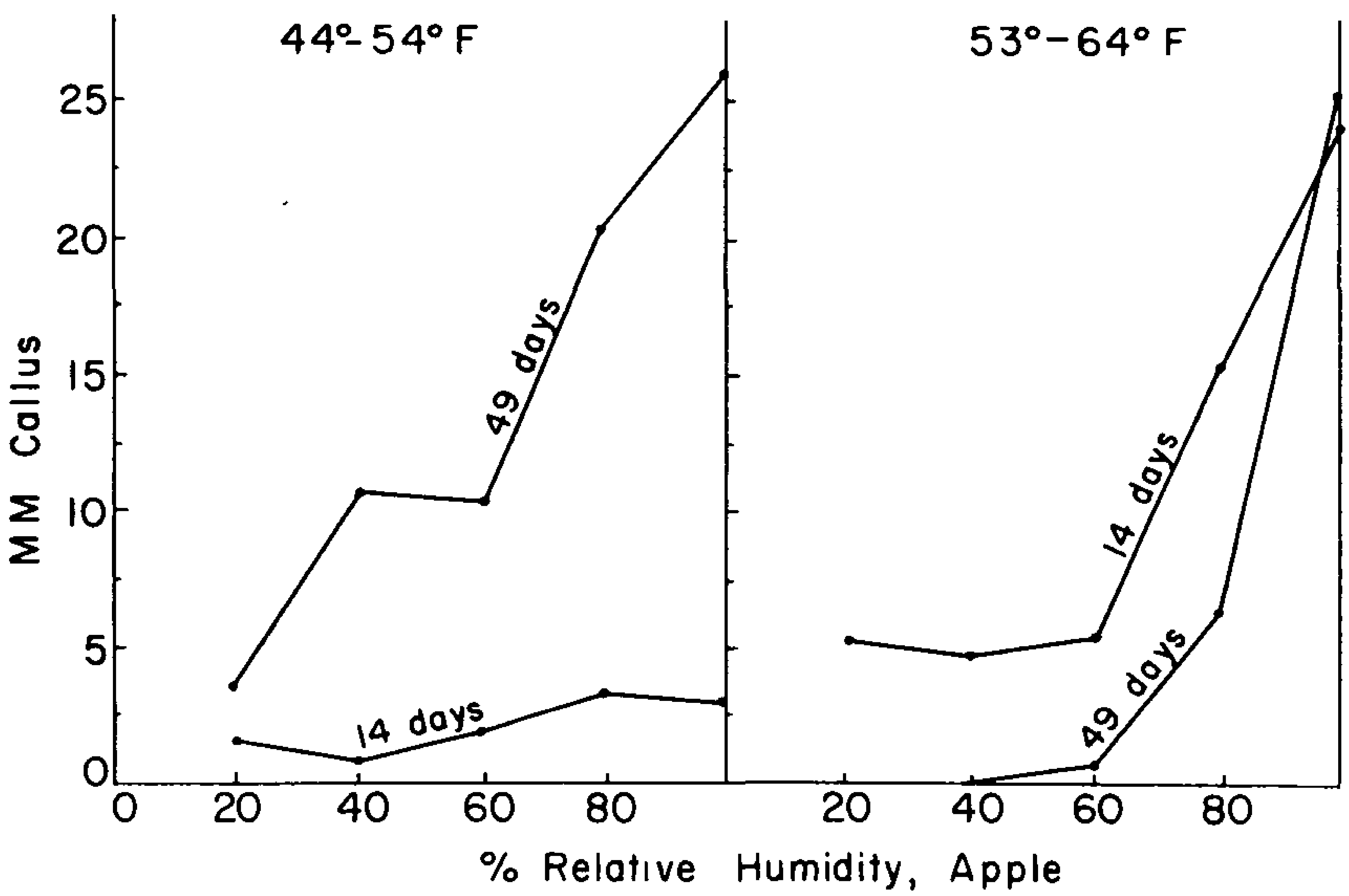

Fig. 6. Effect of moisture on callus formation of apple cuttings in relation to temperature. From Shippy (9).

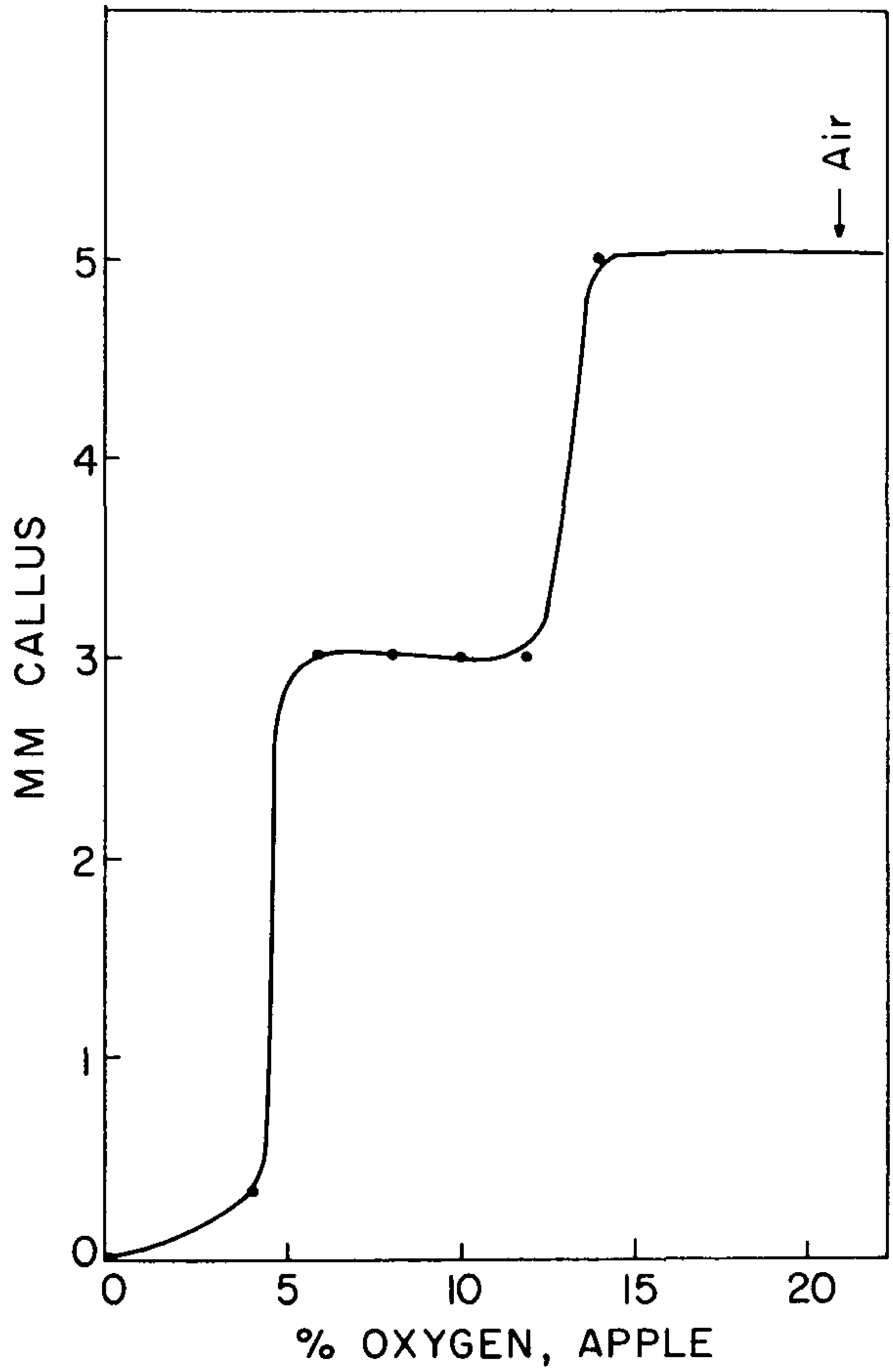

Fig. 7. Effect of oxygen supply on callus formation of apple cuttings. From Shippy (9).

If conditions are favorable, callus proliferates and fills a large part and possibly all of the cavity between stock and scion. Callus from stock and scion meet and intermingle and form a more or less continuous bridge. This may be completed within 5 - 7 days.

II. A connection must be established between water conducting elements (xylem) of the stock and scion. Water supply is the immediate problem of the scion.

Xylem formation is closely associated with new cambium formation and it is not always certain in the studies made whether one is prerequisite to the other. At any rate, new cambium and new xylem cells can be observed to have differentiated within one or two weeks from some of the callus cells. New xylem and cambium begin to appear at the vicinity of the end of existing vascular strands of both stock and scion. These may be parallel to the surface. As a result the appearance seems to be progression toward the center.

It has been demonstrated adequately that this is an "induction phenomenon", brought about by a stimulus from the existing vascular region. This can be illustrated by some experiments on grafting buds onto pieces of root tissue in culture (Fig. 8). A new vascular stand is initiated. The physiological basis for initiation is not understood. except there is evidence that auxin is involved.

The practical application of this information is the well known need to have a reasonably close match of the cambial region of the stock and scion. A large area of contact is not usually necessary, however, since once a continuous connection of the vascular systems is achieved at any one point, it will continue to develop rapidly.

III. The next step is that a continuous connection between the food connecting elements of stock and scion must be

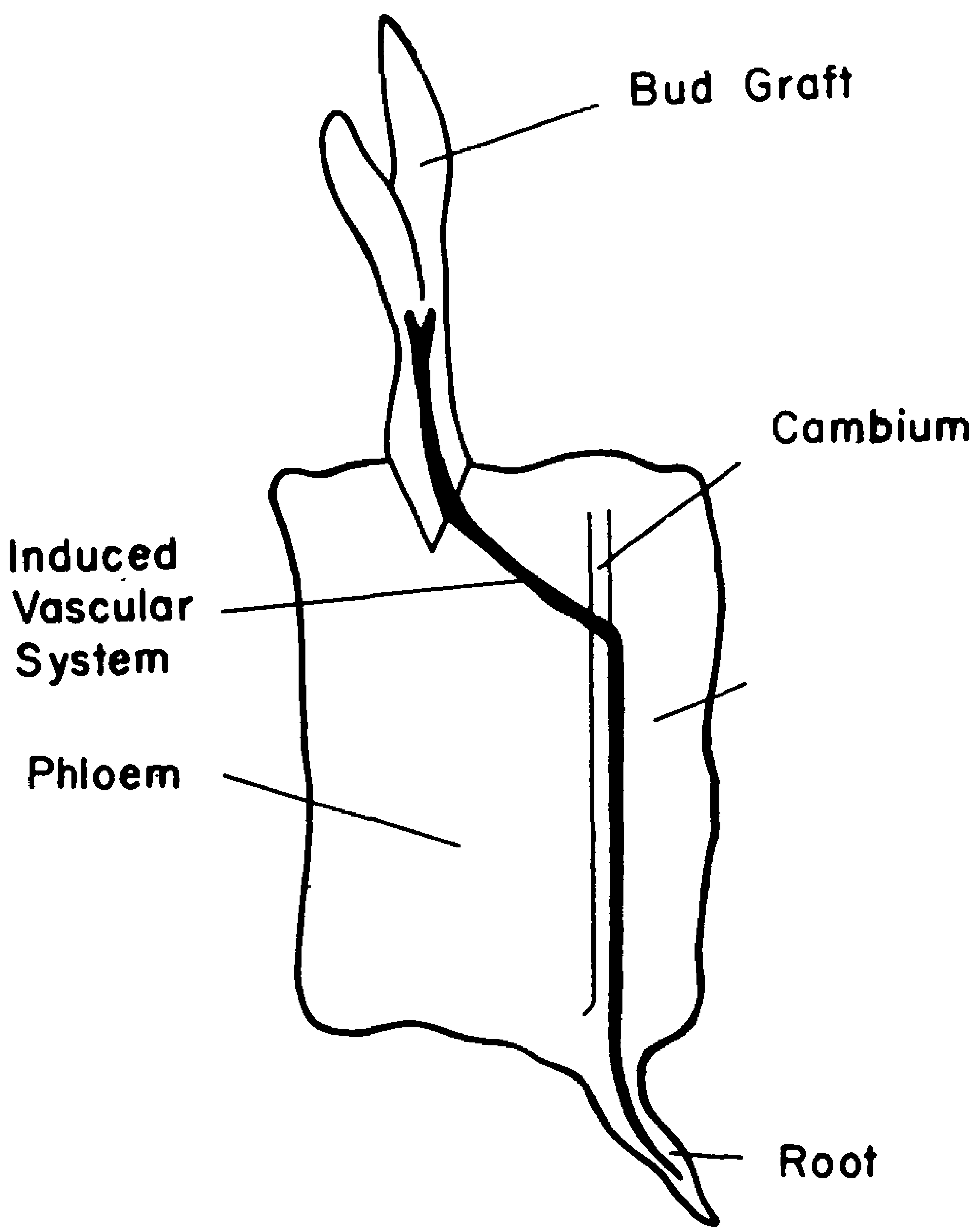

Fig. 8. Induction of a vascular cylinder by grafting a bud on a piece of root tissue From Gautheret (3).

achieved. Timing is less critical since the scion usually has considerable stored food. Once a continuous cambium is present, it will begin to form phloem cells.

Studies with movement of viruses through graft unions indicate that this connection occurs somewhat later than the xylem connection (2).

V. A strong supporting framework within the branch must be established between stock and scion.

Once a vascular system is established, cambium will produce fibers and other strengthening elements at the union just as above and below it. The union should be just as strong as any other place in the plant. However, it may require some time after a graft is made to develop full strength and support.

In some graft combinations a continuous permanent connection between stock and scion is never achieved. The plant grows well for a time, has phloem and xylem connections evidently, but has no strength.

Some time after the graft is made, the top can be broken off at the union to leave a clean break (7. 8). This may occur in one-year-old nursery trees of some combinations, e.g., apricot/almond (5). Clean breaks have been known to occur after 20 years of seemingly normal growth in other cases — for example, peach/almond.

V. The stock and scion parts must be able to grow together and exist in relative harmony for a long period of time. If this occurs, we say they are *compatible*. If for any reason the combination fails or one part has an adverse effect on the other, we say they are *incompatible* (7, 8).

Incompatibility takes a number of forms and much more understanding of the physiological basis for most kinds is needed for reliable methods to make an early forecast of incompatibility.

Fig. 9 shows growth rate during a seven-year-period of a series of varieties of almond grafted to Marianna 2624 plum. Some (Texas and Peerless) are perfectly compatible and grow at constant rate. Other varieties are gradually inhibited in growth, become unhealthy and (sometimes) die. In other cases, as in "blackline" in walnuts, trees may be normal for 15-20 years and then breakdown at the union.

Examination of the union in the almond/Marianna 2624 case shows a failure in the region of the phloem (bark) resulting in gradual girdling of the tree, although the wood portion appears normal and strong. Inserting a compatible interstock between the two incompatible parts does not overcome the bark breakdown in this kind of incompatibility. Instead, whatever it is that exists in the incompatible top that causes the bark breakdown moves across the interstock and causes breakdown at the union below it.

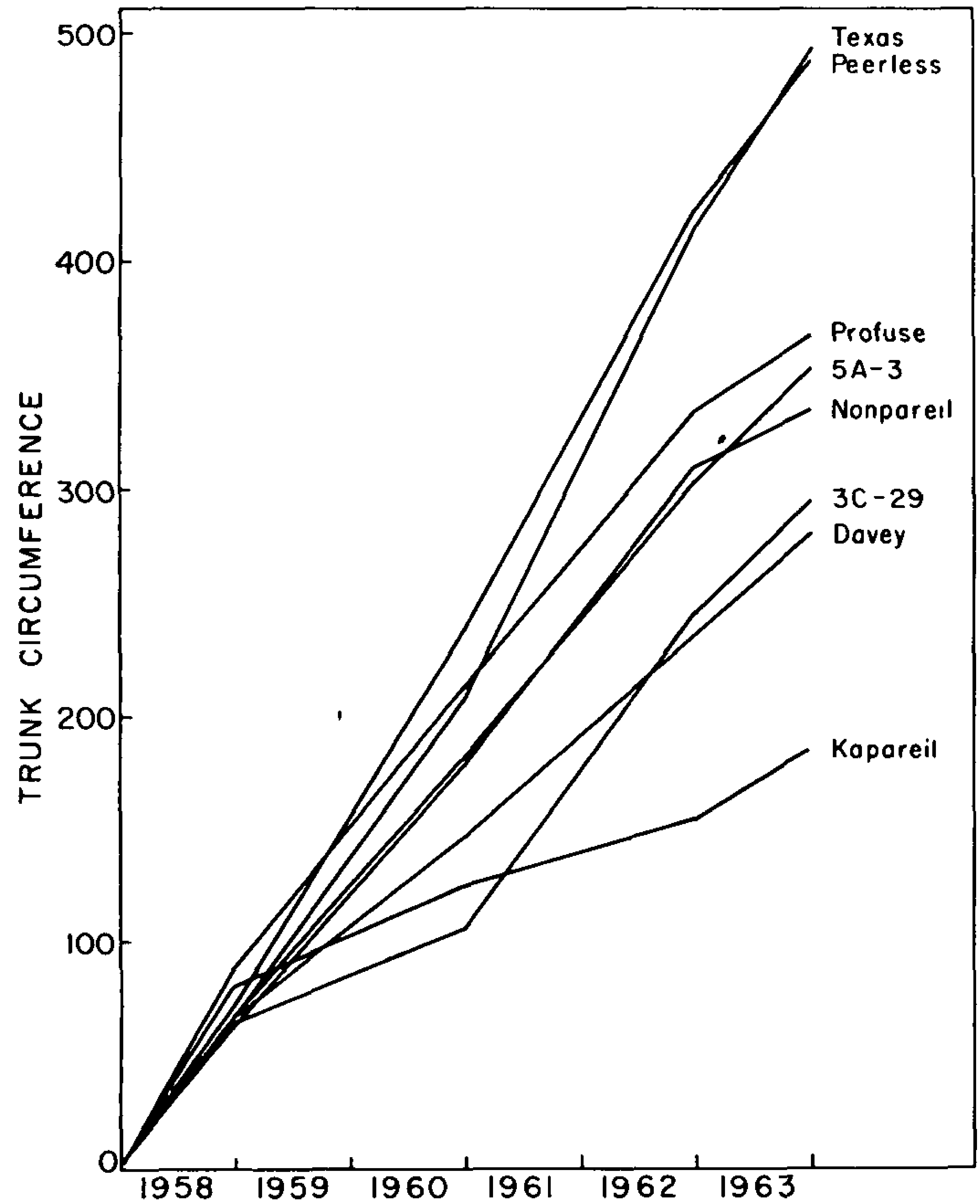

Fig 9. Effect of different degrees of incompatibility of different almond varieties grafted to Marianna 2624 plum rootstock. From Kester, *et al.* (6).

In other kinds of graft combinations, for example pear/quince, obvious breakdown occurs at the graft union throughout the xylem (wood) area. In this case an interstock of a compatible variety will overcome the incompatibility, although some reports suggest that environmental conditions, notably temperature, can influence this effect. A very small piece of interstock, inserted by double budding, is known to be sufficient to correct this kind of incompatibility. Recently Gur in Israel has given evidence that incompatibility of pear/quince is due to accumulation of hydrocyanic acid resulting from breakdown of amygdalin. Rootstocks differed in their ability to produce this compound.

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MODERATOR BRIGGS: Thank you, Dale. To continue on this morning we are going to hear about teaching college students some of the methods of grafting. We have with us Mr. O. A. "Jolly" Batcheller. He is the Chairman of the Department of Ornamental Horticulture, California State Polytechnic College, Pomona, California — Jolly:

METHODS OF TEACHING GRAFTING

O. A. JOLLY BATCHELLER
California State Polytechnic College
Kellogg - Voorhis Campus
Pomona, California

The theory of grafting and budding is easily learned. The conditions and after-care also present no problem, but to teach individuals the actual skill and manipulative practice of budding and grafting is more difficult. It is to this matter I am going to direct my presentation.

Our senses which help us learn: sight, hearing, and touch, are perhaps the most important in this experience because the actual material we are working with is so small that class demonstration does not have the desired effect and can actually detract from the presentation, unless accompanied with larger models. If the students cannot see what is actually being done, they may get the wrong impression or lose interest and be distracted.

The use of the blackboard is helpful, but not always do our drawings appear to others as they do to us. The use of colored chalk improves this, but still this is a two-dimensional presentation while the actual material is three-dimensional.

I have found that after a preliminary presentation by lecture of the reasons for grafting, the limitations, the conditions, and the after-care, that an actual demonstration with living ma-

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I have found that after a preliminary presentation by lecture of the reasons for grafting, the limitations, the conditions, and the after-care, that an actual demonstration with living material and the appropriate model leave an indelible impression on the student. It clearly shows him what has to be done and the manner in which it is actually accomplished.

For some institutions this would be adequate. At Cal Poly we believe that a person should be able to perform the skill of budding and grafting. We do not contend that this must be learned to the degree of a commercial budder or grafter, but to the degree that he can put in a bud or make a graft and expect it to grow. Further, he should be able to direct others, and check the work of others to see that it is done correctly.

To make sure a student knows exactly what the bud or graft will look like when completed, and to insure that all will see exactly the stock and scion in the same position, I pass around an actual bud or graft. The variation from normal comes in the fact that the bud or graft are in large test tubes filled with water. This protects the graft from being changed. The round tube with the water actually magnifies the image. Even without preservatives the bud or graft will keep several weeks in excellent condition.

A sharp knife is an essential tool in proper budding and grafting, and the students are taught how to check a knife for sharpness, and also how to correctly sharpen their own knives. We recommend that each horticultural student purchase a good knife, but we do supply Henkle 302½ straight knives for the laboratory work.

Prior to the start of the laboratory period the knives, the whet stones, rubber bands and a supply of freshly cut material suitable for practice is assembled. In addition, there is the test material tied in bundles with a plant tag which I pass out after the student feels he thoroughly understands and is capable of performing the required graft or bud. I then give another demonstration of the required graft, and pass out the grading sheet. While the students look on I tear the graft apart and grade it. In the case of a large lab of twenty students I may do it two or three times so that each student is thoroughly aware of the points he is to be graded upon.

Following this demonstration the students are allowed to practice on the supplied material while I circulate observing, making suggestions, and actually grading their practice grafts; checking their knives for sharpness and assisting in every way possible.

Because of the varying abilities, some students are ready for their test before others; and the new and different material is handed out. I station myself at one end of the lab, and as they complete the test they label it with their name and bring it to me. While they are standing beside me watching, I tear the graft apart and grade it for them. They can see what they have done correctly, and what they have missed. In the case of budding, the students bring the bud stick from which at least ten buds have been removed. From observing the cuts on the bud stick I can tell a great deal about the buds removed.

