PRESIDENT KRAUSE: Would those new members whose names have been read and who are present please stand? We would like to recognize you. Let's all give them a hand.

I wish to make a plug for the 1970 meetings, which will be a joint venture of the Western and Eastern Regions of the International Plant Propagators' Society. This meeting will be held in St. Paul, Minnesota, September 9 to 12. Both regions will be participating in setting up the program and I am sure this will be a very fascinating one. You will find envelopes describing this meeting on the table in the foyer; please take several of these and hand some to your friends or fellow members who are not here. We would like to see a real good representation from the Western Region in St. Paul next year.

It is time to get on with our program, but first let me make some announcements. Those who are participating in the program, would you take seats in the front prior to the session in which you will be participating. We are very time-conscious at our Plant Propagators' meetings; in fact, we are so bold as to have a warning light that will flick on and off when your time is up, and we will also even be so bold as to cut you off. We want to hear what all the speakers have to say and we do not want to deprive anyone of the time for his presentation. All the proceedings of our meetings are printed. I am sorry that we do not yet have our last year's Proceedings at hand now to show you; they are still in the process of being printed.

The first talk on our program today will be on root initiation in easy and difficult-to-root plants, by Dr. Wesley Hackett.

THE INFLUENCE OF AUXIN, CATECHOL AND METHANOLIC TISSUE EXTRACTS ON ROOT INITIATION IN ASEPTICALLY CULTURED SHOOT APICES OF THE JUVENILE AND ADULT FORMS OF HEDERA HELIX

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INTRODUCTION

One of the characteristics of the juvenile, non-flowering phase of *Hedera helix* is its striking ability to form adventitious roots on the stem of intact plants. In contrast, the adult flowering phase of this species does not form aerial adventitious roots and is difficult to root when leafy stem cuttings are placed under favorable environmental conditions (7). Many observations indicate that cuttings of most plants in the seedling (juvenile) state initiate roots more readily than in any other stage of development.

It has been known for many years that auxins stimulate adventitious root formation (13, 17). However, cuttings of many difficult-to-root plants, including the adult phase of

Hedera helix, respond very little to auxin treatment (2, 9). There is evidence that endogenous factors, other than auxin, are important in the control of adventitious root initiation (4, 7, 8, 9). More specifically there is evidence that phenolic compounds such as catechol, pyrogallol, caffeic acid and chlorogenic acid interact with auxin to induce root initiation (8, 14).

Using root formation on mung bean cuttings as a bioassay, Hess has shown that fractionated extracts of easy-to-root, juvenile *Hedera helix* shoots contain several root-promoting substances while extracts of the difficult-to-root adult form have less activity (7, 8, 9). He postulates that the presence of greater amounts of the root-promoting substances in the juvenile form than in the adult form may account for the higher rooting capacity of the juvenile form as compared to the adult form. Fadl and Hartmann (4), also using mung beans as a bioassay for rooting, found high levels of root-promoting activity in fractionated extracts from easy-to-root 'Old Home' pear cuttings. Extracts from difficult-to-root 'Bartlett' pear cuttings showed considerably less root-promoting activity but did show high levels of inhibitory activity.

The general objective of this investigation was to determine if aseptically cultured shoot apices of *Hedera helix* could be used to study factors influencing root initiation in easy and difficult-to-root plants. A more specific objective was to determine the root initiation activity of fractionated extracts from shoots of juvenile and adult *Hedera helix* plants when shoot apices of these plants are used as a test for root initiation.

MATERIALS AND METHODS

Tissue for extracts and shoot apices for rooting tests were obtained from vegetatively propagated juvenile and adult *Hedera helix* plants which originated from the same plant. Tissue for extracts was from newly matured leaves plus the node and internode directly associated with these leaves. The tissue was lyophilized, ground to pass through a 40-mesh screen and stored at -20°C until extracted. Tissue samples of 0.5 gm were extracted 3 times in 50 ml portions of methanol. The extracts were combined, concentrated under reduced pressure and an aliquot equivalent to 225 mg or 112 mg of tissue was streaked on 4-inch wide strips of Whatman No. 3MM chromatographic filter paper. The chromatograms were developed in isopropanol and water (4:1 v/v) after an overnight equilibration period. Development was stopped when the front had moved 10 inches from the origin.

Rooting tests were performed aseptically in 6-dram flint glass vials using the basal culture medium shown in Table 1. (Modified from a formulation described by J. A. Romberger of U.S.D.A., Beltsville, Maryland, unpublished). Chemicals to be tested for their effect on root initiation (auxins and catechol) were added to the basal medium as supplements. A 0.5 x

4-inch strip of Whatman No. 3MM filter paper folded and placed in vials as shown in Fig. 1 served as a wick and a platform for the shoot apices. The basal medium with supplements was sterilized by passage through a bacterial Millipore filter and vials, filter paper wicks and strips of paper chromatograms (where used) were sterilized by autoclaving at 15-lbs/in^2 for 20 minutes. Ten ml of medium was dispensed into each vial.

For experiments involving fractionated methanolic extracts, chromatograms were cut into 20 strips each equal to 0.5 R_f unit. Each strip was put into 4 pieces and placed in a separate vial prior to autoclaving and subsequently filled with sterile medium.

Shoot apices 2-3 mm in height were excised aseptically and placed on the filter paper wicks in the vials. One apex was used per vial and 10 vials were used per treatment. Rooting tests were run at 21°C and, except as noted, a light intensity of 500 ft. c. from daylight fluorescent lamps was maintained for 16 hours per day. Roots were counted 28 days after the apices were implanted.

RESULTS

Because of well established differences in the effects of various auxins on promotion of adventitious root initiation in cuttings, an experiment was performed to test the effects of

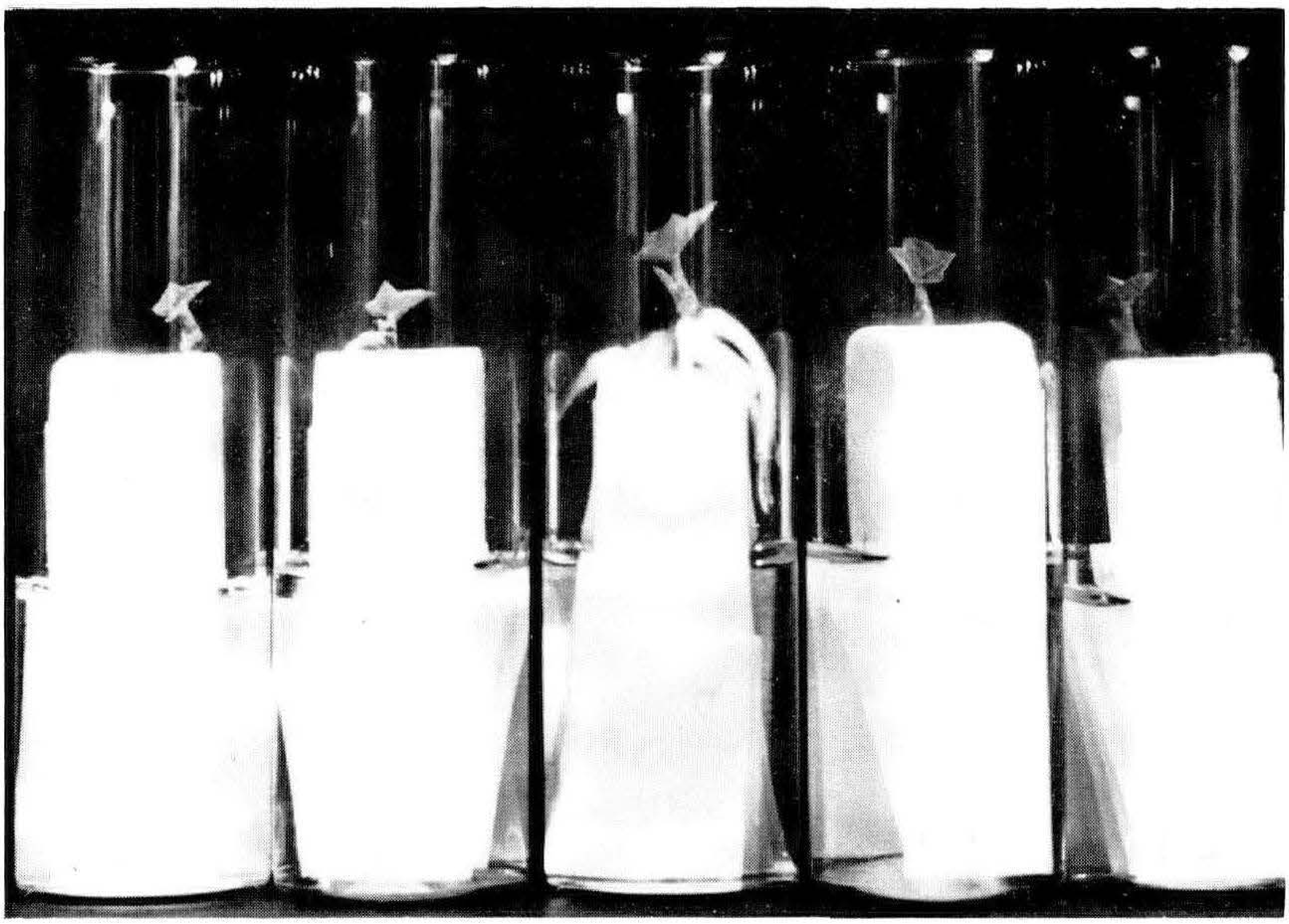

Fig. 1. Juvenile shoot apices in place on filter paper wicks in flint glass vials at the termination of a rooting test.

indoleacetic acid (IAA) indolebutyric acid (IBA) and naphthaleneacetic acid (NAA) on root initiation in shoot apices of adult and juvenile ivy. Although they elongated slightly and unfolded new leaves, none of the 230 adult apices implanted formed any roots with concentrations of IAA, IBA or NAA ranging from 0 to 50 mg/l. In contrast, juvenile shoot apices (Fig. 2) displayed marked response to kind and concentration

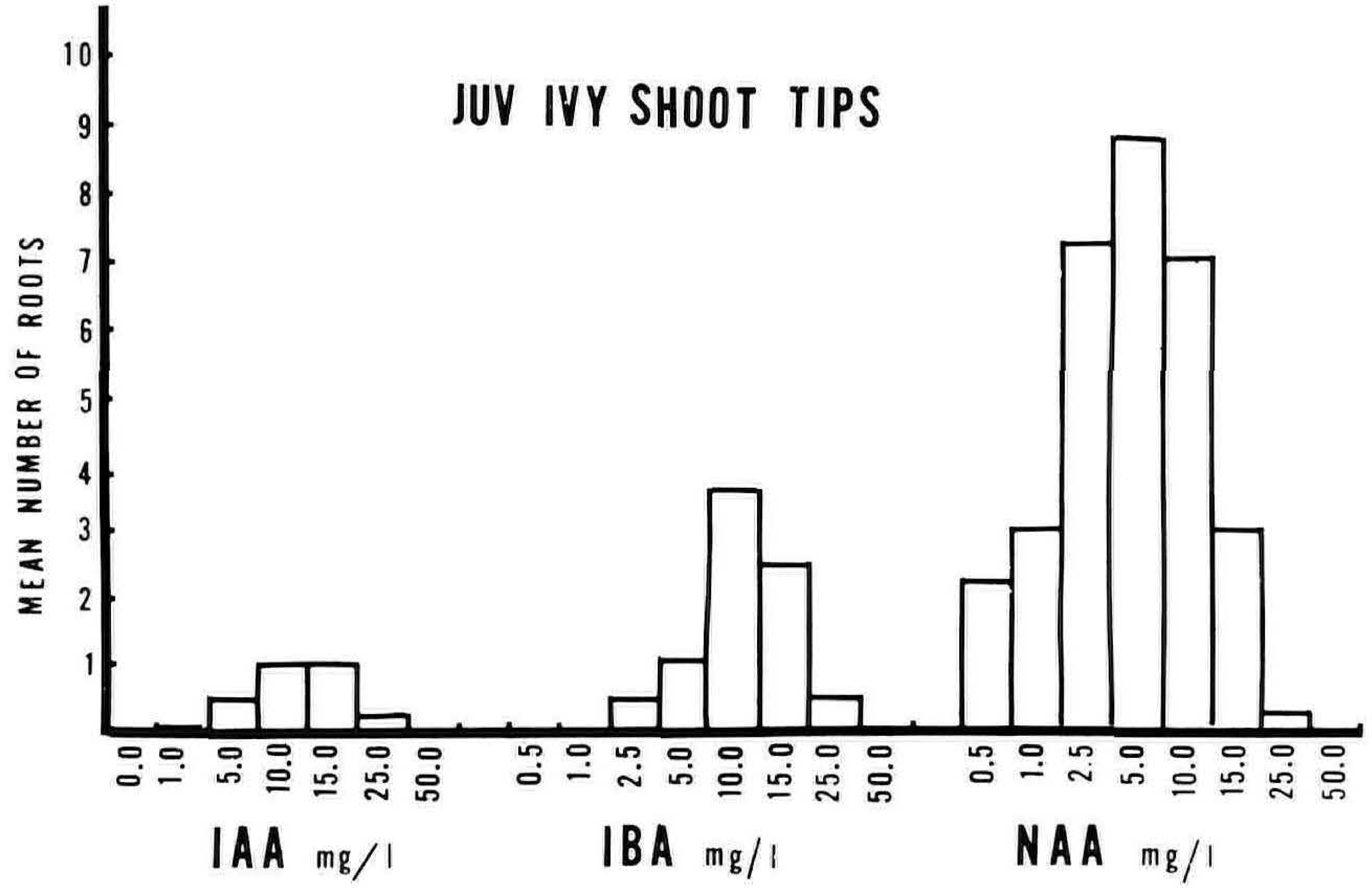

Fig. 2. The rooting response of juvenile shoot apices to kind and concentration of auxin.

Table 1. Composition of basal culture medium. pH adjusted to 5.8.

Component	mg/liters
KH_2PO_4	170.2
KC1	149.2
NaC1	2.3
$MgSO_4 \bullet 7H_2O$	123.3
Na_4 Fe EDTA[1]	25.3
$Ca(NO_3)_2 \bullet 4H_2O$	472.4
$MnSO_4 \bullet H_2O$	1.7
KI	0.17
$ZnSO_4 \bullet 7H_2O$	0.29
H_3BO_3	0.12
$CuSO_4 \bullet 5H_2O$	0.25
$NaMO\ O_4 \bullet 2H_2O$	0.24
myo-Inositol	90.1
thiamin - HC1	0.17
urea	300.5
sucrose	20,000.0

[1] Tetra-sodium-ferric-ethylenediaminetetracetic acid

of auxin. Naphthaleneacetic acid was by far the most active, with IBA intermediate and IAA least active. The optimum concentrations were not greatly different for the three auxins, being 5 mg/1 (2.7 x 10^{-5}M) for NAA, 10 mg/1 (4.9 x 10^{-5}M) for IBA and 10 mg/1 (5.7x 10^{-5}M) for IAA. This is in marked contrast to the great difference in rooting response to the three auxins at their optimum concentrations.

Figure 3 shows the synergism of IAA and catechol in promoting root initiation in juvenile shoot apices. Notice that catechol has no effect on rooting in the absence of IAA. With IAA at 10 mg/1 (5.7 x 10^{-5}M) the optimum concentration of catechol is 6 x 10^{-5}M; with IAA at 5 mg/1 (2.85 x 10^{-5}M) the response to catechol levels off at 3 x 10^{-5}M. So it appears that the maximum response to catechol occurs at a concentration equimolar to the IAA concentration. As was true in the previously described experiment, none of the apices from adult plants rooted.

The data presented in Figure 4 show that there is no response of juvenile shoot apices to catechol when NAA is used as an auxin. A combination of IAA at 5 or 10 mg/1 and catechol at 5 x 10^{-5}M gave a rooting response equal to or better than that obtained with NAA at its optimal concentration of 5 mg/1. Combinations of NAA and catechol were not effective in stimulating initiation of roots on apices from adult plants.

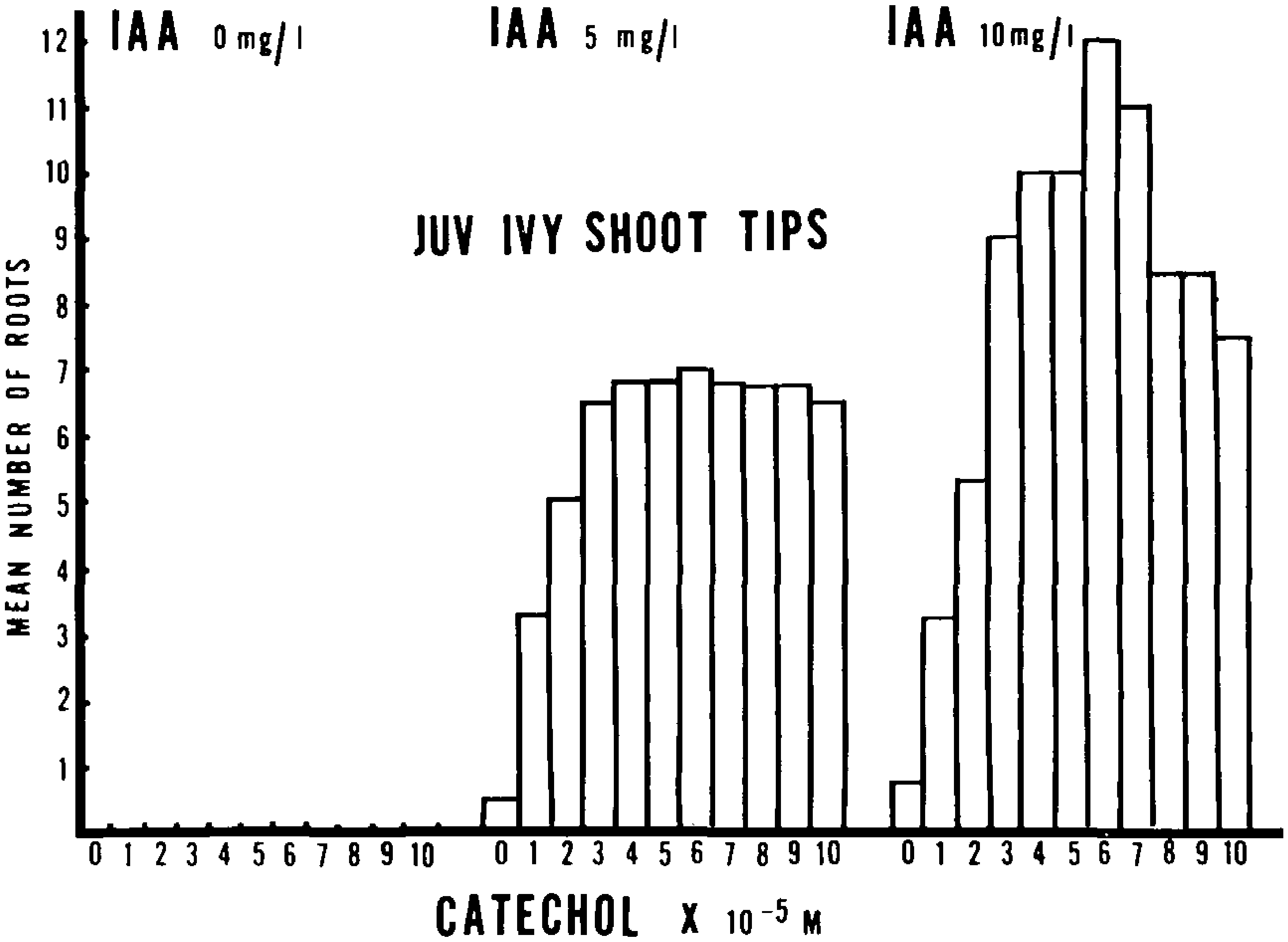

Fig. 3. The synergism of indole-acetic acid and catechol in promoting rooting of juvenile shoot apices.

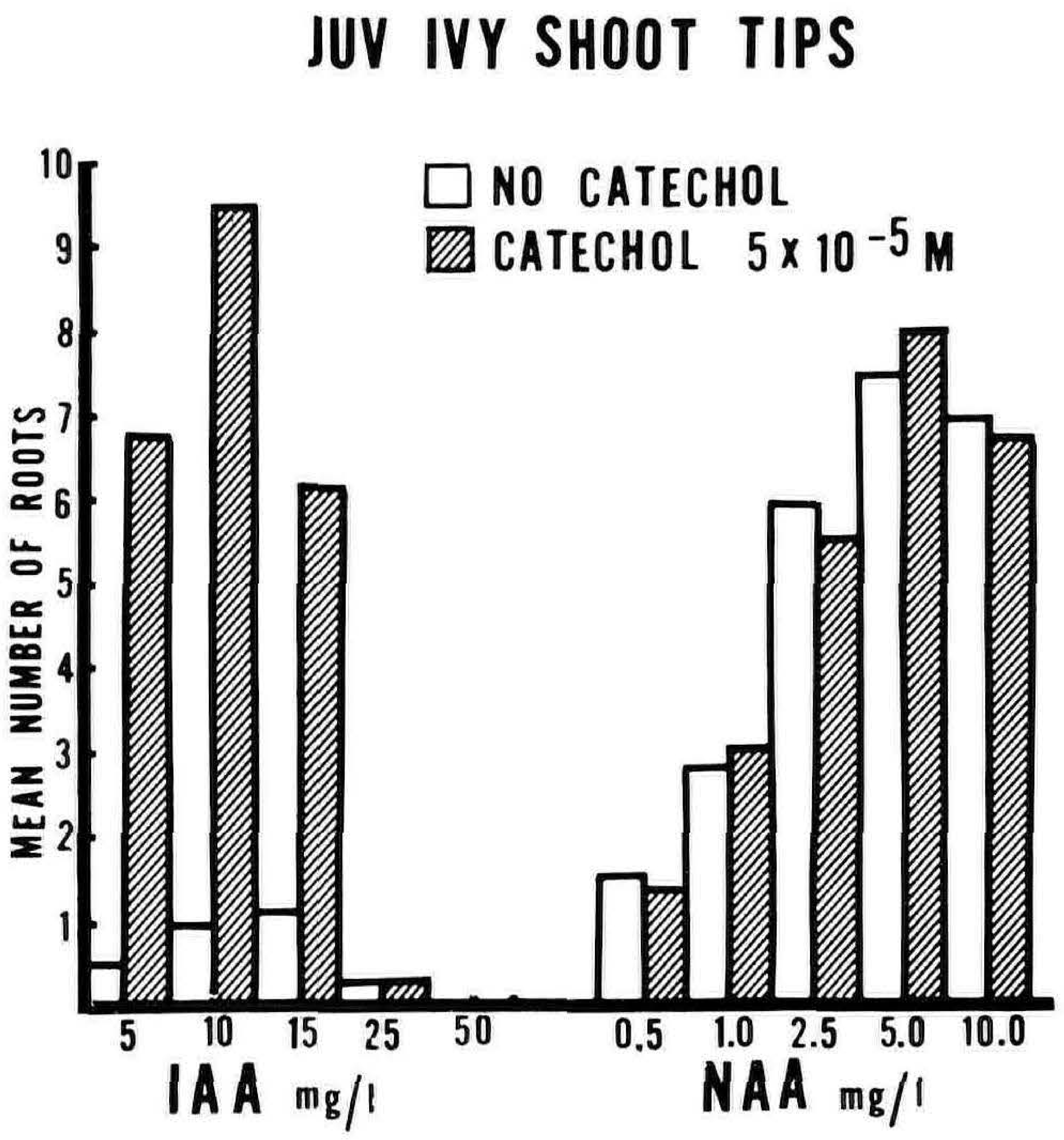

Fig. 4. A comparison of rooting response of juvenile shoot apices to IAA-catechol and NAA-catechol combinations.

When fractionated extracts of adult and juvenile ivy shoot tissue were assayed for root promoting activity using juvenile shoot apices, results as shown in Fig. 5 were obtained. The histograms show peaks of activity at R_f's 0.3-0.4, and 0.5-0.65 and possibly a weak peak at R_f 0.1 (See Fig. 8 also). The area from R_f 0.8-1.0 is somewhat inhibitory to rooting. The root-promoting peak at R_f 0.3-0.4 was not greatly affected by decreasing the amount of extract streaked from 225 mg equivalent of dry tissue to 112 mg but the peak at R_f 0.5-0.65 was substantially decreased. Notice that extracts from adult and juvenile shoot tissue give similar results when assayed using juvenile shoot tips. Fractionated extracts of neither juvenile nor adult shoot tissue were effective in stimulating initiation of roots on apices from adult plants.

In an attempt to stimulate rooting of shoot tips from adult plants, the quality and intensity of light under which the rooting tests were conducted was varied. The following four regimes were used: 1) daylight fluorescent light at 500 ft. c.; 2) incandescent light at 500 ft. c.; 3) incandescent light at 50 ft. c.; and 4) darkness. Figs. 6 and 7 show the response of adult and juvenile shoot tips to light and catechol. Notice that under low intensity incandescent light, and in darkness, adult shoot tips formed about two roots per tip when IAA was provided at 10 mg/1. These treatments gave the first observed instance of root initiation on adult shoot tips. Catechol had no effect on rooting of adult tips in high intensity fluorescent or incandescent light but promoted rooting by 100 to 300% in low intensity incandescent light and darkness. Rooting of juvenile shoot tips was also promoted by reduction or exclusion of light.

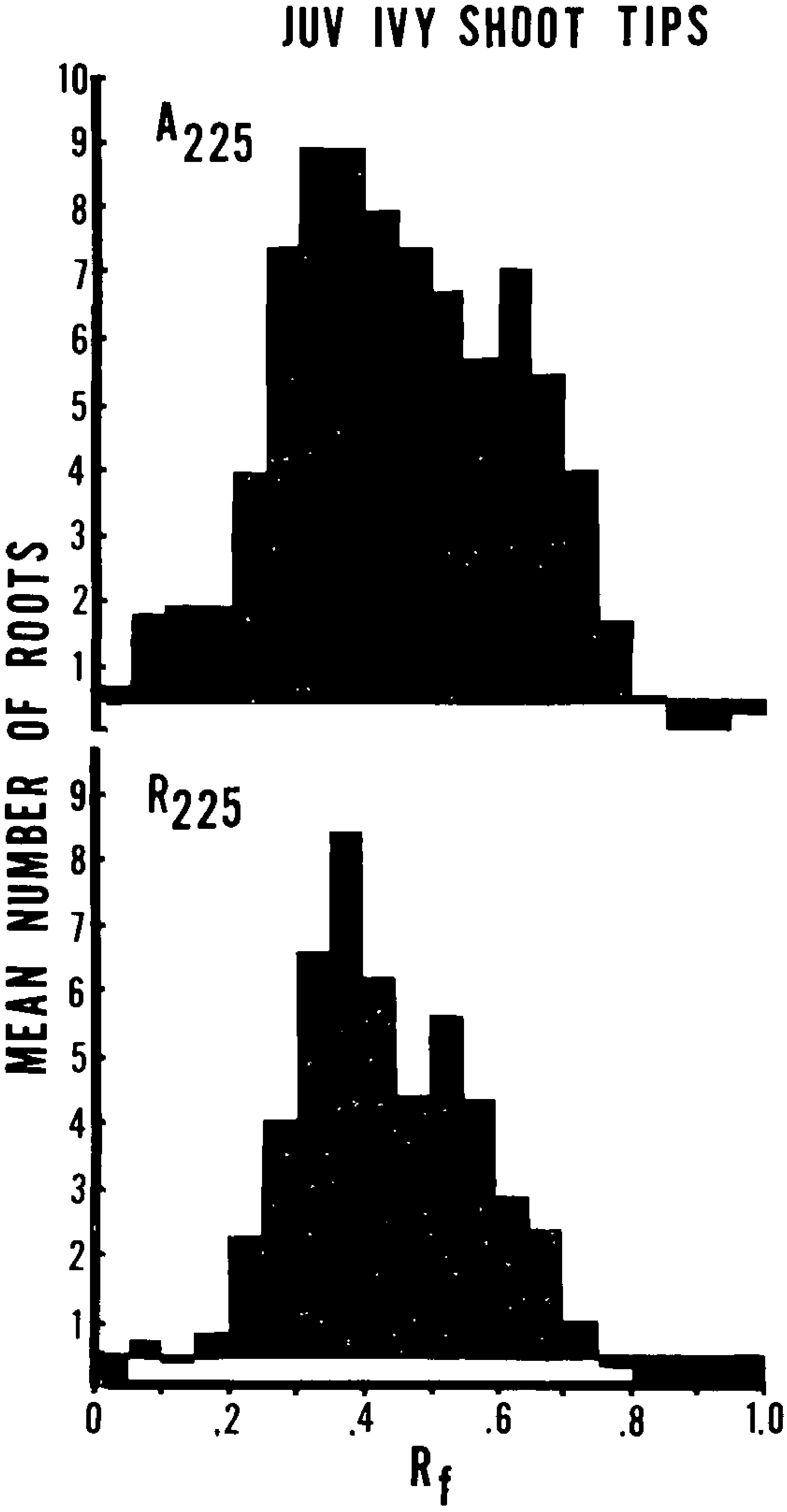

Fig. 5. Histograms showing the rooting response of juvenile shoot apices to chromatographically fractionated methanolic extracts of juvenile (bottom) and adult (top) *Hedera helix* shoot tissue. Extracts from 225 mg. of lyophilized tissue chromatographed on paper with isopropanol and water (4:1 v/v). Basal culture medium supplemented with IAA at 10 mg/l.

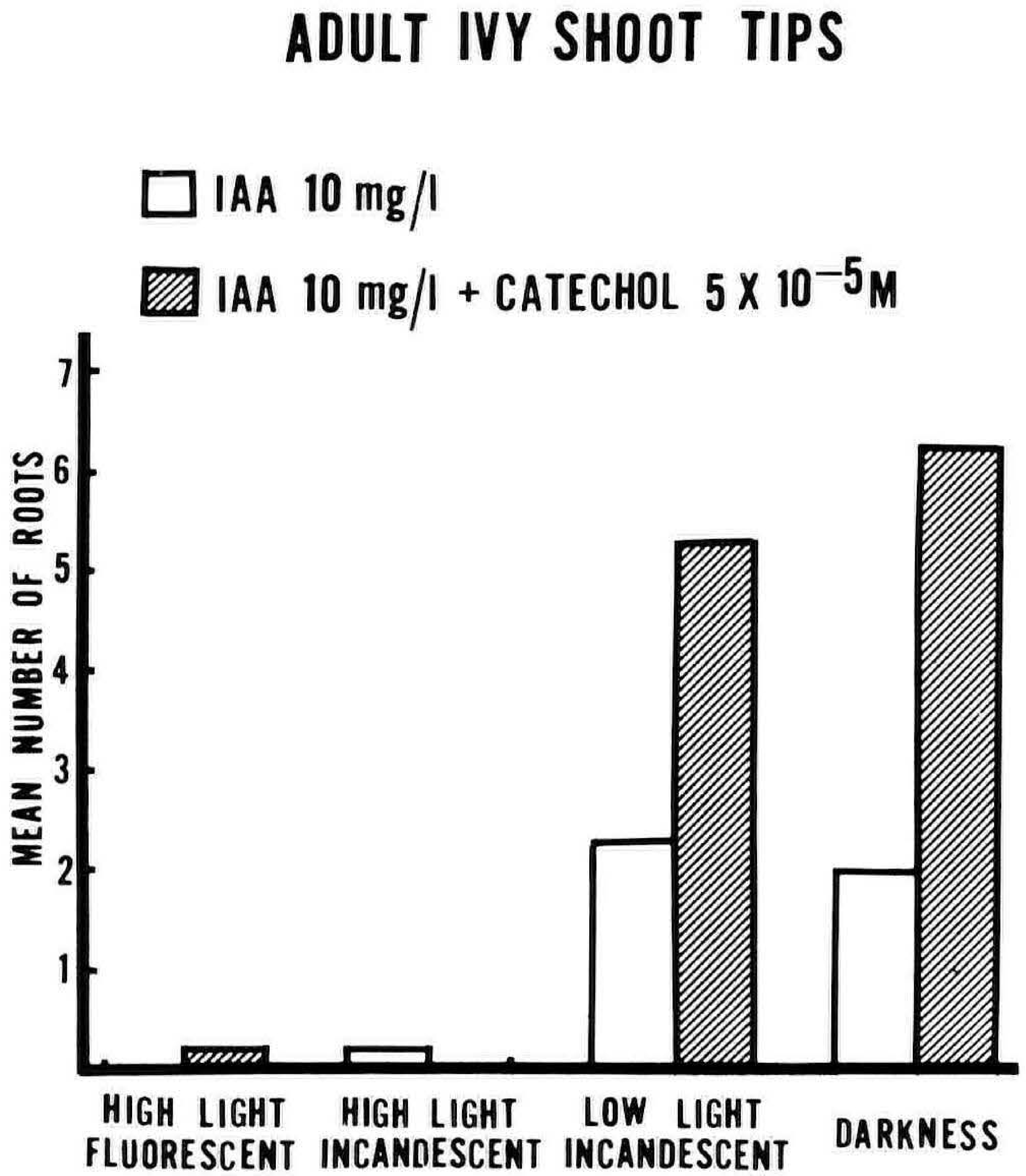

Fig. 6. The influence of light and catechol on the rooting of adult shoot apices.

However, with this tissue catechol was less promotive at low light intensity than it was at high intensity. In darkness catechol had little effect on rooting.

The results of the experiment with light indicate that high intensity light is strongly inhibitory to rooting. A subsequent experiment showed that etiolation of stems on intact adult plants caused the stems to form aerial roots quite profusely. Because of the evidence that low light intensity or darkness is promotive to rooting, fractionated methanolic extracts of etiolated and light-grown shoots were prepared and assayed for root promoting activity under high intensity light (500 ft. c.). Fig. 8 shows the results of this experiment using juvenile shoot tips as the test for rooting. Fractionated extracts from etiolated tissue gave only one peak of root promoting activity at R_f 0.5-0.65 while the light-grown tissue once again showed two large peaks and one small peak of activity. The magnitude of activity at R_f 0.5-0.6 was very similar for extracts from etiolated and light-grown tissue and there was no difference between extracts from adult and juvenile tissue. When these same extracts were assayed for rooting using adult shoot tips there was no stimulation of root initiation.

DISCUSSION

The experimental evidence reported here indicates that auxin is an important factor in the control of rooting in juvenile ivy shoot tips. There is, however, a strong synergism between IAA (but not NAA) and catechol. This strong synergism can possibly be explained on the basis of decreased destruction of IAA in the presence of catechol. It is known that polyphenols such as catechol inhibit the peroxidase type indoleacetic acid oxidase system in peas and wheat (15) and also the photo-oxidation and chemical oxidation of IAA (1, 12).