As matching the cambium is the most important part of a good graft, I check this by stripping the phloem tissue from either side of the scion and observe the match with a hand lens. After checking in this manner I also strip off the phloem from the scion and by sight and touch (dragging the tip of the knife across the stock and scion) I can determine how closely the match has been made.

For large cleft grafts we bring in branches from trees on the campus, and tie them upright to the legs of the benches. The students complete their graft all but waxing and bagging and are then graded as mentioned above. Their label is marked with the grade for the lab and becomes the attendance record for the day.

Following the grading of the graft, students may work on actual material I have brought in gallon container stock, citrus, hibiscus, or camellias. The students are free to graft them over to selected varieties which we have and are then at liberty to take these home for their gardens.

I urge the students to practice before class and to take home the budding rubbers or grafting tools to try something at home.

MODERATOR BRIGGS: Thank you very much, Jolly.

Our next speaker is again from the University of California at Davis who will speak to us on the materials and equipment used in budding and grafting — Mr. Curtis Alley. Curtis:

MATERIALS AND EQUIPMENT USED IN GRAFTING AND BUDDING

CURTIS J. ALLEY
Department of Viticulture
University of California
Davis, California

Grafting Materials

Rubber budding strips of various sizes are used for grafting. Exposed to air this material loses it elasticity and will fall off. Below ground there is no change so the strip must be cut after a period or it will girdle the graft union.

Raffia is used particularly with bench grafts of grapevines. This material is very good in that it rots in the soil. However, the material must be kept moist prior to planting. If allowed to dry it becomes loose and untied.

Medium to heavy cotton string is frequently used in field grafting. When covered with soil this material disintegrates in two to three weeks. If used in the air then it must be cut.

There are the various types of tapes that are used for grafting. Cloth nurseryman's tape has adhesive on one side. It is commonly used for whip grafting. This item is becoming more difficult to find. The cloth tape will deteriorate in the soil. Plastic nurseryman's tape is often used now in place of cloth tape. It is waterproof and very long lasting. Plastic tape is resistant to weather and soil and must be cut.

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For topworking of fruit trees there are the common hot grafting waxes containing rosin, beeswax, linseed oil and sometimes lampblack in various proportions. For such compounds an alcohol lamp or the equivalent is needed in the field to maintain the wax in a melted condition. Overheating, or insufficient heat are problems encountered in the field.

The Gashell Grafting Compound is a type of grafting wax that is semi-solid. It is flexible at ordinary temperature and does not require heat for application. It is applied over the graft by forming with one's hand. It is used in the Pacific Northwest where is appears to be very satisfactory.

Then there are the cold type compounds such as Treseal and Treeheal, which have an asphalt base and are applied with a brush. These are water-soluble materials, that are good for most forms of grafting. However, there are two big defects: one is the compounds tend to crack, necessitating one or more return trips to reapply the material. Second is the fact that the material is black and has to be whitewashed in those areas subject to hot spells so as to prevent injury to the scion and stock from high temperatures.

Another cold type brush-on material is Farwell's grafting compound that is also used in the Pacific Northwest. It is a latex type compound that is made in several colors. This compound drives to form a waterproof flexible coating over the graft. As the graft grows the coat will also expand with the graft and does not need a reapplication as the coat does not crack. Being of a light color, yellow or red, it does not absorb heat like Tree Seal or Treheal. Some grower have had difficulty with this compound by "drowning" the scions from the bleeding of the stock due to the impervious nature of the coating. It was used this year on grapevines and appeared to be satisfactory.

Budding Materials

Rubber budding strips are still the most popular item used for trees, grapevines, and many ornamentals. There are a few other rubber materials that may be used. One is the Speed Easy Patch, which is a small rubber patch having a wire staple stuck through one edge. The patch folds over the inserted bud and the two sides are fastened together with the wire staple. Rapidix budding strip is another type of rubber strip that resembles a modified Band-Aid. The center part of the Rapidix patch is placed over the bud. Then the sides are wrapped around the branch and tied in front and over the corners of the bark thus holding in place the bark and bud.

The above-mentioned cloth and plastic nurseryman's tape is also used for budding.

Budding and Grafting Knives

There are many types of budding and grafting knives available. These are different depending on the size of the stock and scions to be worked and whether we are using trees, vines or ornamentals. Prices range from low cost fixed-blade knives that cost $ .75 to $1.25 to the more elaborate forms of folding blade knives that cost $4.50 to $7.50. Some budders prefer to make their own knives from an old file.

Even though knives may be inexpensive they are still satisfactory if they are made of good steel and will hold an edge. Such knives are primarily for instruction purposes or those who do little budding or grafting. Propagators who do considerable budding generally buy the more expensive European made knives that have a folding blade. One of the best characteristics of a good budding or grafting knife is a large, round handle. One of the best that I have seen is an Italian knife used for chip budding and light grafting of grapevines. The German knives are of excellent quality but the handles are small and more or less rectangular. These are more difficult to hold steady, and are not comfortable to handle all day.

Most budding and grafting knives have a curved blade on both sides. The better knives, however, can be purchased as right or left-handed, being curved on one side and flat on the other.

When knives are sharpened they should be sharpened only on one side. This permits a cut to be made below a bud or on a grafting stick in which the knife will make a straight cut obliquely through the wood very easily. The knife that is sharpened on both sides requires the angle of the blade to be much greater. Thus it is much more difficult to get a smooth flat cut with such knives.

Knives should be sharpened with a medium and then a fine grit stone for the initial sharpening. It should be finished with a very fine stone that nearly resembles marble or with a leather strop. Knives can not be sharpened in three or four minutes. This requires a minimum of ten minutes and preferably longer. When sharpening a knife it is recommended that the blade be moved in one direction, going against the edge of the blade very similar to the way in which a wood chisel is sharpened. After the blade has been well-sharpened, then it is only a matter of touching up the blade at intervals to keep the keen edge.

Once a good knife is well-sharpened it should be used only for grafting and budding, not for general purposes, such as cutting string, paper, or carving wood. When not in use, knives having a straight blade should always have a guard placed over the blade. This can be made easily by folding a piece of cardboard over the blade and fastening firmly with Scotch tape, masking tape, etc. This affords a very inexpensive and quickly-made shield which will protect the fine edge.

There are several methods of determining when a knife has been properly sharpened. An experienced budder or grafter can tell by running his thumb lightly over the edge of the blade when it is sharp. Another easy method is to try to shave one's arm. Still another method is to see if the knife edge will easily cut a thin sheet of paper on edge.

A good budding or grafting knife given good care and not abused will last for years.

MODERATOR BRIGGS: Thank you, Curtis, for a most interesting presentation.

Our next speaker will be Don Sexton, who is a propagator with the Monrovia Nursery Company, Azusa, California. He will discuss grafting procedures for certain ornamentals: Don Sexton:

GRAFTING OF SELECTED ORNAMENTALS

DON SEXTON
Monrovia Nursery Company
Azusa, California

Many desirable ornamental plants are propagated by grafting. This is necessary because of seedling variation and the fact that cuttings of certain plants are difficult to root in high percentages under available conditions. In other cases, cutting-grown plants are very slow or weak-growing.

Fruit trees and certain shrubs, including junipers, have long been propagated commercially by grafting and budding. Fifteen or twenty years ago we grafted about 20,000 junipers each year at Monrovia Nursery Company. Now we are producing at least 200,000 grafted plants each year and the amount is still growing. The demand for grafted junipers has increased, particularly for forms of *J. scopulorum,* so that we grew 90,000 grafted junipers last year. Also, in recent years, grafting of ornamental trees has become a common practice.

Grafted plants, of course, can offer many advantages. When the scion and stock are compatible and a good union is made, rapid and vigorous growth can be expected, provided the stock and root system were in good condition and this is maintained. Uniformity of the grafted plants depends largely on the uniformity of the rootstock, since the scion wood is of a particular clonal selection. If clonal rootstocks grown from cuttings are available, this is best. Otherwise, seed from selected plants known to produce uniformly vigorous seedlings should be obtained. Clones of ornamental trees may be selected on the basis of many different characters. Some of these are habit of growth, foliage quality, time and intensity of fall coloring, absence of undesirable fruit as in *Ginkgo* and *Fraxinus,* cold hardiness, and disease resistance.

At Monrovia Nursery Company, grafting of ornamentals is generally done in the following manner. All of the stock used, with the exception of *Pyrus,* is in containers. Most plants are in four-inch pots moved up from rose pots the previous summer, or in gallon cans. Junipers are moved up about August 1st.

The understock plants, such as *Juniperus,* are carefully cleaned up so that side shoots and stubs are removed and the top cut half way back and thinned. Side grafts with a tongue are generally made, resulting in more surface for the union to take place; the top of the stock "draws up" sap and nourishes the scion. The grafts are tied with rubbers and are thoroughly

MODERATOR BRIGGS: Thank you, Curtis, for a most interesting presentation.

Our next speaker will be Don Sexton, who is a propagator with the Monrovia Nursery Company, Azusa, California. He will discuss grafting procedures for certain ornamentals: Don Sexton:

GRAFTING OF SELECTED ORNAMENTALS

DON SEXTON
Monrovia Nursery Company
Azusa, California

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ORNAMENTALS GRAFTED AT MONROVIA NURSERY COMPANY

Species	Rootstock	Grafting Method	Time Grafted	Remarks
Acer palmatum	Same	Side graft	Jan. before sap flows	Leave outside
Azalea sp.	Same	Whip graft	April-May, or fall	Tied with thread, not waxed
Camellia sp.	*C. japonica*	Whip graft	February	
Cedrus atlantica	*C. dedara*	Side graft	December	
Citrus sp	Rough Lemon Trifoliate Orange	T-bud	Spring	
Cupressus arizonica	Same	Side graft	Winter	
Eriobotrya deflexa	*E. japonica*	Side graft	Dec. - January	
Eriobotrya japonica	Same	Side graft	Dec - January	
Fraxinus uhdei	Same	Whip graft T-bud	Until April	
Ginkgo biloba	Same	Whip graft	Jan. - February	While deciduous
Hedera helix	*Fatshedera lizei*	Cleft graft	Anytime	Use firm scion wood
Juniperus sp.	*J. virginiana* *J. chinensis hetzi glauca*	Side graft	Nov. 15 - Jan. 15	
Liquidambar formosana	*L. styraciflua*	T-bud	July	
Liquidambar styraciflua	Same	T-bud	July	
Lonicera hildebrandiana	*L. japonica halliana*	Whip graft	October	
Magnolia grandiflora	Same	Side graft	Late December	
Persea americana	Same	Side graft T-bud	June	
Photinia arbutifolia macrocarpa	*P. serrulata nova*	Side graft	February	
Pyrus calleryana	*P communis*	Whip graft (Bench graft)	January	Bare rootstock
Pyrus kawakami	*P. communis*	Whip graft (Bench graft)	January	Bare rootstock
Wisteria floribunda	Same	Whip graft	February	As buds start to swell

waxed. Only the cut areas of the stock are waxed in junipers and azaleas. Then the pots are plunged at an angle into a bench having two inches of moist peat moss over wrapping paper. Canned plants are set upright. After being watered in and dusted with a fungicide, a layer of plastic is fastened to a frame over the bench. After two weeks the plastic is raised for airing two hours, three days a week. The plants are watered only when necessary. After a month or five weeks, the plants are taken out as they become ready. Two weeks later the tops of the stock are completely cut off and the cuts waxed. The plants remain in the greenhouse another week when they are taken to the lath house and canned up after two weeks or more. During the first few weeks after the grafts are removed from the benches they are sprayed with water twice a day if the weather is overcast or cool and at least four times if it is warm and sunny.

MODERATOR BRIGGS: Thanks very much, Don. Due to a lack of time now, David Graves' talk on grafting of walnuts will be delayed until the evening session. We will now board the busses for the field trip to Sunnyside Nursery, Hayward, the California - Florida Plant Corporation, Fremont, and the Four Winds Nursery, Fremont. Our first stop, however, will be for lunch at the International Kitchen at Fremont. Thank you.

THURSDAY EVENING SESSION

October 21, 1965

The Thursday evening session convened at 8:00 P.M. with President Robert Boddy presiding.

PRESIDENT BODDY: At this time I will call on Bill Curtis, the chairman of the Nominating Committee, for the report of his committee. Bill Curtis!

BILL CURTIS: Here are the results of the nominating committee: for President, Howard Brown; for Vice-President, Henry Ishida; for Executive Board Member from the North to replace Bruce Briggs, whose term expires, Dr. Ticknor. He will be nominated for a two-year term. For the Executive Board Member to replace Phil Barker, whose two-year term expires, Dr. Andy Leiser. Now if you decide to elect Henry Ishida as Vice-President, we will need a replacement for Hank for one year on the Executive Board and we nominate Dave Armstrong.

PRESIDENT BODDY: Thank you, Bill. The election for these officers will be held at our Business Session tomorrow afternoon. At that time we will also receive nominations from the floor for these same offices. Now I will return the meeting to our Program Chairman, Howard Brown.

PROGRAM CHAIRMAN BROWN: Thank you, Bob. I think the order of business this evening will involve first, letting our speaker who was scheduled this morning and was willing to speak later because of the shortness of time, present his paper now. So in order to do that, I would like to call our morning Moderator, Bruce Briggs, to make the introduction. Bruce!

MODERATOR BRIGGS: Thank you very much, Howard. We are very glad to have Dave Graves with us. Dave is here from Stuke's Nursery, which is some few miles north of Yuba City, California. For many years they have been engaged in grafting of walnuts; this is a particular field which, to me, has always been a difficult one. I am very glad to see him on the program. Dave!

GRAFTING OF WALNUTS

DAVID L. GRAVES
Stuke Nursery Company, Inc.
Gridley, California

In my talk the emphasis will be on our commercial method of grafting walnuts by use of the whip, or tongue, graft. Success with this method of grafting is dependent on a number of factors, all of which must be coordinated. They are: —

(1) Healthy seedlings of sufficient size.
(2) Preparation of seedlings prior to grafting.
(3) Good graft wood.

(4) Proper tools and materials.
(5) Proper time for the grafting.
(6) A good job of the actual grafting, and
(7) Careful follow-up.

I shall later use some slides to show in more detail the above operations and the results obtained.

It is sometimes necessary to mention brand names in order to describe as completely as possible the tools and grafting techniques. However, we are not endorsing or recommending any particular brands as we recognize many others are comparable in quality and as satisfactory as those we use.

The seedlings that we graft in our nursery field are one year old trees. Under proper care these seedlings will have reached a height of 4 to 7 feet and have a caliper of ½ to one inch. A spacing of about 9 inches apart in the rows gives adequate room for satisfactory growth.

We start preparing the seedlings for grafting before they have stopped growing in the fall. In early September the lower branches are trimmed off to a height of 8 to 10 inches above the ground. A week or two later this is repeated and all side branches for an additional 8 to 10 inches are removed. Thus we have seedlings that are free of any side growth on the lower 16 to 18 inches of the trunk. Trimming is done in *two stages* so there will be little or no shock to the seedlings and they will continue their normal growth. This trimming operation is necessary, otherwise these lower branches would be in the way of the grafters when the grafting is performed in the spring. It could be done during or at the end of the dormant season, but we prefer to do it earlier so the cuts will have begun to heal.

The graftwood is cut from selected orchards during January and February when the walnut trees are dormant. Wood which grew the previous season is taken and only the basal portion of the shoot, which usually comprises about one half of the shoot, is used. This part is more mature with a greater density to the wood. The other half, or terminal portion, of the wood is discarded because it is pithy and soft and not desirable for use as graftwood. The wood is carefully selected and stored in 2 by 2 by 4 foot boxes with moist peat moss or cedar shingletow distributed throughout, keeping the wood from drying and at the same time not over-saturating or causing sogginess.

The prepared wood is placed in refrigeration at a maintained temperature of 33° to 35° F. which holds it in a dormant state until the time it is used. The range of storage temperatures for holding graftwood a long period of time is quite narrow, and the above temperature has been found to be the most satisfactory. A temperature above 37° F. for any length of time has been observed to cause the buds to swell, the bark to slip, callus formation to start on the cut ends and to weaken the wood. Freezing temperatures are likely to dehydrate the wood in addition to damaging the tissues of the cambium layer. During the grafting season only enough wood is brought out of storage for each days grafting, and any not used during the day is put back in storage for the night.

The most important tool the grafter uses is his knife. It must fit his hand comfortably for it will be used 8 to 10 hours a day during the grafting season. The blade must be of high quality steel that will hold an edge well, and be of sufficient thickness so it will not bend when the sloping cuts are made on the rootstock and scion. The blade must be flat steel, not hollow ground, so it will be easier to make a smooth straight cut. Our grafters prefer a No. 8 Case knife which is a heavy duty grafting knife that has a 2½ inch blade and a fixed handle. A Corona No. 80 hand shear is usually used for cutting off the seedlings and cutting the graftwood into scions. Larger two-handle pruners are used to top off seedlings too big for the hand shears to cut. Whetstones and a leather strop are needed to keep the tools razor sharp and are used frequently during the day. For field use, this equipment is kept in individual wooden boxes about 2 feet long, 10 inches wide and 12 inches high. The box is constructed to provide shade for the scions so they won't dry out before being used. Only one-third of the box is used for the tools, the balance being for the storage of about a one-hour supply of scions of all calipers to fit the different sized seedlings. These scions have been cut about 5 to 6 inches long and usually have two nodes with two buds at each node.

About the first of March, the seedlings are cut off 16 to 18 inches above the ground. They are cut off 10 to 14 days before grafting starts thus giving the sap a chance to flow and "dry up" the seedlings. Experience has shown that a much higher percentage of the grafts "take" if this is done. The time for topping the seedlings varies each year. A cold wet spring slows the start of growth and the topping is delayed until it is time for them to start growing. Conversely, a warm dry spring encourages early growth and permits starting several days earlier than usual. If there are cold or frosty nights or a day or two of steady north winds after the grafting has started, there is a tendency for the sap to start flowing and the grafting must then be stopped until the seedlings are again dry.

When the grafter is ready to begin, the hand shears are used to re-cut the seedling. Only an inch or two is cut off — just enough to remove the dry surface that formed on the cut after it was topped some 10 days earlier. A smooth straight upward draw is made with the grafting knife and repeated several times until the desired slope is obtained. The knife is then placed in about the middle and across the face of this slope, and a cut is made straight down into the seedling about ¼ to ⅜ inch deep. This is done so the corresponding cut made on the scion will interlock when it is placed, or slid, into the understock. A scion the same diameter or slightly smaller than the rootstock is chosen from the box and a sloping cut is first made to match the face on the rootstock. The next cut on the scion is made by placing the knife across the slope cut, parallel with the grain of the wood, and about ⅓ of the distance from the toe end. It also is about ¼ to ⅜ inch deep. This furnishes the tongue which will interlock into the same incision in the rootstock. The scion is then slid onto the face of the rootstock with the two split parts, or tongues, wedging tightly into each other. The top of the scion is then lightly tapped with the knife to be sure the cambium layers match at the toe, or base, of the union and on at least one side. The grafter next makes two or three cuts on the seedling close to the ground. These cuts are made just through the cambium layer and allow the sap to escape should it start flowing again before the graft has taken hold and started to grow.

A cloth cellulose tape, similar to white adhesive tape, is next carefully wrapped around the union to hold the scion tightly against the rootstock and to make it airtight. The tape is ¾ inch wide and comes in rolls 60 yards long. Tree Seal, an asphalt compound designed for covering wounds and cuts, is then brushed all over the tape and on top of the scion to keep it from drying and to eliminate any errors in taping. It is used cold and when dry is waterproof.

About an hour later, when the Tree Seal has dried, white wash is carefully sprayed or brushed on so it completely covers the rootstock and scion. This also prevents drying and helps eliminate possible sunburn.

By following the above procedures there is usually better than a 90% "take" the first time over the block of seedlings. Any misses are re-grafted 3 or 4 weeks later and eventually the block winds up with better than a 95% to 98% stand of grafts.

The careful follow-up that is necessary for success in grafting takes place in the weeks immediately following the actual grafting process. This includes such items as suckering the seedlings to force out the scion buds, selection of the best growing bud, and cutting of the tape. However, these are primarily problems connected with the growing of the young walnut trees and will not be covered here.

PROGRAM CHAIRMAN BROWN: Thank you. Well, the schedule calls right now for having a discussion of today's field trip. All of you received cards on which you could write down questions. These cards have been collected, I believe, and turned over to the Moderator. I would like to ask the representatives from the companies we visited today if they would come forward please and join us here on the panel. I would also like to introduce the Panel Moderator. Certainly he needs no introductions because of the fine job that he did in organizing and conducting the Tour today. Mr. Byrne is a graduate of UCLA in Floriculture and Soils. He is responsible for the floriculture nursery production work in Alameda County where he has served as Farm Advisor in the Agricultural Extension Service for the past six years. Mr. Thomas G. Byrne —

MODERATOR BYRNE: I would like to introduce the panel members tonight: Margaret Fleming, Production Manager of

California - Florida Plant Corporation, Fremont; Mr. Deiter Luck, Sunnyside Nurseries, Hayward; and Mr. Don Dillon and Mr. Fred Real from the Four Winds Nursery at Fremont, Calif.

First of all, Margaret, you mentioned earlier today that your organization was anticipating getting more into breeding and selection of chrysanthemums in the future. In general, what is the type of problem that you're facing? What do growers want? The people that you're growing for — do you know what they want? Can you give them what you think they want?

MARGARET FLEMING: My impression is that in the florist industry — since the war — the price received by growers for their products is hardly any different than it was twenty years ago. The costs of production must have increased at least 300%. The only reason any of us have been able to stay in business is increased productivity, efficiency, etc. It's the job of the propagator to help the grower increase productivity, to improve varieties, to help with breeding, and with selection to produce varieties which will be uniform so that there will be hardly any dumpage. Varieties must be vigorous so that growing time will be reduced. A few years ago there were no decent white pot chrysanthemums. Breeders realized this, and started working on white pot plants. I'll bet there are fifteen of them now. Selection is exceptionally important. I think fifteen of the varieties which are among the top fifty in chrysanthemums now have been in the trade since 1920. These varieties have been selected and reselected to the point where the originator would hardly recognize them. Selection is toward size because growers are paid by the inch on the standard. You get more for 8 inches than for 7. We select toward vigor. If growers can produce in 14 weeks what took 15 weeks two years ago, they have saved one week of growing time, and in a short time can have another crop. This is very important. The schedules which are followed now are totally different than what they used to be, not only because of varieties but because of improvements in cultural practices. Just recently, working with a grower in St. Louis, he gave us a schedule he followed for March flowering. He finished some Indianapolis varieties, and some pompom varieties in 13½ weeks. When we first started supplying him 4 years ago, he required around 16 weeks for the same crop. He improved his culture. We improved our varieties. We both learned something. We deliver him a certain type of cutting which he prefers; it is a big, husky plant with tremendous roots by comparison with what used to be considered a good cutting. Then he never lets them rest. He plants them and nurses them right up to the finish and sells them well. He, therefore, operates at a profit in spite of increasing costs without compensating increase in returns. In breeding we wish to fill needs; there are no pink standards. We tried hard to supply pink standards but we still have no pink standards. We had a feeling that pot plant growers needed more varieties so we concentrated on pot plant varieties and did much better there. There's still room for improvement but some of the varieties which you saw at Sunnyside this afternoon and some of the varieties on the floor are new to the trade within the past 12 months — not more than 3 years old with us — and there are many more coming. Pot plant growers like new varieties, and they can sell more pot plants because they have them. Cut flower growers are perfectly satisfied with Indianapolis, Albatross, and Good News; the variety would have to be just fabulous to knock these off the list. I won't say that such a variety might not come someday, but it won't be in the near future.

MODERATOR BYRNE: Thank you, Margaret. Deiter Luck, I would like to ask you about growth retardants. Deiter has been using growth retardants for some time on pot chrysanthemums. I would like to ask him what his program is and how he gets the right amount applied to 80 different varieties. I assume they all don't take the same amount. Maybe they do. Would you elaborate on this a bit?

MR. DIETER LUCK: To answer Tom's last question first, do 80 different varieties take the same amount of B-9 (B-995). Yes, they do. When B-9 became first available on an experimental basis, we started our work. We used many different concentrations, starting with 0.05% up to 1.00%. We found that the majority of varieties respond quite well to 0.25% although there are certain varieties that respond to 0.15% and others, like "spiders", would do much better at 0.30% or 0.35%.

B-995 is no magic chemical, but it can really help to improve chrysanthemums, especially in quality. You can use it as an emergency stop. If the crop gets away because the plants are crowded, or light conditions are poor, you can apply B-9 and it will stop the growth wherever it is. There is really no danger in using it. I have used high concentrations right up to the stage where the buds are showing color and I have never seen any injury with B-9. That is, without adding any additional wetting agent. If you do add wetting agents, then you may get some slight burns, but not without them. We are using B-9 as part of our growing program, just like we use fertilizer or insecticides. We take advantage of growing conditions which we could not do if we did not have B-9. Instead of delaying pinching in order to hold our pot plants to a decent height, we give them three or four extra days of light in order to get better foliage. We get deeper flowers, larger flowers, and even better color. Then in order to offset the height we gain by lighting them for three or four days extra, we use the B-9. I think everybody has his own recipe for how much or when to apply it. For us it works fine about three weeks after pinching. You have to have at least two inches of new growth. The "break" should be about two inches. If you apply it too early, then the plants grow out of it just before they're saleable, and then you might get real weak "necks". Certain spider varieties create a bit of a problem because they have long necks or soft necks; you can spray them with B-9 just about dis-budding time, and eliminate the necks and get rather decent pot plants. We have grown fairly nice pot plants out of standard pot mums like Iceberg, which I have seen five or six feet tall. Makes a nice pot plant if you want to do it; so I think it has a place. It doesn't grow your crop for you, but it will certainly help to improve quality; with so many varieties, we would not be able to produce them so uniformly as we are able to do with B-9. That is what I have to say on B-9. There are other growth retardants; Cycocel is used on poinsettias; I know some people are still using phosphon on mums but I think B-9 is much easier to apply. It certainly works well for us. The cost is not excessive. The material will run between 2c and 2½c per pot. You almost have to use power spray if you want to treat 2000 or 2500 pots a week, but with low pressure and fairly small nozzles, where you can direct your spray into individual pots, it will run about 2c per pot, plus the labor — depending on how much you pay your personnel. If you figure $3.00 an hour, it costs ¾c per pot using a power sprayer; it is one of the easiest materials to apply and I think it is almost foolproof.

MODERATOR BYRNE: Thank you, Deiter. Now the last question I have is kind of a perennial one; in Alameda County's nurseries—the ones with whom I deal—container-grown plants, in general, are grown in a medium that has some dirt in it, and I am from the school — the dirt school I guess you would say — where I studied under Dr. Ray Lunt, and some of this rubbed off — where you grow good plants if you have some dirt in the soil. So, Fred, I would like to ask you why you are the only one in our county using an artifical soil mix. What advantages does it have for you?

MR. FRED REAL: After coming from southern California, and using the soil there, to northern California, we found the soil here even worse than that we had down there. With the Soil and Plant Laboratory people working with us, we decided to go into the UC mix. We were supposed to use peat moss but the financial condition of the nursery at that time was such that we could not afford peat moss, so we decided to use sawdust and everybody thought we were crazy. But now I find that we can hardly get sawdust ourselves anymore because some nurseries are getting it from us. We are real satisfied with the UC mix. There were times when we wondered, but we have finally got some dirt into it. At one time we were getting too much sawdust into it and the water was going though it pretty rapidly and we couldn't really get the mixture the way we wanted, but I think we are now where we really have it at its best, at least the way we like it. Also the cans are lighter; with the soil mix we have, we find it holds moisture quite well in our operation. We do not water our plants outside but once a week and we water every can by hose. Personally I like the soil mix and I can't see why a lot of nursery plant materials would not do well in it. I think that redwood sawdust may not be satisfactory for some nursery materials or flower plants on account of toxicity, but otherwise I think it is fine.

MODERATOR BYRNE: Thank you, Fred. At this time we will open the discussion to questions from the floor.

MR. RALPH PINKUS: I want to know the soil mixture you are using with the redwood sawdust. What percentage is redwood and what is the percentage of other materials?

MR. DON DILLON: As close and as accurate as you can get with a skip loader in a transit mix, our mixture is composed, roughly speaking, of ⅔ redwood sawdust and ⅓ sand. Sand is a great big wide world of wonder, and we have gone all the way from white sand, Kaiser sand that is white as snow — beautiful, not a thing in it, and we know it, to the by-products from the gravel quarries for the silt and the real fine sand accumulates. Where this can be obtained in some uniformity, we find this is very good. At the present time we are using a similar material unwashed as it comes from about 25 or 30 feet down, a mixture of very fine particle sand with a slight amount of clay or silt in it. To this is added the usual ingredients of the UC mix, calcium, dolomite lime, blood meal, superphosphate, and so on. I think one of the reasons why we use it is the fact that we do have some control over what is in it. It is uniform. It may be uniformly bad in the opinion of some people; we think it is uniformly good, but it is uniform. It is the same as we can make it from one batch to the next and this is its great quality. I think in everything we do in the nursery business, we should try to standardize, to get into known quantities, whether rootstocks, scions, or soil mixes or amounts of fertilizers. When this man starts talking to me about percentage of 1.0% of B-9, we are talking about known quantities. The soil mixes fit into the same category.

MODERATOR BYRNE: I have another question that ties into this as redwood sawdust becomes less available, and it is becoming so; more of it is going into landscaping purposes. Apparently it is just not much available in the southern part of the state. What thought have you given to using other types of sawdust? There is a vast quantity of sawdust of other species available in the state. Apparently other types or species are being used in the Northwest and other areas.

MR. DON DILLON: We have not given much consideration to other materials. We have been holding our breath and hanging on with the redwood as long as it will last. I understand studies are being made, tests of many other materials, and it seems from what I have heard — I have not read any of this material — most of the wood by-products, after a period of time, come into a certain common denominator. They react at about the same rate. They decompose at the same rate. We have held to redwood by the virtue of the fact that there is very little shrinkage. There is very little decomposition and very little nitrogen demand, but as far as finding another material, we haven't investigated this. Up until just a short time ago, Tom, you mentioned we are the only ones using this material, but I have been supplying sawdust to six other nurseries in our immediate area.

MODERATOR BYRNE: Do we have another question from the floor? Yes, Sir —

MR. BRUCE BRIGGS: Mr. Luck mentioned that if he used a wetting agent with B-9 he had burning. If he used B-9 plus the wetting agent could he dilute the B-9 and get the same results?

MR. DIETER LUCK: I have never tried to do this; I was using various concentrations of B-9 but I did not see any differences in effect by using wetting agents vs. just plain B-9. The reason I used wetting agents was that there are certain varieties that just don't seem to take the material easily. You can see it. The leaves are waxy and they just don't want to accept it, but after getting some burning, I have gone back to using just straight B-9. It works quite satisfactorily.

MR. PETER LERT: I might add to that question. The original B-9 material, the experimental material, contained no wetting agents and so had to have them added. At that time I ran rather extensive tests — all pointing up basically what Dieter has said. Added wetting agent is not a good substitute for concentration. If you increased the wetting agent enough, you induced injury.

MODERATOR BYRNE: I do not know if you noticed out at Cal-Florida that the girls were dipping the chrysanthemum cuttings in rooting hormones. Why would they do this on mums? I can stick these things in a glass of sand or water at home and they root very fast.

MARGARET FLEMING: Chrysanthemums root very well without rooting hormone of any kind. In years past we used to use it on some varieties and not on others, but that is one more classification. We have dozens of other breakdowns, so why save a couple of dollars on rooting compound and have people work separating all these out. Really, now that we know the difference we would still use it, regardless. It gives more roots over a bigger area and more uniform rooting. If we don't use rooting compound, or if (other people have quality control problems, too) by chance, the mixture is not too good, or they forget to put in the IBA, then we get roots only from the bottom of the cutting in about three rows and this is not very satisfactory. As a matter of fact, about three weeks ago we delivered a whole week's production of cuttings with roots only at the very butt of the cutting. We had a new batch of rooting compound and it did not take long to find out that something was wrong with it. With hormone, the cutting stands up better, takes hold faster, and we think it is much better than one with just a couple of skinny roots coming our of the base.

MR. ALBERT NEWCOMB: Do you know how deep the soil is sterilized by the steam rake treatment?

MARGARET FLEMING: Deeper than we used to think because now they tell us that 140° F. is enough. We used to be told that 180° F. was necessary; we think that we are sterilizing to 180° F. in the top several inches and then to 160° F. some more inches down and then to 140° F. some more inches, the total of which is about 14 inches; it depends upon the soil preparation. We rotovate. We sub-soil once a year. We have to have a certain moisture content. All of these are factors. Steam pressure is no factor, whatsoever, because we have too much. It has to be cut down. With the chrysanthemum, a shallow rooted crop, and a very fast crop, it has proven to be adequate even though there are still people who still doubt it. If you have verticillium wilt, as I said this afternoon, on old tomato ground, you must sterilize your soil.

MR. CURTIS ALLEY: Why are plastic pots not used more than they are?

MR. DIETER LUCK: We have to serve two markets with our chrysanthemums — super markets and retail stores. Retail stores prefer clay pots. Super markets, they don't care. They take plastic pots or clay pots because the clay pots are covered with foil and they can't see the pot; they will accept the plastic pot and use it without the foil because it usually stays cleaner than a clay pot. We do use plastic pots in sizes smaller than four inch because they are much easier to care for since they do not take so much watering. They hold a little more soil and are easier to care for, but again it would make things more difficult to plant some of each variety in clay pots and some in plastic pots; that is the main reason why we are using clay pots. Otherwise, we have grown just about every crop in plastic pots and they do quite well. I would say just as well as in clay pots if you treat them accordingly — but one of the main reasons is to simplify things.

PROGRAM CHAIRMAN HOWARD BROWN: We would like to take this opportunity to show our appreciation to the hosts of today's Tour. We have plaques here that we would like to present to each of these representatives for letting us visit their fine operations and for taking all the time to show us through and answer our questions — Don Dillon, Sho Yoshida, and Margaret Fleming.

We will now have a second panel of the evening to answer questions on this morning's talks. Bruce Briggs will moderate.

MODERATOR BRIGGS: Our panel will consist of the morning speakers: Dr. Dale Kester, Dr. O. A. Batcheller, Dr. Curtis Alley, Mr. Don Sexton and Mr. David Graves. To start, we have a question submitted to the panel. The question is: Over in Europe, in the Mediterranean area, I understand the general practice in T-budding is to remove the wood from the shield. Is there any advantage to this and, if so, elaborate. Would you answer this ,Jolly Batcheller?

DR. O. A. BATCHELLER: Well, this is sometimes called a June or "flip" bud here in the United States. We cut in rather deeply in our initial cut underneath the bud. The second cut above the bud goes merely through the phloem tissue and then you take your finger or thumb nail and merely peel off the phloem tissue and that part of the cambium that adheres to it. It was one time thought that in June budding early, removing the xylem, you get a closer contact of the cambium layers. The buds would heal faster and grow faster. The time involved makes it expensive and difficult to do and, if the bark is not slipping, it is nearly impossible because you have nothing to push to give your buds strength in order to insert it. I do not believe there are any great advantages to it here in California or where we have good growing weather and the bark slips rather quickly.

MODERATOR BRIGGS: Thank you. Is there anyone in the audience who would like to add to this?

MR. LLOYD JOLEY: There was considerable work reported in England some time back, probably in the 1920's or 1930's, in which they found no difference in removing the wood from the bud vs. the wood left in the bud. Professor Bradford, working at East Lansing, Michigan, did considerable work along that line at one time. He never published on it, I believe; but he found no difference. At Chico, California, I have tried budding *Pistachia,* both with wood removed from the buds, and wood in the bud and it made no difference.

MR. WILLIAM CURTIS: In the northwest we use dewooded buds when we want to get started earlier. The wood is soft. The buds are a little bit soft, not quite matured enough. Sometimes you can get started a few days earlier in your budding. We found that it works very well with flowering cherries, where it is sometimes difficult to get a good stand with ordinary budding.

MODERATOR BRIGGS: Dale Kester. In double budding, do you permit the interstock bud to leaf out?

DR. DALE KESTER: The interstock is a small piece of wood, or a thin slice, a quarter of an inch thick, at the most, with no bud on it. The bud is removed to make a budless shield.

MODERATOR BRIGGS: Thank you. Curtis Alley, should the string for budding be waxed?

DR. CURTIS ALLEY: I have not used wax string in the budding I have done. If you use a wax string and cover it with soil, I believe you're going to be in trouble because it will not rot out. If you use wax string and leave it above ground in the air, you will have to cut it. However, I am sure wax string would make the particular seal much more waterproof.

MODERATOR BRIGGS: Don Sexton, what time of the year do you graft *Magnolia grandiflora?*

MR. DON SEXTON: At Monrovia Nursery in southern California, we graft *Magnolia grandiflora,* I believe, in January and February; this is the best time and, of course, it takes a while to heal in and to develop. Some tend to be a little slow. They don't all come on quite as rapidly as we would like them.

When the scionwood is reasonably dormant is the time we do it.

MODERATOR BRIGGS: Do you do any budding as well as grafting on *Magnolia grandiflora?*

MR. DON SEXTON: No, we are not doing any budding on these at all at the present time. The understock is usually reasonably large and by selecting, just as with walnuts, the scions for size to match the understock, we can graft both rather large and small understocks.

MODERATOR BRIGGS: Don Dillon, have you tried in your work to check the amount of foliage you have to keep on your cuttings under mist.

MR. DON DILLON: As I mentioned this afternoon, on our citrus we intend to retain all leaves. The wood that we use is not soft wood or very recent growth. It is pretty well hardened off. We do try to retain all the leaves wherever possible. As far as any experiments to see how it works with and without, we have done this against our will, so to speak. Sometimes when the mist goes haywire, we lose the leaves and we know that we don't make any money doing it. The plants just don't root properly, the grafts don't heal properly, and we have them headed for the dump pile.

DR. DALE KESTER: In rooting cuttings of the type that Don is doing, he is rooting them and grafting at the same time. If he removed the leaves, as he said, he would just completely inhibit root initiation.

MR. LLOYD JOLEY: In the case of double working apples, you will get better increase in the diameter of the interstock if you take the leaves all off. That has been done in work at Michigan.

MR. ALBERT NEWCOMB: Dr. Ford, in Florida, carried out an experiment where bare-rooted citrus trees, on which they left a large number of leaves, were found to be likely to wilt and not grow well. If they took all the leaves off, the trees did not transplant well; but if they left on a moderate number of leaves, the plant grew the best. These were rooted, budded, bareroot trees ready to set in an orchard. It was a rather complete experiment; we followed this program ourselves and verified it in our own work. Citrus trees with some leaves retained seem to be able to transplant better, start, and grow better than if they are completely defoliated.

DR. DALE KESTER: In this whole case where you are dealing with a leafy plant, you are working with two processes that are opposed to each other. On the one hand, the leaves stimulate rooting. At the same time, there is a loss of water from the leaves which may result in wilting; the two processes work against each other, so the end result is a compromise between the two.

MODERATOR BRIGGS: Thanks, Dale, for the clarification. Dale mentioned this morning that if you added a hormone, such as naphthaleneacetic acid, to the inserted bud or scion, it did not seem to help the grafting percentage. Has this actually been proven, or is it a matter of timing?

DR. DALE KESTER: What this statement was based on is that although naphthaleneacetic acid and other growth regulators stimulate callusing and theoretically should help grafting, no practical benefit has been consistently reported. Many people have tried it in various ways, and although a few people have reported some benefit, most people have reported none. Failure to produce practical benefit may due to incorrect methods, timing, etc. Since there are reports in the literature where some people have produced some benefit, perhaps more work needs to be done.

MODERATOR BRIGGS: Thanks, Dale. Another question, what type of graft would you advise for azalea grafting?

MR. DON SEXTON: We use a side graft, usually with a tongue. These are usually very small azaleas. We also grow the standard type, the so-called tree azaleas on the southern *indica* stock that may be 2 or 3 feet tall. These are a little huskier and we are able to work them in much the same manner as other grafts and then we tie them with a strong thread. We use just a regular, good quality, white thread; we do not wax it. Then the grafts are plunged and held under polyethylene for several weeks, just as are all the other items.

DR. O. A. BATCHELLER: I have seen Roy Wilcox grafting azaleas that were less than 1/8 inch in diameter. In grafting them they merely cut one side, then made their scion rather tapered, forced it in and then tied the grafts with cotton thread and put them in peat moss; they got a very good union. It was a modified cleft graft.

MODERATOR BRIGGS: Is it possible to apply some kind of "antidote" to buds to prevent such growth as the suckers arising from the base of plants. Dale Kester, will you answer this?

DR. DALE KESTER: If kinetin, adenine, and such substances are associated with growth of buds, then I suppose someone ought to be able to invent an anti-kinetin that would inhibit bud growth. In the experiments where kinetin has been studied, the initiation of buds is involved. In bud inhibition we are talking about a bud that is already formed but is dormant. To keep it from growing we are talking about a different process. Growth is associated with both auxins and kinetins but bud inhibition is probably more apt to be produced by an anti-auxin. The other problem here is that we might inhibit the whole plant rather than certain buds. This question could come up again tomorrow in the symposium on "Growth Made to Order."

MODERATOR BRIGGS: We have a question here for Don Sexton. Will *Juniperus* 'Wintergreen' root well from cuttings?

MR. DON SEXTON: No. We have not had any success growing this particular juniper from cuttings. We have not really tried to grow any the last couple of years because we have not had any results. Now, 'Robusta Green', we do grow from cuttings and we do get reasonably good results although it is somewhat difficult and we do not get nearly the quantity we would like to have. It is rather slow in every respect and in growth afterwards, too. We get more rapid growth by grafting.

MODERATOR BRIGGS: I would like to mention the use of shellac as a seal in grafting. We used it a little this summer. I know the Saratoga Horticultural Foundation has used it for maybe the last two or three years. It looks real fine. It is easy to apply. It dries real quickly. The alcohol in it does not seem to hurt the plant. Shellac itself is pretty much made up of bugs, it is a protein. Therefore, there is nothing injurious to the plant.

MR. WALTER VAN VLOTEN: Somebody told me years ago that the black, cold grafting wax — we call it in Canada, Bracko — has some oils in it. It is an asphalt product. That is, would it be harmful to the tissues of your graft? Is there any truth in that?

DR. CURTIS ALLEY: If this is the same compound as Tree Seal, or Treheal, which has an asphalt base, I am not aware that it is toxic to plant material. I have not heard of this product that you are talking about. These are the only two that I am familiar with — still there is one other compound, too, that is black, which is manufactured at Merced, California, that has a slightly different solvent; we have tried it and found it to be non-toxic to grape material. All three of these have an asphalt base. They are water soluble. You can thin them out with water.

DR. O. A. BATCHELLER: One comment I would like to make. In horticultural class, when I was in college, we spent three laboratories making grafting wax with beeswax, tallow, lamp black, etc. In my first class in grafting at Cal Poly in 1946 we wanted to graft over some avocados; down there they chop them off six inches from the ground and stump graft them. I prepared the proper wax with beeswax, tallow, resin, and lamp black and had just the ideal mix to withstand the hot temperature. Now down there we put paper bags on the top after grafting to protect it from the heat; so the next lab period we went out to check. Of course, we tear holes in the corners to provide ventilation, but the bees are hungry in southern California and they had gone in — because it contained beeswax — and had taken all the beeswax out; in fact, they had stripped all the wax off the graft and, of course, it was dead. Tree Seal or Treheal is good and, as far as I know, the range of distillate they use in the emulsion is such that it is not toxic or harmful to plants.

MR. FRED REAL: Has anyone used plastic tape in budding?

MR. DAVID GRAVES: We do not use it ourselves. We have never tried it but I know that there are nurseries who are using plastic material to wrap around grafts.

DR. DALE KESTER: We have used it in class work quite a bit and it is really quite successful. I have seen published reports from Australia that certain plastics contain some toxic material and were injurious.

MR. WALTER KRAUSE: We have used polyethylene ½ inch tape on walnuts and had some burning beneath the plastic. The plastic was also covered with Tree Seal as a grafting compound.

MODERATOR BRIGGS: This question occurs in our area; some people get more growth on plants in a metal can than in a plastic container with the same item under the same conditions. I am again wondering is there a toxic condition from the plastic that we are also facing.

DR. O. A. BATCHELLER: My guess is that up in Washington the black can absorbs more heat and therefore the plants have a little warmer root condition.

MODERATOR BRIGGS: They are both black though, Jolly.

DR. O. A. BATCHELLER: In Wageningen in Holland, I saw reports of their investigations regarding the use of plastic pots versus clay pots; under proper watering conditions, they claim there was better growth of roots in the plastic container than in the porous clay which everyone says, "breathes and provides better conditions."

MR. WALTER KRAUSE: I have a question for Mr. Graves. After the grafting process in walnuts, what do you do with the sucker growth? Do you retard it or do you keep it absolutely cleaned off entirely? That is, below the graft union.

MR. DAVID GRAVES: We leave the sucker growth on for a certain period of time. We want this sucker growth to absorb all the material from the roots until the scion has had a chance to knit into the rootstock. Now, we do not want to let the sucker growth get too long or it will overgrow the scion; after six or eight weeks we go in and strip off any sucker growth that has come to see if the graft can take it; if the graft does not wilt or show any signs of going backwards, we can go ahead and strip off all the sucker growth. This will force all of the growth into the English variety that we are growing.