The fact that NAA is much more active than IAA in promoting rooting could also be explained on the basis of IAA destruction, as NAA is not destroyed by IAA oxidase (3) and is much more resistant to photo-oxidation and chemical oxidation. Indolebutyric acid which has intermediate root promoting activity is intermediate in its susceptibility to various kinds of oxidative destruction (10). However, the fact that high concentrations of IAA do not promote rooting of juvenile

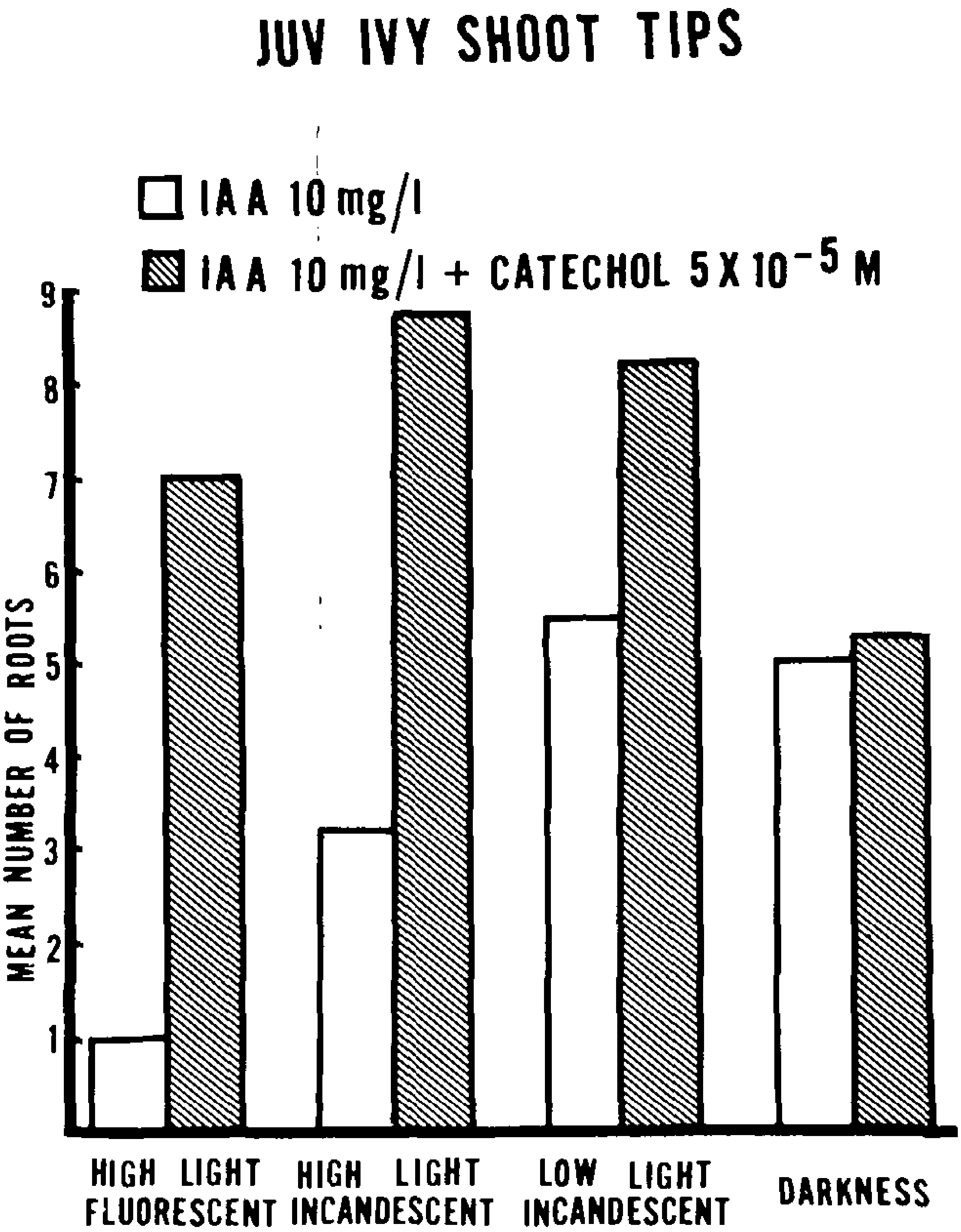

Fig. 7. The influence of light and catechol on the rooting of juvenile shoot apices.

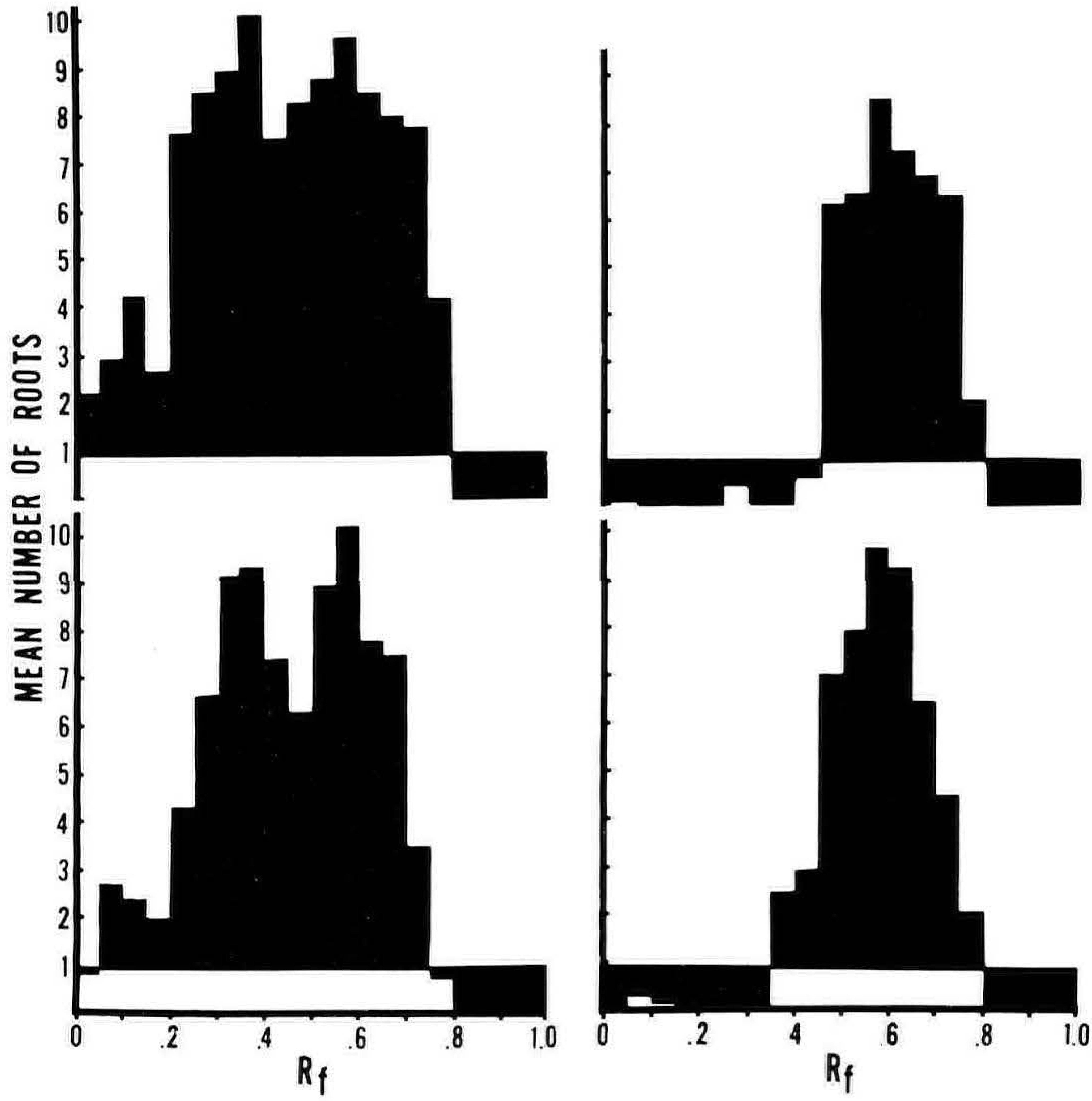

Fig. 8. Histograms comparing the rooting response of juvenile shoot apices to chromatographically fractionated methanol extracts of light grown (*lower left*) and dark grown (*lower right*) juvenile and light grown (*upper left*) and dark grown (*upper right*) adult *Hedera helix* shoot tissue, chromatographed on paper with isopropanol and water (4:1 v/v). Basic culture medium supplemented with IAA at 10 mg/l.

shoot tips (Fig. 2) is difficult to explain unless it is assumed that the products of IAA breakdown are inhibitory to rooting.

Destruction or inactivation of IAA is also indicated by the fact that rooting is much higher in juvenile shoot tips at low light intensities and in darkness than at high light intensities. Fletcher and Zalik (5) have shown that white light reduces elongation of bean seedlings in comparison to those grown in darkness and that there is a direct relationship between IAA content and plant height. They also found a marked influence of light on the metabolism of exogenously applied IAA and speculate that red light stimulates the oxidation of IAA (6). Light promotes oxidation of IAA in some crude enzyme extracts (16) and of course is essential for photo-oxidation.

The synergism between IAA and catechol in promoting root initiation in juvenile shoot tips is very great in high intensity light but much reduced or absent in low intensity light or darkness. It may be that catechol and reduced light are promoting root initiation of juvenile shoot tips through a similar mechanism.

Another possible explanation for the synergism between IAA and catechol in root initiation is the formation of an IAA-catechol complex which is more effective in promoting rooting than either component. Polyphenol oxidase enzymes are known to oxidize catechol to a quinone and quinones are known to condense with IAA giving a colored pigment (11). Fadl and Hartmann (4) have isolated a root-promoting factor which has tentatively been identified as an auxin-phenol complex. The results reported here would indicate that NAA is active without formation of a catechol complex.

The three peaks of root-promoting activity found in fractionated methanolic extracts of adult and juvenile ivy stem tissue have R_f values which correspond with three of the co-factors reported by Hess (7, 9) using a mung bean bioassay. Juvenile shoot tips showed no response to the R_f 0.8-1.0 area of chromatograms which was the area of highest activity reported by Hess. While Hess (9) found greater activity in extracts from juvenile than adult shoots, the results presented here using juvenile shoot tips to assay rooting show no difference between adult and juvenile extracts.

Whereas juvenile shoot tips grown in light respond to auxins and combinations of IAA and catechol by forming more roots, adult shoot tips do not respond to these factors. Likewise, adult shoot tips do not respond to fractionated extracts of adult and juvenile stem tissue whereas juvenile shoot tips do respond to these extracts. This indicates that these factors do not limit root initiation in this difficult-to-root adult shoot tissue and points out a danger in using easy-to-root tissue as a rooting assay in studies of root initiation in difficult-to-root plants.

Reduction in light intensity brings about a qualitative change in the rooting response of adult shoot tips to auxin and catechol(Fig. 6). There is essentially no response to IAA and catechol when adult tips are grown in high intensity light, but when grown in low intensity light adult tips respond markedly to these factors, and in much the same manner that juvenile shoot tips respond to these factors in high intensity light.

There is ample evidence for methanol extractable factors which promote rooting in easy-to-root juvenile ivy shoot tips but no evidence for similar factors which promote rooting of difficult-to-root adult tips. Even the light controlled factor which stimulated rooting of adult shoot tips was not methanol extractable. Further work with different extraction solvents is needed to determine the factors that control rooting in adult ivy shoot tips. It is possible that these factors reside in a fraction of the cell which is not readily extractable or transmissible.

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PRESIDENT KRAUSE: Thank you very much, Wes. After our next two speakers we will have a Question and Answer period, so reserve your questions until then. We will have adequate time set aside for questions and answers.

Our next speaker will talk on etiolation as an aid in propagation. Dr. George Ryan:

ETIOLATION AS AN AID IN PROPAGATION

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Etiolation results from the exclusion of light from plants or plant parts. In this discussion we are concerned only with the effect of excluding light from that portion of the stem from which roots may develop. Effects of light, or absence of light, on chlorophyll formation or other changes in the leaves are not a part of this discussion, because in the use of etiolation for propagation, leaves are allowed to develop normally in the light above the etiolated portion of the stem.

One of the externally visible effects on etiolated stems is blanching, resulting from the disappearance or lack of chlorophyll. Etiolation is sometimes defined in terms of this blanching effect, but in relation to propagation, the presence or absence of chlorophyll in the stem probably is of no significance.

Etiolation is generally thought of in relation to deliberate exclusion of light during stem development, or for a period of time prior to the rooting process, but exclusion of light in the normal procedure of placing the base of the cutting in a rooting medium probably also is a factor in the rooting of many kinds of plants. For other plants an opaque rooting medium is not essential. The primary function of the rooting medium is to support the cutting in an environment with a favorable balance of moisture and aeration, and rooting of many plants can be accomplished if the cuttings are suspended in a suitable atmosphere without excluding light. Aerial roots on such plants as philodendron, and the juvenile form of ivy, are examples of the capacity of some plants to initiate and grow roots in the presence of light.

On the other hand, a number of observations have been made of the inhibiting effect of light on rooting. Sachs (17) reported that cuttings of *Cactus speciosus* (sic) kept in the dark for several weeks formed adventitious roots, while cuttings kept in the light for the same length of time did not. He made similar observations on cuttings of *Tropaeolum majus* and *Hebe speciosa* (*Veronica speciosa*).

Galston (4) cultured asparagus stem tips in nutrient agar containing indoleacetic acid (IAA) and found that they rooted only in darkness. Hackett (7) noted that shoot tips of the adult form of ivy (*Hedera helix*) rooted in the presence of IAA in low light (50 f.c.) or darkness but not in high light intensity (500 f.c.). Rooting of juvenile tips was increased by reduction or exclusion of light. In all of these instances, the entire cutting was in either darkness or light, which may involve a different effect than exclusion of light from only a section of stem.

Mevius (12) reported that rooting of *Tradescantia* cuttings was inhibited when the bases were exposed to light. Once the roots formed, however, they grew well in the light. The adult form of ivy normally does not produce aerial roots, but when light was excluded from a portion of stem, numerous roots were formed (7).

Excluding light from the stem for a period of time before taking cuttings influences rooting of some plants. Regel (14) reported this effect on rose from mounding soil around the bases of the shoots for some time prior to taking cuttings.

Wrapping a portion of stem of clematis with black paper 10 days to 3 weeks before taking cuttings resulted in roots appearing at the nodes instead of only internodally, and more rapid rooting in the internodal region (19).

Herman and Hess (8) studied the effect of excluding light from stems of red kidney beans for 3 weeks before taking cuttings and reported over 5 times as many roots from etiolated as from non-etiolated cuttings after 4 days, and nearly twice as many after 8 days. After treatment with indolebutyric acid (IBA), the difference between etiolated and non-etiolated cuttings was even greater.

The greatest response to exclusion of light is from etioltion during the early stages of shoot development. This is the response that has been of the greatest value in propagating plants that are difficult from ordinary cuttings.

In the stool method of rooting fruit tree rootstocks, established plants of the desired variety are cut to the ground after one season of growth, and as shoots grow in the spring, soil is mounded around their bases. The most shoots are produced when the crown of the plant is left exposed to light until the shoots have made some growth, but rooting is best if the plant is covered lightly with soil before bud break and more soil is added at intervals as the shoots grow. In this way the basal portion of the shoot, the portion from which roots will develop, is never exposed to light. This procedure is essential for success with most plum stocks, vigorous quince varieties, and with pears and cherries. Most apple stocks will root well if the shoots are allowed to grow in the light and mounded up later (9).

The etiolation method of trench layering was developed at the East Malling Research Station in England for propagating those stocks that do not root well in severely pruned stool beds (9). An essential step in this method is the covering of layered stems with 1-2 inches of soil just prior to bud break in the spring, with more soil added as the shoots emerge.

Lambourne (10) used layering for a number of plants in Malaya, but found that covering the buds with soil before they began to grow was fatal to many of the evergreen tropical species. He therefore made the first application of soil when the new shoots were 4-6 inches high, covering them to half their height. Even this delayed exclusion of light was beneficial, as was noted earlier for rose, clematis and bean.

A different version of the etiolation principle was used by Gardner (6) for rooting cuttings from 'McIntosh' apple trees. He wrapped black tape as close as possible to the growing tips of shoots on the tree so that light was excluded from the differentiating stem. Cuttings taken the following spring rooted from the eitolated portion. Herman and Hess (8) increased rooting of 3 hibiscus varieties by the same procedure using *black plastic* as a wrap. Gardner later developed a procedure of covering the shoot tip with a tube of black paper through which the shoot grew, leaving the basal portion in darkness.

Blackie *et al.* (1) used similar techniques for rooting camphor cuttings. Reid (15) enclosed branches of a camphor tree in an opaque bag and found that rooting was accelerated on cuttings taken after 2 to 4 weeks.

Working with avocado, Frolich (2) developed an etiolation method using plants in containers. The procedure as finally developed consists of placing the plants in a dark chamber until new shoots grow to a length of about 3 inches. They are then moved to the glasshouse, and a tar-paper collar is placed around the shoots and filled with vermiculite to exclude light. After the shoots grow out and develop normal leaves in the light, they can be cut off and placed in a cutting bed to root, or girdled and left to root in the vermiculite-filled collar. The method has been used extensively for propagating avocado varieties and rootstocks for experimental work.

Several studies have been conducted in efforts to explain the effect of etiolation on root initiation. Gardner (6) working with apple and Frolich (3) with avocado both determined that the shoo tip could be exposed to light without interfering with the etiolation effect as long as the stem immediately below the tip was in darkness. If the apple shoots were taped only to within an inch of the tip instead of as close as possible, there was a reduction in rooting.

Exposure of etiolated avocado shoots to 12 hours of light reduced the per cent rooting and the number of roots per rooted shoot, but in one experiment a third of the shoots still rooted after 7 daily exposures to 12-hour periods of light, with 1 root per shoot (11). Rooting was reduced by delaying the exposure of etiolated shoots to light as long as 5 weeks after the start of the rooting period, but the greatest inhibiting effect was from exposure at the start or after 1 week. The time of girdling the shoot was considered the start of the rooting period. By microscopic examination of stem sections, evidence of root initiation was seen 3 weeks after the start of the rooting period, and counts of root initials indicated initiation was completed by the end of 8 weeks (11).

Exposure to light reduced the effect of IAA on rooting of cuttings from etiolated pea (5, 21) and mung bean seedlings (16). In some of our studies with mung bean, exposure for 30 minutes to red light at 100 f.c. measurably reduced the number of roots.

Galston's studies with asparagus stem tips indicated the effect of light could not be attributed either to lack of absorption of IAA in light or to light-activated destruction of IAA (4).

Asparagus stem tips repeatedly subcultured in the dark without IAA lost their capacity to root when IAA was supplied, suggesting that an "accessory substance" necessary for root initiation was depleted. Addition of various materials to cultures of "depleted" stems in the presence of IAA did not restore the rooting capacity, although some of them greatly increased stem growth. The materials tested included ammonium sulfate and arginine, which van Overbeek *et al.* (20) reported were effective in combination with IBA in promoting rooting of defoliated hibiscus cuttings.

Rooting ability was restored only by exposing stem tips to light for a week or longer, after which they would root in darkness. Apparently something essential for rooting was produced in the light, but the actual root initiation process was inhibited by light.

Naturally-occurring auxins were slightly higher in etiolated than non-etiolated bean and hibiscus stems, and in some cases higher levels of rooting "cofactors" were found in etiolated stems. However, the etiolation effect on rooting was not attributed to either of these differences. The presence of unknown substance(s) which act synergistically with auxin were postulated (8).

Hackett found no more methanol-extractable rooting cofactor in etiolated than non-etiolated tissue of either juvenile or adult ivy, and there was no rooting response of adult shoot tips to extracts from etiolated shoots (7). He suggested that a suitable extraction solvent had not been found, or that possibly the factors controlling rooting are in a fraction of the cell which is not readily extractable or transmissible.

Frolich (3) found no evidence for translocation of the etiolation response. When a shoot was grown with light excluded from only a marked section of stem, roots developed in that section but not in adjacent areas above or below. Priestley and Ewing (13) had earlier noted that etiolated portions of plants show etiolation effects even though other parts of the same plant are not etiolated.

In a study of anatomical differences between etiolated and non-etiolated shoots, Priestley and Ewing (13) observed the presence of an endodermis in etiolated shoots of *Vicia faba.* They attributed the etiolation effect on rooting to stimulation of meristematic activity by a restricting influence of the endodermis, resulting in root initiation. On the other hand, an endodermis was not observed in etiolated avocado shoots (11) nor in etiolated hibiscus or bean stems (8). Less mechanical tissue and less lignification were seen in etiolated than non-etiolated shoots (8, 11, 18, 19), but these mechanical tissues did not increase when etiolated stems were later inhibited from rooting by exposure to light (11). Several other anatomical differences were observed but none was thought to be responsible for the rooting response (8).

Etiolated tissues generally contain less starch than normal tissues (8, 11, 19). Smith postulated that the reduced starch level resulted in a carbohydrate-nitrogen ratio more favorable for meristematic activity and root initiation than in the mature non-etiolated stem (19).

It is clear that more research is needed to explain the effect of etiolation on rooting. Studies to determine how exclusion of light promotes rooting may also contribute to an understanding of the factors involved in ease or difficulty of rooting in general, and thereby help to improve the efficiency of our propagating methods.

In the meantime, with our present knowledge of the rooting response to exclusion of light, the propagator can continue to make use of the etiolation effect on otherwise difficult to propagate plants without knowing why it is so effective.

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PRESIDENT KRAUSE: We now have time for questions and answers. We have a floor microphone this year. When you have a question we would appreciate your giving your name and to whom you would like to address the question. Do we have some questions? Yes.

AUSTIN KENYON: I would like to ask Dr. Hackett two questions. One, I noticed that with catechol and IAA, you just merely increased rooting up to the level obtained with NAA or IBA. Did you try the other two rooting hormones in this same test? In other words, with etiolation and red light?

DR. HACKETT: Are you asking whether we used catechol in combination with red light?

MR. KENYON: No. It seemed to me that in your comparison of the three hormones IAA was the worst, but combined with catechol you increased rooting up to about the same as the other two. So then did you try the other two in other tests, such as the IAA — catechol combinations?

DR. HACKETT: In one slide I showed the use of catechol in combination with NAA, but there catechol gave no increase in rooting over NAA alone.

MR. KENYON: Right. I understood that, but what I was getting at is that it seemed like NAA and IBA without catechol were equal to IAA with catechol.

DR. HACKETT: That's right.

MR. KENYON: And so I wondered, did you try the other two in the same experiments without catechol, and I wondered too, if maybe they would react better under etiolation and with red light than IAA plus catechol.

DR. HACKETT: We used NAA in the etiolation experiments; NAA was always superior to IAA as far as root initiation was concerned, even when the plants are grown in the dark. The answer to your question is — yes; NAA is a preferable auxin to use, even with etiolation for ivy shoot tips.

MR. KENYON: One more question; in your light experiments how did you obtain the red light — what wavelength was it — and what type of light was used?

DR. HACKETT: We used fluorescent tubes and then used a cellulose acetate, (red cellophane) film to wrap the lamps in.

DON DILLON: Another question for Dr. Hackett. What was the wavelength you obtained with the red light?

DR. HACKETT: About 650 millimicrons. This is more a characteristic of the fluorescent lamps then of the cellophane.

The lamps we used were Grolux fluorescent and their red peak comes at about 650 millimicrons.

ED SCHULTZ: Dr. Hackett, can you convert milligrams per liter to parts per million?

DR. HACKETT: Milligrams per liter is the same as parts per million.

VOICE: Dr. Leiser, has foliar analysis been used as an established technique for determining the levels of nutrition in rooting cuttings?

DR. LEISER: Foliar analysis has been used but the problem is: what is standard? Normal levels vary considerably from variety to variety in a similar nutrient regime, whether it is chysanthemums or azaleas. Most foliar analyses with ornamentals therefore become meaningless. The figures are there but they don't mean much. As a side light, you might be interested to know, there has been organized just this year a Council on Soil and Plant Analysis to which individuals will be invited to subscribe or join. It will attempt to determine standards of analysis for particular plants. Through this Council we finally may arrive at some standards which will be meaningful.

Referring to the previous question on parts per million vs. milligrams per liter, this is really a "plug" for the metric system as opposed to the English system of weights and measures. One reason we like to use the metric system is that milligrams per liter equals parts per million. It is an easy switch back and forth.

JIM BROWN: I have a question for Dr. Leiser. You said that calcium is essential for new cell division in meristematic tissue. I was wondering if this would be a pH relationship or a nutrient relationship?

DR. LEISER: Calcium is essential for the middle lamella — calcium pectate — which is the adjoining line between two cells. Calcium is an essential element in this part of the "building blocks", the structure of cell formation; whether there are other relationships or not, I don't know. Calcium is just an essential nutrient for proper building of the tissue structure. The cell wall has a lot of calcium in it. We might make an analogy of the child who needs good calcium to build strong bones. It is not a pH factor — it is a nutrition factor as far as I know.

LES CLAY: Another question for Dr. Leiser. I understand you to say something about sodium salts being detrimental to the initiation of roots. What would be the effect of the concentration of sodium salts in the water supply?

DR. LEISER: This adverse effect of sodium probably doesn't concern you in British Columbia, western Washington, or western Oregon, like it does us in California. Levels of sodium in the water supply that are detrimental to rooting are found in much of California. For example, the Los Angeles basin gets a lot of their water from the Owens Valley and much of it is rather high in sodium. At Davis, California, we have some well water which is rather high in sodium — high enough to inhibit rooting.

DR. HACKETT: I might add to that. Some city water systems may be softening their water. If you are in a city that is softening the water for general use, then the sodium in that softened water is going to be high enough to be detrimental to root initiation in cuttings.

DON DILLON: On the same point — how high is high; what levels are we talking about, Andy?

DR. LEISER: We have no trouble getting 100 parts per million at Davis, California. Certainly the sodium in your home water softener, if it happened to be hooked up wrong, and you were getting it through your cold water line, into your propagation area, would give you trouble. I think some people may toy with the idea of a water softener unit to avoid the calcium buildup in their misting nozzles. This could be disastrous. You could offset it considerably by just using gypsum in the existing beds, because calcium is held on peat more strongly than sodium. It will displace the sodium, and the sodium will leach on through. Certainly the prevention of calcium buildup on mist nozzles by the use of a table salt rejuvenated water softener is very bad. If you use ion exchange beds you are all right. This is quite different than the usual water softeners.

RICHARD THOMPSON: Dr. Hackett, did you make any attempt to locate any inhibitor for root initiation rather than a root promoter in the initiation of roots in the plants that were grown in the light as compared to those under etiolation?

DR. HACKETT: If you will recall from our graphs, our untreated control plants rooted quite poorly. When we used IAA at 10 parts per million as the auxin, the control plants had only approximately 1 root per cutting. So this left little leeway to assay for inhibition of rooting. Our assay really was not the kind of assay to detect inhibition of rooting so I don't think I could comment whether or not we had rooting inhibitors.

BILL HALL: Dr. Leiser, I just wondered about your statement of using mineral nutrients in the mist system in rooting of cuttings. Does this disprove the old theory that you get best results in either clean river washed sand or peat — perlite or vermiculite, or combinations of these?

DR. LEISER: I think one of the reasons for use of "clean river-washed sand", and so on has been in regard to disease control. Certainly, with nitrogen in the rooting medium, if pathogens — fungi or bacteria — exist, there will be a great increase in these diseases.

PRESIDENT KRAUSE: Thank you very much. We must cut off our question and answer period now. For those of you who have further questions to address to these gentlemen, take advantage of our Question Box.

Our next talk will deal with effects of age, origin, storage and hormone treatments on the rooting response of cuttings, by Dr. A. N. Roberts. Dr. Roberts:

TIMING IN CUTTING PROPAGATION AS RELATED TO DEVELOPMENTAL PHYSIOLOGY

A. N. Roberts
Oregon State University
Corvallis, Oregon

We were impressed with a statement made several years ago by Dr. Vernon T. Stoutemyer of the University of California at Los Angeles, to the effect that possibly the reason cutting propagation research has remained quite primitive is that we have not solved the problem of timing to the extent that we can duplicate an experiment from one year to the next. We have taken this comment rather seriously, because we respect the research done by this worker over the years, and his conclusion matches precisely our own.

With the help of several graduate students, we have been attempting to establish a morphological time scale for predicting rooting potential in certain woody species, and to correlate physiological condition and developmental events with shoot rootability (1, 3). We have had some success, and have changed many of our ideas, but much remains to be done. In the beginning, it was our concept that seasonal changes in shoot rootability were associated with tissue and physiological aging. Now, we are of the opinion that certain events, such as flower induction and dormancy can temporarily change the rootability of shoots, and tissue aging *per se* is not the answer.

One of our gradaute students, Charles Johnson, has recently published results which help elucidate the influence of flowering on shoot rootability in rhododendron (4). This work throws some light on the complex problem of relating such events to timing, and the importance of shoot age, position and stock plant environment in bringing about these events.

We thought some of you might be interested in our recent findings with Douglas fir, which illustrate the correlative relationship between the onset and removal of bud dormancy and root regeneration in this species. We will try to summarize briefly some of our results and relate these to propagation management problems.

As with all species, we have found the usual differences in rootability attributable to cultivar and plant age. We have clones of Douglas fir that can be rooted almost any month of the year, and others that resist all our rooting treatments. However, in classifying clones as easy-or difficult-to-root, it is well to remember that these should be qualified as to time. We have found some to be difficult of rooting at certain times of the year, but quite easy at other times.

When Dr. Holger Brix, who spoke at these meetings two years ago (2), told us that Douglas fir could be rooted most readily in January and February, we considered this indicative of a dormancy relationship. Our results during the past 2 years strongly sustantiate this conclusion. When we subjected terminal and lateral cuttings, taken on November 1, 1967, to 15, 30, 45, 60, 75 and 90 days of 32°F storage, we found rooting increased progressively with duration of storage to 60-90 days, if treated after storage with a 5-second dip of 50% Jiffy Grow (0.5% indolebutyric acid, 0.5% naphthaleneacetic acid, 0.01% phenylmercuric acetate, and 0.0175% boron as boric acid). (Fig. 1). The reduced rooting in some cases with 75 days of storage was attributed to lack of control over rooting bed environment during a critical period for this sample. An unseasonable hot spell occurred shortly after this sample was placed in the rooting bed. Later studies have confirmed this diagnosis.

Another preliminary study showed that terminal and lateral cuttings from non-flowering trees responded differently to such treatments as bud removal and auxin treatment (5-second dip, 50% Jiffy Grow) as shown in Fig. 2. Termianl cuttings were superior to laterals in rooting only when buds

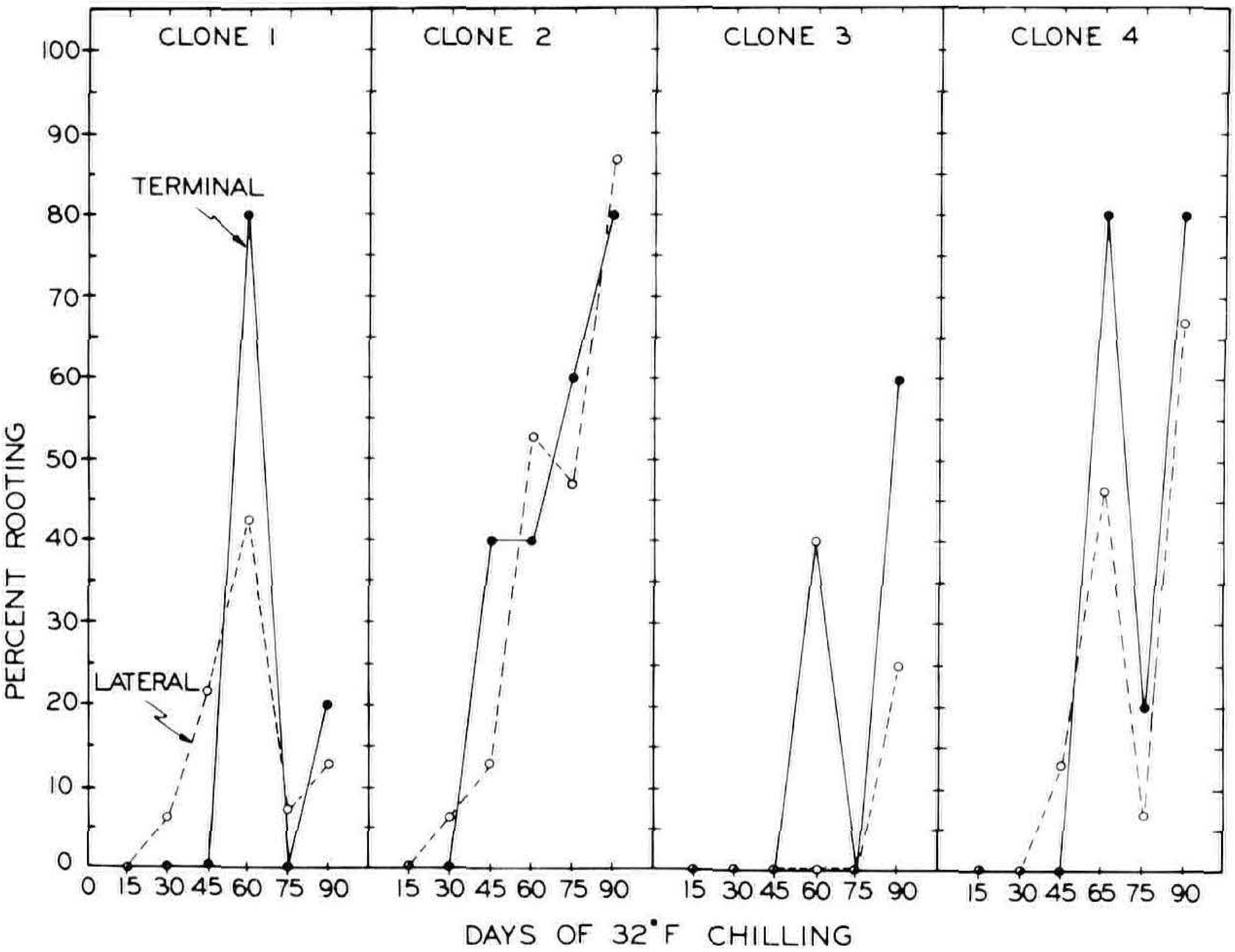

Fig. 1. Effects of various amounts of 32°F storage on rooting of November cuttings of 4 Douglas fir clones. Cuttings received a 4-second dip of 50% Jiffy Grow after storage and before placement in rooting bench.