MODERATOR BRIGGS: Is it harmful to apply water to a graft union during healing? In making an evergreen graft, you put it in the greenhouse and maybe wait twenty-four hours before you water it; or you may apply water immediately after grafting. Is there any harm in doing this?

DR. DALE KESTER: Well, I do not know too much about the evergreen situation. In general, free water or at least a very high humidity on the union is not desirable. With a lot of water, you might get a fungus problem which would cause some trouble. This may be the thing causing the problem, but as far as getting callus to grow, free water, as I understand the situation, is not harmful and probably would be beneficial.

MR. WALTER VAN VLOTEN: I would like to ask about chemicals used in keeping grafts clean under mist, instead of what they use to call double glass grafting.

MR. DON SEXTON: We apply Captan dust after the grafting is completed and just before the polyethylene cover is put on. Our house, of course, is periodically cleaned out and sprayed with Bordeaux or some other fungicide. We try to maintain clean conditions. Usually the knives are dipped in something — sometimes Agramycin — we try to maintain clean conditions at all times. But we do not heal any of our grafts under mist because they are all grafted on a rooted understock. As I pointed out, while they are placed in moist conditions under the polyethylene, they are not watered any further for several weeks unless it is noted that they happen to become dry. They normally would not dry out under polyethylene, especially with the small amount of foliage they have at the time of grafting. Remember we have thinned out the foliage on the stock and cut it back rather severely. The scion itself has a relatively small amount of foliage, not soft foliage, so that we do not have a great water loss, especially when the humidity is maintained at a high level under the polyethylene. We have rather different conditions than at Four Winds Nursery where they are healing a graft union and rooting the understock simultaneously under mist.

FRIDAY MORNING SESSION

October 22, 1965

This session convened at 8:00 A.M. with Moderator Tokuji Furuta, Extension Specialist in Ornamental Horticulture, University of California, Riverside, California, presiding.

MODERATOR FURUTA: In the realm of nursery production and marketing, including propagation, I should like to think of it as a system — just as we have systems of rockets which orbit man, and a system of communications in which we can communicate vast distances in a very short time, so our systems of production and marketing will enable us to profitably produce plants in a very efficient manner and, hopefully, at the highest net profit for the firm. I think that we need to use the concepts of systems engineering to analyze our problems, and, of course, basic to the concept of systems engineering and analysis is the fact that we have to know what each component will do and how it functions in relationship to other parts of the system and particularly the limitations of each component. In order to understand the components of the systems that we are working with we have to have research at the various levels of basic research and development research in order to put this to use.

This morning we will consider several topics, the information of which has been or is being developed by research personnel in this state and in every other state in the Union. It is only a little over a score and ten years that we have begun to understand the nature of plant growth regulators and what they will do. And yet, in this short period of time, we have gone from a very infantile knowledge of plant growth regulators to the point where we cannot only say that we can control plant growth, but we can say that we can control it profitably and practically.

Our first speaker this morning is Peter Lert, who will discuss Plant Growth Made To Measure. Pete:

PLANT GROWTH MADE TO MEASURE

PETER J. LERT

Agricultural Extension Service

University of California

San Jose, California

Historically, man has always shown much interest in tailoring the growth of plants to his economical and aesthetic needs. All of our cultural measures, to some extent, involve tailoring plant growth — even if this only means the growing of larger and more vigorous plants. However, most people think in terms of regulating plant height when we talk about tailoring plants to measure.

At our meeting at San Dimas, California, in 1962, Dr. Harry Kohl presented a paper in which he pointed out that a variety of factors independently and interacting can influence plant height. These include genetic changes, clonal selection, pruning of tops or roots, light, temperature and moisture. But in this modern age of scientific marvels, people are less interested in some of these very effective but "old hat" ideas than in the use of chemical plant growth regulators.

While many chemicals may alter plant growth, including fertilizers, herbicides, auxins and kinins, it seems well to restrict today's discussion to gibberellins, growth retardants, and the growth inhibitor, maleic hydrazide.

So much has been said and written about the discovery and development of the gibberellins that it seems superfluous to say much about them at this time. However, for a better understanding of the mode of action of growth retardants, it is necessary to remember that gibberellins occur naturally in all plants and are responsible in part for the mechanism of elongation. Strangely enough, this particular aspect of gibberellins has not found too much practical application in commercial horticulture. However, other influences on flowering and fruiting have been developed to improve quality or time of maturity. Our moderator for this panel, Dr. Furuta, demonstrated that high rates of gibberellic acid could be substituted for the cold

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Work done by Dr. Mark Cathey at the U.S.D.A. Station at Beltsville, Maryland, and by myself in California, demonstrated that it is possible to improve the shape of the spray of certain cultivars of pompon chrysanthemums by elongating the flower stalk. Unfortunately — or perhaps fortunately — the plant breeders since then have eliminated the necessity for this treatment in pompon chrysanthemums by developing cultivars which have naturally satisfactory spray shape and to the best of my knowledge, no use is made of gibberellins in chrysanthemum production at this time. Dr. Vernon Stoutemeyer has recently used GA to improve the linear growth of carob tree seedlings.

Development of growth retardants began in 1948 with the discovery at Beltsville that certain nicotinium compounds could retard the growth of bean plants without adversely affecting flowering, fruiting, or other normal growth mechanisms. In 1950 it was discovered that certain quaternary ammonium compounds retarded growth more effectively and on a wider range of plants. The best known of these compounds was designated as AMO-1618. However, its high price and effectiveness on a narrow range of plants limited its commercial use. Next came the development of the material designated as Phosfon, a material which is still being used at this time as a commercial growth retardant on chrysanthemums. Next on the scene was Cycocel, or CCC, which is currently being used on poinsettias, azaleas and to dwarf carnations for use as a pot plant. The latest o fthe currently available materials is B-Nine (B-995), which appears to be effective on a wide range of plants. One of its features is the fact that it can be sprayed rather than requiring soil application; another is its low rate of phytotoxicity. Commercial uses at this time include applications to chrysanthemums, hydrangeas, poinsettias and numerous annuals being used as bedding plants. Undoubtedly, additional compouds may be developed in the next few years, and wider uses found for those now on the market.

The most notable feature of this group of growth retardants is that they reduce the length of internodes without substantially inhibiting the development of leaves, flowers and fruits. Additional effects may include a deeper green color of the leaves, increased resistance to water stress, some resistance to air pollution and soil salinity and, in some cases, an increase in winter hardiness. The shortening of internodes is often accompanied by an increase in stem diameter. Precocious flowering is induced in some species, including fruit trees; and bud counts may be increased in azaleas.

In order to extend the usefulness of growth retardants, it is important to understand something about their basic action. Stem elongation takes place in the sub-apical meristem tissue (the area immediately behind the terminal growing point), and it is here that the growth retardants are most effective by reducing the number of cell divisions and the amount of cell expansion taking place. The apical meristem itself is relatively unaffected and continues to produce leaves and flowers more or less normally. The action of the retardants appears to be based on a mechanism which is antagonistic to the naturally occurring gibberellins in the plants, and in most cases it has been possible to reverse the action of retardants by applying GA and vice versa. In looking at plants which respond well to the presently available growth regulators, it seems that the majority of them are plants which in one way or another are day length or photoperiod responsive in either their growth or flowering habits.

Effectiveness of growth regulators can vary considerably depending on such factors as available light intensity, duration of photoperiod, temperature and, in the case of soil — applied materials, the growing medium. In the case of spray applications, the formulation of the material and the selection of the proper surfactent may influence its absorption; and it may well be that the lack of response of some of the woody species is due to failure to obtain proper absorption of the retardant. Generally speaking, the greatest percentage of growth retardation is obtained under conditions of maximum elongation.

So far, I have carefully skirted the special case of the growth inhibitor, maleic hydrazide. Unlike the growth retardants, it is most effective in the apical meristem tissue and inhibits the development of new leaves and additional shoots once it has been applied. It actually stops cell division and perhaps should be better classified as a herbicide. Nevertheless, it seems to have found some application as a substitute for pruning certain ground covers, shrubs and trees. However, the rather limited amount of work done so far indicates that the tolerance between effective control of growth and phytotoxicity is extremely narrow, and widespread side effects often accompany the inhibition of plant growth.

Indications are that we will see the development of more growth retardants and that we will learn ways of making far better use of the ones we already have. After all, it is only in recent years that we are beginning to make optimum use of such an old material as 2,4-D. Undoubtedly, future research will explore in greater detail modifications other than retardation of linear growth such as the effects on flowering and fruiting, reduced moisture stress, smog tolerance, and others.

MODERATOR FURUTA: Thank you, Peter. We would like to focus for a little while now on a relatively new development — I don't know if you really want to call it new — but at least there has been a lot of emphasis on it the last few years — and that is the possibility of fertilizing plants by increasing the carbon dioxide content of the air; fertilization in, perhaps, a different form from that we are used to. Dr. Harry Kohl of the Department of Landscape Horticulture, University of California at Davis. Harry:

CARBON DIOXIDE FERTILIZATION

HARRY C. KOHL, JR.
Department of Landscape Horticulture
University of California
Davis, California

The idea of carbon dioxide fertilization is not a new one. In 1913 the first attempt at commercial application was reported from Europe and for some 20 years thereafter a fairly large amount of work was reported in this field. However, the practice was not adopted most probably because of the presence of injurious contaminants in the carbon dioxide used although lack of good control was also a problem and the limitations on its use were not understood.

In the mid 1950's the practice was revived largely because of the findings of Goldsberry at Colorado State University with carnations and has remained as a controversial, ill-understood practice since that time. A summary of a carbon dioxide survey made by Kennard Nelson in 1964 indicated that 1,478,600 sq. ft. under glass, almost all of which was in the northern tier of states, was receiving some added carbon dioxide. In the same summary a brief report of research work on flower crops by workers at six universities indicated mixed results. About half the findings showed significant gains (10% to 100%) from carbon dioxide fertilization. The other half showed essentially no gain. Only one reported a lower production by carbon dioxide fertilized plants.

Such varied results — even on the same crop — would seem to indicate that we should be thoroughly familiar with what carbon dioxide can and cannot do if a wise decision on if, as, when and how to use it is to be made. Presenting this necessary background is the reason for this paper.

Growth Efficiency

For most ornamental and vegetable crops the production is, grossly, the fresh weight of the crop produced. The amount of fresh weight produced per unit area per unit time is a measurement of the efficiency of production. But for each unit of fresh weight produced there is a minimum dry weight if the crop is of acceptable quality. In a sense then the good grower can be defined as one who can cause the plant to produce the maximum amount of fresh weight of acceptable quality from a given amount of dry weight. Temperature, water relations, mineral nutrition and photoperiod play primary roles here, not carbon dioxide, and hence if production is being re-that is the possibility of fertilizing plants by increasing the carbon dioxide content of the air; fertilization in, perhaps, a different form from that we are used to. Dr. Harry Kohl of the Department of Landscape Horticulture, University of California at Davis. Harry:

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The idea of carbon dioxide fertilization is not a new one. In 1913 the first attempt at commercial application was reported from Europe and for some 20 years thereafter a fairly large amount of work was reported in this field. However, the practice was not adopted most probably because of the presence of injurious contaminants in the carbon dioxide used although lack of good control was also a problem and the limitations on its use were not understood.

In the mid 1950's the practice was revived largely because of the findings of Goldsberry at Colorado State University with carnations and has remained as a controversial, ill-understood practice since that time. A summary of a carbon dioxide survey made by Kennard Nelson in 1964 indicated that 1,478,600 sq. ft. under glass, almost all of which was in the northern tier of states, was receiving some added carbon dioxide. In the same summary a brief report of research work on flower crops by workers at six universities indicated mixed results. About half the findings showed significant gains (10% to 100%) from carbon dioxide fertilization. The other half showed essentially no gain. Only one reported a lower production by carbon dioxide fertilized plants.

Such varied results — even on the same crop — would seem to indicate that we should be thoroughly familiar with what carbon dioxide can and cannot do if a wise decision on if, as, when and how to use it is to be made. Presenting this necessary background is the reason for this paper.

Growth Efficiency

For most ornamental and vegetable crops the production is, grossly, the fresh weight of the crop produced. The amount of fresh weight produced per unit area per unit time is a measurement of the efficiency of production. But for each unit of fresh weight produced there is a minimum dry weight if the crop is of acceptable quality. In a sense then the good grower can be defined as one who can cause the plant to produce the maximum amount of fresh weight of acceptable quality from a given amount of dry weight. Temperature, water relations, mineral nutrition and photoperiod play primary roles here, not carbon dioxide, and hence if production is being restricted by inefficient use of dry weight it is unlikely that carbon dioxide fertilization will very effectively remedy the situation.

Dry Weight Production

Supposing that the dry weight available is being used as efficiently as possible the next concern is providing more dry weight (photosynthates) per unit area to be used in the production of the crop. Carbon dioxide can certainly play a direct role here, but before considering it let's look at some other possibilities. The first I would like to consider is conservation of photosynthates for the purpose of growing the crop, which means having as low an overhead in terms of stems, roots and non-functional leaves as possible. Since this is not of major concern in this paper we will not go into the details of this further but immediately suggest another possibility which is to increase the amount of light either by increasing the intensity during the light period or extending the light period. However, if light intensity is already high this can only be done effectively by increasing the duration of light. The addition of light should result in higher dry weight yield per unit area per unit time, provided said increase does not result in injury such as wilting due to increased water stress. The reason for the effectiveness of added light is, of course, to be found in its role in photosynthesis:

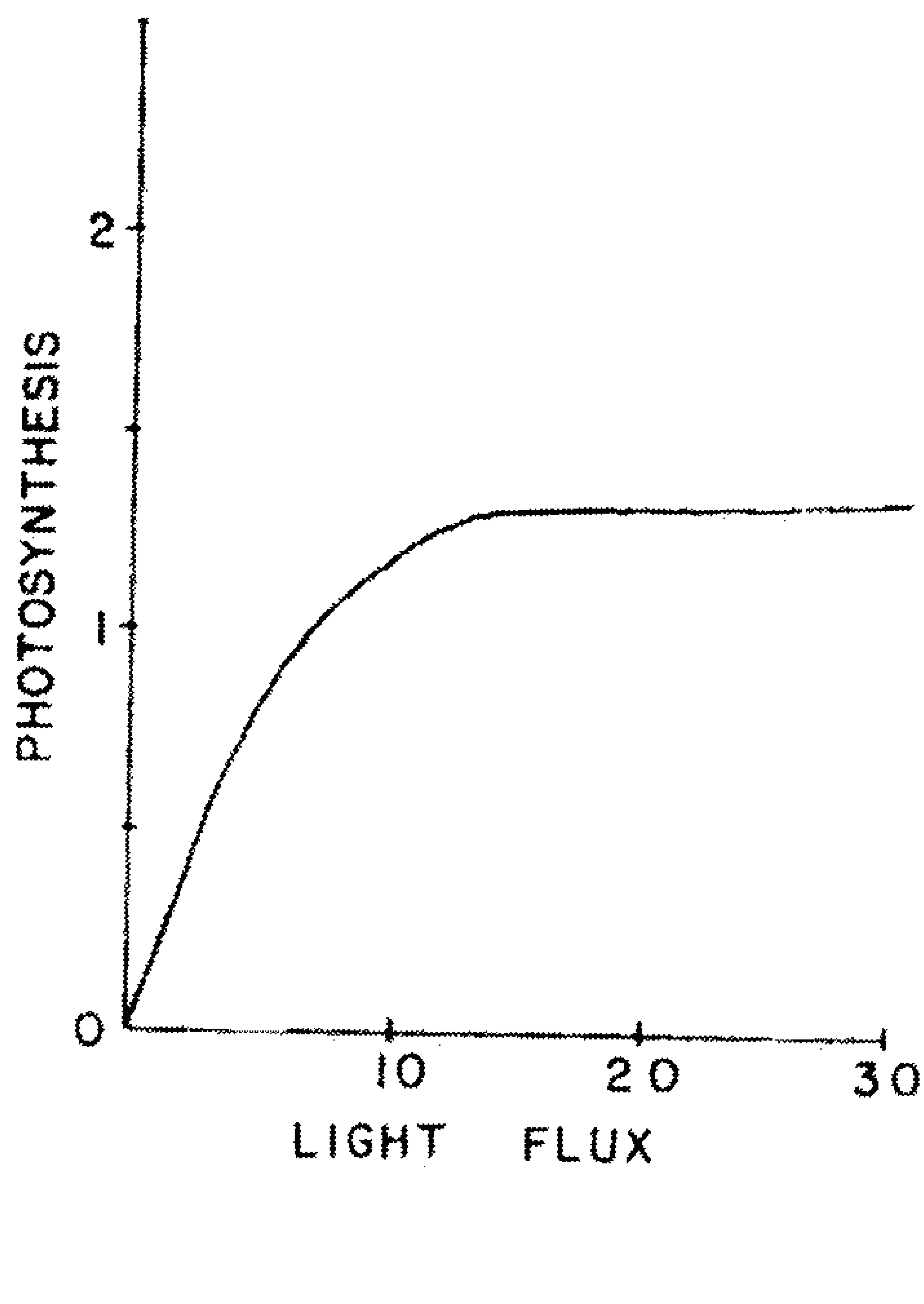

Fig. 1 Photosynthesis (mm^3 CO_2 cm^{-2} h^{-1} 10^{-2}) of single leaf of sugar beet as a function of light flux (erg sec^{-1} cm^{-2} 10^{-4}) Adapted from Gaastra

$$CO_2 + H_2O + light \rightarrow [CH_2O] + O_2$$

Again light is not our primary concern and so we will not attempt a complete discussion although we should not leave the topic without noting that addition of a quantity of light to a crop receiving a relatively small amount of light will result in a much larger absolute gain than if the same quantity of light is added to a crop growing under high light conditions as can be deduced from experimental data generalized in Figure 1.

Now let us examine photosynthesis as a function of carbon dioxide concentration. Gaastra has published data on photosynthesis of leaves of several species which in general show the following:

1. At very low light intensities (circa 300 f. c.) CO_2 concentrations greater than normal ambient, i.e. 300 ppm, did not result in higher photosynthetic rates.
2. At higher light intensities there was a distinct increase in the rate of photosynthesis at increased carbon dioxide levels. The average maximum increase was to 200% of the photosynthesis at ambient CO_2 levels. Saturation occurred at about 1000 ppm CO_2 although the gain at concentrations over 750 ppm was slight. (Fig. 2).
3. At higher temperatures (circa 85° F.) the gain in photosynthetic rate was greater than at lower ones (circa 70° F.) when CO_2 was increased to the same level. (Fig. 3).

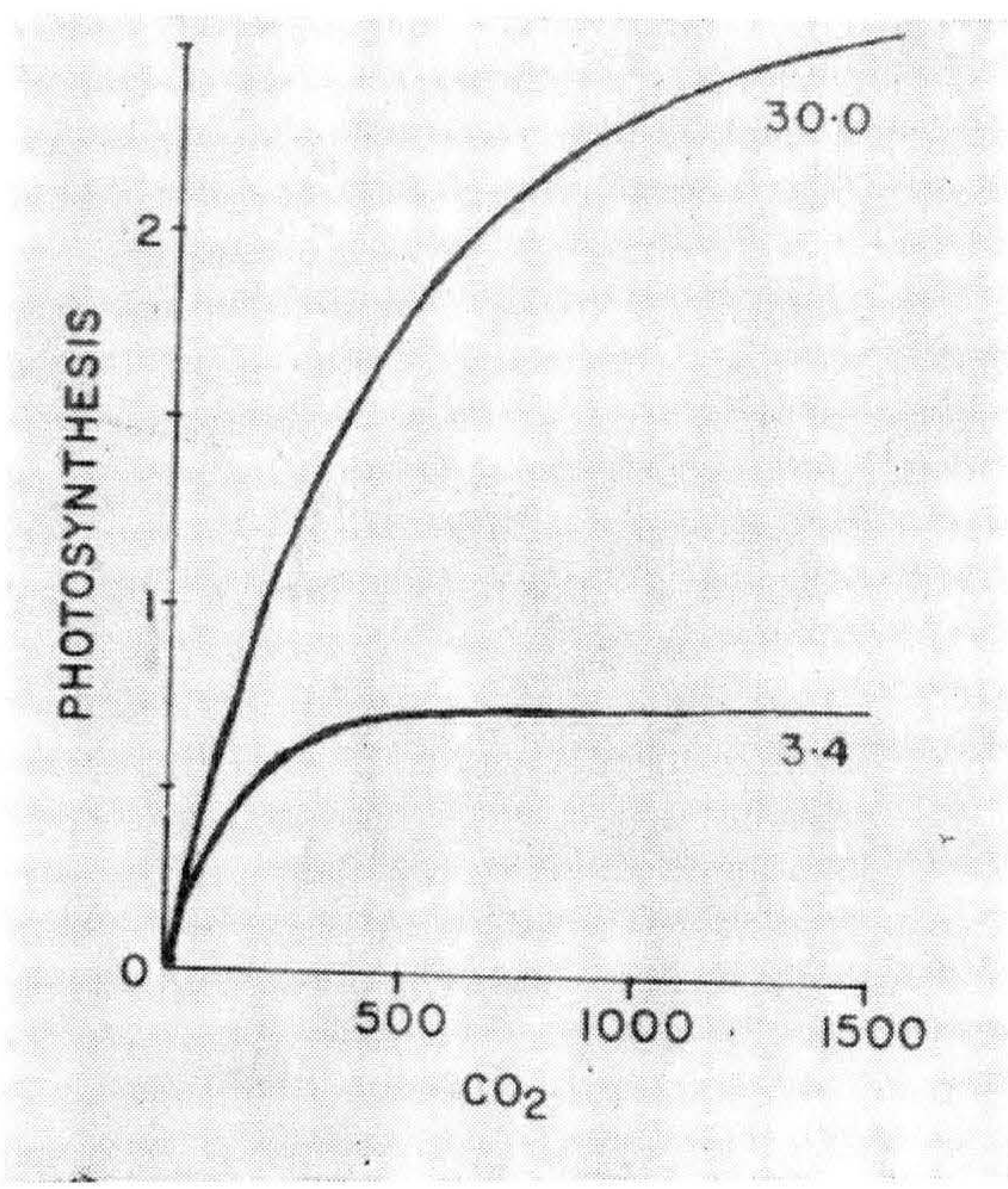

Fig. 2. Photosynthesis (mm.^{3} CO_2 cm^{-2} h^{-1} 10^{-2}) of single leaf of sugar beet as a function of carbon dioxide concentration in ppm at high and low light intensity. Adapted from Gaastra.

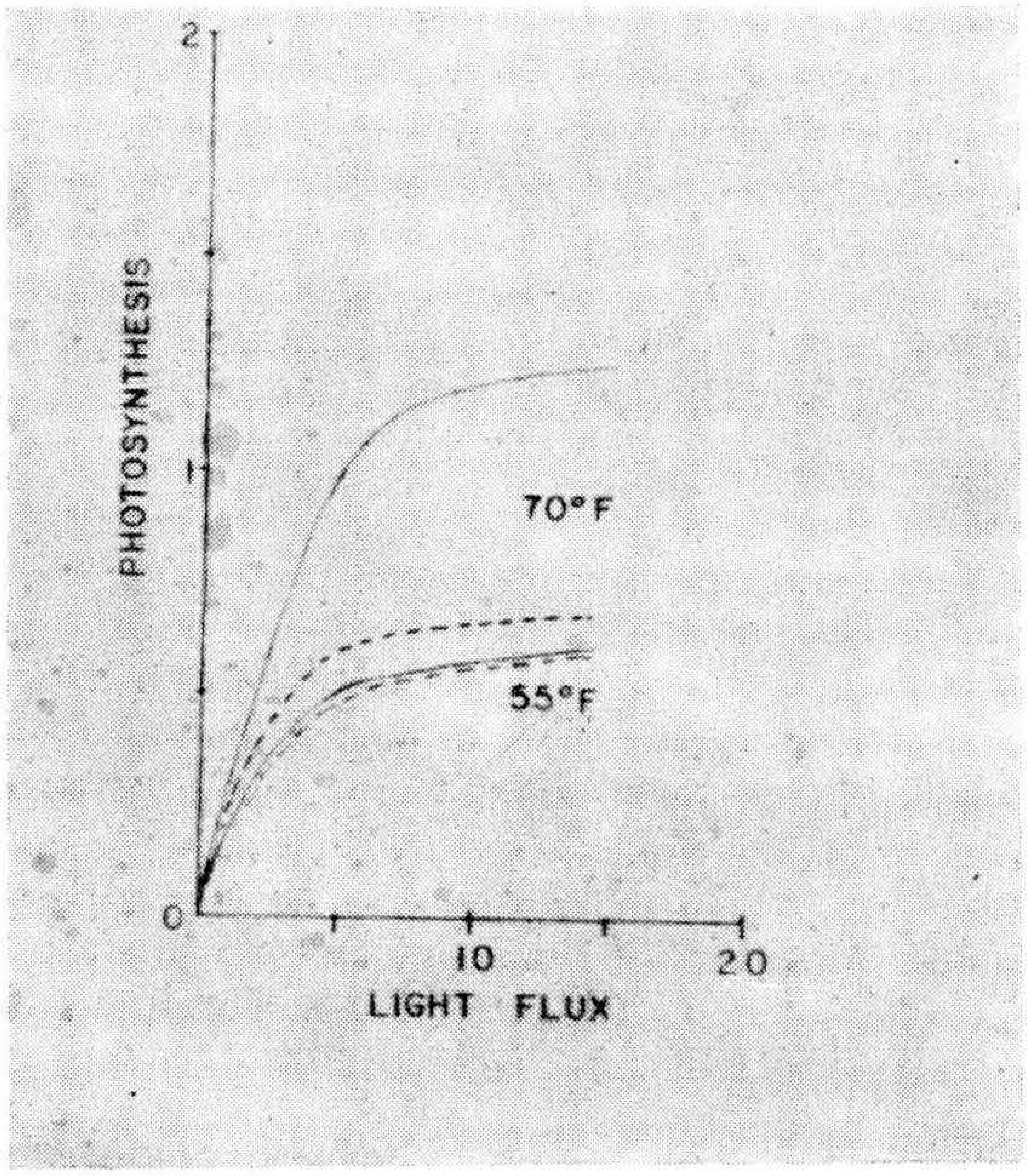

Fig. 3. Photosynthesis (mm.^{3} CO_2 cm^{-2} h^{-1} 10^{-2}) of tomato leaf as a function of light flux (erg sec^{-1} cm^{-2} 10^{-4}). The dashed lines are for a carbon dioxide concentration of 300 ppm while the full-drawn lines are for a higher concentration. The two lower curves are for 55° F. (approx.) and the two upper curves are for 70° F. (approx.). Adapted from Gaastra.

The above information would appear offhand to make a decision in favor of CO_2 fertilization inevitable if the cost of the gas and its distribution and control is at all reasonable. In fact it would appear inconceivable that all experimental work with CO_2 fertilization did not result in increased yield and yet this has not always been the case. Why?

It is my considered opinion that the answer lies in one of two places. Either cultural practices are not adjusted to take advantage of increased dry weight production or the carbon dioxide fertilized plant is made more susceptible to dark weather. Allow me to give examples. First, regarding the adjustment of cultural practices, let us consider the production of some crop such as standard chrysanthemums upon which CO_2 fertilization is superimposed. The spacing, fertilization program, temperature, number of flowers per square foot, the vegetative period, and the response group (flower development time) are all fixed knowingly or unknowingly, to the light intensities and carbon dioxide content normally available so that under those conditions a crop of good quality can be produced. Within such a restrictive framework any potential increase in dry weight production due to carbon dioxide fertilization can express itself only in a most limited form. Perhaps during the vegetative period a few more leaves can be formed and individual leaves can be larger.

But the spacing is too close for these leaves to be of more use to the plant than the fewer, smaller leaves which the non-fertilized plant grew in the same length of time. The extra leaf surface actually becomes a parasitic burden with time since it cannot receive enough light to be useful. Again, during early growth the fertilized plants might produce somewhat thicker stems and a larger root system. Normally this would be an asset as a foundation for a superior plant but for the plant restricted to growth in a limited area such a root system is a luxury, so to speak; it costs more dry weight to maintain and isn't needed except to help supply the excess, parasitic leaf surface. With the above in mind it is a moot question whether the crop which is harvested from the fertilized plants will be worth more than that from the unfertilized plants. If the amount of eventually parasitic tissue is large and light is unusually low during the late stages of production the CO_2 fertilized crop could well be worth less. It may have a higher dry weight overall but not in the flower and useful stem harvested. On the other hand with some changes in growing practices a considerable positive gain might have been realized from carbon dioxide fertilization. For the problem of producing these standard mums I would suggest that the vegetative period might be reduced so that the leaf surface per unit area is essentially normal. The flowering period might be reduced as well by using a variety having a shorter response time. The net result could well be the production of equal worth in an overall shorter time.

Unfortunately, the above explanation is rather long and tedious and, even so, not complete. Even more serious is that the reasoning has not been tested by appropriate experiments. It can, however, be tested by experiments and enlarged upon in the process.

An example of the second way in which I feel negative results might be recorded following carbon dioxide fertilization is by an increased susceptibility of the plants to a low light period. As an example of what I mean here let us assume that we are giving supplementary carbon dioxide to a winter rose crop during relatively bright weather and further let us suppose that the crop is responding beautifully with half again the normal number of breaks about two weeks away from full bloom. At this point let us assume that the weather becomes overcast and remains so for two weeks. What result can we expect? Near disaster, I expect, for we have built up a very large overhead in the form of dry weight needed to support the large canopy and at the crucial moment the productive ability of the leaves has been reduced not only proportionately to the reduction for the unfertilized plants but, as Fig. 3 indicates to essentially the *same* low rate as that of the unfertilized plants. Proportionately the photosynthetic potential is reduced much more for the fertilized plants. Immediate cessation of growth, excessive leaf drop, small — perhaps unsalable — flowers, and an injured plant which will take a long time to recover productiveness would be expected. The unfertilized plants will, of course, also be reduced in productiveness during this period but their lesser crop should at least be salable and the plants should recover more quickly. With this situation as with the chrysanthemums a change in cultural practices may have allowed us to take advantage of carbon dioxide fertilization without such serious risk. In this case I would suggest that rather than build up the excess number of shoots per unit area that the grower slightly increase his growing temperature in the fertilized houses during the bright period not forgetting to reduce them immediately with the onset of overcast weather. In this way production can at least be increased during the bright weather. It is my understanding that tests on roses using higher temperatures along with carbon dioxide fertilization are in progress at Pennsylvania State University.

In Summary

There is considerable evidence that carbon dioxide fertilization can be worthwhile. However, it is neither foolproof nor a cure-all as some might suggest. In its use the grower should try to decrease growing time for a crop rather than increase the plant load per unit area. For most crops, especially young plants, an increase in growing temperature during bright weather — but not during dull weather — is an appropriate procedure.

Effective concentrations above 750 ppm are probably not worthwhile. Furthermore, during dull weather, concentrations of more than 300 ppm are not worthwhile. This last statement should not be interpreted to mean that there should be no carbon dioxide input during dull weather for, if there is no ventilation, greenhouse carbon dioxide concentrations may fall below 300 ppm which should result in a reduction in photosynthesis even at low light intensity.

The above points are of major importance but two other points are of interest as follows:

1. At the end of the night the carbon dioxide concentration in a closed greenhouse is higher than normal and for the first hour after sunrise the stomates are opening so that it would seem wasteful to add carbon dioxide during this period.
2. Unless there is a reasonable amount of air circulation in the greenhouse the carbon dioxide concentration near the leaf, i.e. the effective carbon dioxide concentration, may be considerably lower than the average concentration.

The economics of carbon dioxide fertilization are difficult to figure out because of many factors such as importance of quick turn-over for a holiday, percent of time the vents can be closed when the weather is fairly bright, the cost of the equipment, the cost of the gas, and, of course, the possible overall additional production. Each business situation is unique and it is beyond my competence to advise as to whether a particular enterprise should use carbon dioxide fertilization.

What I hope I have been able to do in this paper is to in-form you on the way to try carbon dioxide fertilization properly.

As a final encouraging statement for you as propagators, interested particularly in the growth of young plants, I would say that it is here where plants are relatively uncrowded and in an exponential phase of growth that I feel the largest gains from carbon dioxide fertilization are likely to be realized.

MODERATOR FURUTA: We have with us this morning Arthur Myhre from Western Washington Research and Extension Center, Puyallup, Washington. He will discuss with us at this time, "Chemical Pre-Emergence Weed Control". Arthur:

CHEMICAL PRE-EMERGENCE WEED CONTROL IN WESTERN WASHINGTON

ARTHUR S. MYHRE
Western Washington Research and Extension Center
Puyallup, Washington

The need for weed control in ornamental nursery plantings is without doubt one of the major problems which confront nurserymen in western Washington. Our moderately cool summer temperatures and abundant moisture cause weeds such as pigweed, lambsquarter, chickweed, smartweed, groundsel annual blue grass, horsetail, quackgrass, etc. to grow and spread with much rapidity. These weeds are commonly found here and are widespread in their distribution.

Extensive weed control research investigations involving the testing of chemical herbicides on different kinds of species and varieties of ornamental shrubs have been underway for nine years at the Western Washington Research and Extension Center, Puyallup, Washington. Cooperating on this project is Dwight V. Peabody, Jr., Northwestern Washington Research and Extension Unit, Mount Vernon, Washington. Our weed control studies have been designed especially for nurserymen. The procedure for testing pre-emergence herbicides is as follows: Rooted shrub cuttings are taken directly from the propagation frames and are lined out in the spring in nursery row plots. Approximately one month later herbicides are applied by machine properly equipped to provide good agitation of spray materials, accurate calibration, and adequate and uniform coverage. Previous to spray application, soil is cultivated and crop plants hoed so that soil is weedfree (no existing weeds). Weed seeds common to this area are sown to insure adequate and uniform infestation throughout the plots. In order to activate the chemical and to bring about fast weed seed germination in the surface soil, irrigation follows spray application when rainfall does not appear imminent. Generally, the herbicides are sprayed directly upon the plant foliage and between the rows and the soil thereafter is left undisturbed. However, certain herbicides were incorporated into the soil directly after application and were found to be more effective when treated in this manner.

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Each year, for a period of at least four years, herbicides are applied at the same rates upon the same group of shrubs. At the end of this period, the shrubs are taken out bare-rooted, the soil in the rows of the most promising treatments is rotovated and sown to a test plant, (oats), which are extremely sensitive to herbicides. This test is made because nurserymen are much concerned regarding persistence of chemicals in soils that have had repeated yearly applications.

Results obtained from these investigations indicate that when properly applied certain chemicals will do an excellent job of controlling many kinds of weeds with little or no damage to a wide range of ornamental shrubs. It was observed that the correct application rates for a particular herbicide varies to some extent with the type of soil, the amount of soil moisture and the kinds of weeds to be controlled. Repeated herbicidal treatments applied on the same group of shrubs over a period of years show that different species vary considerably in their tolerance. It cannot be assumed that when one variety of shrub shows tolerance, then all varieties within the same group or family likewise will react similarly. An example of this can be cited from results obtained on holly. No plant injury was noted on English holly upon receiving yearly herbicidal applications. Japanese holly, however, has shown foliage discoloration and decreased plant growth with similar chemical treatments. Other shrubs that also show varying degrees of tolerance are rhododendrons, azaleas, boxwood and viburnum.

More than sixty herbicides have been tested to date. Of those that have been tested for five years or more, Simazine, Casoron, and Herban have performed best. Treflan, tested only in 1965 also shows promise. Combinations of Paraquat, a contast herbicide, with Simazine and Casoron applied as a directed spray, has merit and should be useful for certain situations.

Simazine 80 *W* has been on test for nine years. It has long residual life and has given good to excellent all summer control of annual weeds at 2 and 4 pounds, respectively.

Coniferous evergreen shrubs have shown much tolerance to this herbicide, whereas some broadleaved evergreen shrubs are somewhat sensitive. These are *Azaleas* 'Hinodegiri', 'Caroline', 'Mollis', *Buxus sempervirens.*

No plant damage has been noted on the following shrubs at four pounds: *Arctostaphylos Uva-ursi, Chamaecyparis* pisifera 'Cyano-viridis', *C. Lawsoniana* 'Ellwoodii', *C. pisifera* 'Plumosa', *Cotoneaster horizontalis, Erica carnea, Erica darleyensis, Euonymus radicans, Ilex aquifolium. Juniperus chinensis* 'Pfitzeriana', *Prunus Laurocereasus* var. *Zabliana, Pernettya mucronata, Potentilla fruticosa.* Rhododendron varieties 'Blue Diamond', 'Cynthia', 'Jock'. 'Sapphire', *Taxus baccata* and 'Repandens', *Thuja occidentalis* 'Globosa' and 'Umbraculifera', *Veronica cupressoides;* two pounds: *Ilex crenata* (established plants), *Osmanthus Delavayi, Pieris japonica, Rhododendron mucronatum, Viburnum Davidii, V. Tinus.*

Results to date indicate good assurance that new plantings of ornamental shrubs can be set out within a reasonably short time in soil that has previously been treated with Simazine 80 W. Oats were planted for several years in soil that had applications of this chemical at 2, 4, 8, and 16 pounds for three consecutive years. Amount of damage to oats varied the first year from no injury at 2 pounds to complete kill at 16 pounds, the seecond year from no injury at 4 pounds to moderate injury at 16 pounds, the third year no injury at 16 pounds. Good tilth was found to be essential to rapid breakdown of the chemical.

Casoron 50 W has been on test for five years. It has fairly long residual life and has given good to excellent control of summer annual weeds at rates ranging from 8 to 12 pounds, respectively.

No plant injury has been observed on the following shrubs with application rates of 12 pounds: *Azaleas* 'Hinodegiri', 'Mollis', *Rhododendron mucronatum,* 'Blue Diamond', 'Sapphire', *Buxus sempervirens;* 8 pounds: *Azalea* 'Caroline', 'Rosebud', *Rhododendron* 'Bowbells', 'Jock', *pemakoense, Pieris japonica, Viburnum Davidii, Osmanthus Dalavayi, Ilex crenata* (established plants).

Casoron 50 W has given excellent control of field horsetail, a common perennial weed in western Washington. Applied in June to freshly worked soil at 8 and 16 pounds, 75% and 98% control, respectively, was in evidence one year later. A two year treatment at the same rates seems to have completely eliminated it from the plots. Less control was obtained when it was applied to emerged horsetail in September.

Preliminary tests in which the 50% wettable powder at 12 and 16 pounds, and the 4% granules at 150 pounds and 200 pounds were incorporated into the soil, show 100% kill of quackgrass for all treatments. Plots badly infested with this perennial weed were rotovated thoroughly in May just previous to application.

Herban 80 W has been on test for five years. It has fairly long residual life and has given good to excellent all summer control of most annual weeds at rates of 4 and 8 pounds, respectively.

No plant damage was observed on the following shrubs at 8 pounds: *Osmanthus Delavayi, Pieris japonica, Rhododendron mucronatum,* 'Blue Diamond', 'Bowbells', 'Jock', 'Sapphire'; 4 pounds: *Azalea* 'Caroline', 'Hinodegiri', 'Mollis', 'Rosebud', *Rhododendron pemakoense, Ilex crenata, Viburnum Davidii.*

Plant performance of the majority of the shrubs tested with the above chemicals at the desirable rates has been consistently better in comparison to untreated shrubs. It is a well known fact that weeds deprive plants of moisture, nutrients, sunlight, and interfere with their root development, thereby resulting in reduced plant growth and poor quality plants. It is inevitable that the use of weed killing chemicals will have an enormous influence on future ornamental nursery operations.

MODERATOR FURUTA: Thank you, Arthur, for a most interesting presentation. We will now open our question and answer period on the talks we have heard so far this morning.

MR. DAVID ARMSTRONG: I would like to ask Harry Kohl what is the effect of air pollutents on CO_2 in the air and what is the natural level of CO_2 in the air.

DR. HARRY KOHL: The natural level of CO_2 in the air is about 300 parts per million. The effect of pollutents on CO_2 is nothing — directly — but the air pollutents can affect the photosynthetic mechanism and make it impossible for carbon dioxide to do anything valuable.

MR. JOHN DRUECKER: What is the effect of the various pre-emergence weedicide chemicals on large-leaf rhododendrons? Have you had any experience with them?

DR. ARTHUR MYHRE: No. The only rhododendrons we have used like those are the large-leaf Cynthia; some of these large-leafed rhododendrons seem quite tolerant — things like Sapphire, Jock, and Beau Belle; but in our experiments we have limited amount of ground. It would take acres and acres to try all these different plants. W try to hit the high spots and take one or two rhododendrons. Generally the broad-leafed evergreens tend to be quite tolerant to the chemicals we used — at least with the varieties that we had.

DR. O. A. BATCHELLER: In connection with Peter Lert's comments about growth control in plants and the use of maleic hydrazide, one of our students wrote an undergraduate thesis on foliage plants; with *Aralia elegantissima* and *Dieffenbachia* he found beautiful control. It gave branching on *Dieffenbachia*. On *Aralia elegantissima* there was beautiful breaking and plant compaction. I feel this is a perfect thing for indoor pot plant growers.

MODERATOR FURUTA: At this time I would like to turn the program over to your next moderator, George Dobbins, so we can get on to the next group of speakers.

MODERATOR DOBBINS: Our first speaker on this symposium on Propagation by Seeds and Spores will be Percy Everett, who we really don't need to introduce at all because you all know him, our past leader, from the Rancho Santa Ana Botanic Garden in Claremont, California. He was given the title "Native Plants of Commercial Value". Percy:

NATIVE CALIFORNIA PLANTS OF COMMERCIAL VALUE

PERCY C. EVERETT
Rancho Santa Ana Botanic Garden
Claremont, California

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I am not quite sure how the title of my discussion fits into a "symposium on propagation by seeds and spores" as it will deal in only a minor way with the role of seeds in the production of commercially valuable native plants and certainly not at all with spores. Further, I am not altogether sure a discussion of the salable qualities of a plant is proper when our main concern is with the various means whereby we can produce by the most economical procedures.

And I am not at all certain that I am the one to carry on this discussion. A "dyed-in-the-wool" enthusiast by nature, I am often accused by some of my close friends of gross exaggerations known as "Everettisms"! Be that as it may, I shall endeavor to look at the subject with a critical eye.

One has only to peruse the literature as far back as the early years of the 19th century to gain an understanding of the role the native plant of California has played in the worldwide field of horticulture. Especially is this true in the European and British literature. Through the earliest pages of the *Gardener's Chronicle, Curtis' Botanical Magazine,* and *Revue Horticole,* to name a few, one finds numerous references to our native plants. In our day many notable publications such as *Sunset Magazine* and the *Journal of the California Horticultural Society* as well as many other periodicals seldom fail to have some article on the qualities of our native plants. You have even requested a discussion of California native plants in this symposium.

Yet what does one find in the nursery trade today? Almost daily, by phone, mail, and personal visit, I am continually asked the question, "Where can I buy such and such a native plant?" True, there are many of the more common varieties found almost universally in the California trade, but by and large there is a woeful lack in nurseries of many of our fine plants. And I know the chief reason — at the least I think I do! Probably our native plants are in the same category as American Indians — too much competition from more vigorous races! While there are few plants offered for sale that can hold a candle to our native plants for profuseness of flowering, the natives should probably have the foliage and flowers of camellias or rhododendrons, the fragrance of roses or jasmine, the disease-resistant roots of any number of introduced plants, the ability to grow under any kind of cultural condition. It is not their fault that the native plants were born and raised in an arid climate and were not introduced here from a faraway country — you know, the grass is greener on the other side of the fence — nor is it their fault that nursery salesmen, both wholesale and retail, have to know something about them. There is a woeful lack of information concerning our native plants among those endeavoring to move them into commercial channels.

How much time and effort have been spent on the hybridization and breeding of the native plants? Comparatively little, when balanced against the time and effort spent with many other groups. However, let us now examine a few that may hold some interest. My choices will not follow the usual line of Ceanothus, Arctostaphylos, Baccharis, Toyon, or Rhus. We all know about them. I shall discuss four plants and show you how they look. If we may have the slide now, we'll go ahead.

(Slides with talk from this point)

Heuchera 'Santa Ana Cardinal'

Among the several species of *Heuchera* native to California, there is a rather vigorous insular entity known as *Heuchera maxima*. It has large, roundish leaves that may turn a deep crimson any time of the year, and 18" to 2' stems surrounded by a large inflorescence of small creamy-white flowers. Under best cultural conditions it is moderately rapid in growth.

After observing this plant for several years, growing on a shady hillside with rocky adobe clay soil, and noting its hardiness, we began to wonder if a more colorful plant could be produced by hybridizing it with *H. sanguinea*. Although this combination had been attained by others, the upshot of it was that nothing very successful was produced until Dr. Lee W. Lenz, Director of Rancho Santa Ana Botanic Garden, started serious work on the project.

The most vivid and deepest red strains of *H. sanguinea* were searched out. Then began the processes of crossing and back crossing; along the way a number of interesting clones were produced. However, we were searching for the plant with the brightest flowers combined with a sturdy, tall, upright stem, relatively large inflorescence, and the general growth habits of *H. maxima*.

The study of many clones gradually narrowed down to the final selection of the clone we offered for introduction into commercial channels. We have preserved at the Botanic Garden many of the other clones, but although we have noted a demand from nurserymen and landscapers, no other clones have been released.