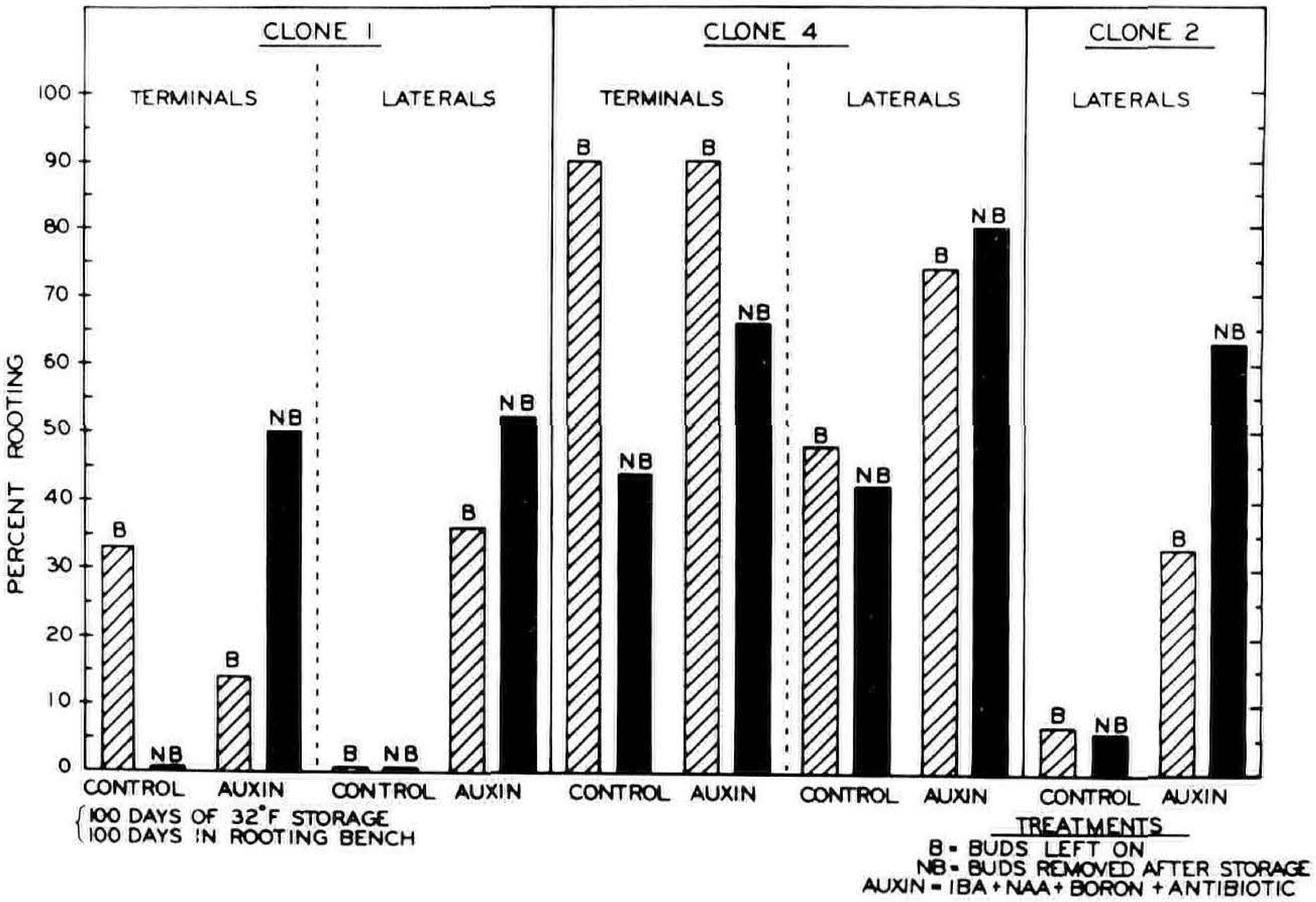

Fig. 2. Effects of bud removal and auxin treatment after chilling on rooting of terminal and lateral cuttings of Douglas fir. Cuttings received a 5-second dip of 50% Jiffy Grow.

were present and/or no auxin treatment was given, indicating that during cold treatment the buds were releasing a root-promoting substance similar in action to the synthetic auxin. Although the applied auxin did not enhance the rooting of terminal cuttings receiving cold treatment, it increased that of the laterals by 30 percent. Auxin treatment actually reduced the rooting of terminals, if buds were left on these cuttings after cold storage (February). Where auxin was not applied to the cuttings, the presence of buds was very important to rooting of terminals but not laterals. It appears that the buds are more important to the rooting of terminal than lateral cuttings, and may be responsible for the terminal's greater rootability. Only where the buds were removed did the laterals approach the terminals in performance. With auxin treatment, bud removal enhanced the rooting of both terminal and lateral cuttings, possibly as a result of removing a competitive growth center or "sink".

These preliminary studies convinced us that bud development and dormancy plays an important role in root regeneration in Douglas fir cuttings and that cold treatment to break dormancy, among other things, releases one or more root promotors similar in action to the rooting compound composed of IBA and NAA. The terminal cuttings appeared to contain more of this natural rooting stimulus.

With this background, a detailed study was made this past year of the seasonal changes in rootability of Douglas fir terminal and lateral shoots and their relationship to the presence or absence of bud activity, with and without auxin treatment. A number of clones were used which show a variety of rooting responses, but since all followed a more or less basic pattern we will confine our report at this time to one of the more easy-to-root selections that illustrates this basic response.

Terminal and lateral cuttings were taken on the first of each month from July, 1968, to April, 1969, and rooted under mist with bottom heat at 65°-75°F and a house temperature of 50°-60°F. The buds were removed from half of the 6-inch cuttings, while the others were kept intact. The monthly samples were further divided to include auxin treatment (5-second dip of 10 or 50% Jiffy Grow), so that the final treatment unit was 5 terminal or 10 lateral cuttings. The cuttings were given 120 days in the rooting bench, then lifted and evaluated on basis of percent rooting and root quality (3 classifications). A rooting index, based on the number of cuttings rooted and the quality of roots produced, was determined for each treatment. The results obtained in this study with clone '12' are presented in Fig. 3.

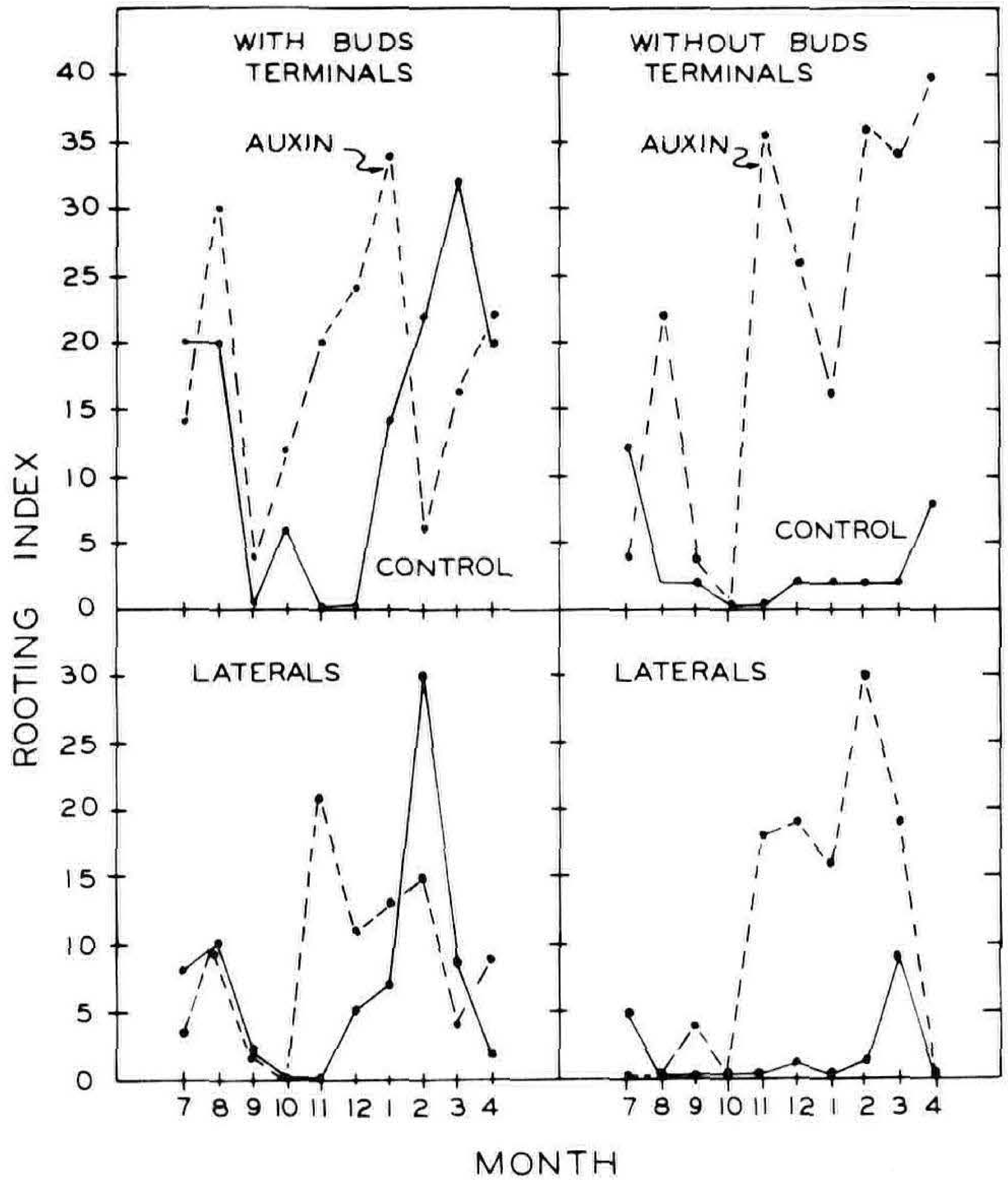

Fig. 3. The rootability of terminal and lateral cuttings of Douglas fir clone '12' sampled monthly from July, 1968, to April, 1969, with and without buds and auxin treatment.

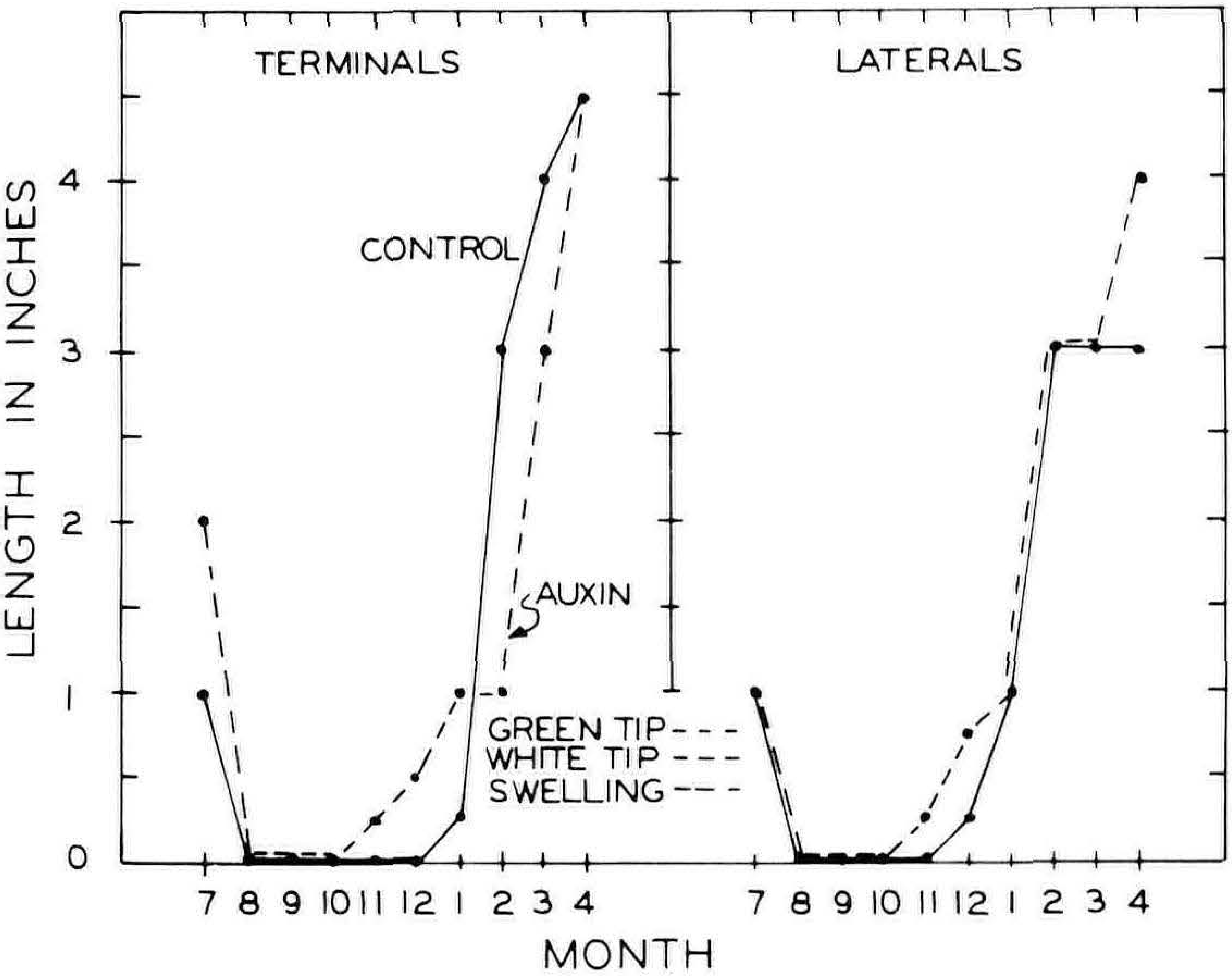

Fig. 4. Bud break on terminal and lateral cuttings of Douglas fir clone '12' after 120 days in the rooting bench from time of monthly sampling. July, 1968, to April, 1969, with and without auxin treatment.

The terminal cuttings of this cultivar could be rooted without special treatment in July and August and again in late winter or early spring (January-April), if buds were present. However, when the buds were dormant (September-December) there was poor rooting, unless the cuttings were given auxin treatment. Even this treatment failed to increase rooting in September and October. Auxin treatment replaced the need for buds after October, but in February and March lateral and terminal cuttings with buds rooted better without auxin treatment. Both terminal and lateral shoots showed similar seasonal curves of rootability and response to auxin treatment. In general, rooting in the untreated shoots coincided with bud break (Fig. 4). These results are similar to those reported by Fadl and Hartmann with dormant pear cuttings (3). Results obtained in more recent experiments show cold treatment of September and October cuttings to be effective in breaking dormancy and promoting rooting.

We conclude from experiments to date that the buds on Douglas fir cuttings have a great deal to do with their rootability. These buds appear at various times to be a source of inhibitors, promotors and competition. It appears that cold treatment, either on the tree or in storage removes inhibitors and releases root promotors. By removing the shoot from the plant before cold treatment, polarity is established and promotors are trapped in the cutting. If synthetic auxin is substituted for that naturally coming from the buds, some of the latter can be removed to prevent their becoming competitive "sinks" during bud break and elongation. Cuttings taken before sufficient natural chilling has occurred must be cold-stored to remove inhibitors to bud break and root initiation.

Studies are being continued to substantiate in detail the conclusions outlined in this paper.

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PRESIDENT KRAUSE: Thank you, Al. Save those questions for the end of our session this morning. Now we will consider techniques in misting; first a talk on under-bench misting by Bruce Usrey. Bruce:

ECONOMICS OF A CONTROLLED HIGH HUMIDITY ENVIRONMENT FOR PROPAGATION

BRUCE USREY
Monrovia Nursery Company
Azusa, California

In 1964 Monrovia Nursery designed and built a controlled environment greenhouse. This plastic house was designed to provide the best possible environment with the least operating and maintenance cost. Along with this was the hope of increasing rooting percentages and decreasing the amount of labor used in airing, watering, and shading the hot frames.

In designing this house a number of problems had to be solved. These were:

1. Control of humidity
2. Efficient heating
3. Control of air temperature
4. High light with minimum heat
5. Low maintenance cost

First, atmospheric humidity is electronically controlled by use of an Hygrodynamics, Inc. humistat. This humistat is extremely sensitive in the range of 70% to 97% humidity while being almost maintenance free. This humistat is tied into the hydraulic and pneumatic mist systems by relays and solenoids and operates either, or both, as needed. The hydraulic system is under the bench and is capable of maintaining a humidity of for that naturally coming from the buds, some of the latter can be removed to prevent their becoming competitive "sinks" during bud break and elongation. Cuttings taken before sufficient natural chilling has occurred must be cold-stored to remove inhibitors to bud break and root initiation.

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80%, when used by itself. The nozzles are Flora Mist and spaced 4 by 8 feet with an operating pressure of 90 pounds. This system uses 75,000 gallons of domestic water per day which, for economy, is recirculated through sand filters.

The pneumatic system cost is about ten times that of the hydraulic system but it was necessary in order to maintain a humidity above 80% on summer days. This system will maintain a relative humidity above 95% at all times and greatly reduces the hand-watering of flats. It also reduces the constant moisture associated with an intermittent mist system. The pneumatic nozzles are placed overhead in the walkways to prevent drip on the flats. These nozzles are Spraying Systems Co. pneumatic 1/4″ atomizers. This system uses 1/2″ O.D. plastic tubing for transporting the 50 p.s.i. water and the 60 p.s.i. air. This combination seems to give the most efficient fogging.

The air temperature can be maintained at 75° F. during the hottest days by using evaporative coolers with the capacity to change the air once each minute. By keeping the air temperaures low, preferably between 60° and 70° F. and providing air movement even on cold, cloudy days, fungus problems can be controlled and excessive top growth is reduced.

Heating requirements are met by circulating warm water in a copper tube grid system placed in concrete, insulated benches. This direct-contact heating, conserves 83% of the fuel as compared to indirect heating. Direct heating also keeps air temperatures down which makes it easier to control the humidity. Rooting media temperatures are generally maintained at 65° to 75° F. depending on the cuttings.

This house was constructed with pipe, steel, concrete and plastic. It has less maintenance than if wood and glass were used. Epoxy paint was used and appears to be in good condition after 5 years even under high humidity conditions.

One of the most important considerations in the propagation of any plant is providing the correct amount of light to aid in disease control and for the plant to carry on photosynthesis. When photosynthesis exceeds respiration (consumption of carbohydrates), the plant will accumulate carbohydrates, hormones, and other necessary organic compounds for proper root initiation. However, excessive light causes heat and transpiration problems within the plant, especially when the humidity cannot be properly controlled. For this reason, we use fiberglass sheets that transmit approximately 1/3 of the light available. In our area, this results in 1500 to 2400 foot-candles of light on the cuttings throughout the year. Over the last five years the fibers have raised on the panels, which have discolored, and collected dirt. This has lowered the light intensity to 500 to 800 foot-candles, causing a considerable increase in disease problems.

I would like to discuss at this time, some of the rooting results obtained in the house, and the techniques used to achieve them. In making these tests, an equal number of cuttings were placed at the same time inside the house and in the hot frames.

In the propagation of junipers, thirty varieties were tested with a total of 53,000 cuttings involved. After one resetting we had 45% rooting inside and only 18% in the hot frames. Our standard practices were used in propagation: cuttings were made in the middle of January using firm wood, cut ¼″ below the node, or heel cuttings were used, with quick-dip in 3000 ppm IBA. The cuttings were placed in sterilized flats of 1:3 peatmoss—perlite. Cuttings were then placed inside the plastic house with bottom heat of 70° F., air temperature of 75° F. and relative humidity of 94%. Others were placed in hot-frames with bottom heat of 70° F and with variable air temperature and relative humidity. Some of the varieties tested and rooting results obtained are: *Cupressus sempervirens 'Glauca'*: inside 67%, hot frames 3%; *Juniperus scopulorum* 'Table Top Blue': inside 33%, hot frames 6%; *Juniperus chinensis* 'Hetzi Columnaris': inside 33%, hot frames 12%.

Tests were also run on camellias and it was found that those inside the house had a rooting percentage of 89% while those in the hot frames had a rooting percentage of 67%. This test was run on nine varieties comprising 80,000 cuttings. For the camellias, relative humidity was maintained at 96% inside the plastic house.

Other ornamentals that we propagate in this house are azaleas, with 90 to 95% rooting, as well as genista, ericas and leucothoe.

To sum up the advantages of propagating in a plastic house with a controlled environment:

1. Rooting percentages are increased
2. Heating expenses are reduced
3. Humidification and cooling are readily controlled
4. Whitewashing, hand ventilation and rolling of curtains is eliminated and watering is reduced
5. Maintenance of the structure, painting, glass breakage, etc., is reduced or eliminated
6. Light is increased (2500 foot-candles compared to 500 foot-candles in the hot frames), with a decrease in fungal infections and an increase in photosynthesis.

By eliminating the frames, production was increased 5 times by greater utilization of area and increased rooting percentages. This increase justifies the cost of construction, which was $6.00 per square foot for 14,500 square feet of house.

I would like to thank Mr. Conrad Skimina, Research Director at Monrovia Nursery, for the use of research reports in preparing this talk.

In conclusion, I would like to mention the summer trainee program Monrovia Nursery has for students interested in the wholesale nursery industry. This program runs for ten weeks starting the middle of June and exposes the student to all aspects of a wholesale nursery, including sales, propagation, shipping, supervision of a crew, etc. while 20 hours of lecture are presented by supervisors and management. I would like you to strongly urge any students you know who are interested in the wholesale nursery industry to attend this ten-week summer course.

PRESIDENT KRAUSE: Thank you, Bruce. Continuous misting is our next topic, by Rudy Wagner. Rudy:

CONTINUOUS MISTING

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

Propagating under continuous mist has limited use and depends upon the plants and type of cutting to be propagated. The location is also very important to consider as it is most useful in outdoor propagation.

We are using continuous mist for summer propagation of ornamental broadleaf evergreen and deciduous stock. We also propagate some fruit rootstocks by softwood cuttings under continuous mist: *Prunus besseyi, P. tomentosa* and some other plum rootstocks. One must be selective as there are a few species that do not tolerate continuous mist. Since our mother stock block is near our lathhouse, we moved our propagating benches right into the lathhouse to avoid drifting mist and to provide some shade from the hot sun. The benches are 30 inches off the ground, four feet wide with eight inch sides. The water is brought in through a one-inch line that runs along the base of the bench's front side with a ¾ inch outlet every four feet. This gives every four square feet of bench space an individually operated line using a 100 Mister nozzle that sprays approximately nine gallons of water per hour at 25 lbs. pressure. The nozzle is manually turned on and off by a ¾ inch gate valve. After the benches were constructed and the pipes laid, ½ inch holes were drilled in the bottom, then they were filled with 2 inches of gravel and 5 inches of sharp sand. This gives good drainage and the sand is an excellent medium for continuous mist.

When making the cuttings it is very important to avoid wilting. Once they wilt it is almost impossible to revive them. I am referring to very soft cuttings. The best time to bring in the material is early in the morning before sun-up. The cuttings are at once rinsed in cold water and dipped in a weak solution of Morten's Soil Drench, ½ oz. to 20 gallons of water.

In preparing the cuttings, we remove the bottom leaves and pinch out the center. This helps keep the cuttings from wilting and saves later pinching, especially in shrubs. The cutting is then cut below a node and dipped in a 1-20 Jiffy Grow solution as a 5-second dip. When sticking the cuttings we always try to complete a 4-foot square with one nozzle so that the shipping, supervision of a crew, etc. while 20 hours of lecture are presented by supervisors and management. I would like you to strongly urge any students you know who are interested in the wholesale nursery industry to attend this ten-week summer course.

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As sand produces very brittle roots, the cuttings should be left sitting in the benches to mature some before potting. The cuttings are then potted in 2½-inch black, whale-hide pots and set in cold frames to be lined out the following spring. Most of these liners make the 18-24″ size the first year. For larger plants they are grown for one more year.

Producing plants by this method is undoubtedly one of the least expensive and most trouble-free ways of propagating.

PRESIDENT KRAUSE: Thank you, Rudy. Next on the program is Ron Klupenger who will talk on misting in storage, Ron:

MISTING IN COLD STORAGE

RON KLUPENGER

Klupenger Nursery & Greenhouse, Inc.
Aurora, Oregon

There have been many problems in cold storage of nursery material in the past, such as plants drying out, plants left in the cooler too long without lights, etc.

I think that misting has helped in solving some of these problems. It eliminates dehydration and drying-out of plants. With misting you don't have to be "Johnny on the Spot" with watering. There has been a great deal of loss without humidity control. We have experienced this over a number of years in precooling azaleas. It was all due to lack of knowledge of misting in cold storage.

Our first experience with misting came a few years ago when we had to rent cooler space and there were humidifiers in them. We were using the coolers for summer chilling, giving the azaleas six weeks of cold storage to produce late September and early October bloom. After the plants were in these coolers for six weeks, we could tell the difference in forcing. They came ou with more lush foliage and dseemed to react better to forcing. Also, we didn't have to watch the watering as closely while they were in the coolers. It does not work to put plants in coolers with mist that are showing colored buds, or in bloom. We tried this also. The flowers bleach out, fungi develop, and very few, if any, of these plants are saleable. So it is very important to pick off all colored buds and flowers before putting the plants into cold storage.

We have now narrowed down the time for summer precooling to a minimum of four weeks at 42° to 44° F. with mist plus 12 hours of daylight (about 18 to 20 foot candles). If the water can be turned on to stay on without interruption during the entire callusing and rooting period. This usually takes 12 to 18 days depending on the weather. As soon as there is a slight showing of roots, the water is turned off for the night. When fully rooted, the water is turned off completely and only a light hand-watering is required once in awhile.

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We have now narrowed down the time for summer precooling to a minimum of four weeks at 42° to 44° F. with mist plus 12 hours of daylight (about 18 to 20 foot candles). If the plants are watered when put into high humidity cold storage, they can go for the full four weeks without being watered.

When chilling at temperatures of 36° to 38° F. it is not necessary to use lights, but it is necessary to continue the misting. The misting cycle is the same for summer or winter precooling.

Misting can be accomplished by mist nozzles or by use of a humidifier. We use the Bahnson mister manufactured by Bahnson Company, Winston-Salem, North Carolina. It has a ¼ H.P. motor.

The misters should operate from ⅓ to ½ of the time while precooling. This can be regulated either by a time clock — 1 hour on and 1 hour off — or by a humidity web control which holds the cooler at about 90% humidity. Our misters are controlled with the web control. We have found this to be very successful because — with this control — you don't over or under mist. However, I have seen the one-hour on and one hour off precedure — with a time clock — used very succesfully on some types of nursery stock. The Bahnson unit which we use puts out a fog vapor at 3½ gallons an hour. We have two units in a 32′ x 60′ cooler.

PRESIDENT KRAUSE: Now, do we have some questions for these gentlemen?

RAY BURDEN: I would like to ask Al if he has done any work with *Libocedrus* cuttings?

DR. ROBERTS: No we haven't. Our work thus far with conifers has been confined to Douglas Fir. The information referred to regarding Taxus is from work being done at Michigan State.

RAY BURDEN: I have done about 50 or 60 experiments with *Libocedrus* cuttings, and have been 100% unsuccessful so far.

ANDREW LEISER: Al, I noticed in your cutting storage periods that you used 32°F. In storage to overcome seed dormancy, it often appears that somewhat higher temperatures are more effective. Have you made any comparisons between 32°F and say 40° or 45°F as to how soon this chilling requirement of the cuttings is filled?

DR. ROBERTS: This is a good question and is of interest to me also. Dr. Westwood at Oregon State finds the chilling requirement for pear seeds is quite close to that of the buds, and 40°F is near the optimum for both. We find the vernalization optimum for lilies is near 40° F also. Dr. Lavender in Forestry at Oregon State has shown that 120 days at near 40°F is optimum for breaking the rest of Douglas fir. However, we find it difficult to store evergreen material for long periods in dark storage at 40°F because of respiration and depletion of reserves, hence our use of 32°F storage for these long periods. You noticed, however, that we are trying cool (40°-45°F air temperature) rooms, with lights, and bottom heat of 70°-75°F as a rooting environment. Our reasoning here is that bud dormancy will be broken sufficiently to release rooting factors for mobilization at the base where, hopefully, root initials will be formed.

STAN WALTERS: Dr. Roberts, you made reference to a preliminary report regarding Taxus. This year I was a little bit behind schedule in making cuttings. About April 15 we made cuttings of a couple of varieties of Taxus; they already had an average of an inch of new shoot growth. We put them in cold storage in plastic bags until May 30, and then stuck them in the usual way for Taxus cuttings. They are now rooted, which is to me quite interesting in the sense that, although I got behind, I could hold them in cold storage and still come out with good rooting.

DR. ROBERTS: This is the reason we have been closely following Dr. Hartmann's work with dormant pear cuttings at the University of California. It appears we have a compromise in attempting to release root promoters from the buds for stimulating rooting but before bud dormancy is broken and shoot growth becomes competitive. We would like to keep the buds dormant while root initiation is taking place. Once rooting has occurred there is the problem of achieving terminal dominance in the cutting again. We find that considerable "push", whatever that means, from the roots is required to re-establish terminal bud dominance. It is similar to tree budding. We cut the stock back to a single bud in the spring, and with a 2-year-old rootstock force a vigorous whip from this single scion bud. So, we are trying to root the cuttings in the fall and have a fairly well-established root system before the cuttings start breaking bud in late winter or early spring and put the cutting under stress.

EUGENE BACIU: In regard to the lateral cuttings you made from the conifers, do you find that in some species the new plants seem to refuse to form a trunk and become a tree, and tend to grow laterally for many years?

DR. ROBERTS: This phenomenon is what the botanist refers to as topophysis, or the cutting persists in its phageotropic habit of growth. Spruce, Douglas fir and many other species present a problem in vegetative propagation because of this lack of terminal dominance in the cutting or graft. We can return apical dominance to Douglas fir in 2-3 years by pinching, pruning, staking, etc. This is as much a problem as rooting in some of these species and is another reason we are going to fall-rooting of cuttings. We feel that the "stress" needles formed on the first growth flush in the rooting bench before or after rooting is due to lack of certain substances from the roots at a critical time. This growth flush under stress will usually not form a strong terminal bud and in some cases it will abort. The fact that terminal buds also have a higher chilling requirement than lateral ones may also present a problem if the cuttings have not received adequate chilling. This may complicate further our ability to get a strong growth flush and terminal bud formed on the newly rooted cutting. As a result, we often see the lateral buds near the base of the cutting breaking ahead of the terminals. Does this mean that something other than water and mineral nutrients are needed from the roots to establish strong terminal dominance to the cutting?

EUGENE BACIU: Would there be any hormones or nutrients that you could feed them to overcome this?

DR. ROBERTS: Of course, one thinks of such things as GA_3 or benzyl adenine, etc. We have trials underway, but haven't been too successful so far. I think our problem is getting the right material at right concentrations into the cutting at the right time. You see, in rooting a cutting one must first mobilize everything to the base first. After one has initiated roots at the cutting base then one has the job of re-orienting the cutting completely, that is, returning acropetal orientation.

MARGARET FLEMING: Dr. Roberts, you mentioned polarity being important. Would you describe, in handling the cuttings, just how important it is.

DR. ROBERTS: We have had to change our ideas about a lot of these things; for instance, I have always thought of timing the taking of cuttings as a matter of tissue age and maturity. Now we think physiological events more than physiological age may be the important thing. Regarding polarity, I have been impressed by comments made in a recent paper I received from Dr. Gorter of The Netherlands. She says that polarity is not induced in the shoot until it is severed from the plant. Even where we have preformed root initials, as in willow, she finds these organized systematically through the internodes. It is only after the shoot is severed that we find an accumulation of certain materials at the base and a concentration of initials developing in that zone. I think these observations are highly significant, and are reasons we are studying the cold treatment of Douglas fir cuttings on the tree as against in storage after severing. We find we can double shoot rootability by giving the cutting cold treatment in storage rather than on the tree.

BILL WIND: We have long observed, at least in Douglas fir cuttings, that quite often the roots come out from one side at the base of the cutting. Would you give us your thoughts on preventing this by some initial treatment of the cutting, or describe what can be done after such roots have been formed.

DR. ROBERTS: A German forester who visited us this last week, and I think he is at this meeting today, has observed this problem you speak of. We have also observed the same thing and find it is a problem in some clones. If we wound the cuttings up the sides, some will root nicely along the wounds while others will root only at the base. Others will root only at the base, and when the first root forms no others appear and this one root will elongate for great distances without branching. Root pruning or breakage in transplanting will encourage root branching and formation of more root initials. Workers in New Zealand report similar results. This may be much like terminal dominance in the shoot and needs study as a horticultural practice.

WEDNESDAY AFTERNOON SESSION

September 3, 1969

VICE-PRESIDENT BRIGGS: The moderator for the second session of our meeting will be Dr. Harry Lagerstedt, who is now a horticulturist with the USDA stationed at Oregon State University, Corvallis. Dr. Lagerstedt will also start the session off by giving the first talk. Harry:

GRAFTING: A REVIEW OF SOME OLD AND SOME NEW TECHNIQUES

HARRY B. LAGERSTEDT
Agricultural Research Service, USDA
Oregon State University
Corvallis, Oregon

The technique of grafting is over 2,000 years old, so it might be presumptous to assume that something new can be added. Yet the wheel, which is thought to be over 5,000 years old, is continually being improved as new materials are developed. There can be no change in the basic design of the wheel, only in its size or the materials utilized. In the same way, there can be no change in the basic principles involved in grafting, only in the tools, materials, or methods used in preparing the grafts. It is the objective of this paper to review certain grafting techniques and to present some materials and methods which have improved nut tree grafting success. This will be done while considering the basic principles involved in grafting.

History:

Grafting involves joining a stock and scion in such a way that they will unite and grow. It is a practice that has been subject to much folklore and misconception. Grafting was first recorded by the Greek philosopher Aristotle (384-322) and his pupil, Theophrastus, the "Father of Botany" (370-287 B. C.) (2). Their casual mention of grafting suggests that it was already a well-established and common practice during their time (5).

Virgil (70-19 B. C.) the Roman poet (2) wrote of grafting in the following terms: (1)

"But thou shalt lend
Grafts of rude arbute unto the walnut tree.
Shalt bid the unfruitful plane sound apples bear,
Chestnuts the beech, the ash blow white with pear,
And, under the elm, the sow of acorns fare."

We are now aware that grafts of such distantly related tree types are impossible. What the ancients had construed as a graft was probably the germination and growth of a tree seed in the crotch of a mature tree. It is presumed that this observation and that of naturally occurring grafts was the basis for the first true grafting attempts (3).

Pliny "The Elder" (23-79 A. D.), a Roman naturalist (2) wrote, "It is a point most religiously observed, to insert the graft during the moon's increase" (1). This was a common misconception associated with ancient grafting. Pliny may have contributed more factual information when he asserted, "A graft should not be used that is too full of sap, no, by Hercules, no more than one which is dry and parched" (1).

During the Dark Ages grafting knowledge became the secret possession of a few practitioners, and little in the way of improvement was added to the technique for several hundred years. Some of the veil of mysticism was lifted from grafting with the writing of herbals, approximately 1475-1625, and the establishment of botanical gardens in the 16th and 17th centuries (11).

One of the first illustrations of grafting occurred as a crude woodcut by P. Crescintiis in 1548 (11). By 1672 Sharrock's "History of the Propagation and Improvement of Vegetables" showed and described most of the kinds of grafting and budding that are known today (1).

As a young man George Washington was an avid gardener and grafter. Washington's detailed diary states that in March, 1760, he grafted 165 trees of cherry, pear, and apple (6).

The development of new grafting techniques is rarely recorded, yet there is one improvement attributed to an American, Joseph Curtis. In 1802, as a young nurseryman, he was acquainted with the common forms of budding and grafting. When seedling apple rootstocks were in short supply, he tried short pieces of root from an apple tree his father was removing. These grafts produced sturdy trees and the technique of piece-root grafting was quickly and widely adopted by nurserymen. Curtis later developed the collar or crown grafting technique where scions are joined to the rootstocks at the ground line. Later still, he developed nurse-root grafting where grafts are planted deep to promote scion rooting (6).

Grafting Principles:

The major principles involved in grafting are:

1. Use stocks and scions having a close genetical relationship.
2. Match the cambiums of stock and scion.
3. Promote rapid callusing of the graft union.
4. Prevent drying of the graft union.

These principles will be examined individually to determine where improvements might be made within their framework.

1. *Genetical Relationship:*

Generally speaking, all trees of the same "kind" intergraft satisfactorily. Botanically speaking, this means that most varieties of a given species will intergraft. Many species within a given genus will also intergraft. For example, most of the species of the walnut (*Juglans*) intergraft satisfactorily, but one combination, *J. regia* on *J. hindsii,* sometimes fails. This graft incompatibility is known as "blackline" and may take 40 years or so to express itself. Grafting between two genera of a plant family is frequently unsuccessful, and grafting between two families is always unsuccessful. The closer the botanical relationship of stock and scion, the greater are the chances of obtaining a functional union.

An attempt to employ this knowledge has been made in grafting the filbert tree. The orchard filbert tree is trained to a single trunk, but in nature it is a large shrub consisting of many stems which arise from underground suckers. These suckers sprout throughout the growing season, and their continual removal consumes a great deal of time and effort annually. A suckerless rootstock would be an obvious solution to this problem, and several species within the filbert genus (*Corylus*) have been tried with limited success. A glance at the taxonomic chart below shows the filbert to be a member of the birch family which consists of two sub-groupings called tribes (8, 9). The sub-groupings suggest that there is a closer genetical relationship between the genera of the tribe *Coryleae* than between their genera and those of the tribe *Betuleae.* The possibilities for intergeneric grafting of the shrub forms of *Corylus* with the tree forms of *Carpinus* and *Ostrya* are now being investigated.

A taxonomic classification of the birch family, Betulaceae:

Tribe I.	Betuleae	Tribe II.	Coryleae
Genus	A. *Betulus*	Genus	A. *Corylus*
	B. *Alnus*		B. *Carpinus*
			C. *Ostrya*
			D. *Ostryopsis*

2. *Match Cambiums*

The principle of matching the cambium of the rootstock and that of the scion is absolute. This principle limits commercial grafting to plants which have a continuous cambium. In all the plant kingdom only a relatively few plants meet this criterion. None of the lower plants possess a continuous cambium and of the higher plants, only the gymnosperms and dicotyledonous angiosperms have it. Thus, for all practical purposes, grafting is limited to the cone-bearing plants and the members of true flowering plants.

3. *Promote Rapid Callusing of the Graft Union:*

Sitton showed that the optimum temperature range for promoting callus tissue formation on black walnut grafts was from 70°-85° F. (13). In Oregon, where cool spring temperatures prevail, successful field grafting of walnuts is frequently a problem. Nurserymen have sought to increase the temperature by tying a brown paper bag over the graft. This technique not only increased daytime temperatures, but provided some frost protection and has become a standard practice.

The idea of "hot caps" used by tomato growers was enlarged upon by the contruction of long plastic tents over portions of grafted walnut nursery rows. For each of seven weeks starting March 19, 1969, 50 walnut trees were grafted of which 25 were covered by a plastic tent 2′ wide, 2′ high, and approximately 40′ long. Hygrothermographs were placed inside and outside the tent to obtain a continuous record of humidity and temperature. Humidity differences were slight, but averaged somewhat lower for the tented grafts. The striking difference was the influence of tenting on temperature. The hours of temperatures over 70° F. were added for a seven-week period. Tented grafts totaled 331 hours while grafts in the open totaled only 59 hours. The grafting success varied from 28 to 100 percent and was strongly in favor of the tented trees during the first, fifth, sixth and seventh weeks of the experiment. The percentage difference was very slight the other three weeks. The influence of tenting on growth, height and uniformity of grafts was striking. Tented grafts leafed out sooner and were several inches long when the buds on grafts in the open were just beginning to swell. Ultimately, the tented trees were taller and more uniform in height than those grafted in the open.

When bench grafting deciduous fruit or nut trees in the fall, before the rest period of the buds has been broken, a heating cable has been used to promote rapid callusing of the union. The heating cable was laid in moist sawdust and covered with sawdust. The roots of the stock were heeled-in and covered by more sawdust. This technique provided protection for the root system, left most of the stem tissue exposed to normal outdoor temperatures, and applied heat only to the union. If done too late in the season, the buds forced, but done in early fall this method of promoting callusing was highly successful.

In 1914, Lowther and Worthington (10) described the use of paper cones to protect pecan grafts in southern United States where excessive heat may retard callusing. Sitton (13) has shown that the rate of callusing decreased as the temperature exceeded 85° F. In 1966, Romberg and Madden (12) combined aluminum foil and polyethylene bags to shade the graft union while maintaining a high humidity. The combination foil-and-bag seal usually resulted in more growing scions than where the conventional wax seal was used.

In addition to various methods used to modify temperature, applications of plant growth regulators have occasionally been used to promote rapid callusing. While a few successes have been reported, there are as yet no reports of a "hormone" which has broad general application or provides consistently good results.

4. *Prevent Drying of the Graft Union:*

One of the most important principles in biology states, "Where there is no moisture, there can be no life." The fourth principle of grafting is based on this fact. The ancients were aware of this requirement and prepared a mixture of clay and cow dung called a grafting "pug" (3). The pug was molded around the graft union and bound with strips of cloth. Since this had serious limitations as a sealing compound, the pug was eventually replaced by waxes which continue to be used to this day. An important requirement of a sealing compound is that it must be elastic enough to stretch as growth occurs beneath it. Waxes often crack, allow air to enter, and drying to occur. Some waxes have too high a melting point and injure tissues when applied; others have too low a melting point and tend to melt in sunny weather.

Now there are polyvinyl acetate paints available which are water soluble, non-phytotoxic, and elastic. These paints do not require heating and are applied as they come from the can. They are available in various colors and are used for pruning cuts and other tree injuries as well as to seal graft unions. Experiments are now in progress combining these paints with plant growth regulators to promote rapid callusing.

Smooth cuts on both the stock and scion insure a close fit of the union without gaps where air can enter. Use of small stems and long cuts makes the union more pliable and provides for a closer fit. Firm binding of the union not only provides support, but helps bring the two cut surfaces into tight contact.

Rubber grafting bands remain one of the best materials available for binding the graft union. They provide a constant pressure yet will stretch with growth. If successive turns of the band are overlapped they form a moisture-tight seal which may not require waxing. However, rubber grafting bands may deteriorate slowly and frequently need to be cut off the union. String, raffia, various adhesive tapes, plastic strips and even nails have been used to hold stock and scion together.

A paraffin film sold by biological supply houses for use in laboratories has also been tested for binding grafts. A small square of this film is commonly used to seal test tubes. The heat of the hand causes it to seal. Being a thin film of soft wax, it has some elasticity when warmed in the hand during application. Successive wraps around the union make a firm binding. Subsequent removal is not necessary because the binding breaks and drops off as the union grows.

The opposite of the grafts "drying out" is having grafts which "flood" or "drown". This occurs in certain plants, such as the walnut, which "bleed" excessively in the spring. "Bleeding" is believed to be due to several causes: a lack of formaion of ttyloses, bladder-like cellular intrusions which block water-conducting vessels (4) ; a combination of root pressure, abundant soil water supply, and a lack of transpiration (7).

Walnut nurserymen in California sever the tops of the rootstocks a day or two prior to grafting. This technique permits some advance "bleeding" to occur and will improve the percentage take. Frequently nurserymen cease grafting all together during periods of active "bleeding".

An Oregon walnut nurseryman, Mr. Scott Parrott of Newberg, discovered a technique to solve the graft "flooding" problem. He drilled a 3/16″ hole through the rootstock a few inches above the groundline. This acted as a "safety valve" in that "bleeding" occurred from the hole and not at the union. This technique allows grafting to proceed uninterrupted through the entire spring and improves the percentage of successful grafts.

The above illustrates that new ideas, new techniques and new materials are continually being employed to improve grafting. All the possibilities and opportunities for improving grafting have not been exhausted. All that is required is some imagination or the ability to see a new application for a familiar item.

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MODERATOR LAGERSTEDT: Our next speaker this morning is also from Corvallis and is with the USDA Forest Service. Dr. Donald Copes will talk on: "External Detection of Incompatible Douglas-fir Grafts", Donald:

EXTERNAL DETECTION OF INCOMPATIBLE DOUGLAS-FIR GRAFTS

DONALD COPES
Forestry Sciences Laboratory
Pacific Northwest Forest and Range Experiment Station
Forest Service, U.S.D.A.
Corvallis, Oregon

Early detection of incompatible stock-scion combinations has been a problem for many years. External symptoms of incompatibility may not become evident until 10 to 40 years after grafting (7). Delayed incompatibility losses impose a serious handicap to nurserymen and orchardists. Internal incompatibility symptoms which are diagnostic of the relative compatibility of the graft have proven accurate for peach, pear, and plums (*4*), apricots (*5*), pear (*6*), and for Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) (*2, 3*). Unfortunately, internal detection requires destruction of the graft, a microscope, and some knowledge of microtechnique procedures. Obviously, nurserymen and orchardists would be better served by a simple visual test based exclusively on external appearance of the grafted plant.

Past attempts to find such a test have generally failed. Symptoms such as chlorosis, leaf drop, initiation of cambial activity, initiation of first-year bud elongation, amount of scion and stock growth, abnormally early flower-bud formation, mechanical breakage, scion dieback, and excessive scion growth have been checked for their correlation with incompatibility (*1, 4*). Unfortunately, most symptoms do not appear in delayed incompatible grafts until a number of years after grafting. Even then, they are not specific to incompatibility but may, instead, result from disease, insect attack, or other environmental stresses. One growth characteristic that has been positively correlated with degree of incompatibility in pear, plum, and peach combinations is delay in initiation of root growth each spring (*1*). Root growth was delayed up to 6 weeks in the most incompatible combination. Unfortunately, the usefulness of this correlation is limited because of the difficulty in observing root systems under field conditions.

In 1967 and 1968, observations on vegetative bud burst of Douglas-fir grafts starting their second year of growth showed bud burst to be delayed in a number of the normal-appearing grafts. Anatomical examination revealed that these were incompatible (unpublished data). From this, it appeared that a correlation might exist between delayed bud burst and graft incompatibility. This report presents results of a study on 116 Douglas-fir clones to determine if such a correlation actually exists.

METHODS

In April 1968, 947 Douglas-fir grafts, consisting of 116 different clones, were cleft-grafted for compatibility testing. Grafts were made on 2-0 stocks of a Willamette Valley seed source and grown throughout the study in a lathhouse at Corvallis, Oregon.

Observations on stage of vegetative bud development were made at the start of the second year. Bud development was checked at 7-day intervals, starting March 25 and ending May 20. Stage of development was based solely on the terminal bud of the scion. All 947 grafts were examined at each date. Stage of bud development of each graft was compared with all other grafts of the same clone. Grafts of different clones were not compared because of the inherent differences among clones in time of vegetative bud burst. Each graft which appeared to be retarded was recorded; also, an average bud development stage of each clone was noted for the nondelayed grafts.

The developmental process of bud burst was partitioned into the eight stages as listed in Table 1. The resulting classification represents a workable system for quickly scoring Douglas-fir buds. Characteristics used to determine a development stage were: (1) extent of bud elongation in length and diameter, (2) bud scale color, and (3) shape of the bud tip (Table 1, Figure 1).

All 947 grafts were sacrificed and anatomically examined in June and July 1969; the graft unions were cut into cross sections 30 microns thick with a sliding microtome and an abbreviated safranin-fast green staining schedule (*2*) was used. The stained cross sections were examined under a microscope

Table 1. Stages of vegetative bud development in Douglas-fir.

Stage of Development	Bud Characteristics
1. None	No expansion in length or diameter. Bud color dull, like that of an overwintering bud. Bud tip acute.
2. Slight	Slight increase in length, but little or no increase in diameter. Bud color yellow-red. Bud tip acute.
3. Slight to medium	Acropetal one-fourth to one-half increased in length, but little increase in diameter. Color similar to stage 2. Bud tip acute.
4. Medium	Acropetal one-half to three-fourths increased in length, but only slight increase in diameter. Color similar to stages 2 and 3. Bud tip acute.
5. Medium to maximum	Bud increased in length over the entire bud surface and exhibited a marked increase in diameter. Color similar to stages 2, 3, and 4 Bud tip blunt (obtuse).
6. Maximum	Buds much increased in length and diameter over stage 5 buds. Color much lighter than in the previous stages due to extreme expansion of bud. Bud tip rounded.
7. Burst	Bud scales separated; needle tips exposed. The new stem not visible.
8. Expanded 1-7 inches	New stem visible, and stem elongated 1 to 7 inches.

Fig. 1. Bud development stages used to detect incompatible grafts in Douglas-fir at the start of the second year. Bud stages are, from left to right: (1) no expansion, (2) slight, (3) slight to medium, (4) medium, (5) medium to maximum, (6) maximum, (7) burst.

for regraft areas (wound-xylem), which indicate incompatible grafts (*2*). The anatomical data were then compared with bud-bursting data.

RESULTS AND DISCUSSION

The anatomical test revealed that 35 percent (328/947) of the grafts were incompatible. Average compatibility among clones varied from 100 percent to 0 percent. These extremes undoubtedly represent sampling variation because previous tests have shown no Douglas fir clones to be either 100 percent compatible or 100 percent incompatible when grafted onto a random group of stocks.

Bud observations before April 29, 1969, were too early for meaningful differences in development to be detected. On April 22, 1969, only 65 of the 116 clones had progressed to development stage 1 or 2. On April 29, 81 percent of the clones were at stage 4 or higher, and on May 6, 93 percent of the clones were at stage 4 or higher (Table 2) ; these were the periods of most accurate bud determination. An evaluation before or after these dates in 1969, except for the seven latest clones, resulted in much lower accuracy in the prediction of compatibility from external bud characteristics.

During the collection of bud-bursting data, differences among ramets as small as two stages were recorded. For example, when nondelayed grafts of a clone were at stage 6, other grafts of the same clone had to be stage 4 or less to be recorded as delayed. But when bud-burst data were compared with the anatomical test results, it was apparent that differ-

Table 2. Average bud development of 111 to 116 Douglas-fir clones on four observation dates, 1969.

Stage of bud development	April 29	May 6	May 13	May 20
		Number of clones		
1. None	3	0	0	0
2. Slight	12	1	0	0
3. Slight to medium	6	6	0	0
4. Medium	38	13	2	0
5. Medium to maximum	15	20	0	0
6. Maximum	37	52	9	2
7. Burst	0	16	21	4
8. Expanded 1-7 inches	0	5	84	110
Totals	111	113	116	116

ences of three stages or larger were required for the differences to be significantly related to incompatibility. Also, to reduce human errors in bud ranking and data recording, a graft was not predicted to be incompatible unless it had been recorded as delayed in at least two different observation periods. If these two criteria were not met, the probability of incorrectly predicting a compatible graft to be incompatible was much increased.

Delay in second-year bud development in Douglas-fir grafts was directly associated with incompatibility. Of the 191 grafts predicted to be incompatible by delayed bud development, 184 proved to be actually incompatible by anatomical test. Thus, only 1.9 percent (7/619) of the compatible grafts had been incorrectly identified as incompatible.

Of the 947 grafts making up the study, 328 were shown to be incompatible by anatomical test. External bud development observations were effective in identifying only 184 of the 328 (56 percent). An examination of bud development and anatomical test data indicated that all degrees of detection accuracy exist among clones; in some clones, all of the incompatible ramets could be detected externally, yet in other clones with the same percentage of incompatibility, none of the incompatible grafts could be externally detected. To investigate the cause of this variation, externally detected and undetected incompatible grafts were anatomically rechecked for possible tissue differences. Microscopic examinations suggested that the ability to predict incompatibility from bud-burst data was directly related to the number of xylem union areas connecting the stock and scion and the size of the regraft areas (wound-xylem) as seen in cross section. Delayed bursting grafts generally had fewer union zones and larger regraft areas. Apparently vascular discontinuities resulting from necrotic phloem and cambial tissues at the time of bud expansion in the spring caused the delay in bud development until the stock and scion regrafted and re-established vascular connections in the phloem and cambial regions. Grafts with many union zones of contact and small regraft areas were not noticeably slowed in stage of bud development; thus, they escaped external detection.

Although 100 percent detection of incompatible grafts has not been attained, the 56-percent success is high enough to recommend bud development screening to Douglas-fir seed orchardists. If, for example, the present group of 116 clones had been externally checked, and if the delayed grafts had been rogued, an 81-precent compatible orchard would have resulted rather than the unrogued 65-percent likely to result without bud screening.

The correlation between bud development at the start of the second year of growth and graft incompatibility in Douglas-fir suggests that horticulturists might benefit by rechecking the relationship of these phenomena in all graft combinations that form regraft areas similar to those found in Douglas-fir grafts.

SUMMARY

Delay in vegetative bud development was correlated with the presence of internal incompatibility symptoms for 116 Douglas fir clones. Of 191 grafts classified as delayed in developing, 184 were found to be incompatible when anatomically checked. Of 619 compatible grafts, seven were incorrectly identified by the delayed bud development as being incompatible. Delay in bud development was found to be related to the number of union areas shared between the stock and scion and by the size of the regraft areas (wound-xylem). Regraft areas occurred in all delayed incompatible grafts. Incompatible grafts that had numerous union zones between stock and scion, plus small regraft areas, were not detected by bud characteristics. Forty-four percent of the incompatible grafts were not identified.

External screening is a usable tool for Douglas-fir seed orchardists. This study showed that an 81 percent compatible seed orchard could have been produced if the grafts showing delayed bud burst had been rogued, as opposed to a 65 percent compatible orchard that would have resulted if no roguing were done.

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MODERATOR LAGERSTEDT: Thank you, Don. Next, Barrie Coate will discuss some aspects of sanitation in the nursery. Barrie:

THE IMPORTANCE OF CLEANLINESS IN THE PROPAGATION HOUSE

BARRIE D. COATE
Pacific Nurseries
Colma and Mt. View, California

Many important propagation procedures become so routine that we often relax our attention to them. I'm speaking of the day-to-day details of cleanliness in the propagation program. Disease organisms can and do travel all the way from the cutting bench, through the greenhouse into 1 and 5 gallon stock, as the diseased crop is transferred to larger containers. It is very difficult to convince some nurserymen that meticulous disease control in the propagation department is worth the man-hours it requires. However, consider the value of 25 5-gallon saleable plants lost to disease in a month as compared with one man-hour per day spent on cleaning propagating tables, floors, and equipment per month.

25 5-gallon plants @ $3.00 ea.	— $75.00
25 hrs @ $2.50 per hr.	— $62.50

Even if only 25 5's per month are lost to disease, and this can be prevented, money would be saved. Another point in favor of good sanitation practices is the fact that chemical control over disease, once the disease is present, is poor at best.

Once *Rhizoctonia solani* or *Phytophthora sp.* are established enough for detection of the symptoms, at best we can only hope to prevent its spread to the remainder of the crop or to other crops. It is virtually impossible to eliminate these diseases once they begin to affect a crop.

Many nurserymen are "living with" infected stock maintained under "low stress" conditions. When this diseased stock is shipped to higher stress conditions (retail nurseries, high temperature areas, poor water areas) it often declines or dies, leaving the purchaser with a poor memory of the supplier and no repeat orders.

One question we should ask ourselves periodically is, "when did I last empty and disinfect my greenhouse?" The answer should be — "not more than 6 months ago."

Probably the easiest, least costly, and most rewarding single sanitation effort one can make is as follows: a 2% formaldahyde drench applied through a large sprayer. This will

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One question we should ask ourselves periodically is, "when did I last empty and disinfect my greenhouse?" The answer should be — "not more than 6 months ago."

Probably the easiest, least costly, and most rewarding single sanitation effort one can make is as follows: a 2% formaldahyde drench applied through a large sprayer. This will take only an hour for a 50′ x 100′ house, including preparation and cleanup; if done twice a year this will provide a sanitary environment for cuttings.

The next most basic, and inexpensive step is to paint all interior greenhouse surfaces from table height down with copper naphthenate, including the gravel in the benches. Any disease organisms landing on this green copper surface will be killed. In other words — "green is clean", in a propagating house.

Here is a list of procedures which have produced good results for me.

General

1. Flats dipped in copper naphthenate often enough to keep them green.
2. Greenhouse sprayed twice a year with a 2% formaldehyde solution and allowed to stand, tightly closed, for three days.
3. Cutting flats and seed flats filled with planting medium sterilized with either methyl bromide, or steam, in small enough batches to prevent recontamination before each batch is used up.

Cutting propagation

1. Cutting material taken only from healthy, vigorous plants and only from areas off the ground.
2. Cutting material washed outside propagation house to remove all dust.
3. Headhouse benches as well as the immediate area of the benches, washed every morning with LF-10[1] before cutting material is handled.
4. All workers hands and all tools rinsed in LF-10[1].
5. Cutting material placed in a sink in propagation house, from which rough cuttings are made onto a previously sterilized propagation table.
6. Cuttings dipped in Morsodren or SD-345[2]. Personnel should use rubber gloves or large salad forks for removal.
7. Cuttings stuck in previously fumigated flats.
8. Full flats carried to copper-naphthenate benches and watered-in with a Morsodren mix from watering can.

Seed propagation

1. Seed sown in previously-fumigated moist seed flats.
2. Flats placed in cold frames, previously sprayed with copper naphthenate.
3. Seen watered-in with a Morsodren mix.
4. Fumigated burlap placed over flats and watered with Morsodren mix.

In conclusion, it is far more efficient and less costly to prevent disease than to attempt to cure it.

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[1] LF-10 is a hospital disinfectant manufactured by Lehm & Fink Products, Toledo, Ohio 43612.

[2] SD-345 is a soil fungicide, a product of Shell Development Co. and available from Moyer Chemical Co., 1310 Bayshore, San Jose, California.

MODERATOR LAGERSTEDT: We will now entertain questions for any of the three previous speakers.

DALE KESTER: I would like to ask Don Copes two questions. First, do all Douglas-fir grafts fail?

DON COPES: No, with a group of 947 grafts, 35% of them died from incompatibility. This is fairly normal; we have an average of compatibility with random clones of 60 to 65 percent.

DALE KESTER: You have some that you can select?

DON COPES: Yes, even from our most incompatible combinations, some of those scions put on random stocks will be compatible.

DALE KESTER: The stocks are different, but the clonal tops are the same — is this right?

DON COPES: Yes, we don't have clonal lines for understocks yet but we are working on it. From our testing we determine which stocks are compatible with certain clones; for the severely incompatible clones we root the understocks. This is very easy to do with two, three and four-year-old Douglas fir.

DALE KESTER: Another question. In our almond-plum graft combinations, the most sensitive test we have to indicate incompatibility is early defoliation of the trees in the fall. Do you see anything in Douglas fir grafts comparable to this?

DON COPES: No, this delay in bud-burst is the very first thing we can pick up. The amount of needle drop we have in Douglas fir during the first winter is very small, probably less than 1 or 2%, depending on the year. Oregon has quite a bit of precipitation in the winter and I think that the scions could be totally dead and still not drop their needles until June.

RALPH MOORE: I was interested in the drilling technique described by Dr. Lagerstedt to stop "bleeding" in walnuts. All you need though, is some knife slashes below the graft; on large trees we use an axe and cut several slashes to alleviate this "bleeding" from the graft union and it works fine. It is very simple.

HARRY LAGERSTEDT: Yes, I know this has been done with a knife slash; we feel, though, that it may not go deep enough. Such cuts may only go into the primary phloem whereas the main root pressure is involved with xylem tissue. So going all the way through as by drilling a hole, the trunk bleeds from both sides; this procedure seems to work better for us.

CURTIS ALLEY: On grape vines, we use a pruning saw and make a cut below the graft after they are growing. Also, if the grape vines are in leaf if you leave a nurse branch below the graft then they will not bleed at all.

HARRY LAGERSTEDT: This bleeding is not a problem throughout the season. It will happen for perhaps two or three weeks and can be related to certain temperatures situations. With a lot of ground moisture and cool, muggy, days and with the plants starting active growth, bleeding can be a problem.

VICE-PRESIDENT BRIGGS: For the second half of this afternoon session, Dr. Dale Kester of the University of California at Davis, will be our moderator. Dale:

MODERATOR KESTER: This afternoon we have some very interesting topics. The first talk will be given by a speaker that you heard this morning — Wes Hackett. His topic now is on bulblet formation under aseptic conditions. Wes:

ASEPTIC MULTIPLICATION OF LILY BULBLETS FROM BULB SCALES

WESLEY P. HACKETT
Department of Environmental Horticulture
University of California
Davis, California

It has been known for many years that individual lily bulb scales when separated from the mother bulb will form adventitious bulblets at their base when placed in favorable environmental conditions. Three to five bulblets will usually develop from each scale depending on the species and cultivar. This propagation technique is called "scaling" and is useful for rapid build up of stocks of a new cultivar or to establish pathogen-free planting stocks.

The objectives of the experiments reported in this paper were to find methods of producing bulblets under aseptic conditions and to increase the efficiency of bulblet production from scales. Accomplishment of these objectives would increase the commercial feasibility of multiplying and maintaining pathogen-free stocks and also increase the rate at which planting stocks of new cultivars could be built up.

In performing these experiments, bulb scales of *Lilium longiflorum* 'Croft' about 1.5 cm wide and 3.0 cm long were used. 'Croft' is a cultivar used as a flowering potted plan tfor Easter. Early experiments showed that scales can be sterilized by washing them for 10 minutes in a 1:10 dilution of commercial bleach (Clorox or Purex) followed by thorough rinsing in sterile (autoclaved) water. After sterilization the scales were asceptically cut into a proximal and da distal section each 1.0 cm^2, as shown in Figure 1, and kept separate for experimental purposes. These scale sections were implanted aseptically in glass vials (See Fig. 2) on a culture medium consisting of inorganic salts, vitamins, sucrose and agar (3). The vials with implanted scale sections were placed at 70°F under fluorescent lights with an intensity of 400 ft. c. (Bulblet formation will occur just as well at 100 ft. c. light intensity and in the dark).

In one experiment, the plant growth regulators, indoleacetic acid (IAA) and kinetin were incorporated into the me-and with the plants starting active growth, bleeding can be a problem.

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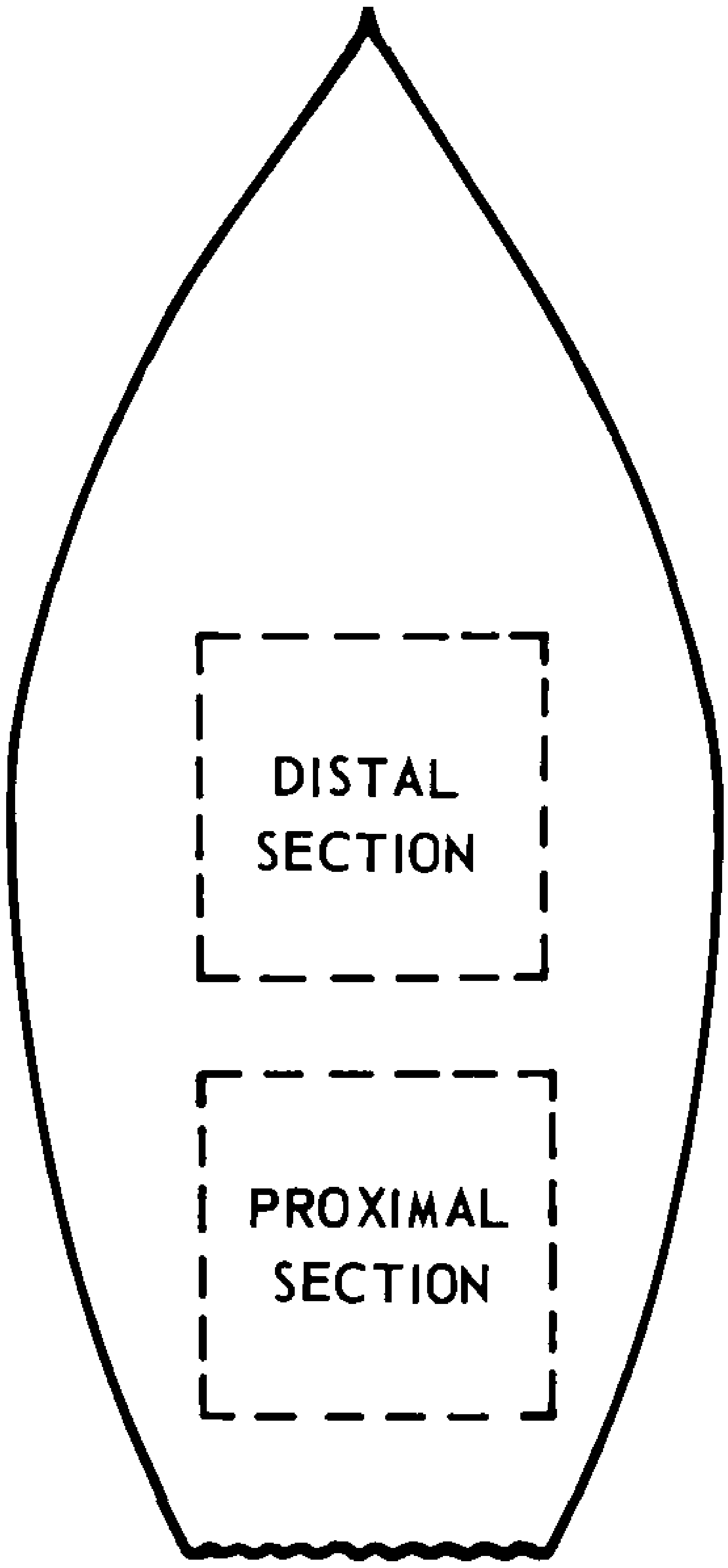

Fig. 1. Diagram of lily bulb scale showing the proximal and distal sections used in the experiments.

dium at various concentrations to test their influence on bulblet formation. The scales were implanted with their abaxial side (convex surface) in contact with the medium because bulblets naturally form at the base of the adaxial side (concave surface) of intact scales (2). This experiment showed that the proximal sections form more bulblets than do the distal sections. With regard to plant growth regulators, IAA has a much greater influence on bulblet formation than does kinetin. When no kinetin is added, IAA at 10 mg/1 gives a 100% increase in bulblet formation and the response has not reached its maximum with this concentration. When no IAA is added, there is little or no response to kinetin. However, there is an interaction between IAA and kinetin and maximum bulblet formation occurred when IAA was incorporated into the medium at 10 mg/1, along with kinetin at 0.1 mg/1. Figure 2 illustrates bulblet formation on proximal and distal sections. Notice that there are not only more bulblets on the proximal sections but the bulblets formed are larger.

Orientation of the scale section on the medium is very important. When distal sections are placed with their abaxial surface on the medium, an average of 4.1 bulblets form on the adaxial surface. In contrast, when similar sections are placed with their adaxial surface on the medium, only an average of 0.4 bulblet forms on the abaxial surface and knobs form on the adaxial surface in contact with the medium. This difference in potential of the two surfaces to form bulblets is not nearly as great in proximal sections. This means that when proximal sections are bisected parallel to their two surfaces and the two pieces placed with their cut surface on the medium both pieces will form bulblets. When both proximal and distal sections are bisected parallel to their two surfaces and the pieces implanted with the cut surface on the medium, a total of 12.5 bulblets are formed per scale. This production occurs when using a suboptimal combination of IAA (1.0 mg/1) and kinetin (0.1 mg/1) and is a great increase over the 3-5 bulblets produced with whole scales. If the IAA concentration were increased to 10 mg/1 the production would be even greater.

These procedures have also been successfully used with *Lilium longiflorum* 'Ace' and several aurelian and oriental hybrids which do not form bulblets profusely on whole scales.