Flowering peak for *Heuchera* 'Santa Ana Cardinal' occurs during March to July with sporadic flowering through the year. Since asexual reproduction is necessary for continuous production of the clone, it fortunately is relatively simple. As soon as each plant is large enough to produce several branches, it can be lifted and the branches cut from the main stem. By careful procedures, 100% rooting can be attained. Our gardeners often dig up a large clump, tear it apart, and replant the unrooted branches. A very large percentage will take root and quickly fill in vacant spots.

Deigaard Nursery, Monrovia, California, undertook the process of naming and introducing *Heuchera* 'Santa Ana Cardinal' to the nursery trade.

Pacific Coast Iris

Searching for novelties to satisfy the increasing appetite of the specialist and enthusiastic amateur, the iris growers have brought into the trade many interesting color combinations produced naturally among the widely scattered species throughout the Pacific Coast states. Most of these were color selections of *Iris douglasiana* and *I. innominata*. More thorough searching during the past 15 years has revealed a wealth of what is presumed to be natural hybrids.

Seeking to improve upon what Mother Nature already had done, Dr. Lenz sought out and studied all the native species, and brought together in one place a wide selction of color forms. It appeared that to produce an acceptable clone for the commercial interests, several qualities had to be introduced into the various strains. Most of the native species flower rather profusely, but their flowers may be small, down among the foliage; they may have poor standards or very narrow falls, or spindly weak stems. These needed to be corrected, and this we set out to do.

Since then a multitude of color combinations and tall, upright, strong-stemmed clones with flowers above foliage, broader falls, and stronger and broader standards have been developed. They have become extremely popular with our visitors.

If seed were sown, still greater color combinations would be produced, and iris seed is relatively simple to germinate. Just sow the seed either in its site or in a flat and wait for about a month. Of course, embryo culture can be employed, but on the whole the simple methods are the quickest and best. The technique of dividing the clone needs only one strict rule to follow — start irrigating the plants in early fall and when examination shows white new roots about an inch to two inches long, then dig them up for clonal increase — never during the dormant summer periods.

Berberis 'Golden Abundance'

The progeny from seed harvested in the Botanic Garden are always observed with a critical eye for some unusual feature. Invariably we have discovered that Botanic Garden harvested seed will produce any number of hybrids when, of course, more than one species of a genus is present.

This was the case with our immediate subject. While nothing particularly unusual among a large group of *Berberis amplectens* seedlings showed up in the seedling stage, after two years in the Botanic Garden the wide variation among the plants was quite evident.

When the first flowering season was in full swing, we noted with considerable interest one plant with masses of large, somewhat drooping clusters of golden flowers, later followed by an equally attractive fruiting period. Here was an exceptional plant. The plant continues to prosper, and is even more beautiful with large leaflets of shiny dark green leaves and a rather compact habit of growth. It is now about 5′ tall, 4 years from seed.

Although we first considered it a cross between *B. amplectens* and *B. piperiana,* we are now quite confident it is a cross between *B. amplectens* and *B. aquifolium.*

What about its asexual production? The various species of *Berberis* have always been somewhat difficult for us to root. Yes, we have had nominal success, but not what could be called good. However, this hybrid was rooted reasonably well, in the

65% - 75% average, with best results occurring in November when cuttings were firm and beginning to turn a slightly reddish color — treated with regular Rootone and put under mist and fogging conditions in 50% perlite and 50% peat moss.

I believe this clone is worthy of introduction to the trade. It looks good in a gallon container, is moderately fast in growth, has clean dark shiny green leaves, and produces an abundance of flowers in large drooping clusters to be followed by equally beautiful bunches of dark purply-blue fruits. Above all, it can accept plenty of water. Do I have any takers?

Fremontia 'California Glory'

In the winter, 1962, issue of "Lasca Leaves" (Vol. XII, No. 1) a publication of the Los Angeles State and County Arboretum, Arcadia, California, there was published my formal description and other pertinent information concerning this cultivar.

We had observed this presumed hybrid of *F. californica* x *F. mexicana* for some ten years| After our formal introduction, rooted cuttings were sent at their request to the Royal Horticultural Society testing garden at Wisley, England. Some two years ago I visited Wisely and there saw our cultivar growing reasonably well in a protected site adjacent to the administration building. Nearly a year ago a picture and an extensive article about it appeared in *Gardener's Chronicle.*

Just recently I received a letter from Lord Talbot de Malahide who grows all sorts of plants in his castle grounds near Dublin and who visited the Botanic Garden about two years ago. Lord de Malahide discussed some of his results with California native plants, some of which we had sent him. In his discussion he referred to various types of fremontias he was cultivating, with comments on growth and results. He went on to say that just recently Frank Knight, Director at Wisley, had shown him a branch of *Fremontia* 'California Glory'. Lord de Malahide's comment was "An astounding plant"! Now watch out for an "Everettism"; his sentiments are exactly our own because this plant at the zenith of its flowering is certainly a most glorious spectacle. Visitors by the hundreds have told us they wait until after the middle of April to visit the Botanic Garden so they can enjoy the beauty of this plant.

To my knowledge descriptions of methods for clonal production of *Fremontia* by asexual means had not appeared in literature, at least I could not find any, and judging from questions put to many propagators I thought failure would be our lot. (Even the propagators at Wisley have rooted only one!) Such was not the case, and with some experimentation we have been able to produce all the plants we need and have some left over for others.

While we have taken and rooted the cuttings in various seasons, we get best results in the fall from firm tip growth, treated with Rootone, and bottom heat. An expert propagator tells me that he has had nearly 100% rooting, and I believe him, and have seen his results. But other professionals have not fared so well.

In a gallon can, this would be a good, salable item because huge flowers clothe the stem the first season. But like the species, a weak root has been inherited and while our mature plant losses are minimum, they might not be so for the commercial producer. While some fine plants are produced, seedlings are highly variable and losses are high from the many weaklings in every lot. So what does one do until a satisfactory root system is found for this fine cultivar? We continue to search for and to study various characteristics of other genera within the same family. And until we find a suitable understock, this beautiful flowering shrub may never be fully accepted.

MODERATOR DOBBINS: Thank you very much, Percy. We will move on now to our next speaker, Mr. Eugene Baciu, from Santa Barbara, California, who will speak to us on seed collecting. Gene.

METHODS OF SEED COLLECTING

EUGENE BACIU
Mistletoe Sales, Wholesale Seeds
Santa Barbara, California

There are many ways to get started in the seed harvesting business. In 1952, I was gathering dry materials for the florist trade, and one day on the way to the disposal area a nurseryman stopped me and asked what I was doing with the load of *Strelitzia nicolai podds*. He was informed that the color was not suitable for the florist trade and the pods had to be discarded. His reply was that the nursery growers "could surely use the seeds in those pods." So the pods were returned home, the seeds extracted, and a trip to Los Angeles was made. I received .02 cent each for the seed and a list of different shrub and tree seeds that were in demand. Now all that was necessary was to match the odd latin names to the trees, so you can imagine what a time one would have, not knowing one plant from another. After much misinformation, many mistakes and much time studying, the list was ready to go out to the growers. The first years were spent in supplying seed brokers.

There are many problems that arise in harvesting seed; I will attempt to give a few that cover the wide ranges of methods used.

Many of the trees and shrubs do not bear fruit every year and some will go many years before they set a crop. A good example of this is *Araucaria bidwellii*, which has a very good crop about every fourth year; in between, the crop is almost nil.

The method used in harvesting *A. bidwellii* is to gather the cones from the ground, or from the trees when the cones are beginning to fall very heavily. These are brought into the yard and as they fall apart, each petal is handled separately. There have seen his results. But other professionals have not fared so well.

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The method used in harvesting *A. bidwellii* is to gather the cones from the ground, or from the trees when the cones are beginning to fall very heavily. These are brought into the yard and as they fall apart, each petal is handled separately. There are many empty seeds, and these must be separated from the viable seed. Cleaning steadily, one can get about 3000 seeds in 8 hours. These seeds must be kept fresh, with the moisture content at 60%, or the seed loses its viability. This is a good species to illustrate one of the biggest problems a seed collector faces; this is to let the grower know how best to plant and care for the seeds. With *Araucaria bidwellii,* the seed is covered just enough to hold it in place. Then after about one month you dig up a small root or tuber and plant it with about a quarter of an inch above the soil line in the container. This gives you a plant in a short while. Otherwise it takes up to one year for the leaf shoot to come out above the soil level.

Cedrus deodora seed has always been a problem. Imported seed, after its long transportation period and fumigation, has a low percentage of viable seed.

After much looking in a very wide range of climatic conditions from San Diego to Oregon, sufficient trees were located that would give a crop each year. First there must be a rain in October, and more than one tree in a locality is necessary to insure good pollination. In August of the following year you can start checking the cones. At this time they are starting to firm up from the milky stage of the immature seed. Along in mid-September or the first of October the cones will start to pop (shatter) and the seeds will be lost. You have to work fast when the cones are ready to harvest. The way to do this is to climb the tree with a pole ten feet long and a strong curved hook attached at one end. A quick pull will usually get the cones from out at the ends of the limbs. The smaller trees are best for ease in picking.

After the cones are gathered, they must be put in the sun so that the pitch will dry and the cones can be broken. This must be done with care, so that the seeds are not damaged. This is done by hand — using a hammer to open the cones. Next is the screening so that the seed can be separated from the bracts. This presents quite a problem since the wings on seeds are about the same size as the bracts. With 1¼ inch wire screen you can get about ¾ of the bracts out of the seed at the first screening. The next screening is done with a ¾ inch hardware cloth, and this gets the rest of the bracts and part of the wings. Removing the rest of the wings is done by putting the seed in a sack and working them gently back and forth and around, then blowing the wings from the seed. Next, increase the velocity of the wind and by so doing you can remove the empty seed from the viable seed. For storage of *Cedrus* seed the best method is to mix the seed with about ⅓ bracts and ⅔ seed in paper cartons of about 3 cubic feet capacity. In this way the seed can be kept six to eight months without loss of germination, as long as the seeds do not become overheated or lose their moisture.

Mahonia aquifolium is an unpredictable plant. It is the state flower of Oregon, and is spread all over the state. About the end of July is the best time to gather the seed. After many years of travelling along Oregon's highways and secondary roads the locations of many acres of *Mahonia aquifolium* plants have been found. There are a few large groupings of this plant but most are found in patches along the fence lines and roadways. A large percentage of time involved is in travelling along the roads looking for a patch that is covered with berries. We use twenty-gallon plastic pails and a stick about two feet long. Gather a bunch of stems in the pail, and hit the stems with the club till the berries fall off into the pail. This is much more simple than picking by hand and more productive. You can pick about 400 pounds in a day this way but when the crop is poor it may take a week to get half that amount.

To clean the seed you can use a vacuum cleaner. At the right speed this will mash the berries and release the seed. Wash and drain the seed but do not dry. Now they are ready for planting or storage.

To obtain *Philodendron* seed, first you have to consider the pollination of the flower. After about three months, the fruit will ripen. This occurs when the upper part of the fruit falls off, leaving the lower part for the birds to eat and distribute. At this time, cut the fruit from the plant and remove the berries into a cloth sack. Tie the sack tight and work the juices and pulp through the mesh of the stack till you have only seed and the large parts of the fruit left. Screen this from the seed, wash and put out to dry in the shade. After the seed is dry, store in an air-tight, dark container.

Pine seeds do not present too many problems. The number one job is to get the cones at the right time. The cones are gathered by climbing the trees and picking by hand. Some cones open easily during the heat of a forest fire; the next best method is to take them to the desert. With a temperature of 110° in the shade and, of course, no shade, the cones open rapidly. *Pinus radiata* cones, under the right conditions, will open in one day. All that is left to do is wing the seed and blow the empty hulls out of the good seed and they are ready for planting or storage. Some conifer seed, like *Sequoia sempervirens,* can be shaken from the trees. All you need for this is enough tarp to cover the area around the tree. A good material for tarp is polyethylene sheeting. The weather must be right to successfully gather seed this way. You climb the tree, and starting at the top, when the wind is in the right direction, shake the limbs, completing the work before the wind changes.

Harvest time is an ever-changing time. Some plants that have been transplanted to our Western shores just don't know when to flower and the seed to ripen. Some will have a harvest time variation of two to three months or more, so you have to check on your seed sources every so often — first to see if there is going to be a crop and then when to harvest the seed. Sometimes wind or heavy rainstorm will destroy the crop and some of these sources are four or five hundred miles away. The only way to overcome this is to have many different climatic conditions. This will give different maturity times and give one a better chance.

Another example is *Arbutus unedo.* The plants might be ready for seed harvest any time of the year. First one must find a tree with good character and a heavy crop of fruit. When the fruit starts to drop, pick it from the ground at least once a week. Wash the small seed and pulp through a $\frac{1}{16}$ inch mesh screen, then through a small-meshed window screen. This will wash the small sand-like material from the seed. Dry inside, out of the sun, and then keep under refrigeration until planted.

Soft seeds must never be exposed to sun or heat. Most seeds of soft-fruited plants should be dried inside or kept moist until planted. Other seeds must be cleaned and planted as soon as possible. *Syzygium paniculatum* or *Eugenia myrtifolia* are good examples of this. Just spread a tarp under the tree, climb up the tree, shake it vigorously and if the berries are ready, down they come, with flowers, leaves and stems. Blow the leaves and flowers from the berries, then mash the berries and wash the fruit pulp from the seed. Keep the seed moist until planted. Permission to gather seeds in most instances is no problem. Most home owners are happy to let you have the seed. Often it is a problem to explain for what purpose you are collecting seeds, since some people do not analyze how a nurseryman gets his plants. Some think all nursery plants grow from cuttings only.

MODERATOR DOBBINS: A very interesting talk, Gene. Now our last talk this morning will be by David Roberts of El Modena, California, who will discuss a subject we do not hear about often — propagation of ferns. David:

MODERN PROPAGATION OF FERNS

DAVID J. ROBERTS
Roberts Wholesale Nursery
El Modena, California

Two decades ago, commercial fern sporing firms in the West were generally small, "hit and miss" operations with insufficient scientific knowledge and capitalization to insure consistent production in an expanding market. Today, increasing availability of new insecticides and fungicides, as well as ample help from State Universities, County Agricultural Offices, and private soil laboratories, contribute much to our knowledge and efficiency.

With all this help at our back those of us in the trade still have our everyday problems in this devious art of artifically encouraging sporogenesis. It is through exchanges of information ,such as we are participating in today, that difficulties will be alleviated or resolved.

To begin let us review and discuss some of the mysteries about ferns that botanists have unfolded for us.

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To begin let us review and discuss some of the mysteries about ferns that botanists have unfolded for us.

The probable ancestors of ferns and mosses were liverworts, which appeared on earth long before seed plants. Yet, while they resemble liverworts and mosses, ferns also bear a resemblance to plants propagated from seeds. Both mosses and ferns require water to fertilize, and both have similar structures.

Ferns are widely distributed throughout the world in climates ranging from moist to dry, and species native from British Columbia to Tasmania are propagated and distributed here in California, where a variety of climates exists.

Ferns as we know them with roots, stems, and fronds are the asexual or sporophyte generation. The sexual or gametophyte generation is a small, independent plant devoid of roots, stems and leaves, and is called prothallium. Interestingly, then, ferns go through two separate processes, and in the second, they transcend the liverworts and mosses so majestically that they become the soaring, sixty foot tree ferns of New Zealand, matching the beauty of "higher" plant forms.

The spores appear as brownish 'dots" under fronds in clusters of sporangia, or spore cases. The sporangia form small groups called sori. In some ferns the sorus is covered by a protective outgrowth called indusium. The tissue of each sporangium forms sixteen spore mother cells. Each of these divide into four spores. Most fern spores have two coats, or wall layers. The tough outer layer (exine), and the delicate inner layer (intine).

The chromosome laden spores are discharged from the sporangia, and the under favorable conditions of moisture and temperature, water is absorbed by the spore, the exine is ruptured, and the spore contents surrounded by the intine protrude as a short tube.

Cells elongate and multiply until the flat, green plate of cells called prothallium is formed. This develops temporary roots called rhizoids. In most ferns each prothallium bears both male and female gametangia. Some species, however, have male and female parts on separate gametophytes with the female being the larger and developing later.

The male chlorophyll-bearing cells (antherida) develop into sperms. In the presence of water the neck canal of the female cell (Archegonium) swells, and the cover cells open allowing the sperms to swim down the neck canal to the egg. A number of sperms may be attracted to the Archegonium, but only one fuses with the egg.

At fertilization the chromosomes double, and the resulting nucelus in the fusion of sperms and egg is called a zygote. The zygote nucelus has male and female chromosomes in equal number.

After fertilization the zygote divides and develops into the "fern plant" or sporophyte. Now, the primary organs of the embryo are developed. These are:

1. *The foot* which temporarily connects the sporophyte with the prothallium, and supplies food and water to the young

embryo until it develops its own roots.

2. *The root* which grows downward into the soil.
3. *The primary leaf* which is a temporary leaf little resembling the permanent fronds, but serving as the first photosynthetic organ of the sporophyte.
4. *The stem* which becomes the rhizome from which fronds and permanent roots arise.

In the early stages of embryo development the young sporophyte is entirely parasitic upon the prothallium. As soon as the primary root and leaf are developed, however, an independent organism is formed. The gametophyte withers, and the foot ceases to function. Of the four structures mentioned, only the stem (rhizome) is permanent. This soon develops fronds and roots, and the primary root and primary leaf die. The fern as we know it is "born".

Now, let us reveal some of the practical procedures by which we in the commercial nursery propagate ferns from spore. As we go along, keep in mind the two separate processes just covered, the sexual or prothallium generation, and the asexual or sporophyte generation.

Commercially, spore is asquired in several ways. In addition to gathering spore from a nursery's own stock plants, it is possible to secure spore from foreign seedsmen, fern collectors, campuses, parks, arboreta, and from other nurseries.

Those ferns that are low-growing, ground cover types, mature early, making it possible in some cases to collect ripe spore from one gallon size plants. In this group would be the Maidenhair and the Rabbitsfoot ferns. Intermediate height species usually mature for spore collection at about five gallon size. In this class would be Leatherleaf, and the Brake ferns. Tree ferns must be about seven gallon specimen size, or larger before ripe spore may be taken.

Let us now suppose that we have located a mature plant at the right time of year, and that the specimen appears to be sporiferous. With our magnifying glass we will now examine the underfrond, checking to see that the spore cases are neither an unripe "green", nor that the sporangia is open, and its contents spent. It is possible to remove a frond that includes an unripe to over-ripe sequence. By so doing we can be reasonably sure that ripe spore will be included in the gathering.

The frond now removed is put into a large manila envelope and allowed to dehydrate for a week or two at dry room temperature. This causes the spore laden cases to be released from the withered frond. When the crisp frond is finally removed from the envelope we see inside a composite of sporangia, indusium, spore, and waste matter which we will call chaff.

This done, the task is now to extract the "pure" spore from its protective tissue and from the chaff. This is done by a series of usually three screenings. The spore of some species is so minute that the final screening is performed by passing the spore through a women's nylon stocking. After refining, the nearly pure spore can be poured into small vacuum tight jars, and stored for future use.

Growers differ in their opinions as to what is the best medium upon which to sow fern spores; this disagreement is understandable when one visits the native habitats of ferns, and sees the wide range of soils upon which the plants fertilize and thrive. In Africa, Water Ferns grow upon lakes with no soil at all present. In our own San Diego County of California we see Maidenhair Ferns clinging to sandstone banks, where rainfall is less than fifteen inches a year, and precipitation occurs only in winter and spring.

Most ferns can be spored successfully on a mixture of two-thirds peat moss, and one-third perlite (Sponge Rok). An ordinary nursery flat can be filled, and carefully levelled for this purpose. All soil components, tools, flats, and greenhouse surroundings should be sterilized before the spore is sown. Greenhouse temperature should be held in the range of 65° to 75° through the use of evaporative, or other cooling, and thermostatically controlled heat. Bottom heat, also, has proved to be an aid in accelerating fertilization. At this early stage a heavy whitewash coating on greenhouse glass should be supplemented with an outside saran covering, or the inside draping of cheeesecloth.

These preparations made, the spore is poured from the small air tight jars onto a clean sheet of ordinary 8½ x 11 inch writing paper. By cupping the sheet in the palm of one hand, and tapping at the bottom of the paper with the opposite hand, the spore can be dusted evenly onto the soil medium. The spore is further purified during this process by the gravitational sliding of the paper's contents. Care must be taken that the distribution is performed without wasteful caking or neglect of sowable area. This is especially so, since the dark spore color of certain species blends inconspicuously with the moist peat moss mixture.

After sowing, the flats are covered with 18 x 18 inch sheets of glass, and kept moist by frequent misting. To avoid damage from salts or chlorine in tap water, distilled water is dispensed from Hudson type pressure sprayers.

"Fertilization" usually takes place within three to six weeks. Beyond this time cell growth is unlikely. We have no answer to the riddle of why apparently ripe spore, taken fresh from healthy specimens fails to fertilize. The sexual generation now appears on the soil surface as a green "moss". As the cells continue to elongate and multiply, a fairly even ⅛ inch thick "stand" soon covers the soil in the flat.

Some troubles may now appear in the form of the fungal disease, *Rhizoctonia solani*, and in the presence of fungus gnats, and their larvae. Any browning or greying of the felt-like surface of the culture is the indication that pathogens are present. The spread of the fungus may usually be stopped through the local use of a mild, protectant fungicide solution. The gnats are able to pass around the glass covering, and produce larvae which attack from just below the surface of the soil. Sprinkling dieldrin granules over the forming prothallium generally controls these gnats.

It is now time for the first transplanting. Again, an ordinary nursery flat is filled with soil mix. The Sponge Rok, however, is replaced with screened, steamed leaf mold. Using a sterilized dibble, small indentations are made in the new soil surface in the amount of about 324 per flat. Small "dabs" of prothallium (about the size of a 6 d nail head) are removed from the original flat with tweezers and transplanted to the accommodating recessions. Light feeding with a mild chemical fertilizer may be introduced as the tiny pads grow and expand.

Our original flat contained several thousand potential sporophytes. The prothallia discs in the subsequent flats will expand to about the size of a dime. These plates in turn will be divided several times as the primary leaves appear.

In the second removal we will transplant, along with bits of prothallia, the connecting feet, primary roots, primary leaves, and stems. The sporophytes at this progression are still parasitic upon the prothallia. They are planted into the peat moss — leaf mold mixture in the number of about 160 per flat.

Finally, the feet wither, primary roots and leaves die, and the remaining stems become the rhizomes with their fronds and permanent roots. Thus after two transplantings we have produced the "seed" flats of the fern-growing trade.

Not all the young ferns will be eligible for shifting to liner pots. For in the continuing development of plantlets at varying periods, a lack of uniformity develops. The rejects are graded according to size, and replanted into flats where they remain until ready for potting.