From the standpoint of producing pathogen-free plants these results have considerable implication. Kohl and Nelson (1) showed that pathogen-free bulbs can be obtained by use of heat treatment and meristem techniques. Using aseptic propa-

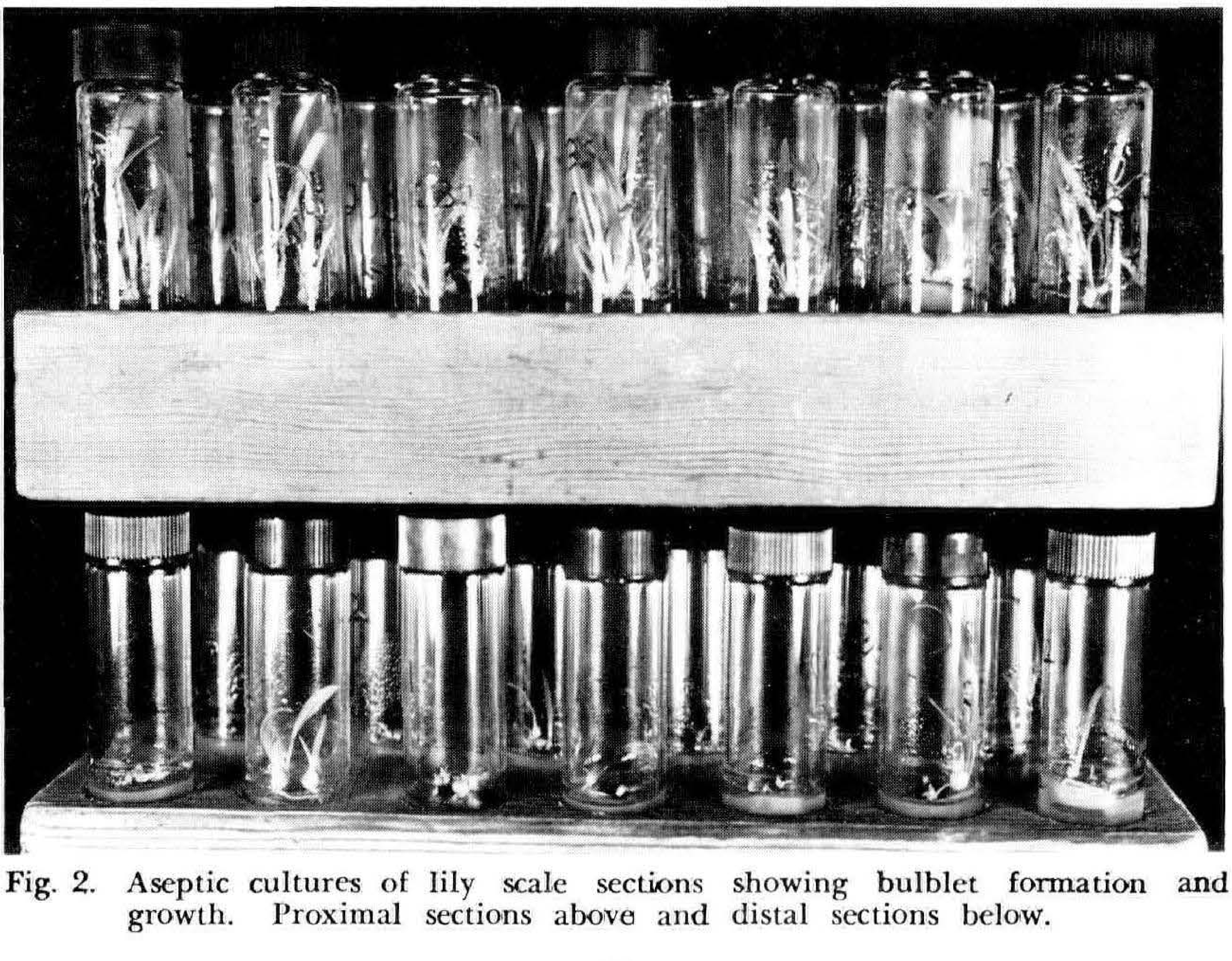

Fig. 2. Aseptic cultures of lily scale sections showing bulblet formation and growth. Proximal sections above and distal sections below.

gation of bulblets from scales, these plants could be rapidly multiplied and maintained pathogen-free.

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MODERATOR KESTER: Our next speaker is Dr. Hudson Hartmann of the University of California at Davis and Editor of the Western Region of the IPPS. He will discuss some of the factors involved in rooting hardwood cuttings. Hudson:

SOME PHYSIOLOGICAL FACTORS INVOLVED IN PROPAGATION BY HARDWOOD CUTTINGS

HUDSON T. HARTMANN
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Some of our most ancient cultivated plants, as the fig, olive and grape, are ones that are readily propagated by hardwood cuttings. With these plants early man was able, when he turned to agricultural pursuits, to easily establish clones of superior types merely by inserting into the ground sticks broken from desirable seedlings, thereby producing great numbers of equally desirable plants.

Propagation by hardwood cuttings is, no doubt, the simplest and least expensive method of vegetative propagation. It would be most desirable to be able to extend this type of propagation to a much greater range of plants. It would be particularly desirable to be able to utilize hardwood cuttings in place of the more laborious layering methods now widely used in propagating clonal fruit tree rootstocks and other difficult to propagate plants. Furthermore, hardwood cutting propagation procedures lend themselves readily to mechanization practices which are more and more being utilized by the nursery industry. However, as is well known, striking differences are encountered among the various species and clones in adventitious root initiation. Some plants, as the willow, poplar and citron, have preformed root initials in the shoots of the intact plants. Cuttings made from such material quickly develop roots when placed under the proper environment. Hardwood cuttings of many other plants too, as the grape, rose or privet, will rapidly form adventitious root initials after the cuttings are prepared, with new roots forming soon after planting so that the developing buds and subsequent leaves are supplied gation of bulblets from scales, these plants could be rapidly multiplied and maintained pathogen-free.

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Hardwood cuttings of more difficult-to-root plants may form adventitious roots after the cuttings are made and planted in the nursery row in the spring but so slowly that the opening buds and developing leaves dessicate the cuttings, causing them to die before roots can appear and begin water absorption.

Cuttings of many other kinds of plants have failed to produce adventitious roots under any circumstances and their propagation by this method has not yet been accomplished. The stem tissues of such plants may contain a high level of one or more rooting inhibitors, or they may lack a biochemical component essential to reactions which lead to critical changes in certain groups of cells that are the starting point of adventitious root initials. It is likely that the explanations for the differences in root initiation between difficult and easily-rooted plants lie in biochemical factors rather than in anatomical relationships.

There are many naturally-occurring plant regulators, as the auxins, cytokinins, gibberellins, inhibitors, vitamins and undoubtedly others. It was postulated by Skoog (30) 25 years ago from research using tissue culture techniques that cell differention and organ formation is most likely based on certain combinations and balances among these naturally—occurring growth substances. Galston and Davies (12) state that these hormonal materials are probably producing their effects by controlling the synthesis of particular enzymes, through some yet unknown mechanism concerned with nucleic acid metabolism.

Successful rooting of cuttings of some plants may not be accomplished until further basic information is developed concerning the biochemical reactions and components essential for root formation.

The most fruitful area at present for extending the practical use of hardwood cutting propagation would seem to be with those plants which will form adventitious roots but slowly and sparsely.

It is now well accepted that auxins, such as indoleacetic acid, are a required component of, perhaps, a complex of substances in the plant necessary for root initiation. Many plants have ample amounts of auxin in their tissues and do not respond to added synthetic auxin by increased root initiation. Many other plants, however, may have native auxins in such slight amounts that they will show a definite response to added auxin by increased numbers of roots forming, or by a reduced time of root development or both. In rooting hardwood cuttings of all but the easiest-to-root plants, treatment with a synthetic auxin — as indolebutyric acid — is likely to be of considerable benefit.

In attempting to root hardwood cuttings of "difficult" plants, temperature control during the root initiation period can be most useful for those kinds which will produce adventitious roots — but slowly; some method of inducing root initiation well in advance of the time of bud break and leaf development in the spring is essential. For plants which have a definite bud dormancy ("rest") condition, this characteristic can be used to good advantage. Buds of deciduous woody plants, in the fall before exposure to winter-chilling, are usually in a pronounced physiological "rest" or dormant condition. Hardwood cuttings made during the autumn, with buds in the "rest", can be treated with auxin, then held at warm (70° to 75° F.) temperatures, packed in a moist, well-aerated, relatively sterile medium — such as peat moss. They will then often develop adventitious roots quite profusely at the base of the cuttings in 2 or 3 weeks. Such treatments were shown by Chadwick (6) almost 40 years ago to be beneficial in rooting hardwood cuttings of several deciduous ornamental shrubs. Since the buds on cuttings taken in the fall are blocked from developing, probably by an unfavorable inhibitor-promoter complex, unwanted leaf production at this stage does not occur. Once there is evidence of root emergence after the auxin-warm temperature treatment, however, the cuttings must be promptly planted, if outside nursery conditions permit, or moved to cold storage (35° to 40°F.) to prevent further development of the roots, while awaiting suitable nursery conditions for planting (14). In either case, the chilling given the cuttings will lead to physiological changes in the buds, changing the inhibitor-promoter complex in favor of promoters so that the buds will start growth upon the advent of warm weather in the spring. But at that time, with cuttings handled as described, roots will have been initiated and will quickly resume growth, along with the shoots. Hardwood cuttings of some plants, however — as the peach (15) and walnut (27) — do not seem to tolerate any disturbance of even quite incipient roots. Fall-planting directly in place in the soil where they are to grow, once they have been made and treated with auxin, seems to be the most successful procedure, utilizing the warmth of the soil in the autumn to obtain the necessary temperature levels to stimulate rooting.

Warm storage plus auxin treatment procedures, such as these, have been perfected by various researchers to successfully root hardwood cuttings of the pear (2, 16, 17, 18, 35), plum (14, 16, 21), peach (15, 29) and apple (21).

Warm temperature treatments following auxin application, as described above, when given the entire cuttings, resulted in good root initiation with some plants, such as 'Old Home' pear, but have given poor results, in some instances, when used with other clones, for example the 'Bartlett' pear (18). To root 'Bartlett' pear it was found necessary to increase the temperature at the base of the cutting to stimulate root activity while simultaneously chilling the buds on the upper portion of the cuttings. Subsequently, Fadl and Hartmann (11) determined that in the 'Bartlett' pear, rooting inhibitors produced in the buds depessed root initiation, but chilling the buds, or bud removal, reduced inhibitor production and increased rooting.

This practice of applying heat to the bases of hardwood cuttings, while the tops are maintained at a lower temperature, has also been used in the successful rooting of apples in England (24, 25) California (19) Italy (13) and apples and cherries in Michigan (5). Such procedures probably involve the same physiological principles used in the old practice of storing cuttings out-of-doors, buried in pits upside down vertically to warm the bases of the cuttings while keeping the buds cool.

The presence of rooting inhibitors was noted by Spiegel (31) in grape cuttings over 15 years ago. These inhibitors could be leached out with water, and when subsequently recovered, caused reduced rooting if applied to cuttings of easily-rooted grape clones. Buds seem to be a source of such rooting inhibitors, the production being related to bud activity. In hardwood cuttings of 'Old Home' pear (10), for example, the presence of buds promoted rooting when they were in a non-dormant stage, etiher in early fall or late winter. But if the buds were in a physiologically dormant condition in early winter, their presence on the cuttings inhibited rooting. Bud removal increased rooting. In Fadl's (9) studies with pears, such an effect of bud removal was related to the absence of the bud itself and not just to a possible wound stimulus arising from cutting out of the bud, as was noted by Howard (26) in rooting plum and apple hardwood cuttings.

Apparently, too, certain root-promoting factors — other than auxins — exist in hardwood cuttings — in greater amounts at some periods of the year than at others, and in greater quantities in some clones than in others (1, 7, 11, 36). There is evidence that these factors are phenolic compounds, which probably interact enzymatically with applied or native auxins to form substances responsible for triggering differentiation of groups of cells, leading to adventitious root formation (4, 1, 22, 23). An increase in the activity of such native rooting factors was noted by Challenger, *et al.* (7) when temperatures were elevated at the base of 'E.M. 26' apple cuttings during pre-planting warm storage periods, which may, in part, account for the beneficial rooting effects of such temperature control treatments.

Van der Lek pointed out (33) many years ago the influence of buds on the rooting of hardwood cuttings. As previously mentioned, this influence is likely due, at least in part, to the production of rooting promoters or inhibitors, or both, varying according to the activity of the buds at different times of the year. However, this effect of buds on rooting and possible explanations for such effects is complicated by the fact that active buds utilize stored foods for growth and are in competition with metabolic processes involved in root initiation (2). Warm storage periods, following auxin application, which have been shown to promote rooting, also increases the respiration rate of the cutting's tissues and, if prolonged, can deplete stored food reserves.

In considering the propagation of plants by hardwood cuttings, a clear distinction must be made between the internal mechanisms involved in root initiation and in the survival of the cuttings in the nursery. For example, profuse rooting can often be obtained in the laboratory with auxin-treated cuttings enclosed in plastic bags (28) or set in containers of a sterile medium under precisely controlled conditions of temperature and humidity. Similar cuttings set in the nursery where they may be obliged to contend with unfavorable weather conditions, fungal attacks, or less than ideal soil situations often succumb even though roots may have been initiated.

There seems to be rather convincing evidence from various studies (32, 34) that fungicide applications, particularly Captan, is of real benefit in protecting cuttings from fungus attack in the nursery, which apparently is its primary benefit, rather than a direct stimulus of root initiation (20). It is probable that more widespread use of such fungicidal treatments is justified and would be helpful, particularly in years of wet springs and in heavy soils.

Ciampi and Gellini (8) and Beakbane (3) have proposed, to account for the variability in rooting among clones, that the ability of stems to produce adventitious roots is related to the anatomical structure of the primary phloem. In supporting this theory it is pointed out that difficult-to-root cuttings, as those of 'Conference' and 'Bartlett' pears, have an almost continous cylinder of mature, thick-walled fiber cells encircling the secondary phloem, whereas in easily-rooted cuttings, as 'E.M. V', E.M. XI' and 'E.M. XIII' apples, this sclerenchyma ring is not continuous, and would permit the emergence of roots formed inside the ring. However, while such anatomical relationships may influence root development, it is unlikely that they are primary factors in root initiation. 'Bartlett' pear cuttings, for example, even with an almost continuous schlerenchyma ring can be rooted in fairly high percentages with the proper procedures (18). Studies by Sachs, *et al.* (29) with olive, cherry and pear stem cuttings failed to show any clear relationship between continuity of a schlerenchyma ring and rooting ability.

There are, of course, many other factors which can influence the success attained in hardwood cutting propagation, such as the source and type of cutting material, the concentration of auxin used, weather, and soil conditions of the nursery site. It is certainly advisable for each propagator to do some experimenting with the variable factors at his disposal under the fixed conditions with which he must work and with the particular clones he is attempting to propagate.

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ROOT INITIATION IN HARDWOOD CUTTINGS OF PEACH-ALMOND HYBRID CLONES

DALE E. KESTER
University of California
Davis, California

This report summarizes results of experiments carried out during the fall and winter, 1968-69, as part of a program to select clonal rootstocks for stone fruits (*Prunus*), with emphasis on peach x almond, F_1 hybrids. Earlier, we found that cuttings of almond clones were impossible to root; peach was relatively easy-to-root and hybrids of peach and almond (P-A) were intermediate, with a range among clones from easy to difficult (3, 4). Hansen (1) has selected P-A clones that are nematode resistant and Hansen and Hartmann (2) reported good survival of hardwood cuttings of P-A clones if taken in the fall or early winter, treated with IBA and Captan, then planted directly into the nursery.

The purpose of the experiments reported here was to evaluate rooting of different *Prunus* clones. To do this we wanted to develop a screening procedure whereby we could accurately and easily evaluate the genetic ability of individual

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The purpose of the experiments reported here was to evaluate rooting of different *Prunus* clones. To do this we wanted to develop a screening procedure whereby we could accurately and easily evaluate the genetic ability of individual clones to initiate roots. We also wanted to distinguish "rooting ability" from "survival ability" in the nursery although we recognized that the two characteristics were closely related.

PROCEDURE

The basic procedure was to make cuttings of 3 lots of 25 each, treat them with IBA and Captan, and either store in damp peat moss for weekly examination of root initiation, shoot development, and callusing — or plant cuttings directly in the nursery. Three clones were tested at various temperatures and treatments, with one group in storage and a comparable group planted directly in the nursery. Fifty-two other clones were evaluated in storage only at 68°F.

RESULTS

Data on root initiation and cutting survival of the three clones is given in Table 1. Contrary to what was expected, the best rooting in all cases was obtained with cuttings planted directly in the nursery. The values obtained can be taken as the upper limit for rooting under the conditions used. Factors involved in determining rooting in particular cases were (1) clone, (2), time of collection; (3), method of handling; and (4), temperature. Being able to judge the best rooting clone therefore required the evaluation of the effect of a number of factors on both root initiation and survival.

Table 1. Percent rooting (storage) and percent survival (nursery) of hardwood cuttings of peach x almond (P-A) clones.

Clone	Treatment	Collected November 22, 1968		Collected January 16, 1969	
		Storage	Nursery	Storage	Nursery
'P-A 2-16-8'	Direct planting	—	60	—	69
	50°F storage	30	—	32	—
	59°F storage	60	—	40	—
	68°F 4 days[1]	46	69	9	31
	68°F 10 days[1]	60	64	24	42
	68°F continuous	22	—	45	—
'P-A 3-8-9'	Direct planting	—	77	—	50
	50°F storage	38	—	15	—
	59°F storage	70	—	25	—
	68°F 4 days[1]	46	74	15	57
	68°F 10 days[1]	50	57	55	54
	68°F continuous	5	—	18	—
'P-A 2-16-5'	Direct planting	—	62	—	17
	50°F storage	17	—	0	—
	59°F storage	23	—	12	—
	68°F 4 days[1]	14	45	3	16
	68°F 10 days[1]	8	46	0	17
	68°F continuous	0	—	6	—

[1] Followed by 50°F storage or direct planting.

(1). The easiest-rooted clone appeared to be 'P-A 2-16-8'. Rooting was best at 59°F storage at the December collection and equalled direct planting. Storage at 50°F gave poorer rooting in both collections. Exposure to 68°F decreased rooting; the limiting factor at this temperature with this clone was greater decay at these warmer temperatures.

Cuttings taken in January rooted as well as November collections if directly planted, but all storage treatments resulted in poorer rooting.

Cuttings taken in November required 50-60 days to develop roots in storage (Fig. 1), depending on temperature. During this long period, decay developed at the higher temperatures, thus decreasing rooting. The buds were evidently in a rest period since few shoots grew. In contrast, roots developed rapidly and completely (once started) on 'Marianna 2624' plum taken at the same period without any decay appearing.

Cuttings taken in January (Fig. 2) were not in the rest since shoots grew readily. Roots developed in 20-30 days but decay occurred and survival was reduced.

(2). 'P-A 3-8-9' had a better rooting capacity in general

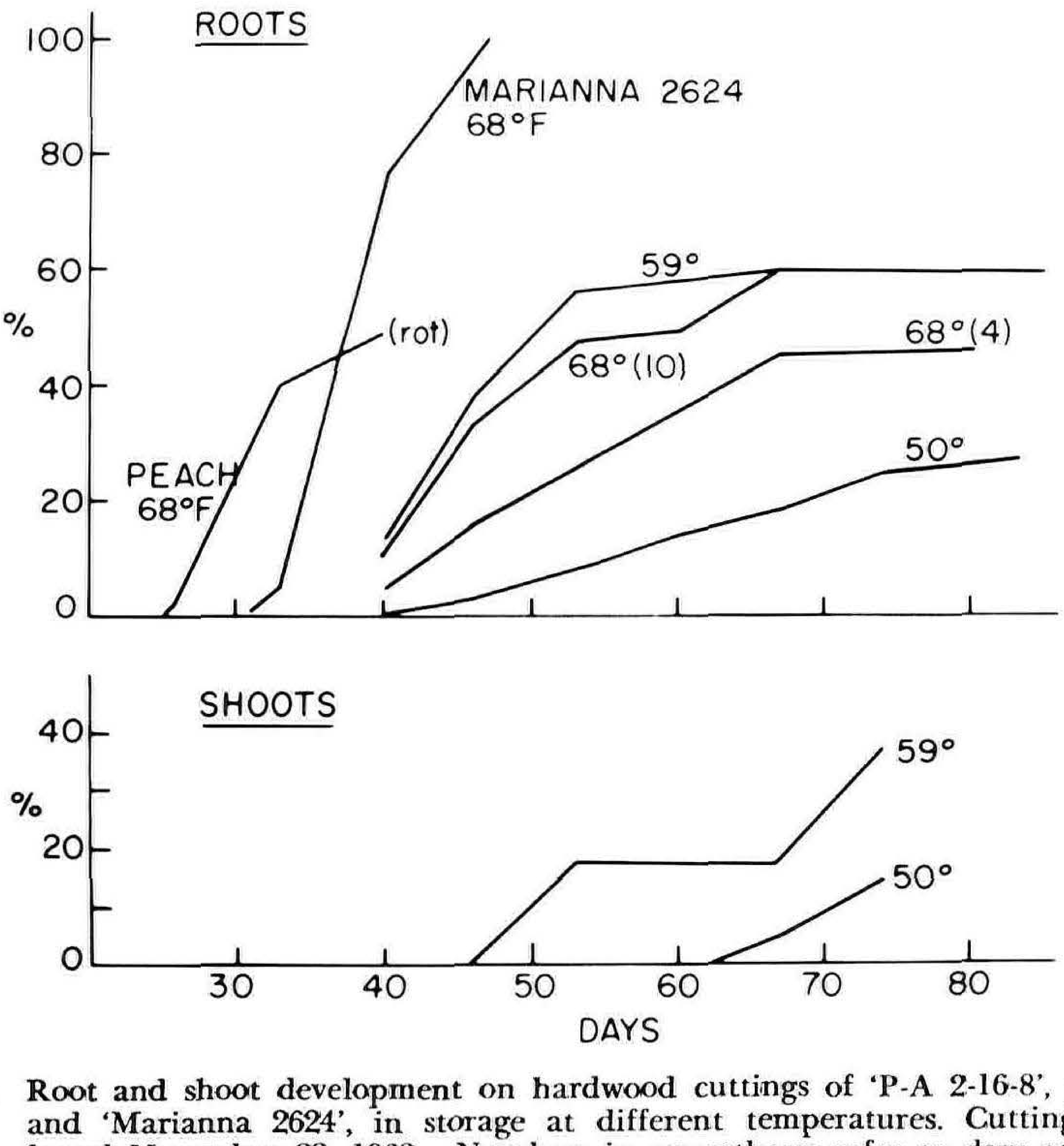

Fig. 1. Root and shoot development on hardwood cuttings of 'P-A 2-16-8', peach, and 'Marianna 2624', in storage at different temperatures. Cuttings collected November 22, 1968. Numbers in parentheses refer to days at 68°F, after which the cuttings were shifted to 50°F.

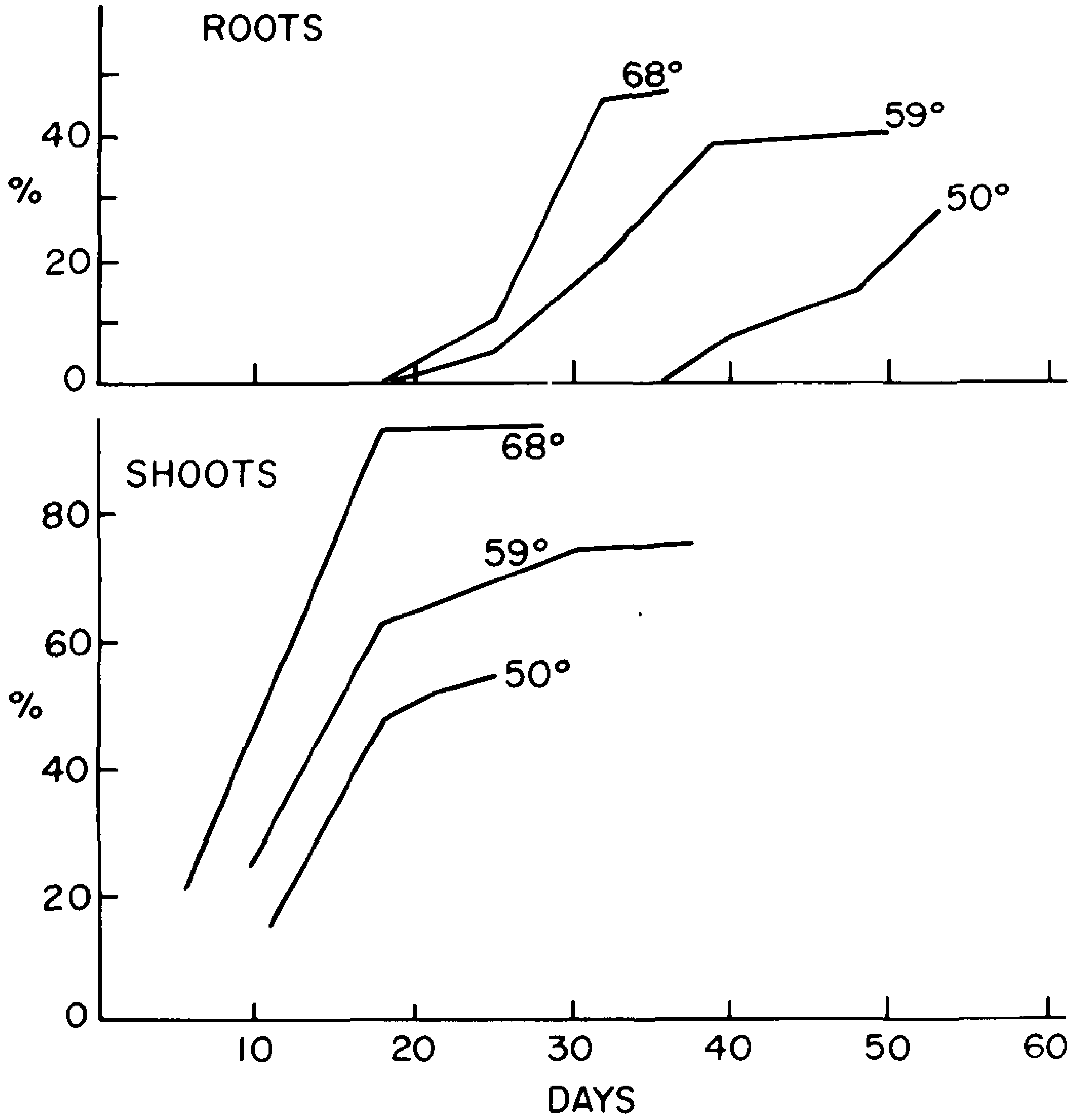

Fig. 2. Root and shoot development on hardwood cuttings of 'P-A 2-16-8' held in storage at different temperatures. Cuttings collected January 16, 1969.

(at least with the November collection), but survival tended to be low in many of the treatments. Temperature responses were the same as for 'P-A 2-16-8'. The January collection resulted in lower survival possibly because of more susceptibility to rot at that stage.

(3.) 'P-A 2-16-5' was the poorest rooting clone but it was uncertain whether this was due to inadequate rooting or poor survival. Storage was damaging but difficulties were overcome by direct planting. Collecting these cuttings in January decreased rooting markedly.

CONCLUSIONS

Evaluating clones for rooting ability is not easy because one must consider their response to various factors. It appears that P-A clones would produce consistently good results if directly planted in the nursery under conditions used here. However, storage of the cuttings at 59°F might be a better test of rooting potential since it could bring out possible differences in survival ability that would not be apparent by direct planting.

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MODERATOR KESTER: Our next speaker is going to talk about rooting hardwood cuttings of a specific plant, the red smoke tree. He is Lee Rosenkranz of Doty and Doerner, Portland, Oregon. Lee:

EXPERIMENTS IN ROOTING HARDWOOD CUTTINGS OF RHUS COTINUS 'ROYAL PURPLE' — RED SMOKE TREE

LEE ROSENKRANZ
Doty & Doerner, Inc.
Portland, Oregon

Initial work on rooting cuttings of *Rhus cotinus* 'Royal Purple', (red smoke tree), was started in the summer of 1965 with an attempt at rooting softwood cuttings taken at several intervals. This resulted in a complete failure, and a decision was made to look into the prospects of hardwood cuttings.

In the past all smoke trees had been propagated by grafting, but a shortage of understocks, and the tendency toward weak graft unions, prompted a consideration of rooting of cuttings.

In January, 1966, the first cuttings were stuck in pure sand in a heated greenhouse with a bench temperature of 70° to 72°F. One hundred cuttings were put in a regular cutting bench, and another 100 were placed under intermittent mist. All were terminal cuttings. Most cuttings leafed out, but those in the regular bench failed even to callus. Those under the mist lasted longer, and a few rooted, but the roots decayed before they were ready to dig.

In December, 1966, a cutting bed was built in an unheated poly house which used the heated greenhouse for its south wall. The bed was on the ground against the north wall of the greenhouse, and was equipped with bottom heat. The cable was under five inches of fine sand. Depending on the outside temperature, the bed remained between 60° and 72°F. Terminal cuttings were made 8 inches long, and half of them were wounded. The cuttings were treated with Hormodin #1 or #3, or Jiffy Grow, diluted 1 to 10 with water; an untreated check was included. A few sub-terminal cuttings were used to fill out the counts. Four batches of cuttings were stuck at two-week

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The results were:

1. Cuttings rooted nearly 100% in the two December groups while the second two taken in January, ran 50% and 20% each.
2. Wounding seemed to have little effect on the rooting.
3. Jiffy Grow produced a slightly better root formation than Hormodin.
4. Wood from any part of the current year's growth rooted as well as the terminal wood. This included cuttings up to one-half inch in diameter.
5. Rooted cuttings placed in gallon cans kept in the heated greenhouse sustained a 30% loss, which was largely due to a weak root system.

In 1967 the same procedure was followed except that only Jiffy Grow was used. Again, the results were much the same, and pointed conclusively to the taking of cuttings as soon as the stock goes dormant. The plants this year were canned and put in a cool poly house. This resulted in a 60% loss, although most of these, again, were the ones with weak roots.

In 1968 conditions prevented putting in cuttings before mid-December. Two small batches of cuttings were put in a week apart in the same bed as before, and a third, larger group of cuttings was put in a new bed on the east side of the greenhouse in an unheated poly house. Cuttings were used from all parts of the current year's growth, and treated with Jiffy Grow. None of the cuttings were wounded.

Between Christmas and New Year's Day a storm hit. No more cuttings were taken until late January. The cable in the new bed failed during the hardest freeze, and could not be repaired. The cuttings froze in place. The cuttings taken in late January were a complete failure. From a total of nearly 2000 cuttings only 150 survived and these were from cuttings taken in mid-December.

MODERATOR KESTER: Thank you, Lee. Now Rudy Wagner will discuss some of his experiments in propagating fruit tree rootstocks by hardwood cuttings.

ROOTING HARDWOOD CUTTINGS OF FRUIT ROOTSTOCKS

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

Propagation by hardwood cuttings is known to be the least expensive and easiest way of reproducing plants vegetatively. The cuttings are easy to prepare and no special equipment is needed during the callusing and rooting period. Hardwood cuttings are made usually from one-year-old dormant wood.

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However, in propagating fruit rootstocks, one should follow the method best suited for his region. Factors to consider are:

(1) Source of the cutting material
(2) Timing — when is best to take cuttings
(3) Preparing the cuttings
(4) Treatment of the cuttings
(5) After-care of the cuttings

In 1960, Dr. Hudson Hartmann and Prof. Carl J. Hansen reported that 'Old Home' pear (*Pyrus communis*), is a valuable rootstock in combating pear decline and fire blight. Cuttings can be rooted if taken in November with the bases soaked 24 hours in 200 ppm IBA, packed in moist, *not wet,* peat moss and placed at 65° to 70°F. These root in 3-4 weeks and can then be planted immediately in the nursery, weather permitting. If stored at 40° F., only 1/3 as many survived.

In late October, 1962, we started propagating 'Old Home' pear along these recommended lines on a small scale. Although we did not have a large supply of suitable plant material, there was enough to gain the necessary experience to prove it to be commercially feasible in our operation.

1. *Source of cuttings* — The cutting material should be taken only from clean, healthy and vigorous parent trees with the shoots having completed their first year's growth. Shoots one to three feet long and 1/4 to 3/8 inch in caliber make excellent cuttings. If not fully defoliated at cutting time the leaves should be pulled off.

2. *Timing* — After experimenting in taking the cuttings at various times from September through October, and into November, October seems best in our region.

3. *Preparing the cuttings* — The cuttings are cut into 8 to 10-inch long sticks, either by a hand shears or tied in bundles of 50 or 100 and cut to length with a fine-tooth band saw to make a fairly smooth cut. We prefer the saw.

4. *Treatment of cuttings* — As soon as the cuttings are prepared, the basal ends should be soaked for 24 hours in a 200 ppm IBA solution, which is made by dissolving 1/2 teaspoon IBA in a small amount of ethyl alcohol, then diluting it to one gallon with water. After trying out various solutions and strengths, including a quick-dip of 2000 ppm IBA, the 200 ppm, 24-hour soak, seemed the most satisfactory.

5. *Care of cuttings after treatment* — After the cuttings are removed from the solution, they are packed horizontally in moist, *but not wet,* peat moss. To maintain an even moisture around the cuttings we line our boxes with 4-mil poly and also tie a sheet of poly over the box. This usually holds the moisture during the callusing and rooting period. Do not allow roots to elongate during the callusing period. This is when our problems started; we were able to get good strikes, but to carry them through the winter until spring and line them out was another thing. Several attempts in storing the cuttings in

moist peat at 35° to 37°F. until the following spring gave complete failure. We then tried repacking the cuttings in a mixture of ½ sand and ½ peat. The bundles were cut open and the cuttings were then put vertically and singly in boxes with the 2 top buds showing. Approximately 500 cuttings per box were used. The boxes were then buried right in the field, covered with sawdust, straw, or a similar material. This seems to be the answer in keeping the frost out of the boxes. This extra effort is well worthwhile when you see a fine batch of rooted 'Old Home' pear cuttings coming safely through the winter.

Clonal apple rootstocks are mainly propagated by stooling, but when a certain clone needs to be on its own root, we may resort to hardwood cuttings. The cuttings are made in the same manner as all other hardwood cuttings except no heat treatment is needed as is the case with pears. The bundles of cuttings are packed in moist peat moss and stored in temperatures of 40° to 60°F. until planting time. The tops should be kept somewhat cooler than the base to hold back top growth until rooting is completed.

Quince rootstocks are propagated either by stooling or by hardwood cuttings. When multiplied from hardwood cuttings, shoots that failed to root in the stooling beds furnish the cutting wood, or mother plants are grown for the purpose of providing one-year-old wood to be made into cuttings. Such cuttings seem best for quince, with the cuttings being stored like apples at cool temperatures until spring. Under good growing conditions the cuttings can even be directly lined out in the field in seasons with ample moisture. Often 80% rooting can be obtained.

MODERATOR KESTER: We will now open up this session for questions.

BRIAN GAGE: Are there any differences in vigor — now I am asking a general question — in plants from rooted cuttings as compared with those grown from seed and then grafted or budded, which is, of course, the usual method of propagating trees?

MODERATOR KESTER: I might make a comment. It seems to me it is going to depend upon the rootstock; there may be an inherent vigor because it is a seedling. I am not aware that this has been shown, however, as opposed to hardwood cuttings from the same plant. Now somebody else might comment on this.

DR. HARTMANN: I might mention a specific case of 'Bartlett' pear trees started from hardwood cuttings versus those that were grafted on *Pyrus communis* seedlings. Dr. Griggs, in our department at Davis has several pear rootstock plantings where he has various stock-scios combinations, as well as 'Bartlett' pears on their own roots. The latter has been a somewhat dwarfed tree in comparison with 'Bartlett' grafted on seedling roots. With the present interest in dwarf trees and close planting, this could be an advantage.

MODERATOR KESTER: It would be difficult to make a general statement that all plants on seedling roots would be better than those on clonal rootstocks with the same scion material, or vice-versa. Probably each combination is going to have to be checked-out.

DAN GIBBIE: I would like to ask Dr. Hackett a question. I think it might be interesting to know, concerning heat treatment for elimination of some diseases, approximately what the heat treament is, how high a temperature is used, and for how long.

DR. HACKETT: In general, I think we can say that for actively growing plants — plants not in a dormant state — not many of them will stand much more than 100°F. for any length of time. The general experience has been that the heat treatments used are approximately 100°F., with the length of time varying according to what the plant will stand. A standard practice for carnations has been three weeks at 100°F. Some other plants will stand this temperature for longer periods. Perhaps there are differences, too, in what different species will stand.

JOHN TRAAS: Dr. Hartmann, for a month, approximately from mid-September to mid-October there is a period that the shoots in the stool beds form roots abundantly. Is this a question of temperature in night and daytime, or a different physiological structure of the plant — or is it a matter of high humidity or of reduced light? Thank you.

DR. HARTMANN: This is a difficult question to answer since it would take quite a bit of study to determine which of those, or other, factors is responsible. It may be a complex of things that could be tied in with rooting promoters or inhibitors which are involved with bud activity, or it could be some other of the points you mentioned. In order to come up with a real answer, it would take a good bit of study to eliminate the various factors one by one. I can't give you a meaningful answer without a study of the problem.

MODERATOR KESTER: It seems like timing is certainly involved in this. This has been experienced in our peach/almond material. We feel that the earlier in the fall hardwood cuttings are taken the better the rooting. I would suspect it is related to timing.

HARRY LAGERSTEDT: Is it correct that the pear initiates roots from the callus, rather than from the stem tissue. It seems to me that I heard this somewhere and I thought that if this is true it might have a relationship to timing and the forming of callus first.

DR. HARTMANN: I am not aware of studies showing that roots originate from callus in pear. I believe they arise in the stem tissue itself.

HARRY LAGERSTEDT: It seemed to me that Dr. Westwood thought they originate from the callus rather than from the stem tissue. I may be incorrect, so this is why I asked the question.

FRIDAY MORNING SESSION

September 4, 1969

VICE-PRESIDENT BRIGGS: After our tours all day yesterday we will again resume our technical sessions. Our first moderator today will be Dr. J. Harold Clarke, Clarke Nursery, Long Beach. Washington. Dr. Clarke:

MODERATOR CLARKE: The first speaker on today's program will be Dr. Jean P. Nitsch, Director of Laboratoire de Physiologie Pluricellaire, Gif-sur-Yvette, France. He will talk to us about his most interesting work on plant reproduction at the cellular level under aseptic conditions. Dr. Nitsch:

PLANT PROPAGATION AT A CELLULAR LEVEL: A BASIS FOR FUTURE DEVELOPMENTS

J. P. NITSCH
Laboratory for Multicellular Physiology, C.N.R.S.
91, Gif-sur-Yvette, France

Plant biologists have become convinced that each of the numerous cells which form a plant contain the complete genetic information necessary to reproduce a similar individual. Thus, if we could isolate a cell from either the root, the stem, or the leaf of that plant and find a way to make it grow, it would develop into a new plant exactly like the stock plant from which the cell had been isolated.

POSSIBILITIES OFFERED BY SINGLE CELLS

What would be the advantages of such a system? Essentially two main types of application are possible, one concerned with the *multiplication* of a given sport or variety, the other with the *modification* of the hereditary traits of that variety.

(1). *A means to multiply plants.* The culture of cells, and the subsequent development of each of them into a new plantlet apparently allows rapid multiplication of a single sport into millions of copies which would be like the original. One could thus multiply an outstanding plant of carrot, asparagus, lily, orchid, etc.

(2). *A means of modifying plants.* The technique of cell culture could also be used to change certain heritable characters such as height, shape of leaves, shape, size and color of flowers, etc. Various possibilities may be used for this aim, namely: mutation of certain genes, changes in the number of chromosomes, even the mixing of cells of different individuals.

> (*a*) *Cell mutation* — Once cells are well separated and plated on agar media in Petri dishes, it is possible to treat them with chemical mutagens or to irradiate them. Some of these cells will mutate. If per-

suaded to divide and to regenerate a whole plant, these mutants will have the advantage of being spotted easily and to consist entirely of mutated cells. This is not the case when one irradiates the apex of a plant: an apex contains many cells of which only a few may mutate, so that one obtains a mixture of mutated and normal cells. Another drawback in the use of whole apices lies in the fact that the normal cells may outgrow the mutant ones, which leads to the loss of the mutant character.

(*b*) *Change in chromosome number* — The chromosome number of a given cell may be changed either by being multiplied by a given factor (polyploidization) or by having a few chromosomes added or lost (formation of aneuploids). Formation of polyploids (such as tetraploids) can be brought about by applying colchicine, or by the process of *endomitosis* which occurs when undifferentiated calli are grown *in vitro.* Aneuploids may also be formed during the culture of such calli.

(*c*) *Mixing cells of different individuals* — In the past, certain graft-hybrids have become famous; for example, *Cytisus adami.* A French horticulturist, Mr. Adam, grafted *C. purpureus* with purple flowers onto *C. laburnum* with yellow flowers. From the region of the graft union a shoot arose which had regions which looked like *C. purpureus,* others which looked like *C. laburnum.* It was actually a chimera, that is, a mixture of cells of the two types. It could be perpetuated by grafting, although some branches tended to revert to one type, others to the other type. This example shows that cells of two different species can grow as a mixture and form organs such as stems, leaves and flowers, which may be composed partly of cells of one partner, partly of cells of the other, each cell retaining its genetical characters.

Instead of using grafting techniques, one could think of *mixing* cell suspensions obtained from two different plants in an effort to produce buds that would contain cells of both and give rise to composite plants. In fact animal biologists have obtained muscle tissue composed of chicken and rat or rabbit cells. Why should it be impossible to mix cells of a rose bush with those of an apple tree?

One could go even further and attempt to *fuse* two cells into one. Such a prospect seems dim since plant cells are surrounded by rigid cellulosic walls. However, it has recently been possible to digest these walls with enzymes and to obtain "protoplasts". A protoplast is the content of a cell without its cellulosic wall; that is, actually a mass of cytoplasm containing the nucleus. As soon as they become liberated from their envelopes, protoplasts take a spherical shape. Of course, they are very fragile and may burst easily if not surrounded by a medium with the right osmotic pressure. Under appropriate conditions, protoplasts may remain alive for several days. The nucleus may divide, and a cell wall regenerate. Fusion of two protoplasts may be attempted before wall regeneration takes place. Although fusion of the nuclei in addition to that of two cytoplasms may be much more difficult to achieve, the mere presence in the same cell of two nuclei endowed with different genetical potentialities may already lead to changes in the properties of that cell.

TECHNIQUES OF CELL CULTURE

The process of producing whole plants from single cells comprises at least three main steps: (1) separating the cells, (2) growing the separated cells, and (3) causing the formation of buds and roots.

(1). *Methods for separating the cells.* Among the techniques devised for getting the cells apart, the three following ones seem most promising at the present time:

(*a*) *Mechanical separation after tissue culture* — This technique — the oldest and most widely used at the present time — consists in obtaining first a callus culture from the species which is to be used; a fragment of the cambial region of a root or a stem, or of the apical meristem in the case of monocots. This is grown on a standard mineral medium (2,7,15) enriched with 2% sucrose, an auxin such as naphthalene -1-acetic acid (NAA) or 2,4-dichlorophenoxyacetic acid (2,4-D) at concentrations ranging from 0.1 to 1 mg/1, certain vitamins such as thiamin (1 mg/1) and *myo*-inositol (100 mg/1), and a cytokinin, for example benzyladenine (0.1 mg/1). The pH is adjusted to 5.5 with dilute hydrochloric acid or potassium hydroxide solutions, and the medium may be solidified with 0.8 to 1% agar. Naturally one has to operate under aseptic conditions, which means that the medium has to be sterilized in the containers (generally test tubes), by autoclaving at 110° C for 15 minutes. The plant parts are disinfected by plunging them in 70% ethanol for a few seconds and immersing them for 15 minutes in a filtered solution of 7% calcium hypochlorite in water. After rinsing them with sterile (autoclaved) water, one cuts out pieces from the inside of the plant fragments with tools which have been disinfected with ethanol.

Once planted in the test tubes, the cultures proliferate, giving rise to undifferentiated cell masses. If the auxin level is sufficiently high, the cells do not adhere strongly one to the other, so that they can be shaken loose when placed on a shaker in a liquid medium. The liquid containing free cells can be filtered under aseptic conditions through sieves of appropriate mesh sizes in order to remove the clumps and select single cells of similar caliper.

The method just described requires the preliminary raising of callus cultures, which means a loss of time. In addition, the treatments given during the callus phase may affect the growth of the single cells derived from the calli in a manner which may be difficult to control. For example, the extent of endopolyploidy which may occur during the callus phase depends upon the nature and concentration of the auxin and cytokinin used, the length of the period during which the culture has been growing, as well as the physical constitution of the medium (solid or liquid).

(*b*) *Mechanical separation of leaf cells* — A new technique, developed in our laboratory by Rossini (14), eliminates the drawbacks of the previous method. It consists in taking leaves which — after proper disinfection — are ground lightly in a "Potter" homogenizer in the presence of the liquid medium in which the cells are to grow. The tissue is disrupted, but — with some species at least — the cells are not broken. The grindate is then filtered through sieves of appropriate mesh sizes, and the fraction with single cells plated on nutrient agar in Petri dishes. Among the species which yield single cells in this manner are bindweed (*Calystegia sepium*), peanut (*Arachis hypogea*), apple, pear, blackberry (*Rubus*), etc. However only the two first-mentioned species have produced cells which have divided freely. Paradoxically, it is the mature leaves, rather than the young ones, which give the best results.

(*c*) *Use of enzymes* — Pectinases are capable of digesting the pectic cement which holds young cells together, at least those of young leaves. Japanese workers have reported success with this method in dissociating the cells of young tobacco leaves. Further experiments are necessary in order to know if this procedure may be generalized to other species and, also, if the enzymically dissociated cells are capable of dividing, once plated on nutrient agar. Work of this nature is in progress in our laboratory.

(2). *Methods for growing cells.* Once cells have been separated from each other, the next step consists in getting them to grow and divide. Here a particular situation has to be taken into consideration. If a cell isolated from the others was placed in too big a volume of medium, it seems as if the cell was loosing some important factors — leaking out of it, as it were. Such a cell fails to divide and finally dies. Muir and co-workers (6) have devised a technique which consists in placing an isolated cell on an actively growing callus, separating it from the callus cells with a piece of moist filter paper. The isolated cell, nourished by what the callus cells give off, divides and forms a new callus. Other authors have found that suspensions of separated cells which would not grow in a given medium, can grow in the same medium if other cells have grown in it previously. These first cells apparently have changed the properties of the initial medium, possibly by diffusing some important substances in it; such a medium is said to have been "conditioned".

However, a conditioned medium is not needed if one inoculates a new medium with the right proportion of cells, for example of cells obtained by grinding leaf tissue of *Calystegia sepium* or *Arachis hypogea.* Apparently these cells condition the medium one for the other, if the distance between the cells plated on nutrient agar is not too great.

Numerous formulae have been devised for nutrient media. At first, the addition of natural extracts, such as coconut milk or yeast extract, was recommended. In most cases, however, it is possible to omit them, provided a strong auxin (such as 2,4-D) and a cytokinin (such as benzyladenine) are present. An organic source of nitrogen, such as glutamine, asparagine, arginine, or urea, is sometimes beneficial. Mineral salts, sucrose (2%), and vitamins complete the list of ingredients. An example of such a medium is that used by Rossini (14).

(3). *How to grow whole plants.* Once the isolated cells have been stimulated to divide, they grow and develop into an unorganized mass called a "callus". In order to cause this callus to regenerate whole plants one can try to get in motion one of two processes, namely: (a) the formation of buds followed by the eventual rooting of such buds, or (b) embryogenesis.

> (*a*) *Bud formation* — Bud initiation in tissue culture requires an optimal level of sucrose (1-2%), a low level of auxin (preferably IAA, between 0.01 and 0.1 mg/1), the presence of a cytokinin (preferably zeatin or isopentenyladenine, between 0.05 and 0.2 mg/1) and adenine (40 mg/1) as a synergist (12). Once buds have been initiated, they may be transferred to a similar medium lacking adenine and the cytokinin and having only about 1% sucrose. IAA (0.1 mg/1) may be added to encourage rooting. Once rooted, the new plants can be transplanted into pots and grown in the greenhouse. Commercially, this method is being used to propagate high-yielding clones of asparagus.
>
> (*b*) *Embryo formation* — Embryogenesis, as strange as it may seem, may also be induced in certain types

of tissue cultures, especially in the case of plants belonging to the Umbrelliferae. Such calli may form thousands of little embryos — that is, bipolar units consisting of a bud primordium attached to a root primordium — if first cultured on 2,4-D (1 mg/1) or naphthoxyacetic acid, as shown by Norreel and Nitsch (13), on a medium containing NH_4^+ ions, as shown by Halperin and Whetherell, (5), and subsequently transferred to a medium having litte or no 2,4-D (4). Like normal seed-embryos, the "vegetative" embryos have cotyledons, but they differ from the former ones in that they are all genetically like the mother plant and form one uniform clone.

Many plants can be raised in this manner from a single carrot, water parsnip, etc. An interesting offshoot of this technique has been the formation of embryoids from the mature endosperm of certain species. The endosperm is a triploid tissue; that is, each of its cells contain a triple set of the basic chromosome number of the species instead of the double set which normally occurs in ordinary cells. The production of buds or embryos from such endosperm tissues may become a new means of obtaining triploid plants.

PLANTS FROM POLLEN GRAINS

Among the techniques which have been developed recently, one is particularly notable; this is a procedure which uses the male germ alone to produce a new plant. In 1966 Guha and Maheshwari (3) in India observed that some of the *Datura* stamens they had planted *in vitro* produced embryo-like structures, and that these structures were haploid. In our laboratory, we tried to stimulate the proliferation of pollen grains of various species and observed that stamens of tobacco produced little plantlets which, once transplanted into the greenhouse, developed into flowering plants which had only half the number of chromosomes (1,8,9). These investigations were pursued actively and led to a clarification of the factors necessary for success.

How to obtain plants from pollen grains — Extensive trials with different types of media in which all known hormone types, (auxins, gibberellins, cytokinins, dormins), nucleic acid constituents, many amino acids, vitamins, sugars, etc. were tried, led to the conclusions that: (1) a combination of an auxin and a cytokinin as used by the Indian (and later by Japanese) workers gave rise to rather undesirable effects such as callus formation, and that (2) simple nutrient media were superior. In fact, a sucrose solution alone, solidified with agar, allows pollen grains to develop into embryos, although development does not proceed beyond the "globular stage". A complete medium has been devised for various species of *Nicotiana* (8). This medium allows the formation of plantlets as early as 4 weeks after planting in nearly 50% of the anthers.

The crucial factor lies not so much in the composition of the medium as in the stage of development at which the anther is excised from the flower bud. Anthers excised too early, for example at the "tetrad stage", do not lead to embryo formation, nor do anthers excised once the pollen grains have become binucleated. The right stage occurs just before mitosis, when the grain is still a *microspore* containing a single nucleus. This moment occurs in *Nicotiana tabacum* when the tips of the growing petals just reach the tips of the sepals. Flower buds having reached that stage are cut off the plant and sterilized superficially. The anthers are excised and laid horizontally on the nutrient medium, four anthers to a tube (25 mm in diameter). The culture tubes are kept under 16-hour days at 28° C (day) and 20°C (night).

Monoploid plants — Using such a technique, we have obtained thousands of haploid — or monoploid — plantlets, that is plants with only one set of chromosomes: 24 in the case of *Nicotiana tabacum,* 12 in that of *N. sylvestris,* as revealed by counts made from root tips. Some of these plants have been grown to full size in the greenhouse and have flowered abundantly, but, of course, without setting any seed. The size of the flowers was about one-fourth smaller than that of the diploid flowers, and the coloration was lighter.

Geneticists are very interested in monoploid plants because mutations, which generally bring about recessive traits, are immediately visible in such plants. We have obtained several types of mutants by subjecting young plantlets derived from pollen to radiation produced by a cobalt source. Some mutants of *N. N. tabacum* 'Wisconsin 38' had strapped, narrow leaves, others had white flowers (instead of pink ones), or flowers with petals of a different shape (11).

Diploidization through tissue culture — Once one has produced the haploid mutant, one wants to make it diploid again in order to obtain seeds. This can be done by treating the buds with colchicine. We have devised a different technique, which — again — makes use of tissue culture. A piece of the stem or leaf petiole of a monoploid plant is cut off and aseptically planted on a medium which favors callus formation (2,4-D and a cytokinin — such as kinetin).

In the cells of this callus, the process of endopolyploidy takes place; that is, there is a doubling of chromosomes in some cells without the division of these cells into two daughter cells.

When this callus is then transferred to a new medium with a low auxin content and containing zea-

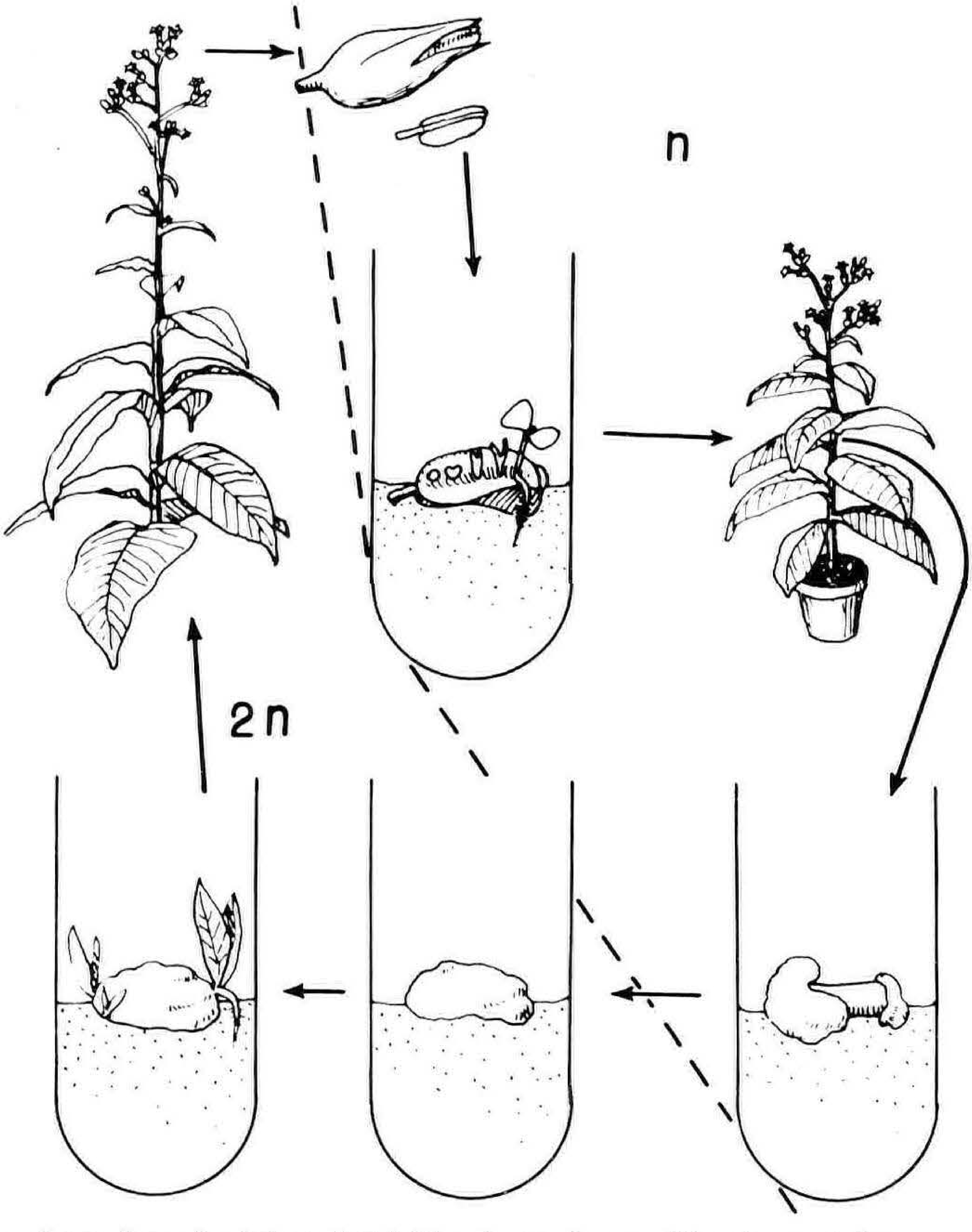

Fig. 1. Procedure for obtaining haploid plants from *Nicotiana tabacum*, then diploid individuals from the haploid ones. A flower bud at the right stage is excised from a flowering plant (*top, left*). The immature stamen is removed and planted aseptically on the proper nutrient medium. Pollen grains at the uninucleated, microspore stage develop into haploid embryos which germinate and form plantlets which are transplanted in pots in the greenhouse. The haploid plants flower abundantly, but do not set seed as they contain only n chromosomes per cell. In a second step, stem sections of haploid plants are surface-sterilized and planted aseptically on a nutrient medium which favors the proliferation of a callus (*bottom, right*). This callus can be transferred to the same medium in order to get rid of the initial explant and to let the process of endomitosis produce diploid cells. The callus is then transferred to a new medium which favors the formation of adventitious shoots (*bottom, left*) from which whole plants can be raised, the majority of which are diploid and capable of setting seed.

tin (0.1-0.2 mg/1), plus adenine (40 mg/1) instead of kinetin, buds are produced which now have cells with 2 sets of chromosomes. Once rooted as indicated above, these buds may be transplanted in the greenhouse and raised to form new plants. These plants are now diploid and set seed (10). Thus new mutant strains can be established, as well as non-mutant ones. They are homozygous strains which can be used in crosses in order to bring forth hybrid vigor. Figure 1 summarizes the main steps of our method.

Incidentally, in the course of their culture *in vitro,* certain cells may acquire chromosomal aberrations which may lead to various freaks. Thus, from a red-flowered strain of tobacco, we have obtained plants bearing double flowers with a dark red, velvety appearance. This new strain has been called 'Double Velvet'.

CONCLUSION

The various possibilities which have been presented are at the present time lines of research which present exciting problems to the biologist. They may seem far remote from the daily preoccupations of the plant propagator as they are today. However, as it seems to be the rule, new scientific discoveries sooner or later are being adapted by ingenious minds to yield practical applications. I am confident, therefore, that some of the processes which have been presented here will help, sometime in the future, in creating new varieties and multiplying them rapidly.

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MODERATOR CLARKE: We will now hear a review by Dr. Robert Ticknor, of the North Willamette Experiment Station, Aurora, Oregon of work that has been done on the rooting of pine cuttings. Bob.

REVIEW OF THE ROOTING OF PINES

R. L. TICKNOR
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Propagation of pines by cuttings has received comparatively little attention from horticulturists until recently (13, 19,22) but has been the subject of intensive investigation by foresters at least as far back as 1934 (1). Most of the results reported in this review have been reported since O'Rourke's (19) article in the 1961 Proceedings. Much of the work has been done in non-English speaking countries so that I have had to depend on *Forestry Abstracts* for most of the results reported in this review. Each of the many factors which influence rooting will be discussed separately.

Tree age. Tree age is probably the most important factor in rooting pine cuttings. Watanabe (26) reported 4, 17 and 30 year *Pinus densiflora* rooted 62, 42 and 30% respectively. Kummerow (10), reporting on rooting needle bundle cuttings of *P. radiata,* found average rooting percentages for 1-3 year trees as 24.7%, for 7-9 year trees as 19.5%, and for 28 year trees as none. An even earlier loss of juvenile rooting ability was reported in *P. thunbergiana* by Ogasawara (16) where cuttings from trees 1, 2, 3, 6 and 10 years old rooted 40, 16, 2, 0 and 0%, respectively.

A possible explanation for this observed decrease in rooting with tree age is contained in reports on content of indoleacetic acid (IAA) and growth inhibitors in pine trees. Yim (31) studied the growth substances in the terminal buds of *P. rigida* 1, 10, and 17 years old. Concentrations of IAA were highest in 1 year and very low in 17 year trees. In 10-year trees, IAA was highest in the buds in the lowest third of the crown. Better rooting of cuttings from the lower third of the crown has often been reported (19). Ogasawara (15) found similar results with 1, 2, 8 and 15 year *P. densiflora.* In addition, he found the content of growth inhibitors tended to in-

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Some rejuvenation appears possible as Ooyama (17) reported that cuttings from 5-year cutting-grown trees rooted better than the cuttings from the original 11 year trees. Patton and Riker (20 reported that cuttings of *P. strobus* from trees originating as cuttings were consistently superior in rooting ability to those originating from seedlings until the parents were 9 years old. Cameron (1) reported that hedged trees remain physiologically juvenile in that cuttings taken from these root more readily than cuttings from unhedged trees of the same age.

Time to take cuttings. Apparently there are two time periods in which rooting is most successful — November-January (2, 21) and in spring as the new growth matures (13, 22). Roberts and Moeller (22) reported one group of 13 clones of *P. mugo mughus* taken June 8 rooted 50-100% with an average of 78%, while a group of 15 clones taken June 28 rooted 0-100% with an average of 32%.

Cutting length. Short cuttings 4-5 cm have been reported as a factor in successful propagation (30); others feel cutting length is not a factor (29). Very short cuttings, 0.5 cm below the buds, have been used by some Japanese investigators (8, 9, 28).

Needle bundle cuttings, which are composed of the needles surrounding a bud and a small section of stem tissue, have been investigated by several workers (6, 10, 27). Although this technique promises the rapid increase of elite clones, in practice, rooting percentages have been low and much difficulty has been experienced in getting the buds to grow. Ishikawa and Kusaka (7) reported that the removal of the new growth leaders in the spring caused the development of the dormant buds which were used as cuttings the following winter and produced strong shoots. Kummerow and Schmidt (11) suggest the use of cytokinins to develop the buds of needle bundles.

Rooting hormones. McGuire and Sorenson (13) and Roberts and Moeller (22), working with June cuttings of Mugo pine, reported no advantage to the use of rooting hormones. Working with Mugo pine in December, I found Jiffy Grow #2, diluted 1:10, was beneficial but stronger strengths caused excessive callusing and decreased rooting (25). Other workers (12, 23) have reported rooting hormones, generallly IBA, beneficial in degree as well as percentage of rooting. Ooyama and Toyoshima (18) state IBA increased rooting percentage, if some of the untreated checks rooted, but not otherwise. Reines and Bamping (21) reported Rootone better than Hormodin in rooting slash and loblolly pines.

Fungicide treatments. A Spanish report (2) indicated response to 40:60 fungicide-talc mixtures when applied to needle bundles of *P. elliotti.* These fungicides—Maneb, Nabam and Ferbam — induced 60, 40 and 15% root formation, respectively. Grigsby (5) reported on the use of 25% Captan plus 0.8% IBA in rooting of loblolly pine which gave more rooted cuttings with more, stronger, and better distributed roots per cutting than did IBA alone. Doran (3) also reported benefits in using Captan with IBA in the propagation of *P. strobus.*

Rooting media. In the Orient, soil seems to be the favorite propagating medium. A red subsoil was used by several investigators (8, 28, 30). Nagano (14) tried 10 different media for the propagation of cuttings taken from 2-year *P. thunbergiana* seedlings. Rooting percentage was best in black volcanic soil, followed by loam, loam with sand, and vermiculite. The number of adventitious roots was greatest in pumice dust followed by "Kamuma" soil, black volcanic soil and loam. Root length was greatest in sand, followed by vermiculite with sand, black volcanic soil and loam with sand. Ishikawa and Oohasi (9) reported quartz sand the best media, red soil poorest and vermiculite intermediate. Patton and Riker (20) reported sand was better than a mixure of sand and peat.

Media temperature. Grigsby (5) reported his highest soil temperature (78°F.) gave the highest percentage rooting (40%) of 6-year loblolly pine. Ooyama and Toyoshima (18) reported that *P. densiflora* and *P. thunbergiana* rooted best in unheated beds, while *P. massoniana* rooted best in a heated bed. Watanabe, *et al* (26) working with 4, 17 and 30 year *P. densiflora* reported that with soil heating the rate of development of roots from young trees was faster but old trees tended not to root. Increased rooting with bottom heat in a "good" rooting year but decreased rooting in a "poor" year was reported by Patton and Riker (20).

Mist propagation. Although mist propagation has been widely used in the propagation of pines, research reports comparing mist vs. no mist are lacking. One report by Watanabe, *et al* (26) compared the number of days from 20 to 150 that mist was applied to *P. densiflora.* The longest period produced a slight increase in rooting, but they felt that best root growth resulted from 20 to 50 days of misting.

Other practices. Enright (4) found cuttings from 3-year *P. resinosa* and *P. strobus* rooted more quickly and in a higher percentage when taken from heavily fertilized plants than from the unfertilized plants. Libby (12) suggested that cold storage of the cuttings at 38° F. for 20 to 50 days could be beneficial.

Thulin and Faulds (24) report a modified air layering technique helpful in rooting *P. radiata,* and states that, "Vigorous shoots were ringbarked about 6″ below their terminal bud and a ½″ wide section of bark, phloem and cambium was removed. The girdled area was covered with aluminum foil as a protection against drying. Well-developed callus formed at the base of the girdled shoots in 4 to 6 weeks, after which the shoots were cut from the tree and set as cuttings."

Table I. Reported rooting results with various pine species.

Species	Tree Age	Rooting Hormone	Rooting Percentage	Comment	Ref. No.
P. armandii	14		10		26
P. ayacahuite	14		20		26
P. banksiana	13		2.5		26
P. contorta	8	Jiffy Grow, 1:10	40	March	25
P. contorta	8	Jiffy Grow, 1:10	10	March	25
P. densiflora	17		2.5		26
P. densiflora	4		62		27
P. densiflora	17		42		27
P. densfilora	30		38		27
P. echinata	14		7.5		26
P. elliotti	3	Maneb	60	Needle bundle	2
P. elliotti	3	Nabam	40	Needle bundle	2
P. elliotti	3	Ferbam	15	Needle bundle	2
P. elliotti	14		0		26
P. excelsa	14		62		26
P. koraiensis	13		52.5		26
P. luchuensis	15		12.5		26
P. monophylla	6	Jiffy Grow, 1:10	100	March	25
P. monophylla	6	Jiffy Grow, 1:5	0	March	25
P. mugo	8	Jiffy Grow 1:10	100	December	26
P. mugo mughus	6		50-100 (78 ave.)	13 clones. June	22
P. muricata	14		45		26
P. nigra	12		30		26
P. patula	14		0		26
P. peuce	14		37.5		26
P. pinea	15		0		26
P. ponderosa	12	Hormodin 3	20	March	25
P. pungens	14		40		26
P. radiata	14		32.5		26
P. rigida	20	Hormodin 3	66	Stump sprouts	23
P. rigida	14		12.5		26
P. strobus	4	IBA	30-90	Varies by year	20
P. strobus	13		65		26
P. strobus	4	IBA	95	81 days to root	29
P. strobus	4		100	81 days to root	29
P. strobus	45	IBA	60	157 days to root	29
P. strobus	45		0	157 days to root	29
P. sylvestris	12	Hormodin 3	20	March	25
P. sylvestris	14		0		26
P. taeda	6	0.8% IBA+10% Captan	10	Bottom heat 72°F.	5
P. taeda	6	0.8% IBA+10% Captan	29	Bottom heat 78°F.	5
P. taeda	6	0.8% IBA+25% Captan	23	Bottom heat 72°F.	5
P. taeda	6	0.8% IBA+25% Captan	40	Bottom heat 78°F.	5
P. taeda	14		0		26
P. thunbergiana	1		40		16
P. thunbergiana	2		16		16
P. thunbergiana	3		2		16
P. thunbergiana	6		0		16
P. thunbergiana	10		0		16
P. thunbergiana	17		15		26
P. virginiana	14		5		26

SUMMARY

Table I lists pines species from which cuttings have been tried and the results obtained.

Following are suggestions for those who wish to try pine cuttings. Take short 4 to 5 cm cuttings in November-December, or in late spring as the new growth becomes firm, from as young a stock plant as possible or from the lower part of older trees. Treat with IBA in talc up to 0.8-1.0%, to which 25% Captan has been added for winter cuttings, with bottom heat up to 78° F. and mist for the first 50 days. Be sure to root prune all rooted cuttings to develop a well-branched root system (24).

If you have a bad year in your pine rooting trials, try again. Patton and Riker (20) took cuttings from *P. strobus* transplanted seedlings each year from 1949 through 1956 and had yearly rooting percentages of 30 to over 90%.

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MODERATOR CLARKE: Our next speaker will be Mr. Brian Gage. He is from the Saratoga Horticultural Foundation, Saratoga, California. This is a non-profit corporation which develops and propagates superior forms of various kinds of plants, particularly trees, trying to build up the general level of the various types of trees with which they work, and getting them into the trade. Mr. Gage:

BRIAN GAGE: Thank you, Dr. Clarke — Many of you have visited the Foundation and are aware of the facilities we have there. We have a small area, just 5½ acres, and therefore we are not in any large scale seed production, but we do have quite a number of species of trees and shrubs that we are growing from seed.

SEED PROPAGATION AT THE SARATOGA HORTICULTURAL FOUNDATION

Brian Gage
Saratoga Horticultural Foundation
Saratoga, California

Our average annual quantity of plants grown from seed is 90,000. Twenty-five per cent of these are used as understock for our selected forms of magnolia, liquidambar, ginkgo, etc. A further 15% are California natives, the remaining being eucalyptus and miscellaneous trees and shrubs. We collect our own seeds where this is economically feasible, or when seed is not readily available from commercial sources.

We keep accurate records of our seed collections, time of year, location, etc.; but, despite this information, it is interesting to note that each year our timing appears to be astray, and it is usually necessary to return to the site for further inspections of the new crop of seeds before collection. These extra trips usually prove fruitful, although in some cases very time-consuming, especially if we are collecting natives from high elevations, such os the hubkleberry oak, *Quercus vacciniifolium,* or the pine mat manzanita, *Arctostaphylos nevadensis.* The current season at Saratoga and in the local foothills appears to be two weeks later than in 1968. This may be reflecting the abundant late rains we had during the past winter.