So, with the help of modern facilities, fungicides, and insecticides we have retracted a prehistoric and marvelous process of Nature. Through the continuation of this work, and with the help of scientific organizations and educational institutions, we are hopeful that many more of the 9000 species of ferns may be made available for the enjoyment of Westerners.

MODERATOR DOBBINS: Thank you, David. Now we will open the meeting for questions.

MR. WALTER VAN VLOTEN: I would like to ask Percy if this *Fremontia* 'California Glory' is hardy in British Columbia.

MR. PERCY EVERETT: Well, I really don't know. It has not gone far enough astray yet. It was growing rather satisfactorily in Wisley Garden in England. In Dublin, Ireland, there was a specimen, not of *Fremontia* 'California Glory', but of a *Fremontia* hybrid which undoubtedly was very close to it and it was 25 feet tall. It had survived there. I just don't know. This is something that we have to find out. I would be glad to have some plants tested.

MRS. IRENE BURDEN: I was interested in the hardiness of the *Heuchera.*

MR. PERCY EVERETTS. Well, *Heuchera sanguinea* has considerable hardiness in it. It is a native of Arizona and the Southwest. One of the parents — the one that was used — was obtained from Carl English around Seattle. I would say that it would probably be the same hardiness as *Heuchera sanguinea.* It is a much larger plant, of course, and produces a great amount of tall, upright stems. I counted as many as 150 stems on it.

FRIDAY EVENING SESSION

October 22, 1965

The Sixth Annual Banquet was held in the Main Banquet Room of the Los Gatos Lodge.

The speaker of the evening was Dr. Hudson T. Hartmann, University of California at Davis who spoke and showed slides on the subject, "Plant Propagation in Italy".

SATURDAY MORNING SESSION

October 23, 1965

The session convened at 8:00 A.M. in the Conference Room, Los Gatos Lodge, with Dr. Andrew Leiser, Department of Landscape Horticulture, University of California, Davis, as moderator. The session started with a Question and Answer period covering the tour of the Saratoga Horticultural Foundation. Mr. Maunsell Van Rensselaer, Director, Mr. Dwight Long, Mr. Barrie Coate, and Mr. Brian Gage, all of the Foundation, were on the Panel.

MODERATOR ANDREW LEISER: Two people have asked essentially the same question — Jack Crossley and Mary Ryan. Both have asked in essence, "What is the modified U.C. mix and feeding program of the Foundation for your container trees?" Jack Crossley is referring particularly to the 15-gallon Liquidambar specimens.

MR. BARRIE COATE: Our modified U.C. mix, as you might call it, is composed of two-thirds fine redwood sawdust and one-third sandy loam. It is based on a redwood sawdust, sandy soil mix with nutrients added, as the U.C. Mix prescribes. The sandy loam is a 60% fine sand, 27% clay, and 13% silt loam.

very drop-tolerant and this clone is, of course, a selection for a fruitless quality. It is a dioecious species; we have selected a male form, a fruitless form, and one with an upright, well-branched head. The species itself is a very good tree; bright green, always healthy, very drop-tolerant, and then the male clone, of course, additionally eliminates the possibility of any seed which would be messy if it were used as a street or yard tree.

MODERATOR LEISER: Our next speaker on this symposium is Jack Crossley from the Canada Department of Agriculture, Saanichton, B.C., Canada. His crop specialties are flowering bulbs, chrysanthemums, holly and nursery crops; his current research is in the latter two areas. Today he will tell us of some of that research, 'The relationship of temperature and light to the growth and flowering of seedlings and cuttings of *Rhododendron molle* hybrids". Jack:

MR. J. H. CROSSLEY: I have enjoyed the visit to California immensely. I found it very stimulating and certainly entirely different from what I have been used to. I do want to thank you in all sincerity, on my own behalf, and I am sure the delegation — the other seven from British Columbia — are equally grateful for the way you throw things open to us with no holds barred. When you come up our way we hope we can reciprocate in some small way.

LIGHT AND TEMPERATURE TRIALS WITH SEEDLINGS AND CUTTINGS OF RHODODENDRON MOLLE

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Plant propagators are always searching for ways to reduce the growing period of seedlings and rooted cuttings. This paper deals with only two factors, supplemental light and temperature, as aids to growth stimulation, marketable size and flower initiation of *Rhododendron molle*.

Stimulation of shoot growth by supplementary lighting of *Rhododendron molle* was reported in 1960 and 1963 by Weiser and Blaney (1, 2), by Spicer (4) and in 1964 by Goddard (3). Stimulation of seedlings of rhododendron (*R. catawbiense*), azalea (*R. japonicum* x *R. molle*) and their hybrids with supplementary illumination was reported in 1955 by Doorenbos (5). Weiser and Blaney showed that shoot growth of several clones was greatly stimulated by supplementary low-intensity fluorescent light (150 f.c.) between dusk and dawn. They also reported stimulated growth with prolonged illumination at light intensities of 35 to 50 f.c. and by incandescent light. They experimented with deciduous azaleas under constant illumination and grew them to marketable size in less than a year from time of taking the cuttings (2). Spicer (4) working with Ilam deciduous azaleas of which *R. molle* is a parent, reported satisfactory shoot growth with as little as three hours' supplementary illumination using 100-watt globes, 3 feet above the bench covering 12 square feet. Spicer also stated that if plants were left under the lights, kept pinched and fed, they would make strong well-formed plants, 18 to 24 inches high, in a 3-inch pot. This, Spicer claimed, was undesirable; his preference was to give only sufficient time to get them into growth and shift them to a covered frame to harden off, when the cover was removed for winter.

Goddard (3) in 1962 used dusk-to-dawn supplementary illumination to produce winter cuttings from summer-rooted stock plants and concluded that growth under 60-watt incandescent lamps in a 45° F. night minimum plastic greenhouse was unsatisfactory. On the other hand, excellent results were obtained with Gro-Lux in standard fixtures under similar conditions. He stimulated stock plants derived from June cuttings, 18 inches high at 12 months and well branched after yielding 3.5 cuttings each. At 3 months, these made salable 6-inch liners.

Doorenbos (5), exploring the possibility of shortening the breeding cycle of seedling rhododendrons and azaleas found optimum results when plants were grown in the greenhouse at a photoperiod of 24 hours (natural days extended to 24 hours) by "weak incandescent" 60-watt lights. Lateral shoots were kept removed. When plants were kept in a "very long" photoperiod at 59 to 68° F., the number of growing periods was increased; the majority of the plants grew about twice as fast as plants grown in natural days and in one experiment, 7 of 10 azalea seedlings initiated flowers in about 16 months from sowing. When 30 plants were moved outside in May, 14 months after sowing, only twelve formed flower buds.

Materials and Methods

Experiment 1 (1963-64) *Effect of light duration on seedlings.*

Two hundred *R. molle* plants sown in January, 1963, and potted in August were grown under five different light regimes in a greenhouse maintained at a 45° F. minimum from September 6, 1963 to February 14, 1964.

The five light treatments were:

1. 24 hours light (normal daylight, then Gro-Lux fluorescent dusk to dawn).
2. 20 hours light (normal daylight, then Gro-Lux fluorescent commencing at dusk).
3. 16 hours light (normal daylight, then Gro-Lux fluorescent commencing at dusk).
4. Normal daylight plus one-half hour Gro-Lux fluorescent at midnight.
5. Normal daylight.

Each plot received supplementary light by two 40-watt tubes, 20 inches above pot rims covering a 3 by 4 foot bench. Plot layout was four randomized blocks.A plot consisted of 20 plants in 4½-inch square plastic pots. Plants were fed and pinched periodically to encourage bushiness. On February 14, 1964, plant grade and height were recorded.

Experiment 2 (1964-65) *Effect of temperature and light on seedlings.*

From September 13, 1964, until April 29, 1965, 800 spring-sown, hand-pollinated *R. molle* seedlings were grown in greenhouses under two temperatures and four light treatments to determine the effect on growth and subsequent flower-bud formation. The temperatures were 45° and 65° F. night minimum provided by eight identical compartments equipped with automatic separately-controlled light, temperature and ventilation facilities. Each compartment was divided into four sub-plots, 4½ by 4½ feet consisting of 25 plants, by curtains raised at dusk lowered at 8:00 A.M., providing the four light treatments. Lights were placed 24 inches above the pot rims. Plants were pinched to encourage bushiness, an given liquid feeding until mid-August.

1. 24 hours light (normal daylight, then Gro-Lux fluorescent 160 watts, 50 to 70 f.c. dusk to dawn).
2. 24 hours light (normal daylight, then incandescent 400 watts, 30 to 100 f.c. dusk to dawn).
3. 16 hours light (normal daylight, then Gro-Lux fluorescent 160 watts, 50 to 70 f.c. commencing at dusk).
4. Normal daylight only.

Light-temperature treatment terminated April 29 (228 days). After a hardening-off period, April 29 to May 29, in unheated greenhouses, the plants were transferred to fully exposed outdoor conditions to complete their growth.

Growth increment data and plant grade were first recorded March 2 and again on September 15 when flower buds were also counted.

Experiment 3 (1964-65) *Effect of light quality on rooted outtings.*

From November 6, 1964 until April 29, 1965 ninety plants from August cuttings were given dusk-to-dawn supplementary illumination with five different kinds of lights. The object was to determine the effect of light quality on shoot growth and subsequent flower-bud formation.

Lights as listed below were placed 36 inches above the pot rims. Plot area was nine square feet of bench.

1. Mercury vapour (H.P.) Total wattage-400; f.c. 180-300
2. Fluorescent, Gro-Lux Total wattage-400; f.c. 20- 38
3. Fluorescent, Daylight Total wattage- 80; f.c. 50- 95
4. Fluorescent, Verd-A-Lite (industrial) Total wattage- 80; f.c. 40- 90
5. Fluorescent, DSW/29 (industrial) Total wattage- 80; f.c. 40- 70

Night minimum greenhouse temperature was 65° F. Cultural methods were similar to Experiment 2.

Results

Experiment 1 (*Table* 1)

Increasing the total hours of light to 16, 20 or 24 hours by supplementary illumination with Gro-Lux fluorescent in a greenhouse set for a night minimum of 45° F. resulted in graduating increase in height (3.9, 4.5 and 5.3 inches respectively) and also in percentage of grade one plants (17, 35 and 50 percent respectively) for the 161-day test period. While one-half hour of supplementary illumination at midnight with Gro-Lux resulted in a significant increase in height compared to natural day treatment, it was valueless for production of grade one, and nearly so for grade two plants.

Table 1. Effect of supplementary illumination on growth increment and grade of *R. molle* seedlings, 1964

Light treatment Sept 6 to Feb 14, 161 days (min night temp 45°F)	Hgt Incr Av [1]	% Plants grading[2] Good	Fair	Poor
	ins			
24 hrs (Gro-Lux dusk to dawn)	5.3a	50	13	37
20 hrs (Gro-Lux starting dusk)	4.5ab	35	35	30
16 hrs (Gro-Lux starting dusk)	3.9b	17	10	73
Natural days + ½ hr. midnight	3.3b	0	7	93
Natural days	0.6c	0	0	100

[1]Values with a letter in common are not significantly different (P = 05)
[2]Arbitrary grade based on leafiness and bushiness

Table 2. Effect of temperature ranges and supplementary illumination on *R. molle* seedlings, 1965

Trt No	Treatment: Night Min Temp	Light (Sept 13 to Apr 29, 228 days)	Growth results[1] in 170 days: Hgt Inc	Av Pinches/ Plant	% Gr 1[2] Plants	Grade[2] Index (all)
			ins			
1.	45° F.	24 hrs (Gro-Lux dusk-dawn)	0.7c	1.0b	19.1b	19.2b
2.		24 hrs (Incand. dusk-dawn)	1 0c	1 7c	35 3c	22.7c
3.		16 hrs (Gro-Lux start dusk)	0.1a	0 4a	0.1a	10.0a
4.		Natural days	0.1a	0.5a	0.1a	10.2a
5.	65° F.	24 hrs (Gro-Lux dusk-dawn)	2.4d	2.7d	61 7d	26 0d
6.		24 hrs (Incand. dusk-dawn)	2.3d	2.8d	73.9d	27.7d
7		16 hrs (Gro-Lux start dusk)	1.2b	1.4c	39.7c	23 0c
8.		Natural days	0 1a	0.4a	0.1a	10.7a

[1]Values with a letter in common are not significantly different (P = 05)
[2]Visual grading for leafiness, foliage color, plant vigor and bushiness, Grade index 3 = Gr 1, 2 = Gr 2, 1 = Gr 3

Experiment 2 (*Tables* 2, 3, *and* 4) — *Initial effect.*

Data for the initial growing period in the greenhouse, September 13 to April 29, 1965 indicated that growth stimulation

Table 3. Residual* effects in 139 days of temperature ranges and supplementary illumination on *R. molle* seedlings, 1965

Treatment			Percentage of plants[1]		
No	Night Min Temp	Light	Gr 1	Gr 1 & 2	w/flower buds
1	45° F	24 hrs (Gro-Lux dusk-dawn)	3 7abc	10 5b	42 3cd
2.		24 hrs (Incand. dusk-dawn)	3 0abc	11 2b	47 0d
3		16 hrs (Gro-Lux start dusk)	1.7ab	6 5a	22 0b
4		Natural days	4.7c	13 0b	30 0bc
5	65° F	24 hrs (Gro-Lux dusk-dawn)	5 0c	10 2b	60 7ef
6		24 hrs (Incand. dusk-dawn)	4.0bc	11 0b	65.7f
7		16 hrs (Gro-Lux start dusk)	3 5abc	10 7b	47.4de
8.		Natural days	1 0a	6 0a	7.0a

[1]Values with a letter in common are not significantly different (P = 05)

*Based on original treatment period, 228 days (Sept 13 to April 29) and total growth period of 367 days (Sept 13 1964 to Sept 15, 1965)

of *R. molle* during the dormant season is governed by both temperature and daylength. For example, the responses in height increment and average number of pinches per plant were practically nil under natural days at both 45° and 65° F. minimum temperature ranges, but under 24 hours light, growth increased significantly, particularly at the higher temperature.

Data also show that growth of grade one plants and grade index were most satisfactorily promoted by the higher temperature and 24 hours of light (illumination dusk to dawn, treatments 5 and 6). At 65° F. the two kinds of supplementary illumination were not significantly different. Reducing the total light period materially reduced growth and the number of grade one plants from 61.7% for 24 hours to only 39.7% for 16 hours (treatments 5 and 7).

Residual Effect

Plants with flower buds. Dusk-to-dawn illumination with either Gro-Lux or incandescent lights (24 hours) plus a minimum night temperature of 65° F. resulted in over 60 percent of plants initiating flower buds. This compared with only 30 percent from the higher yielding check treatment (natural days at 45° F. night minimum).

For 65° F. night minimum 16 and 24 hours of total light were equally effective when Gro-Lux was the supplementary source, but 16 hours with Gro-Lux was not as effective as 24 hours when incandescent was supplementary.

Plant grade. One hundred and thirty-nine days following termination of lighting, with grade based on plant size and appearance but not flower buds, no improvement was shown from supplementary illumination.

Experiment 3 (*Tables* 5 *and* 6)

In general, growth stimulus during the 122-day test period with mercury vapour and four fluorescent supplementary lightings was not appreciably different though mercury vapour did

Table 4. Residual effects of temperature ranges and supplementary illumination on *R. molle* seedlings after treatment, comparing Saanichton (SG) and Goddard (GG) gradings.

Trt No	Original treatment[1]		Percentage of plants				Percent plants w/flower buds all grades
	Min Night Temp	Light	Grade 1		Grade 1 & 2		
			SG	GG	SG	GG	
1.	45° F.	24 hrs (Gro-Lux dusk-dawn)	3.7abc[2]	29.3c[2]	10.5b[2]	60 5bc[2]	42.3cd[2]
2.		24 hrs (Incand. dusk-dawn)	3.0abc	24 2bc	11.2b	72.7cde	47.0d
3.		16 hrs (Gro-Lux start dusk)	1.7ab	11.1ab	6.5a	54.0ab	22.0b
4.		Natural days	4.7c	28.1c	13.0b	71.4cde	30.0bc
5	65° F	24 hrs (Gro-Lux dusk-dawn)	5 0c	30.1c	10.2b	82.1de	60.7ef
6.		24 hrs (Incand. dusk-dawn)	4 0bc	22.9bc	11 0b	87.8e	65 7f
7		16 hrs (Gro-Lux start dusk)	3 5abc	21.3bc	10 7b	69.7bcd	47 4dc
8.		Natural days	1.0a	7.1a	6 0a	42 8a	7.0a

[1]Sept 13 to April 29, 1965 (228 days)
[2]Values with a letter in common within columns are not sigificantly different (P = 05)

Table 5 Growth results (122 days, November 6 to March 8) with five supplementary lightings on rooted cuttings of *R. molle,* 1965

Treatment (24 hours light (suppl illumin dusk to dawn)	Growth[1] incr	Av[1] No pinches/ plant	Percent Gr 1	Grade Index all plants
	ins			
1. Mercury vapour	1 8c	1 1b	10 0	1 7
2 Fluorescent Gro-Lux	0 6a	0.4a	10.0	1 8
3 Fluorescent Daylight type	1 4bc	0 5a	12.5	1 8
4 Fluorescent Verd-A-Lite	1 4bc	0 5a	15 0	1.9
5 Fluorescent DSW/29	0 9ab	0.5a	2 5	1 8
			N.S.	N.S

[1]Values with a letter in common within columns are not significantly different (P = 05)

result in more pinches per plant. This is not surprising as energy output is greater from mercury vapour than fluorescent (in this case, 400 compared to 80 watts). What is surprising is that with daylight fluorescent or the industrial Verd-A-Lite, growth increment surpassed the Gro-Lux fluorescent treatment, a type primarily designed for optimum plant growth. Results are inconclusive but it appears that with dusk-to-dawn supplementary illumination, quality of light is not a highly important factor of growth stimulus and early flower initiation of young azalea plants.

Table 6. Residual growth effect of five supplementary illuminations on rooted cuttings of *R. molle,* 139 days after treatment

Original treatment[1] (24 hrs light + suppl illumination dusk to dawn)	% Grade 1 plants	% Grade 1 & 2 plants	% Plants w/flower buds
1 Mercury vapour	5.6	33.3	72
2. Fluorescent Gro-Lux	0.1	16.6	77
3 Fluorescent Daylight type	11.1	22.2	44
4 Fluorescent Verd-A-Lite	27 7	49 9	77
5 Fluorescent DSW/29	11.1	38.8	38
	N S	N S.	N.S.

[1]Based on original treatment period, 174 days (November 6 to April 29, 1965 and total growth period, 313 days, (November 6 to September 15, 1965).

Summary and Conclusions

Three experiments dealing with the effect of supplementary illumination on growth stimulus, grade of plant and flower bud initiation of young *R. molle* seedlings and rooted cuttings were carried out in 1963-64 and 1964-65. A total of 1,090 plants were subjected to not less than 161 days of treatment in which temperature, and fluorescent, incandescent and mercury vapour lightings were variables, though not necessarily in all experiments.

Maximum growth response, *initially* determined immediately after the lighting period, and based on height increment, number of pinches per plant, percentage of grade one plants and grade index, resulted from 65° F. night minimum plus 24 hours light (supplementary illumination dusk to dawn). Gro-Lux fluorescent and incandescent were equally effective.

Final independent gradings by a nurseryman and the author in September, 139 days following termination of lighting with grade based on size and appearance only, revealed no improvement as a result of supplementary illumination.

On the other hand, dusk-to-dawn illumination with either Gro-Lux fluorescent or incandescent plus a minimum temperature of 65° F. resulted in over 60 percent of the plants initiating flower buds compared to 30 percent for the higher yielding check (natural days and 45° F. night minimum). Light for 16 hours, where Gro-Lux is supplementary, is equal to dusk-to-dawn lighting with lighting with Gro-Lux, but less than equal to dusk-to-dawn with incandescent.

Light quality from mercury vapour and four kinds of fluorescent used in this experiment, is not considered critical for dusk-to-dawn supplementary illumination where growth stimulation of *R. molle* is the objective.

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Acknowledgments

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MODERATOR LEISER: Our next speaker is Gottlob "Rudy" Wagner from C. and O. Nursery at Wenatchee, Washington. Rudy!

PROPAGATING APPLE ROOTSTOCKS BY THE METHOD OF CONTINUOUS LAYERING

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

The increasing use of vegetatively propagated rootstocks in our fruit tree nursery, in search for better rooted liners and for a constant source of supplies, made us decide in 1962 to grow number of pinches per plant, percentage of grade one plants and grade index, resulted from 65° F. night minimum plus 24 hours light (supplementary illumination dusk to dawn). Gro-Lux fluorescent and incandescent were equally effective.

Final independent gradings by a nurseryman and the author in September, 139 days following termination of lighting with grade based on size and appearance only, revealed no improvement as a result of supplementary illumination.

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The increasing use of vegetatively propagated rootstocks in our fruit tree nursery, in search for better rooted liners and for a constant source of supplies, made us decide in 1962 to grow some of our own rootstocks. As clonal rootstocks cannot be reproduced true-to-type from seed, we must therefore resort to asexual methods of propagating. The methods used for propagating clonal rootstocks commercially is either by mound layering or by continuous layering, but mound layering seems to have the preference by many propagators. I think the reason for this is the lower cost in establishing the stool beds. But we must not count out other methods such as hardwood cuttings, root cuttings and softwood cuttings. All these will eventually be as important commercially as the layering methods. In either case a fertile, well-drained, soil should be used in establishing the stooling or layering beds. Before planting we apply the following fertilizers: (actual per acre) 320 lbs. nitrogen, 320 lbs. phosphate and 160 lbs. potash as early in spring as possible.

We use the continuous layering method in our operation. It requires more labor and care in establishing the beds and the initial cost is much higher, but continuous layering has the advantage of distributing the shoot growth over a larger area much faster than the mound layers and produces more uniform layers of the desired medium sizes. But once the layering beds are established, the layers are easily managed and the results are superior to other methods.

Spring planting is the most suitable in our region. We plant our rows 8 feet apart, 16 inches in the row, and the mother plants are set at a 45° angle for easy layering and preferably pointed to the south for good light exposure down the rows. To get the sawdust into the layering beds has always been a big chore. We now haul the sawdust directly from the mill right into the rows and unload the truck from both sides. This of course must be done early and soon after planting while we still can straddle the rows. The 8′ rows give us plenty of room to pile enough sawdust between the rows for several years of covering. Having the sawdust in rows between the mother plants is also a good weed control. After a full year's growth and root development of the mother plants, the shoots are then pruned and prepared for the actual layering. Any branches that cannot be held flat against the soil should be pruned off. The whole top and the lateral shoots are then pegged down on the ground and spread in alternating directions for a good distribution of the shoots. We prefer wire over wooden pegs because wire is easier to pin with. We use No. 10 galvanized wire cut in 24″ lengths and bent in a "U" form; near the end of the prong we put an extra little bend which helps in holding the shoot to the soil. This operation is very important; the shoots must fit and be held very firmly to the soil. otherwise the mother plants cannot establish a good root system if left dangling between the sawdust and the soil. If the plants are planted in a slight depression or furrow 2 to 3 inches deep it will make this operation much easier. A wedge of soil should be removed from the base of the plant to help bend the stock. It will also relieve pressure on the shoot and less popping up will occur. For the base we use double prong hooks and for the top and lateral shoots a single hook will hold. After the shoots are firmly pegged down, the entire layer is then covered with an inch of soil or sawdust before bud activity starts; this is to bring about etiolation and better rooting of the new shoots. The layering must be done in early spring before the buds break into growth and care must be taken that the soil or sawdust is in a good moist condition when the hilling-up operations are carried out. The root formation on the new shoot is influenced by hilling-up early in the growing season before the shoots become hard and woody. The hilling-up is done usually in four stages and the last one should bring the mound up to at least 12 inches if sawdust is used as the medium. Soil requires only 6 to 8 inches. With every hilling-up, the sawdust must be thoroughly worked in around each shoot. After the hilling operation is completed often prolonged periods of dry and hot weather occur, in our region, which sometimes creates a serious problem for us through overheating of the stool block medium. If not corrected at once it will hinder the root formation and the base of the shoots can easily become hard and woody. To lower the temperatures in the beds, we have changed our method of watering; instead of one heavy watering every few days, we now water several times daily. With our cold Columbia River water this drops the temperature from 10° to 15° degrees very quickly. This has or seems to have a very satisfactory effect on root formation.

The layering beds are by now in full operation and a close watch must be kept on the performance of the layers. If sawdust is used it can create a problem in available nitrogen and phosphorus. To overcome this we make two applications of ammonium phosphate (16-20), 50 lbs. actual nitrogen per acre; the first application is made just before the first covering of the shoots and the time of the second application depends on the vigor and color of the leaf. Neither very vigorous nor weak plants make good layering material; medium sized shoots are the most likely to have a high percentage of rooting and produce the most desirable medium size plants.

Insects can be troublesome in the layering beds, but can be controlled without much difficulty. If the terminal shoots are attacked by leaf hoppers or aphids and damaged, the results will be short lateral shoots and spurs instead of a clean slim stem of a rooted layer. Such short lateral shoots and spurs must be trimmed off before the shoots can be used as lining out stock. But much more serious damage can be caused by the woolly apple aphid. The aphid colonies can become established on the root of the mother plant, as well as in the rooting zone of the young shoot growth, therefore it is very important to keep this insect out of the layering beds. We are able to control them with two applications of Lindane, 2 quarts per 100 gallons of water. The first application is applied by drenching the plants thoroughly just before the first cover goes on the new shoots and a second application is applied after the hilling-up operation is completed, which is usually about the middle of July. We sometimes encounter slight attacks of powdery mildew; usually a few sprays of Karathane, ½ to 1 lb. per 100 gallons clears it up pretty fast.

Harvesting the rooted layers can be done anytime after leaf fall if the roots are sufficiently hardened off. We prefer fall to spring cutting of the rooted layers as it gives us the exact count of stock on hand for spring planting; harvesting in the fall involves some extra work, however, as the crown of the mother-stock must be protected in winter and the winter protection must again be taken off in spring to expose the crown to the all-important sun rays. When cutting the rooted layers from the original layered stock (as close to the base as possible), we leave some of the unrooted shoots stand. Such shoots serve to maintain the layering beds; if all the shoots are rooted we leave some of the most vigorous rooted shoots stand in the beds to fill in the gaps if so needed. Eventually older plants of the layers will die out or break out through harvesting, so care must be taken each year that some new shoots remain to replace those that have been lost.

Yields of the layering beds depend on many circumstances, like any other crops, such as variety, location, fertility of the soil, variation of the season and, above all, the management practices used. The layering beds usually come in full production during the 4th and 5th years. Well-established and well-kept layering beds will produce with EM VII and EM IX approximately 50,000 per acre; EM II, if good, 25,000 per acre. Our MM 104, 106, and 111 rooted exceptionally well this year and indications are of a 60 to 65,000 yield of rooted layers per acre.

Clonal rootstocks are with us to stay from which the industry will not turn back, but will move steadily towards an even greater exactness in predictable control of orchard performance.

ROUND TABLE DISCUSSION ON PROPAGATION OF DIFFICULT PLANTS

WILLIAM J. CURTIS, *Moderator*
Wil-Chris Acres
Sherwood, Oregon

MODERATOR CURTIS: I would like to have Mrs. Whalley come forward as the first member of our program. Mrs. Whalley has a wholesale nursery in Oregon and does custom propagation; there is no one that does a better job of this than Mrs. Whalley. In fact, when we have trouble with some items, we take them over to Mrs. Whalley. Jean:

is completed, which is usually about the middle of July. We sometimes encounter slight attacks of powdery mildew; usually a few sprays of Karathane, ½ to 1 lb. per 100 gallons clears it up pretty fast.

Harvesting the rooted layers can be done anytime after leaf fall if the roots are sufficiently hardened off. We prefer fall to spring cutting of the rooted layers as it gives us the exact count of stock on hand for spring planting; harvesting in the fall involves some extra work, however, as the crown of the mother-stock must be protected in winter and the winter protection must again be taken off in spring to expose the crown to the all-important sun rays. When cutting the rooted layers from the original layered stock (as close to the base as possible), we leave some of the unrooted shoots stand. Such shoots serve to maintain the layering beds; if all the shoots are rooted we leave some of the most vigorous rooted shoots stand in the beds to fill in the gaps if so needed. Eventually older plants of the layers will die out or break out through harvesting, so care must be taken each year that some new shoots remain to replace those that have been lost.

Yields of the layering beds depend on many circumstances, like any other crops, such as variety, location, fertility of the soil, variation of the season and, above all, the management practices used. The layering beds usually come in full production during the 4th and 5th years. Well-established and well-kept layering beds will produce with EM VII and EM IX approximately 50,000 per acre; EM II, if good, 25,000 per acre. Our MM 104, 106, and 111 rooted exceptionally well this year and indications are of a 60 to 65,000 yield of rooted layers per acre.

Clonal rootstocks are with us to stay from which the industry will not turn back, but will move steadily towards an even greater exactness in predictable control of orchard performance.

ROUND TABLE DISCUSSION ON PROPAGATION OF DIFFICULT PLANTS

WILLIAM J. CURTIS, *Moderator*
Wil-Chris Acres
Sherwood, Oregon

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PROPAGATION OF DIFFICULT PLANTS

JEAN WHALLEY
Whalley Nursery
Troutdale, Oregon

I will remind you of some rules to follow in dealing with hard-to-root plants.

First — Study your subject. It may take several years of observation before you know the peculiarities of the plant in question. (Unless you are lucky enough to hear about it at a Plant Propagators' Society Meeting, that is.) The parent plant may need to have special care, perhaps more or less water than most, more or less fertilizer, shade or sun.

We have trouble in the Northwest in rooting *Juniperus torulosa* (Hollywood Juniper.) It seems the only way we can get it to root is by putting it in and after it has callused, take it out, remove the callus, redip with hormone, after which it roots quite well. Of course, this is not very practical. I've been told that cuttings which are very small and soft will root readily, but ours merely rotted. Bruce Briggs told me he had had the very same trouble, but when he took cuttings from some plants he got from California they rooted "like crazy". I believe this means the parent plants were in the right condition for the cuttings to root. Perhaps this year ours will do better, as we have had so much more sunshine than usual.

Daphne cneorum is quite difficult to root. However we learned some years ago that if we took cuttings from more or less neglected parent plants, where the cuttings were small and hard they do very well. Our books had told us that cuttings from plants brought into the greenhouse and forced into lush growth rooted well — but they didn't for us!

That brings up another important point — environment. Every propagator will tell you to find the way that is best for you in your own environment and not to change because someone else does it differently. I know people who *do* root soft lush cuttings of *Daphne cneorum*, but ours do best treated as I have said, and we have also learned to keep them away from the mist — just water when the sand starts to dry out and try not to drench the foliage.

Timing may be very important. In Rhododendrons, for example, some varieties like to be put in early, others do better when stuck quite late in the season. If I'm working with a hard-to-root variety and find a date when it does well I try to put it in on that date every year. Sometimes a difference of two weeks or even less will be the difference between success or failure. In Rhododendrons, too, some need more misting than others. Unique and Bowbells have rather cupped leaves which hold the water; Blue Peter has a soft texture which also keeps moist, but Jean Marie looks dry as soon as the mist is off of it.

We used to have trouble rooting *Thuja aurea nana* (Berckman's Arborvitae) when we put it in in the winter with our other narrow-leafed evergreens. One year we put it in in early March and had great success, so now we always put the cuttings in then and they root almost 100%.

Some cuttings just take *longer* to root than others of the same genus. This year we have reserved one bed for slow and hard to root varieties of Rhododendrons, so that we can leave them all on the heat for a longer period of time instead of taking out cuttings here and there as they root and wasting our electricity in the empty part of the bed.

Of course sometimes success or failure comes as a surprise, when you think you've done exactly as usual. For example we've tried Britannia Rhododendrons just about every month in the year, with different hormones, straight sand, mixtures of sand and peat, etc., with very little success. However, last year we gave them one more try with our own cuttings and, as usual, some of our optimistic customers brought us cuttings to root. They all did fine — ours rooted 90% or better. We don't know why, although we do know that last summer was very cool and rainy and perhaps that put the parent plants in better condition than usual for good cuttings of that particular variety.

On the other hand, Susan, which is a very difficult-to-root rhododendron, did quite well for us year before last and didn't root at all last year.

Last year a customer brought us cuttings to root of tall, second-year growth holly with berries already developed on them. We were very dubious about taking them, but they rooted beautifully. This year the same kind of cuttings look quite poor. Last year, as I have said, we had a cool rainy summer and this summer was hot and dry. These people don't irrigate their holly orchard, so the parent plants apparently were not in the right condition to take cuttings. Also they were just loaded with berries, which of course had used up a lot of strength; then — to top it off — they brought them a week later. So in this case it could be a matter of the parent plants being in poor condition and possibly the timing was a little off also.

In closing, I would like to mention an experiment we have run with Jiffy Grow. Mr. Jackson, the representative of Jiffy Grow, told me about the carnation growers putting their cuttings in with no hormone, then sprinkling over the bed with the Jiffy Grow. We tried a small plot of Rhododendron cuttings this way. He said the carnation growers did this to avoid contamination from one cutting to another as they were dipped in the same solution, also to save time in dipping, as it would be quicker to spray over the whole bed than to dip each cutting. However, we are finding that the small plot which we sprinkled after planting is rooting much faster than the same variety dipped in the usual way. Bruce Briggs tried sprinkling some *Daphne odora* cuttings with the Jiffy Grow solution some time after planting and is finding it is also rooting much better than the rest of the same cuttings, which he did not sprinkle. I believe these cuttings had been dipped in his usual hormone when they were planted. About two weeks ago we sprinkled the holly bed I mentioned with the Jiffy Grow solution and are now hoping it will work as it did for Bruce with his Daphne. We had dipped them previously when planted about a month before. I'll let you know later if this turns out as we hope.

Finally, lest we grow conceited, each one of us should remember what Paul wrote — "I planted, Apollo watered, but God gave the growth."

Thank you.

MODERATOR CURTIS: I do not believe our next gentleman on the program has need for a lengthy introduction. He is head propagator for Oki Nursery, Sacramento, California; he was one of those that did so much work to help make our program last year such a great success at Sacramento. Mr. Ed Kubo:

PROPAGATION OF XYLOSMA CONGESTUM

ED KUBO
Oki Nursery, Inc.
Sacramento, California

Defoliation of *Xylosma congestum* during the rooting and liner stage is of great concern to most propagators. Defoliated *Xylosma* cuttings or liners, regardless of rooting, will not grow.

We, at Oki Nursery, have tried to determine how to prevent defoliation. Hormone applications of different concentrations have been used — for example, 650 ppm to 10,000 ppm of indolebutyric acid. We have tried interval misting and no misting, and collecting cuttings from new and old wood at different times of the year. Different ingredients for liner soil mix, rooting medium and variable temperatures and humidity have also been tried.

For the present time, with our experience, we have come to the following conclusions:

Time of Taking Cuttings: We have found that the time of year cuttings are taken has a great effect on the amount of foliage drop. In our area we have found the best time to take cuttings is from August through the middle of October.

Type of Wood: The first and second cuttings, below the tip, are the best cuttings to take. The older the wood, the greater the problem of defoliation.

Rooting Medium and Rooting Hormone: For the rooting medium we use 25% sphagnum peat moss and 75% perlite. We have found 5,000 ppm of IBA in 50% alcohol to be best for rooting of *Xylosma congestum*.

Misting and Hardening Off: Interval misting is required in rooting of *Xylosma* with bottom heat of 70° F. After the ing much better than the rest of the same cuttings, which he did not sprinkle. I believe these cuttings had been dipped in his usual hormone when they were planted. About two weeks ago we sprinkled the holly bed I mentioned with the Jiffy Grow solution and are now hoping it will work as it did for Bruce with his Daphne. We had dipped them previously when planted about a month before. I'll let you know later if this turns out as we hope.

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Misting and Hardening Off: Interval misting is required in rooting of *Xylosma* with bottom heat of 70° F. After the cuttings are rooted, frequency of misting should be cut off gradually. The hardening-off stage is very critical. We have found that by utilizing greenhouses that are equipped with evaporator coolers, using the pad and fan system, losses are considerably reduced during the hardening-off process. By using the pad and fan system, our greenhouses are always at a relative humidity between 60 and 80% with temperatures between 70° and 80° F.

Handling of Liners: The handling of liners is as critical as handling of cuttings. It is important that the greenhouse in which the liners are handled not be extremely cold nor hot. The ideal temperature is between 70° and 75° F. Our liner greenhouses are also equipped with the pad and fan system of cooling.

Firbark or redwood sawdust used as component parts of a liner mix will also cause defoliation. We know that both firbark and redwood sawdust have chemicals that are toxic to plants. Also, there are certain varieties that are more sensitive to the chemicals. Fifty percent sand and fifty percent sphagnum peat moss, which has been steam sterilized, has been found to be best for *Xylosma* liners.

Condition of Stock Plants for Propagation: We suspect that the fertility requirements of stock plants have great influence on success or failure of *Xylosma* propagation. We feel that by experimenting with zonal fertility, interesting facts can be obtained. For example, *Xylosma* stock plants that are low in fertility, propagate better than those that are high. On the other hand, Camellia cuttings propagate better if fertility is high. But what is the optimum range? This can only be determined scientifically by block testing and data accumulation of performance through zonal fertility. When such data is accumulated, we are confident that plants such as *Xylosma congestum* can be grown for a specific purpose.

MODERATOR CURTIS Our next speaker, Mr. Ed Wood, is a graduate of Oregon State University in Ornamental Horticulture. He has a nursery operation in Portland where he grows ground covers. Mr. Wood:

MR. ED WOOD: Bill asked me to talk about difficult to propagate plants. I should not be up here. If I find they're difficult, I wax enthusiastic, think they should be in the trade, find somebody like Bill who thinks they're beautiful and let him propagate them; I throw them out because I can't make any money on them. Primarily, in growing ground covers, obviously most of our plants are not hard to root, so what we want to do is to find a way to make the easy rooting ones, easier. I am glad to hear that more and more florists are coming into this organization. For twelve years we were mixing up concentrate dips and spraying carnations, and we were plating out for bacterial wilt to avoid contamination. It worked beautifully. Here I changed to a nurseryman, and promptly forgot all about what I was doing as a florist, so I think the more we get an interchange between these fields, the more we are all going to learn.

They say the average small grower sometimes is not set up to mix rooting promoting "hormones" in large quantities but there is now a new liquid concentrate preparation on the market. It is being used quite strongly in the Northwest; it is called "Jiffy Grow". I have had some questions on how it is formulated. There is no secret about it. In this solution there is 175 parts per million of boron, added as boric acid. It contains 5000 ppm of indolebutyric acid and 5000 ppm of naphthaleneacetic acid; it also contains phenylmercuric acetate as a germicide and, of course, alcohol as a solvent. Now, on the directions it says use it straight; it is implied that you should try it out with your own crop which is a wise thing to do no matter what the label says. Mrs. Whalley mentioned some of the hard-to-root rhododendrons. A friend of mine in Oregon tried it last year on rhododendrons — dipped them straight and burnt the bottoms right off, but then they just rooted like the dickens right above the dead part. This year he cut down the concentration, using two tablespoons per gallon. I dilute mine a different way. I usually use it about 1 to 10 in water. But with these rhododendrons he has had real success. He stuck them to root in individual pots about the middle of August; I looked at them about the middle of October and they had beautiful roots out in all directions on some of the real toughies, so I think it is worth a try. Someone mentioned spraying the rooting hormone on the plants. I think with heavily cutinized plants you may have a little more difficulty than on some of the others with absorption into the plant. I figure, though, this may speed application up a little. On *Euonymus* we found, with soft cuttings — if we spray it — right at the rooting medium line we get a great big ball of roots where this liquid ran down the cutting. We have gone back to dipping because it is quite rapid. We just take large quantities of cuttings and give them a swish. Now, whether it is one second, or five seconds, or ten seconds, it doesn't matter too much, because you do not dry the cuttings off after they are dipped. You set them down and the chemical soaks in anyway, so I do not think it is critical. I do believe that the concentration is critical, even on the same plant, depending upon the hardiness of the wood. In many plants, we have burnt the bottoms right off of them, but it didn't matter, they rooted right above the dead part. It was a very definite deliniation line where the concentrate dip solution came. These are just a very few things to mention; I think this material is available now to the average small grower. I would certainly recommend trying it. It has helped us a lot. Thank you.

MODERATOR CURTIS: The next member of the program is well known to all you folks here. Bruce Briggs has a wholesale nursery in Washington. Bruce is always experimenting. Bruce's nursery is a real interesting place to go. It is one of the places that, if you come North, you should go to visit because Bruce is always trying something new. I would like to now present Bruce Briggs:

PROGRESS REPORT ON THE ROOTING OF JAPANESE MAPLES

BRUCE A. BRIGGS
Briggs Nursery Co.
Olympia, Washington

We will attempt, with the aid of some colored slides, to cover the highlights of our experience during the last eight years or so on the rooting of the many forms of *palmatum* maples.

Soil Mixes: Our first work was with the same mix used for Rhododendron cuttings, 50% each of sand and peat. The rooting was good, but we had trouble hardening them off for winter. We then tried many other soil mixes, such as sawdust, charcoal, pumice and perlite, looking for one which would give good drainage when the cuttings are set outside for the winter.

Perlite offered many advantages such as drainage, sterility, lightness, and obtainability. However, with perlite alone, the maples failed to root. This was also true with *Rhus cotinus* 'Royal Purple' cuttings tried the same year. This year we did root *Rhus cotinus*, R.P., cuttings in perlite alone, but under heavy mist.

At the present time, we prefer a mixture of some 40 to 50% peat and Sponge Rok, #3 medium. This mix gives lots of air and drainage with enough peat to bring rapid rooting. We root the maples in this mix in deep plastic pots, where they are left through the first winter.

Treatment of Cuttings. Cuttings are taken from actively growing tips and are prepared by removing all except the top few leaves. A heavy wound aids rooting and in some cases, a double wound on the heavier wood is used. The cuttings of normal length are then put into a bath of Morton's Soil Drench or a 5% solution of household Clorox. (Clorox as it comes from the store is diluted 20 to 1). Either drench seems to give excellent disease control.

After draining, the cuttings are given a quick dip in a solution of 5000 ppm each of indolebutyric acid and naphthaleneacetic acid. We have found here on the West Coast, as did Mr. James Wells (1) on the East Coast, that the maples react well to a high strength of hormone. A close examination of the roots shows that at times, the high strength of hormone burns some ½ inch of the bottom of the cutting. However, they still root much better and faster, even with the burn.

Overwintering of Rooted Cuttings. A large percentage of *palmatum* maples are successfully rooted during the summer, but are lost during the first winter. Various methods of overwintering have been tried, including: removal of all soil the places that, if you come North, you should go to visit because Bruce is always trying something new. I would like to now present Bruce Briggs:

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Overwintering of Rooted Cuttings. A large percentage of *palmatum* maples are successfully rooted during the summer, but are lost during the first winter. Various methods of overwintering have been tried, including: removal of all soil from the plant and storage in plastic bags under cool conditions, leaving the cuttings in flats and storing them outside, or putting them under lights in the greenhouse. Because maples are so subject to verticillium wilt, we have found that it is best not to cut, transplant, or in any way disturb the plant going into the fall and winter season.

Hardwood Cuttings. It would be desirable to find a feasible way to root *palmatum* maples by hardwood cuttings, as they would then have a longer growing season to become established and there would be fewer losses in overwintering. We took cuttings of maples late in the fall, treated them with hormones and stored them for callusing, following procedures tried on fruit tree cuttings at Oregon State (2) and the University of California (3). Our results were no better than the check.

Better results have been obtained when the cuttings were taken earlier while the plants were more active. However, this presented the problem of storing the callused wood.

This year we intend to try the method reported by John Ravestein (4) on magnolias, maples and other deciduous materials. This calls for completely covering the dormant wood with sphagnum moss in a propagation bench with high bottom heat. Then after callusing, potting up the cuttings to carry through the winter in the greenhouse.

Summary. Take cuttings from young plants in vigorous growth, such as those growing in greenhouses or plastic sheds.

Root maples as early as possible in the spring, in order to get one summer's growth before winter dormancy. The faster they root, the better they grow.

Uses a strong hormone with a heavy wound, even on soft wood.

Never let the soft leaves dry or burn on the edges, as this will stop the rooting.

Give them a high humidity and lots of water in well drained soil. If a closed case is used, remove the cuttings immediately after rooting.

There is evidence that top applications of hormones every 10 days or so onto the foliage of the harder-to-root *A. palmatum* forms will increase the hormones within the cutting and produce faster rooting.

Rooting directly in a pot has many advantages.

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[1]Wells, James S Plant Propagation Practices p 183-192, Macmillan, N Y 1955

[2]Roberts, A N Propagation of Cherry Rootstocks Proceedings Fourth Annual Meeting, Western Region Plant Propagators' Society p 269-273 1963

[3]Westwood, M N and Brooks, L A Propagation of Hardwood Pear Cuttings Proceedings Fourth Annual Meeting, Western Region Plant Propagators' Society p 261-268 1963

[4]Ravestein, John, 1958 Rooting of **Magnolia** and **Viburnum** from Hardwood Cuttings Proceedings Eighth Annual Meeting, Plant Progagators' Society p 96-98 1958