The stage of ripeness at which seed should be gathered also appears to be variable according to season. During the summer of 1967, we attempted to collect *Dendromecon californica* from a site at an elevation of 1,500 feet in the local foothills, only to find the pods had dehisced. Not wishing to lose the 1968 crop, we visited the area several weeks earlier and gathered the pods while they were still green. They were placed in a shallow tray to dry. The seeds inside the pods soon turned from green to black and we sowed them promptly, obtaining good germination. Attempting to repeat this performance, we collected the 1969 crop at the same stage of development as last year (i.e., while the pods were still a straw green color) only to find that, when the pods dehisced, the seeds inside had not ripened, but had shriveled.

Much has been written on the timing of seed collection, some of the following characteristics being recommended indications of maturity:

(a) Fullness
(b) Size.
(c) Color.
(d) Milkiness.
(e) Hardness of seed coat.
(f) When the first seeds begin to fall naturally.

From our limited experience, it would appear that the last point is probably the most important; however, it introduces the possibility of competition from birds and animals.

It is reported that some trees consistently produce high quality seeds. On the basis of this, we collected seeds of *Pistacia chinensis* from selected individuals over a four-year period. The result was inconclusive, but it did show quite clearly that point (f) was the most important factor, regardless of which trees we collected from, and at this stage of maturity the seeds have turned from red to blue, making point (c) a useful guide.

Many seeds require special handling after collection to ensure that they will germinate well. Our methods of pretreatment are fairly standard, and have been used and recommended for many years; i.e., cold stratification for various lengths of time, ranging from 30 to 120 days. We mix the seeds with an equal volume of 50% moist peat moss and 50% Sponge Rok, and enclose them in a polyethylene bag.

Other pretreatments include scarifying, using a knife or a file. We have found this method works well on *Cercis occidentalis,* especialy if the seed is subjected to a hot-water treatment first, which for us means placing the seeds in a container and then pouring boiling water over them. They are then left in the water overnight. The next morning they have swollen sufficiently to be held individually. A small cut is then made through the seed coat with a knife. Also used in pretreatment methods are acid, freezing, hot/cold, and burning. The latter method has been used on seeds of *Dendromecon californica* and *Arctostaphylos* species. This consists of sowing the seeds in a flat and covering with ¼″ of soil. Three to four inches of straw or excelsior wood is then placed over the soil, lighted, and allowed to burn out. This method does not give consistently good results, which may be due to several variables; i.e., the amount of moisture present in the sowing media, speed at which the cover burns, etc.

Our normal practice of handling seeds which we have not grown before is to check the available literature for recommendations. If none can be found, we divide the total volume of seed into three equal amounts. One batch is sown immediately, the second batch receives 30-days stratification at 40°F., and the third group is stratified at the same temperature for 60 days. If these methods prove unsuccessful, we try various other pretreatments.

We are currently growing *Quercus* species and *Ceratonia siliqua* by direct seeding into 2½″ and 3″ peat pots; otherwise, the containers we use are flats measuring 16″ x 19″ x 2½″. For small quantities of seed we use clay pots and pans. Our compost is, by volume, one part coarse sand and one part fine peat moss. On occasion we have made changes in this combination, especially with some of the more difficult species, attempting to simulate mineral or organic soils which may have some effect upon germination. This has not been successful on the trials we have made to date. Following seed sowing, the containers are covered with glass, and newspaper is used for shading. Covering the flats with burlap, instead of glass, conserves moisture and eliminates the need for extra shading; however, there is a problem with fungi and we have discontinued this practice.

We have found that a number of species germinate more readily if given bottom heat. For example, our annual crop of *Magnolia grandiflora* is stratified at 40° F. for 60 days and placed on benches in a glasshouse, using bottom heat. Germination takes approximately 27 days. An alternate placement employed for some years was to use plastic-covered cold frames without artificial heat; under these conditions, germination took 72 days, and our percentage of good seedlings was also less. We are currently germinating all of our seeds under glasshouse conditions, using bottom heat for many species. Once germination is complete, we remove the flats to a cold frame, or lath house, to ensure that the seedlings will be sturdy. An added advantage of seed propagation under glass is that we do not have to take precautions against birds (bluejays) eating the acorns and mice consuming the magnolia crop, as they have done in the past. The main disadvantage is that seedlings can quickly become soft and leggy if they are not removed to a cooler environment soon after germination is complete.

Despite our efforts to follow all of the rules, we consistently have difficulty in germinating some trees and shrubs. One in particular is *Carpinus betulus*. For several years we have purchased seed from the east, and have pretreated various lots in the aforementioned ways. An additional treatment tried was freezing the seed for a 6-week period. To date we have been unable to raise a crop of any significance. In 1968 we received a small batch of seed from Mr. Frank Knight of the Royal Horticultural Society Gardens, Wisley, England. This seed was divided into four equal parts and subjected to the following treatments:

(1) Stratified at 40° F. for 60 days.
(2) Frozen for 60 days.
(3) Hot/cold treatment for 60 days.
(4) Hot/cold treatment for 120 days.

Treatment No. 1 resulted in 20% germination — by far our best results to date — which would indicate that the source or the freshness of the seed may be important with this species, and the pretreatment critical.

Carpinus caroliniana, which we have also been raising from seed bought in the east, has not presented any problems, germinating well after a 130-day cold stratification period. We would appreciate any information, comments, or suggestions from propagators having had experience with *Carpinus betulus.*

At the other end of the scale, eucalyptus seeds appear to be the fastest germinating and easiest trees and shrubs to raise of any plants with which we are currently working. We recently sowed seed of 63 different species without any pretreatment. Of this number seed of 61 had germinated by the tenth day; seed of the other two species failed to germinate, which would indicate that they may require special handling.

The case with which we are able to raise some plants from seed and the challenge and uncertainty afforded by the "difficult" ones makes this phase of plant propagation a fulfilling experience to those of us who are fortunate enough to be employed in this field.

MODERATOR CLARKE: We will go right along and save the questions until later. The next speaker is a member of a nursery family, a graduate of Oregon State University and now has a wholesale nursery at Vancouver and, I believe, he recently has branched out into the retail business. Jack Doty is going to talk about direct seeding into peat pots, Jack:

DIRECT SEEDING INTO PEAT POTS

JOHN C. DOTY
Viewcrest Nurseries
Vancouver, Washington

We are all aware of certain plants which are difficult to transplant. In view of this, one can readily see the advantages of direct seeding into peat pots so as to reduce transplanting shock to a minimum.

Seeds selected for our tests were *Arbutus menziesi* (Pacific madrone), *Mahonia nervosa* (Cascade mahonia), and *Cornus nuttallii* (Pacific dogwood). It should be noted here that for the first two plants there is no problem if more than one seed were to germinate in a pot. Therefore, in the case of arbutus and mahonia, two to three seeds were used per container, but only one per pot for *Cornus nuttallii.*

Two types of containers were used: (1) 2½" x 3⅛" peat pot filled with a standard potting mix, and (2) Jiffy "7's", which are basically a fertilized peat contained in a plastic net. Both the peat pots and the Jiffy "7's" were placed in standard 15 x 20 in. nursery flats to facilitate production seeding. An assembly line was set up on roller conveyers. Peat pots were filled at the potting bench, flatted, and fed onto the conveyor where they were dibbled, seeded, and then covered lightly with a fine peat over the whole flat for better moisture control. In the case of the Jiffy "7's", it was necessary to set up tubs for soaking, as they come in a dehydrated form and expand to size when wet.

In direct seedling, one must give careful consideration to seed stratification. As all seeds used have a dormancy problem. we felt it best to stratify them, at least partially, before seeding. However, this could be done naturally by seeding in the fall and maintaining the moisture content during the winter. In our case, direct seeding worked out very well in the tenth day; seed of the other two species failed to germinate, which would indicate that they may require special handling.

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Another variation of direct seeding was done using *Araucaria araucana* (*A. imbricata*), monkey puzzle tree. Seeds were stratified until germination had begun in early summer; then they were planted in peat pots with no losses involved. When working with an expensive seed such as this one, the advantage of having each plant established in a pot is obvious. They could readily be transplanted into a larger container later.

An interesting thing was noted in the use of flats. Cedar flats were dipped in a solution of copper naphthanate. A midsummer set-back was noted with Pacific madrone and the native dogwood. On further inspection, the cause of the set-back was attributed to the tap-root coming in contact with the copper-treated flat where the root would become dessicated. Other roots would subsequently be forced out within the medium and a fibrous root system would soon develop. When transplanting to larger containers, the protruding roots were broken off when possible, giving the plants an extra root pruning.

Other experiments were conducted to a lesser degree with *Liquidambar, Sequoiadendron giganteum* (*Sequoia gigantea*), *Acer circinatum,* and *Albizia julibrizzin.*

After looking back over the results of our tests for the season, we are certain that transplanting shock can be minimized, or completely eliminated, by using these procedures.

MODERATOR CLARKE: I don't think our past president needs any introduction. If I want to caracterize him, I would just say that he is an old-time nurseryman. Bill Curtis, Sherwood, Oregon is going to talk on *Acer palmatum,* seed germination and culture. Bill:

SEED GERMINATION AND CULTURE OF ACER PALMATUM

W. J. CURTIS
Wil-Chris Acres,
Sherwood, Oregon

Over the past years I have grown a few *Acer palmatum* seedlings with varying degree of success. Poor germination occurred sometimes but at other times germination was excellent; however other problems developed. I have sown the seed outside in beds, covered with sawdust, but always with a variable survival percentage. Some adverse problems are birds or mice in the beds; the mice ate the seeds or the pheasants picked off the seedlings as they came through the sawdust. On one occasion I was too late with shade on an April day when the temperature climbed to the high 80's. On another day I forgot to water when watering was critical.

Two years ago I changed procedures and have been following closely a more exact method of handling the seeds and spring as a fill-in for our weeding and seeding crews during the showery periods.

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Two years ago I changed procedures and have been following closely a more exact method of handling the seeds and seedlings of this plant. The seeds are picked as soon as they are ripe and spread out on newspapers in the greenhouse bench for a day or two. The wings rub off more easily with a little drying.

A standard flat is filled with a mixture of ½ peat and ½ silty sand. The soil is firmed in the flats so that the soil level will be ⅜ to ½ inch below the top of the flat. The seeds are sown quite thickly for the plants only stay in the flats until the second leaf is formed.

After sowing the seeds, the flats are set outside in a well-drained area; the seeds are covered with clean sawdust. A clean flat is turned upside down over the filled flats, using flats that have narrow cracks. These small cracks slow the entry of winter rains and keep out mice and birds.

As soon as there is sign of germination the flats are returned to a warm greenhouse and the seedlings are pricked off after the second leaf has fully developed; the small seedlings are planted in 4″ plastic pots. With good care over 50% of these will be ready to graft by the next spring.

We use a mix of ⅓ peat moss (coarse "greenhouse grind") and ⅔ silty sand. To a wheelbarrow of this mix we add one 4″ pot of fine ground bone meal. In a week or ten days after potting, we begin feeding, using a dilute mixture of one tablespoon of "Fish and Six" to one gallon of water, applied with a Hayes fertilizer applicator attached to a hose. This can be purchased at any garden store supplier. At the end of 30 days we increase the "Fish and Six" to three tablespoons per gallon of water, applied weekly. If aphids or leaf rollers are not bothersome we add an insecticide to our fertilizer solution using wettable diazinon, Cygon, or malathion. When leaf rollers are too persistent we use nicotine dust applied in the evening just before quiting time. Many of our pests build up an immunity to the best new materials available to-day. When all else fails nicotine dust will give a good kill, but be careful, for it will also kill warm-blooded animals.

We leave the seedlings in the greenhouse until late October, for by then they are going dormant. During November, December and January they are placed outside; in February they are returned to the greenhouse and in two weeks or less they are ready to graft.

Now, if you are real thrifty, you can cut the seedlings back to the desired height for grafting and root the tops that normally are thrown away. Make short cuttings, three or four inches long, dip in Hormodin #3, sticking them close together, 300 to 400 to a flat. Don't over water — 50% or better will root and they will reach grafting size by next season.

MODERATOR CLARKE: Thank you, Bill. Our next speaker comes to us originally from Boskoop, Holland, that great nursery center. He is now with the University of Washington Arboretum at Seattle. Mr. Richard Van Klaveran is going to talk to us on *Acer palmatum* forms and their rooting.

GROWING ACER PALMATUM FROM CUTTINGS

RICHARD VAN KLAVEREN
University of Washington Arboretum
Seattle, Washington

Propagation of maples has always been considered a difficult task. Some maples, such as *Acer platanoides* and *Acer saccharum,* can be readily grown from seed, while others, such as *Acer griseum,* produce few fertile seeds, and these are difficult to germinate. Some maples, such as *Acer saccharinum* and *Acer rubrum,* produce seeds which will germinate soon after falling to the ground in midsummer, while seed of other species, such as *Acer negundo* and *Acer triflorum,* develop a hard seed coat which must be treated by scarification and they also need to be stratified. Most maples available in nurseries today have been grafted.

Only in recent years has the propagation of maples from softwood cuttings become practical. Two new techniques, the use of controlled mist and the availability of polyethylene plastics, have made this possible. The use of controlled mist in rooting softwood cuttings is not new, but its use on a widespread scale is. When a polyethylene cover is used, mist is unnecessary.

One maple currently being propagated from softwood cuttings with great success is *Acer palmatum* and its many forms. Several factors are involved in making this a successful operation: the type of cuttings taken, their preparation, the rooting medium, and, perhaps most important of all, proper timing to enable newly-rooted plants to be set out in cold frames or lathhouses early enough in the season so as to establish new growth before the dormancy period is encountered in the fall.

Softwood cuttings are made from actively growing wood collected from young plants; in many instances the age of the stock plant determines whether or not the cuttings will root. The younger the plant from which the cutting is taken, the better are the chances of success. Tip cuttings are used because they root readily.

Cuttings are cut four to six inches in length with basal leaves removed from that portion of the stem which is to be inserted in the rooting medium. The cutting is wounded on one side through the cambium layer, and is then dipped in Hormodin #3 or in a full-strength solution of Jiffy Grow, then inserted into the rooting medium. If Hormodin is used, it is advisable to use one part Captan to three parts Hormodin to prevent damping-off. If Captan is not mixed with the Hormodin, cuttings may be dusted with Captan.

A good rooting medium consists of 3 parts peat to 1 part sand or perlite. Vermiculite is unacceptable because it becomes slimy if too much water is used. The medium should be crumbly-damp and about six inches deep. Perhaps the most essential requirement is that it have good drainage. Bottom heat is used.

After the properly prepared cuttings are carefully inserted in the medium, the entire bench is covered with polyethylene and sealed with laths. If plastic is not used, mist is necessary. Experimentation with lights — fluorescent, red, and Gro-lux, has indicated no great differences or advantage in rooting. Rooting normally occurs in three to five weeks.

As soon as adequate roots have formed, plants are transferred to individual pots, hardened off, and sunk in a cold frame with shade overhead. They are left out all winter. A mulch is unnecessary. The important thing is to have the plants rooted as early as possible to permit them to make some new growth before the dormancy period. Plants which do not continue to grow and develop some new growth after being potted will not break dormancy in the spring.

To summarize — if cuttings are taken as early as possible, are properly prepared, and are set out in sufficient time to make some new growth before they go dormant in the fall, 80 to 90 percent will root, and 60 percent of those rooted will grow through the first year after potting.

MODERATOR CLARKE: Thank you very much. Our next speaker is a horticulturist at the Santa Barbara Botanic Garden located at Santa Barbara, California. Mr. Dara Emery will speak on some native plants of the Santa Barbara area and their propagation. Mr. Emery.

THE PROPAGATION OF SOME NATIVE CALIFORNIA PLANTS

DARA E. EMERY
Santa Barbara Botanic Garden
Santa Barbara, California

The Santa Barbara Botanic Garden is devoted exclusively to native California plants. The propagation unit at the garden consists of a small glass house, a lathhouse with a hotbed inside, and an intermittent mist unit with bottom heat located outside in nearly full sun. A modified U.C. mix is used for seed flats and pots. The canning soil, sterilized, is variable depending on what is obtainable. Cuttings, after being prepared are totally immersed in a malathion-Captan solution and, in most cases, the basal portion is dusted with Rootone. Because of our highly mineralized water, cuttings in the mist unit not rooted by 2½ to 3 months have very little chance of rooting and by 4 months are dumped. As soon as cuttings are rooted in the mist unit they are potted in plastic pots and placed in a hotbed with extra shade for two weeks to harden-off. The following eight native California species have presented propagation problems of one type or another.

Tree anemone, *Carpenteria californica;* this is an attractive evergreen shrub which grows 4 to 7 feet tall and as much across. Its foliage is dark green, and the flowers, borne in

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Tree anemone, *Carpenteria californica;* this is an attractive evergreen shrub which grows 4 to 7 feet tall and as much across. Its foliage is dark green, and the flowers, borne in large clusters, look very much like large single white camellias. The flowering period is June to August.

Carpenteria seed is very small and the viability is quite variable. First germination occurs in about three weeks. The emerging seedlings are very susceptible to damping-off, especially if the stand is dense. All the usual procedures to prevent damping-off should be followed carefully with this species. Once the seedlings are well established there are no other cultural problems. Tree anemone can be easily and more quickly propagated from tip cuttings taken in spring using bottom heat with or without intermittent mist.

California wild lilac, *Ceanothus* species, are mostly evergreens. They vary in size from attractive dense mats and ground covers to large shrubs or small trees. Most species under garden conditions are apt to be short-lived — four to eight years — in southern California. Their very rapid growth and profuse blossoming traits, however, more than compensate for the short life span. Flower color varies from white to blue to purple.

Most all ceanothus seed requires a hot water treatment for prompt germination and, depending on the species, cold stratification also. The seed germinates readily but can only be spotted-off satisfactorily immediately after germination, when the radicles are about an inch long. This can be within two weeks of first germination. Germination is quite uniform and the percentage germination usually high. Because of the spotting-off timing problem, the seed is best sown a few each to small rose-type Jiffy Pots. Then, if the spotting-off is not done in time, the best seedling per pot can be saved and the rest culled. Ceanothus hybrids and many of the species can be propagated readily from soft tip cuttings using bottom heat, with or without intermittent mist.

Southern fremontia, *Fremontodendron mexicanum*, is an evergreen shrub that grows 8 to 15 feet tall. Its leaves are glossy dark green above and covered with stiff brown pubescence beneath. The large, deep-yellow flowers are borne in great profusion in spring.

Southern fremontia seed, after being given the hot water treatment, germinates readily. It should be sown two or three per small rose-type Jiffy Pot, as the seedlings do not spot-off satisfactorily. First germination occurs in two to three weeks. The big problem with this plant is to keep it alive in containers once it has reached planting-out size. The sterilized canning mix should be very well drained and the plants grown on the dry side. Whenever possible container plants should be disposed of and planted out before the nights turn cool in the fall, as they are particularly susceptible to root rot at that time. Cutting propagation is possible using tip cuttings in spring with bottom heat and intermittent mist, though the percentage of cuttings that root may be small.

Douglas iris, *Iris douglasiana*, forms compact plants up to one foot tall and two to three feet wide. The relatively dense, arching foliage is medium to dark green, and the non-bearded flowers are 2 to 3 inches in diameter and borne two to three per stem. They vary in color from white to purple. The flowering period is May to June.

Untreated seed has rather specific temperature requirements. If sown between September 1 and 15, first germination occurs in 30 days; but if sown October 1 to 15, first germination starts in 90 days. Seed sown in the spring after three months of cold stratification also starts to germinate in about 30 days. Germination is uniform and of high percentage. Once germinated the seedlings are easy to handle. Douglas iris can also be propagated from divisions taken in spring during the active growth period.

Silver lupine, *Lupinus albifrons,* an evergreen mound-shaped shrub grows 2 to 6 feet tall and has dense silvery blue foliage. The typical pea type flowers are very fragrant and usually bluish-purple in color, but occasionally white or wine-red flowered forms appear. This lupine is apt to be short-lived under garden conditions but compensates by being a very rapid grower.

Seed propagation is not difficult. The seed should be knicked or given a hot water treatment. The use of a legume inoculant is also helpful. Seed are best sown in small rose-type Jiffy Pots, one or two seeds per pot. First germination occurs in one to two weeks. If necessary the seedlings can be easily spotted-off immediately after germination. Cutting propagation is usually unsatisfactory; however, stem cuttings taken in early December, stuck in coarse vermiculite with bottom heat and intermittent mist (outside unit), root reasonably well. Once rooted the plants grow well in containers.

Island ironwood, *Lyonothamnus floribundus* var. *asplenifolius,* is an attractive evergreen tree 25 to 50 feet tall with reddish-brown exfoliating bark. The handsome medium-green leaves are pinnately compound. Small white flowers are borne in large terminal clusters in May or June.

Seed propagation of this tree has two problems — viable seed for those who collect it and weak stems for those who grow it. Production of viable seed is quite variable from year to year even on the same tree, and the seed is quite small and difficult to separate from the chaff. Spring sown seed, under lathhouse conditions, will start to germinate in about two weeks. The seedlings have very weak stems and when watered are very easily knocked over. The subsequent growth will turn up again but the stems are then malformed. The seedlings can be spotted-off in early spring when the maximum daily temperature is from 60° to 70° F. If the maximum temperature is higher, the newly spotted-off seedlings can be placed under intermittent mist without bottom heat for two weeks or so until they are well established. These procedures will minimize stem malformation. Until the liners are about six inches tall the stems are still subject to lodging and special care is necessary in watering. Cutting propagation has been unsuccessful.

Cleveland sage, *Salvia clevelandii,* is a short-lived evergreen to semi-deciduous shrub. It forms a 2 to 4 foot mound and has gray-green aromatic foliage. The ¾ to 1¼ inch long flowers are deep blue in color or sometimes whitish. They are borne in whorls one to several per stem. The flowering period is May to August.

To obtain maximum germination of untreated seed the sowing time is important. The best time in Santa Barbara is December or early January. Seed sown then in the lathhouse will give good germination starting in thirty days. Once germinated. the seedlings, if spotted-off in April or May, are easy to handle. Seed sown later or during the warm part of the year germinate poorly. Cleveland sage can be quickly and easily propagated in early spring from soft tip cuttings using bottom heat.

Evergreen or California huckleberry, *Vaccinium ovatum,* in our area forms a 4 to 8 foot shrub. It has leathery dark green leaves and axillary clusters of small pink or white urn-shaped flowers. The flowering period is March to May. The small bluish-black berries are edible.

Propagation of this vaccinium has been a problem as our water is highly mineralized with a pH of 8.4. Fresh or stored seed sown in the lathhouse in early fall on milled sphagnum moss germinates well. First germination occurs in about 90 days. We use a potting mix of equal parts #30 washed sand and Canadian peat moss with no fertilizer added and either plastic pots or Jiffy Pots.

Tip cuttings taken in January and rooted in fresh, fine-grade pine shavings with bottom heat and intermittent mist root well — 80 to 100%. Rooted cuttings are potted in 3-inch plastic pots, later shifted to 4-inch plastic or Jiffy Pots, and then to one-gallon cans. Shifting the plants from 3-inch pots to gallon cans has given poor results. The potting mix used is the same as for the seedlings — equal parts #30 washed sand and Canadian peat moss with no fertilizer added. The gallon can mix is our regular canning mix plus one-third to one-half peat moss.

MODERATOR CLARKE: Our next speaker, Dr. J. H. Crossley, Canada Department of Agriculture, Saanichton, B.C., Canada, was unable to be here. However, his paper will be published in the Proceedings but will not be read this morning.

SOME LONG-TERM RESIDUAL EFFECTS OF RETARDANTS ON CHAMAECYPARIS LAWSONIANA "ELLWOODII' AND RHODODENDRON 'A. R. WHITNEY"[1]

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Within the last decade chemical growth retardants have opened a vast field for exploration in plant growth and flowering. The effects of these chemicals on ornamental plants have been widely reported, especially on rhododendrons, by Cathey (1, 2), Criley (3, 4), Leach (6), and Ticknor (7, 8), but there is very little information on the long-term residual effect of retardants on shoot growth, flowering or propagation of retardant-treated ornamentals. This prompted the author to make this study.

EFFECT ON SHOOT GROWTH

Chamaecyparis lawsoniana, 'Ellwoodii'. Established rooted cuttings of *Chamaecyparis lawsoniana* 'Ellwoodii' were sprayed with Alar and Phosfon-S to the run-off stage 1, 2, 3 or 9 times at weekly intervals commencing May 24, 1964. The rates for Phosfon-S were 100, 1000 and 10,000 ppm; rates for Alar were 200, 1000 and 5000 ppm. Altogether there were 23 treatments and 115 plants.

At the end of the first growing season nearly all the Phosfon-S treatments showed varying degrees of foliage injury and for this reason all were discarded from the test. None of the Alar treatments showed injury and only the low concentration, applied once, failed to retard shoot growth significantly. Plants sprayed either three or nine times at 5000 ppm showed greatest and equal retardation.

Because of the large number of plants in the test, only the check plants and those sprayed nine times at 5000 ppm were carried on for further studies. These were subsequently transplanted twice to larger containers and at all times given the same cultural conditions. The comparative growth data for 1964, 1966 and 1969 are shown in Table 1; growth and condi-

Table 1. Average height of foliar sprayed and unsprayed *Chamaecyparis lawsoniana* 'Ellwoodii" following Alar treatment (1964) to established rooted *cuttings.*

Year	Average* height (inches)		Percent difference
	Alar in 1964 only	Check	
1964	7.7	12.1	44
1966	21.7	46.1	52
1969	52.4	72.1	27

*Average of five plants per treatment

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[1] Contribution No 225, Research Station, Canada Department of Agriculture, Saanichton, British Columbia

tion of the plants on August 23, 1969 are illustrated by the two specimens in Figure 1.

Rhododendron 'A. R. Whitney'. Established rooted cuttings of 'A. R. Whitney' rhododendron were grown in the greenhouse under two light regimes during the summer of 1965 to compare growth and flower bud production. One half of the plants in each lot were given a single soil drench of one U. S. pint of Phosfon solution, concentration 337 ppm, to each 7-inch azalea pot as outlined by Cathey (1). The remainder received no retardant. In the fall of 1966 all plants were transplanted to larger containers of Phosfon-free soil after one-third of the root ball was removed, only enough so that subsequent plant growth was not impaired. The unremoved portion of soil obviously retained sufficient Phosfon to account for the residual effects recorded. Following transplanting all plants received the same cultural conditions. The comparative growth data for 1965-1969, inclusive, are shown in Table 2; plant growth and condition on August 23, 1969 are illustrated by the two specimens in Figure 2.

Fig. 1. Comparative height and condition of the plants on August 23, 1969, of sprayed and unsprayed *Chamaecyparis lawsoniana* 'Ellwoodii'. *Left.* Alar (5000 ppm), nine foliar applications at weekly intervals in 1964 to established rooted cuttings. *Right.* Control. No Alar.

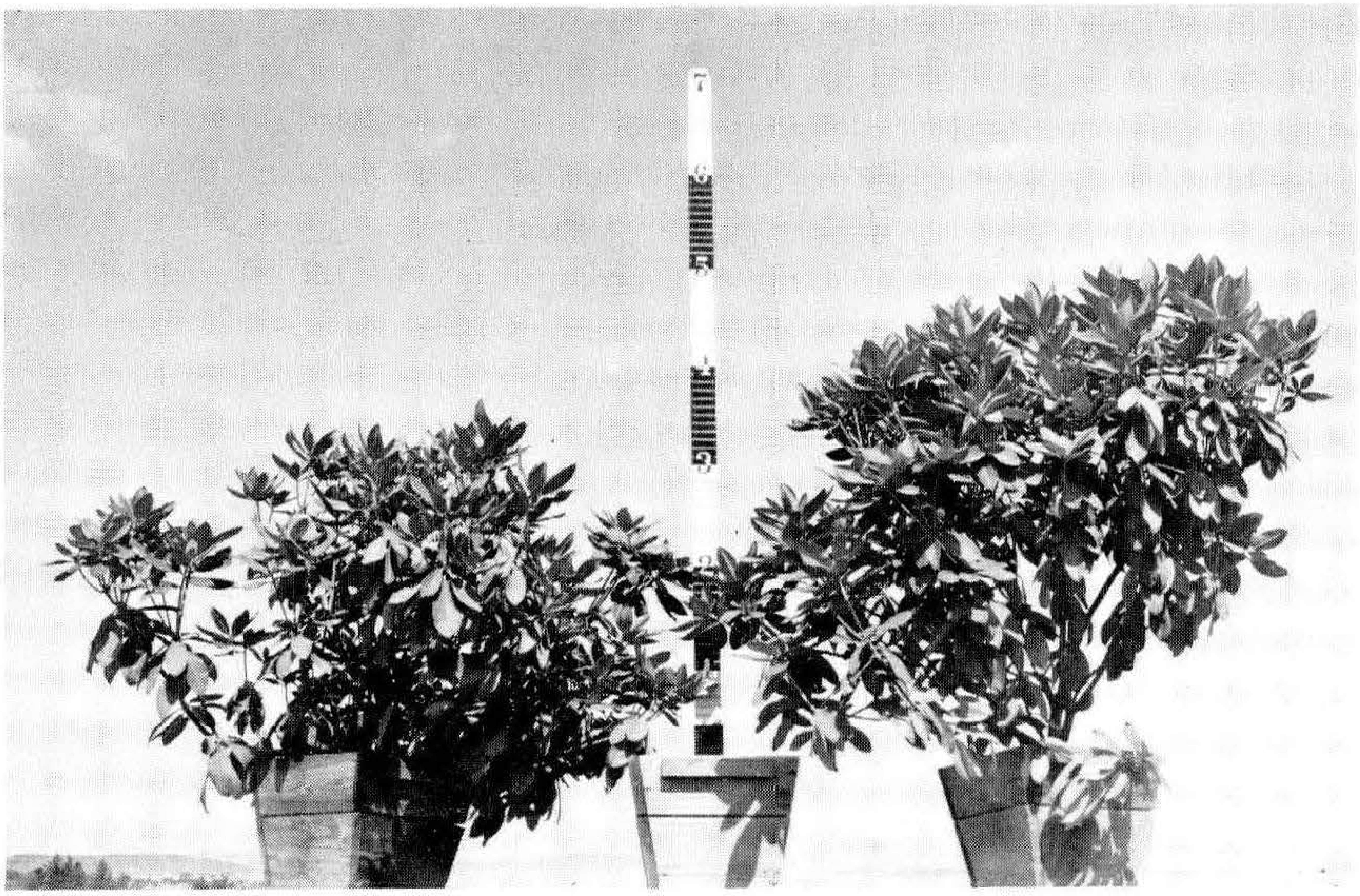

Fig. 2. Comparative height and condition of the plants on August 24, 1969, of Phosfon-treated and untreated 'A. R. Whitney' rhododendron. *Left.* Single application of Phosfon soil drench, one U. S. pint of Phosfon solution, (337 ppm) per 7-inch azalea pot in 1965 to established rooted cuttings. *Right.* Control. No Phosfon.

Table 2. Average height of treated and untreated 'A. R. Whitney' rhododendron following a Phosfon soil drench plus night illumination (1965) to established rooted cuttings.

	Average plant height (inches)			
	Natural days		Natural days plus supplementary night light	
Year	Phosfon	Check	Phosfon	Check
1965	13.1 c	16.1 b	12.4 c	19.8 a
1966	19.7 b	31.8 a	21.1 b	34.5 a
1967	25.8 b	39.7 a	29.8 b	42.0 a
1968	35.4 b	53.8 a	41.6 b	55.0 a
1969	43.2	62.1	48.2	61.3

Within years, figures with no letter in common are significantly different (P = 0.05). Figures are averages of a minimum of five plants in any one year.

EFFECT ON FLOWER BUD PRODUCTION

Rhododendron 'A. R. Whitney'. The same plants used for the shoot growth experiment were used in this test. Flower bud counts (Table 3.) show that the Phosfon and natural-day treatment resulted in significantly more flower buds than any other treatment during the first year (1965), and in significantly less numbers of flower buds than any other treatment during the second year (1966). The number of flower buds in the various treatments in the third year (1967) was not sig-

Table 3. Comparative number of flower buds of treated and untreated 'A. R. Whitney' rhododendron following a Phosfon soil drench and night illumination (1965) to established rooted cuttings.

Year	Average number of flower buds per plant				
	Natural days		Natural days plus supplementary night light		
	Phosfon	Check	Phosfon	Check	
1965	4.4 a	0.1 b	0.7 b	0.1 b	
1966	13.4 c	20.8 b	28.4 a	20.6 b	
1967	36.4	34.6	37.8	44.4	N.S.D.

Within years, figures with no letter in common are significantly different (P = 0 05) Figures are averages of a minimum of five plants in any one year.

nificantly different, indicating the effect of the treatments in 1966 had dissipated.

EFFECT ON PROPAGATION

Rhododendron 'A. R. Whitney'. Ticknor (8) applying Phosfon spray, CCC and other growth regulators to 3-year-old field-grown rhododendron to induce flowering, found that propagation as determined by cuttings taken the year of treatment was not affected by these growth regulators. But the author applying two concentrations of Phosfon drench once to established rooted cuttings, found the quantity of top grade rooted leaf-bud cuttings significantly curtailed. Leaf-bud cuttings, following Leach's (5) description, were taken at random from non-flowering shoots of the current season's wood on October 29, 1968, dusted with Seradix No. 3 and then stuck in a rooting medium of granite-sand, perlite, vermiculite and styrofoam (2-2-1-1 by volume). The rooting medium was held between 68° and 72° F. and intermittent mist was used during the daylight hours. There were eight replications per treatment with ten cuttings per replicate. The cuttings were examined on April 30, 1969 and those with roots were graded, according to the size of the root ball, as "excellent", "good", "fair" and "poor".

Results (Table 4) indicate that while the total number of rooted leaf-bud cuttings in 1968-69 derived from plants treated with two levels of Phosfon soil drench in 1966 was not significantly different from that obtained from the check plants, the quantity in the two top grades of Phosfon-treated plants was significantly less. There was no significant difference in grade between the two concentrations of Phosfon used.

Shoot growth of the rooted leaf-bud cuttings derived from the Phosfon and check plants following planting was not significantly different.

Table 4. Average[1] quantity, grade and shoot length of rooted rhododendron leaf-bud cuttings from Phosfon-treated and control plants.

Treatment	Grades				
Concentration Phosfon-soil drench applied 1966	'Excellent' grade (April 30, 1969)	'Excellent' and 'good' grades (April 30, 1969)	All grades (April 30, 1969)		Average shoot length (June 25, 1969)
				Value[2] (Weighted)	
(ppm)	Number	Number	Number		(inches)
0	7.0 a	7.5 a	8.3	31.2	12.3
337	4.6 b	5.6 b	7.5	24.8	12.3
1011	5.3 b	5.2 b	7.6	24.7	12.5
			NS	NS	NS

Within columns, values with a letter in common are not significantly different ($P = 0.05$)

[1] Average of 80 cuttings, 10 per replicate

[2] Determined by substituting the values 4, 3, 2 and 1 for "excellent", "good", "fair" and "poor" grades of rooted cuttings, respectively

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MODERATOR CLARKE: That brings us to the question and answer period. Do we have any questions now?

VOICE: I would like to ask Mr. Doty at what temperature he stratified his *Araucaria* seeds?

MR. DOTY: Our cooler stays at 36° to 41° F. All we did was to place the seeds between two layers of burlap with a little peat around them, because they are rather large seeds. Then we checked them every week for germination. Some would germinate ahead of others, but at that time we had enough coming on and we would pull them out and seed them in our Jiffy 7's or Jiffy Pots. Incidentally, there was quite a problem trying to figure out which end was which on the seed. We did find out after we germinated them that the pointed end, where the first signs of life appears, is the correct end to put downward.

VOICE: Did you use moist peat moss or put the seeds in dry to stratify?

MR. DOTY: Just wet enough to supply moisture to the seeds.

VOICE: In my experience with monkey puzzle trees I believe that a germination inhibitor is in the seed coat; if you remove this you will not need to stratify the seed — at least local seed. On any seeds that I have imported from Chile, they have all died; I have yet to produce my first seedling. I don't know if they get killed during importation, or if they are such an oily seed that they become rancid. On local seed, I almost always get 100% germination. Another thing, you don't need to worry about which end is up when you plant seeds of monkey-puzzle tree, or I don't. Plant them sideways. The radical grows out like it does in an oak seed, then it turns downward and there is a division just above it where the new shoot develops and so on. Usually you lay it on top the pot, let the root go down and the shoot will come from a division of the radical.

BOB TICKNOR: I would like to comment on *Ceanothus* seed germination. I worked once in a seed laboratory where we tried to germinate *Ceanothus prostratus,* which has a heat plus cold requirement. We found that besides the hot water treatment we could put the seeds under heat lamps, to get about 70° C. Five to ten minutes of this adequately substituted for the hot water treatment. There had been a previous graduate thesis at Oregon State University on germination of *Ceanothus velutinus* seeds, which was a real problem before we worked out the techniques. It might be one to try.

BARRIE COOKE: I have a question for Dara Emery. I believe there is a nursery in southern California growing the new introduction, a bispecific hybrid, *Fremontia californicum* x *F. mexicanum,* called 'California Glory'. I believe this grower was grafting them. Have you any comments on cutting propagation vs. the advantages or disadvantages of grafting this plant.

MR. EMERY: I have had no experience grafting this. However, I am familiar with the nursery that has been doing it, and they have discontinued this procedure because it was unsatisfactory. It is very difficult, or at least no one, so far, has found a close relative to *Fremontia* that forms a satisfactory rootstock.

DR. KESTER: This is a general question to the panel, or to anyone else. One of the problems of hard-to-germinate seeds may be a question of viability. Sometimes it is difficult to know whether seeds are non-viable or just difficult to germinate. I have wondered how many people have used the tetrazolium test to determine seed viability. It seems to me that it has some very practical uses in nursery work and I have heard no mention of it in any of our meetings. The test has been available for quite a while, and I wonder if anyone has had any experience with it as a practical test at the nursery level.

DR. LEISER: In our direct seeding program of woody ornamentals we are working with the California Highway Department. Our concern has been — "are we using viable seeds?" Frank Chan is an associate with us who is using this test quite a bit on seeds of a number of different species. It appears to be very satisfactory. This summer I had a graduate student working on *Ceanothus* seed germination, and before we started we ran the tetrazolium test to determine approximate viability of the seed lots that we had. One seed lot indicated little or no viability but we went ahead through the whole series of seed treatments. We did not get any germination from this lot. Another seed lot had about 50% viability, and in our best treatment we had about 50% germination and that was the peak we could get out of it. We have only been using the tetrazolium test in a concentrated fashion for a few months, but it looks like a good, quite easy, method for determining seed viability. Then one would know, when reporting on seed treatments and germination, whether the seeds were viable or not to begin with. We gave the *Ceanothus* seed a hot water treatment initially because many of them have hard seed coats, and this cracked the seed coats very well.

Tri-phenyltetrazolium chloride is a colorless chemical which is changed, during the respiration processes in any living cell, to a red-colored compound, tri-phenyl formazan. About 24 hours after treatment the seeds are examined. If the seeds are red or pink they are viable; if they are colorless they are dead.

VOICE: I would like to make a quick comment on that. One very simple way you can check a seed is to cut it open, and if there is no "meat" in there, you know it is not going to germinate.

DR. LEISER: Yes, but some seeds can have "meat" but still not be viable.

VOICE: This is probably true, but with local seed we have found in almost 100% of the cases, the seeds that have "meat" in them will grow, if they are stratified properly. This is not the case when you are buying seeds, because there may be quite a few harmful factors, like fumigation, poor storage, too much heat, or poor transportation, and what have you. You don't know these factors.

FRIDAY AFTERNOON SESSION

VICE-PRESIDENT BRIGGS: For our final technical session of the meeting we will have Joe Klupenger of the Klupenger Nursery, Aurora, Oregon, as moderator. Joe:

MODERATOR KLUPENGER: Our first speaker this session is Production Manager of Greenleaf Nursery, Park Hill, Oklahoma. Mr. Austin Kenyon is going to speak to us on "Winter Storage of Container Plants". Mr. Kenyon:

WINTER STORAGE OF CONTAINER PLANTS

AUSTIN KENYON
Greenleaf Nursery Co.
Park Hill, Oklahoma

Our nursery has been providing winter protection for container-grown broadleaf evergreens since the winter of 1963. This was necessitated by severe damage and heavy losses during each of the three previous winters.

We are located in northeastern Oklahoma in the Cookson Hills approximately 50 miles west of Ft. Smith, Arkansas. The average minimum temperature is 5° to 10° F. below zero. However, overwintering in our area is further complicated by rapidly fluctuating temperatures, with highs in the 70° F. range sometimes being only 24 to 36 hours ahead of the extreme low temperatures. Therefore, most broadleaf evergreens grown in containers, such as pyracantha, euonymus, holly and the soft varieties of deciduous shrubs are subject to varying degrees of winter damage. We felt that polyethylene-covered houses offered the most promising solution, but several criteria had to be considered:

1. The houses had to be low in cost.
2. They had to be able to hold snow loads of 6 to 12 inches.
3. They had to withstand winds in excess of 60 mph.
4. They had to be easily erected and dismantled as we intended to put up the houses in the fall and take them down in the spring.
5. They had to do an adequate job of protecting the plants.

The structures I am going to describe are being prepared for use for their sixth winter. We decided on A-frame construction because of its relative strength and simplicity. By making individual A-frame bows and joining any number of bows with stringers, a house of any desired length can be erected. The A-frame bow is constructed from two 2 x 6's — 19½′ long, with a 12′, 2 x 4 cross brace, and gussets of ⅜″ plywood, resulting in a bow 33′ wide, 11′ high, each leg making an angle of 31 degrees with the ground. The bows are spaced

8′ apart with 2 x 4 stringers 16′ long, nailed to the bottom, middle and top. Diagonal braces are put at each end and, in the case of a long house (200′ or more), braces are put in the middle. Metal stakes constructed of 1″ structural pipe are driven into the ground to hold the house down. The ends are then covered and padded and the stringers inspected and rasped down if necessary in order to prevent tearing the plastic sheet.

The house is now ready to cover. However, in practice, we will bunch up the plants first and erect the house over the plants. The containers are stacked three high if necessary, so that a block of spaced plants 100′ wide will fit into the 30′ useable width of the house and allow an 18″ aisle down the middle and a cross aisle every 40 feet. The stacking of the plants is very important. On the bottom layer the plants are put can to can. The second layer is can to can in one direction, but spaced the size of a can in the other direction. The top layer is spaced all the way. The result is, that for each 4 cans on the bottom layer, there are 2 cans on the second layer, and 1 can on the top layer. In the case of 1-gallon cans, this is 7 plants per square foot.

After the plants are stacked, the house is erected over them. The plastic sheets are ordered to fit the houses plus about 10% extra length to allow for adding a couple of bows if necessary. and to allow for possible slight errors on the part of the plastic manufacturer in cutting, the sheet. The sheets are all 40′ wide. I don't know of any company manufacturing sheets wider than 40 feet. Our houses vary in length up to 500 feet.

When the house is completely ready to cover, the plastic is rolled out beside the house and carried over and draped in place. The sheet is then nailed down with lath at one end and stretched to the other end.

It is important that the weather be suitable. It is virtually impossible to handle these large plastic sheets in winds over 15 mph; a completely calm day is very desirable and makes the job much easier. The temperature should be 40° F. or above on a clear day, and 60° F. or above on a cloudy day; otherwise it is impossible to obtain the necessary stretch on the plastic.

The plastic is stretched and nailed to the middle stringer by a crew of 5 or 6 men on each side of the house pulling against each other. Then the plastic is stretched and nailed to the bottom. The plastic should be drum tight when the job is completed in order to withstand the winter winds. The plastic is then nailed over every other bow in order to break it up into small, repairable sections. The house is then sealed along the bottom with sawdust. Shading material is applied to the houses as desired. The doors are closed any time the temperature is expected to go below 32° F. In the spring, cigar-shaped holes can be cut in the plastic above the middle stringer to improve ventilation.

We will evaluate these overwintering houses with regard to the criteria outlined earlier. First we said the houses had to be low in cost. Here is a cost breakdown on one A-frame bow:

40 feet of 2 x 6 @ 10c ft.	$4.00
12 feet of 2 x 4 @ 6c ft.	0.72
40 feet of 2 x 4 @ 6c ft.	2.40
two metal stakes 2 feet long plus 1 foot of strap metal, plus labor	1.00
3 sq. ft. of ⅜″ plywood @ 13c sq. ft.	0.39
4-mil polyethylene, 8′ x 40′ @ 0.7c sq. ft.	2.24
estimated labor to build bow	0.50
estimated labor to haul bows, erect buildings and cover with plastic	2.00
50 feet of lath @ 31.80 bundle	0.45
nails	0.15
Total for 240 sq. ft. usable space	$13.53

Thus the initial cost per sq. ft. is 5.8 cents. However, if we assume that the bows will last 4 years, the lath 3 years, the stakes 10 years, and that the labor to disassemble the houses is the same as that to erect it, we came up with a prorated cost of 3.5 cents per square foot per year. When it is considered that it is possible to stack as many as 7 one-gallon plants per square foot, the cost can be as low as ½ cent per one-gallon plant, which we feel is certainly reasonable.

Next, we said the structures must hold snow loads of 6 to 12 inches. The heaviest snow load we have had while using these houses, was 6 to 8 inches but this didn't seem to be very close to the structural limit.

The houses have gone through winds in excess of 60 mph and the only damage was a few iron stakes pulling loose and a few rips in the plastic which were easily repaired. If stronger winds were expected it would be necessary to use more iron stakes, or to use an entirely different means of anchoring the houses to the ground. It would also be necessary to lath the plastic to every bow rather than every other bow.

Next, we said that the houses must be easily erected and dismantled. It takes a 6-man crew approximately 4 hours to erect a 300′ house, if the materials are all close by. It takes 20 men about 2 hours to cover the same house.

The last criteria was that the houses had to do an adequate job of protecting the plants. I can say with no reservations, that ours do an excellent job. Winter damage is practically a thing of the past for us. On a cold night the temperature inside is usually 20 to 30 degrees above the outside temperature. In our climate the soil ball of the plants never freezes more than 1″ deep. Here are two exerpts from temperature records I kept the first winter we used the houses:

Dec. 22, 1963 — The outside temperature has not been above freezing for several days. It snowed approximately 3″ last night; at 5:30 P.M. the temperature outside was 14° F, inside it was 32° F. The low outside during the night was 7° F below zero; inside the low was 26° F.

Jan. 13, 1964 — The low outside was 4° F; inside 26°F. High temperature outside was 30° F; inside it was 56° F.

It is also important to note that the foliage color of most plants overwintered inside is much better than those left outside. This is certainly an important spring sales consideration. However, unless the houses are shaded, the plants inside will break dormancy 2 to 3 weeks ahead of plants left outside. Also, it is necessary to water the plants inside once or twice a week, or even more often during a warm spell. We use #20 Rainbird sprinklers, equipped with a baffle, spaced 20′ apart down the center of the house. Rodent damage in the houses can be quite severe, and it is necessary to maintain bait stations. The warm temperatures and high humidity in the houses are very conducive to insect and ddisease development, so we spray every two weeks with Captan, and every four weeks with Sevin.

During the winter of 1964 we decided to experiment with white opaque plastic. We used two overwintering houses of the same width and length, located side by side, one covered with clear plastic and one covered with white plastic giving 40% light transmission. A maximum—minimum recording thermometer was placed in each house at identical locations in order to compare inside air temperatures. Also, a continuous recording thermograph was placed in each house with the probe buried 6″ deep in a 5-gallon can to compare soil temperatures. Finally, a contintuous recording thermograph was placed outside to record outside temperatures. Due to the favorable results with white plastic from this experiment, the following year we covered approximately ⅓ of our overwintering houses with white plastic. In comparing clear plastic with white plastic, we have come to the following conclusions:

1. Night air temperature is approximately the same in both clear and white houses. We had expected the white to be warmer at night due to reduced heat radiation. However, on a cold night a heavy layer of frost forms on the inside of the clear plastic, resulting in heat transmission approximately equivalent to the white plastic. Also the frost layer, from ⅛″ to ¼″ thick, has some insulation value.
2. The daytime air temperatures are much higher in the clear plastic houses, approximately 15° to 20°F difference. The temperature in the white houses is about the same as the outside temperature during the day.
3. The soil temperature is quite uniform in the white houses while that in the clear houses fluctuates somewhat, being higher on the average.
4. Water requirements are much less in the white

houses, the plants needing water only about every two weeks.

5. The plants stay dormant 2 to 3 weeks longer in the white houses, breaking dormancy about the same time as plants left outside.
6. Foliage color is a little better on plants in the white houses.
7. The clear plastic is much stronger than the white plastic. The white plastic on all the houses covered for the winter of 1964 failed before March 15, 1965. This was a serious problem and forced us to abandon the use of white plastic. However, it is possible we used an inferior grade of opaque plastic in our tests.

MODERATOR KLUPENGER: Our next speaker is Mr. Henry Mollgaard, Mollgaard Floral Co., Snohomish, Washington who will speak to us on mechanization of propagation structures. Mr. Mollgaard:

MECHANIZED GLASS STRUCTURES

HENRY B. MOLLGAARD
Mollgaard Floral Co.,
Snohomish, Washington

In a structure where three to six crops of potted plants are being transported during a year, provision for moving plants quickly and easily is essential. One effective means of operating a greenhouse efficiently is to mobilize equipment, using trucks, hand, and electric carts.

Easy accessibility around, to, and in the greenhouse must be provided for this equipment. Roads and walks inside and around the greenhouse should be either blacktop or concrete. The first is the least expensive, but gives some problems resulting from the weight of heavy equipment and from its softness during warm weather. The packing shed, too, should be completely surfaced.

Inside most new pot plant greenhouses the benches run crossways with a wide access aisle going the long way. As an example, a 37½ foot wide house may have a 5½ foot aisle and 32 foot long benches. The 5½ foot aisle provides enough space for an electric cart. Between the houses, a sheet of plastic is sometimes used to help control the heat. It can be raised for moving plants on the bench. Through this arrangement the plants are only carried as far as the center of the bench, which is 16 feet. A road wide enough to accommodate trucks crossways through the middle of the house will also cut down loading and unloading time. Of course, the gutters have to be high enough for the top of the truck to clear. The greenhouse doors used most often preferably should be electronic with the electrical carts and trucks equipped with devices to operate the doors. This will enable the driver to move swiftly about the greenhouses.

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A roadway through the greenhouses makes it possible to move pallets of pots and potting tables or wagons close to the area where the potted plants are being finished. Also, potting tables where one side can be lowered can be used to sterilize the soil after it has been mixed in a concrete mixer or by a conventional soil shredder. In some instances, of course, soil is moved by tractors with scoop shovels and the pallets moved with tractor attachments. Conventional hand carts, electric carts, and fork lifts are also used.

In northern regions, where weather conditions are a problem during a short period of the year, more attention must be given to greenhouses in achieving good control of temperature and humidity. Control of air circulation and heat, plus the use of CO_2 has seen a marked change during the last few years. A real effort has been made to make the controls automatic. Thus it would be possible to set a dial for the correct temperature and this would be achieved automatically by a step-controller. These have up to 10 steps with high to low temperature alarms. Two steps of heat, one louver, three exhaust fans, and one pump for pad and fan air-conditioning. One sensing unit per house will switch on, in turn, the units in the right sequence as needed.

More than one thermostat or control per house usually leads to complications and unsatisfactory results. In heating greenhouses, polyethylene tubes have been used for convection-ventilation for forced air circulation, for heating systems, and for CO_2 distribution. Since only one or two tubes are able to take care of all of these functions they are economically feaible to use.

In pot ranges, as well as cut-flower ranges, watering of plants is being controlled more and more by time clocks operating individual tubes going into each pot with the main plastic distribution pipes being turned on by section. Clocks of the type used for golf course watering work well and are readily available in all price and quality ranges. Each section can be watered from one control station with a maximum of accuracy and a great savings in time.

Boilers, of course, are all automatic and can be operated by gas or oil just by the flick of a few switches. Here, we can take advantage of the low, interruptible, rates.

Electric time clocks can control the shading of mums with one clock and motor operating a shade cloth cover for a whole range. Electric clocks permanently installed can also control the lighting schedule for mums. Electric timers, too, can control the misting schedule for cutting propagation.

MODERATOR KLUPENGER: Our next speaker is a past president of the California Association of Nurserymen. He is with Perry's Plants, Inc., La Puente, California. This is a very unique operation, another one of California's great enterprises.

He is going to speak to you on "Propagation Toward a Fast Turn Over", which sounds very interesting. Now I would like to present to you, Carl Zangger.

PROPAGATION TOWARD A FAST TURNOVER

CARL ZANGGER
Perry's Plants, Inc.
La Puente, California

Perry's Plants are growers of ground cover plants, mostly herbaceous types of perennials, and low-growing woody ornamental plants, as well as annual and perennial bedding plants. We produce several hundred thousand flats of these types of plants each year and are in production twelve months of the year.

All of our production is grown in standard southern California nursery flats, which are approximately 18 inches square and 3 inches deep. To us the unit of production is a flat, not a single plant. Most flats are planted 100 plants per flat although some have as few as 48 depending upon the plant and the specifications for a particular job

Almost all of the material we grow from cuttings or divisions are rooted and sold in the same flat without transplanting; seedlings are started in seed flats and transplanted Most varieties we grow are ready for sale in 30 to 90 days although a few slower growing types may take up to 120 days. Since most of these are grown quickly, it means that they must also be sold quickly or they become overgrown and have to be discarded. As everyone knows there is no profit in the dump pile. So it becomes extremely important for us to program our production according to the demands of the market.

Through all the years we have been in business we have maintained records, by the month, of each variety of plant we sell. Those of you who have done this will find, as we have, that most varieties fall into a pattern of sales, month by month. It is true, of course, that extraordinary circumstances such as one large order can affect the overall picture severely. However, each month, after we have accumulated the data on sales, we go over our merchandise "take off", as we call it, and make notes. If there was one large order for a particular variety we indicate this; if we had too many plants of a variety we note this, or if we were short and needed more plants we also indicate this. We make notes on the weather, such as particularly long rainy spells that would stop sales or affect either growing or sales. We establish quotas of each variety of plant that we want to grow. The information that we have accumulated now becomes very valuable to us for we know how many plants we sold in the same sales period the previous year; we know if there were any abnormal circumstances. We then take into consideration the condition of the market for this season and we establish the quota we need to produce. We normally set this quota at least 3 months ahead so that we can see what is before us and plan to have the necessary material — cuttings, seeds, etc. — available at the proper time. Our production is then planned a week at a time. Each Friday we lay out a production schedule for the succeeding week so each week we are, in effect, reviewing and revising our projection. We are not perfect by any means but we are able to have a sustained production of most varieties that we grow and we are right more times than we are wrong.

In our operation we have attempted to make each job as simple and uncomplicated as possible. For example, we use just one soil mix throughout our nursery. This mix is used for planting our seed, transplanting our seedlings, or sticking cuttings; as you can readily see this eliminates the necessity of someone having to make a decision on what to plant each variety in. Our soil mix is composed 50% of a composted redwood sawdust which contains all necessary growing elements with the remaining 50% consisting of equal parts of fine sand, peat moss and perlite. All of our soil is mixed in stationary mounted concrete mixers. While it is mixing we inject steam into the mixer and bring the soil temperature to 180° F. The mixer is then turned off and the soil allowed to set for 30 minutes after which it is run into our flat-filling machine. This machine is capable of filling whatever type of container we are planning to use; it will fill flats at the rate of 16 per minute. The flats of soil are stacked on pallets and taken by fork lift to whatever planting area they are needed. In our production of bedding plants we have established a very routine process. Soil is taken to the seed house where it is placed on the greenhouse bench. The soil is fluffed by hand. Then we put a Ross fan-type sprinkler on the hose and turn the water on with a very sharp spray. This spray is run over the flat which agitates the soil and fills the flat with water. When the water drains out of the flat the soil settles to an even level seed bed and then each flat is uniformly watered. In settling, a small amount of peat and some fine components of the soil mix rise to the surface. This makes an excellent seed bed upon which to broadcast our seed. The seed is placed in the flat, lightly moistened, then covered uniformly with a crushed granite rock. When the seedlings have germinated and grown to a desired size they are moved onto hardening-off benches from whence they are taken to the greenhouses for transplanting. All transplanting is done at the bench where the plant are to be grown. We employ women to do all of the transplanting because they are more dexterous with their fingers than men and of a more even temperament, enabling them to do routine, repetitive jobs day after day with no frustration. The flats of transplanted seedlings are generally in the greenhouse for about a 10-day period, but occasionally are there up to two weeks. After the plants have grown to the desired size they are ready for moving to the outside growing areas where they are finished off. To facilitate the moving of flats we have designed our greenhouses so that we can open doors running the entire length of the greenhouse at the bench level. The flats can be moved out at any desired point along the greenhouse rather than carrying them down the aisle for removing from the end doors. The flats are put onto racks and the racks are transported either by fork lift or a train of small carts to the desired outside growing area when they are placed and left until they are sold.

Many of the same procedures we use in producing our bedding plants from seed are also used in the production of the plants we grow from cuttings or divisions. Again we have attempted to make the job as simple, quick and easy as we can. As every grower knows, having a source of good quality material from which to propagate is of prime importance. This is certainly true with us. We maintain approximately 10 acres of plants growing in beds in the field from which we can take cuttings. It is necessary to have these plants in a good vigorous growing condition in order to get the best quality cutting wood. Our fields are rotated constantly and each year we do a considerable amount of replanting so that we may have plants coming on constantly. We fumigate most of our field growing areas with methyl bromide plus chloropicrin prior to planting to eliminate fungus diseases as much as possible and to reduce the weeding problem. Cutting wood is brought in from the fields each morning prior to the arrival of the crew who will be making the cuttings. The wood is taken to the various houses where the cuttings will be processed and stuck into the soil mix; it is placed on the benches of the misting houses or growing beds depending upon where the crop is to be grown. Women make the cuttings, either with a knife, shears or by snapping the wood. We prefer not to use either a knife or shears on any variety where the wood can be snapped for with the latter method we find less incidence of fungus diseases. After the cuttings have been made they are placed into tubs of fungicide made up of Morton's Soil Drench and Terrachlor. After soaking in this dip a few minuutes they are taken out and stuck into the growing medium. Flats of cuttings are then placed under mist on the bench. Our misting systems are the conventional intermittent type controlled by clocks and timers. When rooting has been initiated the mist is turned off and the plants immediately fed and allowed to harden off in the house after which they are moved to outside growing beds for finishing and sale.

All of our outside growing beds are covered with automatically controlled sprinkler systems. We have found this to give us more uniform watering than hand watering and also more uniform growth. Also we have eliminated a tremendous amount of labor. Automatic systems are great and we highly recommend them; however, they can break down and it is impossible to completely eliminate the necessity of having a good mechanically inclined man to look after them.

Another great aid to us is our water treatment plant. We run all of our water through a deionization unit which completely removes all of the minerals from our water. The resulting water after treatment is nearly as pure as distilled water. After deionization we mix back in a proportion of the untreated water and then inject into our water system a small amount of fertilizer. So each time we water our plants we are using a water which is low in harmful salts and feeds the plants at a regulated rate. Initially when we installed this system we found that we had to do a lot of reprogramming of our crops as most varieties then grew much faster.

In summary, we have attempted to forecast our production based upon as many known facts as possible. We then have broken each job of production into a set procedure which can be followed by relatively unskilled people. The facilities for production have been provided to suit the requirements of our particular type of growing; each job is mechanized as far as we are able to do at this stage of our development. We can now maintain a constantly regulated production aimed at fulfilling the market demand. We are not perfect — probably never will be — but we have enjoyed a growing market year after year and the future looks as bright for continued growth as at any time and we intend to keep growing.

FIRST SESSION

September 11, 1968

ROSE ROOTSTOCKS — PERFORMANCE AND PROPAGATION FROM SEED

A. R. CARTER
*Experimental Horticulture Station,
Luddington, Warwickshire*

This review will be in the form of a progress report.

GERMINATION OF SEEDS — About 350 B.C., Theophrastus reported that germination of rose seed was very slow and erratic so that, in order to avoid delay, cuttings were made. Some 450 years later, Pliny mentioned that rose seed germination was a very slow process. Here am I, about 2,300 years later, agreeing with both these learned gentlemen and one wonders just how slow progress can be!

The so-called "seed" found in rose hips is really a fruit and in many species, such as *Rosa canina*, such "seed" lies dormant for many months before germination takes place. If it were possible to control this dormancy, one would be nearer to being able to control the plant density in the field which, in turn, should lead to more uniform rootstock production.

Source of Seed — For the current work at Luddington Experimental Horticulture Station, homeproduced seed is being used. The seed from different bushes of wild *R. canina* is likely to behave differently, so hedges of various commercial selections have been planted.

The work of Rowley at the John Innes Institute, suggested that hips of *R. canina* should be firm and then picked as soon as ripe. In October, 1967, hips of *R. canina* 'Inermis' were obtained from the National Agricultural Advisory Service Centre at Shardlow. After suitable treatment, a field germination of 37% was obtained in the spring of 1968. The first hips from a hedge at Luddington were saved in autumn, 1968, but were comparatively unripe even when picked on 18th November and the response to treatment was very disappointing. *R. corymbifera* (*R. dumetorum*) 'Laxa' seed has responded well when taken from both firm and from squashy, over-ripe hips.

Seed Treatment — After consulting the relevant literature, it was decided to concentrate our studies mainly on the effect of temperature.

R. canina 'Pfander' has not responded to any treatment. *R. canina* 'Inermis' has been good one year and a failure the next. *R. corymbifera* (*R. dumetorum*) 'Laxa' has given 12%, 62% and 12% field germination in the three years of the trial when subjected to a storage treatment of 8 weeks at 70°F and 12 weeks at 39°F.

Stratifying Media — During the storage period it is essential to keep the seed moist and in the main work at Luddington vermiculite was used as suggested by Rowley. In 1969 three different media were used. Vermiculite was better than peat or sand.

Other Factors — Research work by Jackson and Blundell at Bangor has given interesting results and the part played by the pericarp has been investigated. The use of concentrated sulphuric acid to aid germination of difficult seeds is well known. Soaking seeds in acid for half an hour, or for one hour prior to storage treatments had no effect on seed germination for *R. canina* 'Inermis' or for *R. corymbifera* (*R. dumetorum*) 'Laxa' at Luddington. Similarly, treatment with gibberellic acid and thiourea prior to storage failed to help in breaking dormancy. With the seed used at Bangor greater success was obtained with sulphuric acid.

With rose rootstock work currently being carried out in Ireland, Scotland, Wales and England, one is optimistic that more control over the germination process will ultimately become possible. In the case of some rootstocks, such as *R. multiflora* and *R. rugosa,* some seeds germinate the first spring after being harvested. The field emergence of seedling rarely ties up with laboratory germination tests and the number of saleable rootstocks is only a fraction of the number of seed sown.

Field Emergence — At Luddington in 1969, laboratory germination tests were made on samples after various treatments and then counts were made on field emergence. The results, as percentages were as follows:—

	Laboratory	Field
R. multiflora	67	9
R. corymbifera (*R. dumetorum*) 'Laxa	25	17
R. rugosa	37	20
R. canina 'Inermis'	0	2
R. canina 'Pfander'	1	5

Herbicides — Chemical weed control is almost essential. The use of 3.9 lb. propachlor (as 6 lb. Ramrod) *or* 1.0 lb. lenacil (as 1.2 lb. Venzar) in 100 gallons per acre gave good results as a pre-emergence herbicide in 1968 but the results are not so clear cut in 1969. The number of *R. multiflora* seedlings appears to be reduced. Noruron at 1.6 lb. active ingredient (2.0 lb. commercial product) also looks promising but we must wait until the crop is lifted before drawing any conclusions. It gave good weed control. Post-emergene materials being tried are simazine, 0.5 lb.; lenacil, 1.0 lb.; and phenmedipham, 1.0 lb. None of these materials has reduced seedling count.

Mildew — This can be very troublesome on young seedlings; 5.7 lb. sulphur, as 6 lb. Electrosulph; and 0.25 lb. quinomethionate, as 1 lb. 25% Morestan, gave good results in the trial on *R. canina* but the latter material caused partial defoliation of *R. multiflora* when sprayed in the field. Of the newer materials being tried, 3.7 oz. beonmyl (as 7.5 oz. 50% Benlate) was quite promising.

EVALUATION OF ROSE ROOTSTOCKS

Few experiments have been carried out in this country but there are some running at present. Rowley planted some trials at the John Innes Institute and included some plants on their own roots but many of these failed to establish themselves. Trials are in progress at the Glasshouse Crops Research Institute and 13 different rootstocks are being tested in a series of trials at Merrist Wood in Surrey, Shardlow in Derbyshire, and at Luddington in Warwickshire. At the last three centres, a two-year nursery cycle is being repeated on three occasions in the hope that a variety of climatic conditions will be experienced. The stocks and budwood are from common sources for all centres.

Stocks 5-8 mm in size were planted in late winter 1967, 1968 and 1969, but as only one crop has been lifted to date, what follows can only be regarded as a progress report. These records give information on the relative ease of handling the stock.

Table 1. Dormant stage evaluation

Rootstocks (dormant stocks as purchased, 1968)	No of shoots	*No of thorns	Collar length (in)
R. corymbifera (*R. dumetorum* 'Laxa'	2.2	0.0	1.6
R. micrantha (*R. rubiginosa*)	1.9	5.0	1.4
R. 'Superbe'	1.6	0.0	1.6
R. multiflora 'Inermis'	1.3	0.0	1.3
R. multiflora 'Japonica'	2.7	0.0	1.2
R. canina 'Succes'	2.3	0.9	1.0
R. canina 'Pfander'	2.3	0.0	1.8
R. canina 'Inermis'	2.4	0.0	1.5
R. canina 'Heinsohn's Rekord'	1.8	0.2	1.6
R. canina 'Wild'	2.8	1.8	1.5
R. canina 'Schmid's Ideal'	2.4	3.0	1.4
R. canina 'Brogs'	3.8	0.0	1.4
R. canina 'Pollmers'	2.4	0.3	1.3

* 0 = nil 5 = very thorny

Measurements have been taken and quality varied a little from year to year. The thorns at this stage are generally small and are not troublesome in most stocks. *R. micrantha* (*R. rubiginosa*) however is always very thorny. *R. canina* 'Schmid's Ideal' was quite thorny in 1968 but much smoother in 1969.

The number of shoots per stock varies from season to season and collar length has also varied but the two *R. multiflora* stocks included have always been the shortest.

Establishment of rootstocks — At Luddington, establishment was generally better on sandy loam than on clay soil. In 1968, a dry spring, *R. micrantha* (*R. rubigiginosa*) both *R. multiflora* stocks, and *R.c.* 'Heinsohn's Rekord' did not establish as well as the others in spite of irrigation. In 1969, *R. multiflora* and *R. micrantha* (*R. rubiginosa*) again did not establish very well, but 'Heinsohn's Rekord' did not suffer any losses.

Summer growth and ease of budding — Ease of budding is affected by thorns, type of growth and bark thickness.

Table 2. Growth characteristics at budding time

Variety	Habit	Ease of Collection	Collar	Ease of Access	Bark	Ease of Budding
R. canina 'Heinsohns Rekord'	Straggly	Easy	Medium	Good	Thin	Easy
R. canina 'Inermis'	Thin	Easy	Medium	Good	Thick	Easy
R. corymbifera (*R. dumetorum*) 'Laxa'	Compact	Easy	Medium	Good	Good	Easy
R. canina 'Superbe'	Bushy	Easy	Medium	Good	Good	Easy
R. canina 'Brogs'	Bushy	Fair	Medium	Good	Good	Fairly Easy
R. canina 'Pfander'	Open	Easy	Long	Good	Good	Fairly Easy
R. canina 'Pollmers'	Stiff	Easy	Medium	Fair	Good	Fairly Easy
R. canina 'Schmids Ideal'	Bushy	Fair	Medium	Fair	Good	Fairly Easy
R. canina 'Wild'	Upright	Fair	Medium	Fair	Good but variable	Fairly Easy
R. multiflora 'Inermis'	Vigorous Spreading	Difficult	Short	Difficult	Good	Fairly difficult
R. multiflora 'Japonica'	Vigorous	Difficult	Short Fat	Difficult	Good	Fairly difficult
R. micrantha (*R. rubiginosa*)	Stiff	Easy	Medium	Fair	Fair	Difficult
R. canina 'Succes'	Stiff	Difficult	Medium	Poor	Variable	Difficult

"Ease of collection"; in the above table, refers to the ease or difficulty with which the growth can be handled to expose the collar for budding purposes. Having exposed the collar, some stocks are still rather troublesome as stiff, thorny growth, a multi-branching head, or surface rooting makes successful budding difficult.

Budding Season — Assessments of "buddability" were made at frequent intervals from the end of May. At Luddington, no buds were inserted but T cuts were made to discover if the bark was in good condition and "running" well. In 1967, buds could have been inserted in all stocks from 2nd June until 15th September and for a further week at the end of the season for *R. c. (R. d.)* 'Laxa', *R. canina* and *R. canina* 'Inermis'. In 1968, all stocks were satisfactory until the end of September but the fact that the bark could be lifted well, does not mean that budding would necessarily have been successful.

The results from Shardlow were similar to those at Luddington but the Merrist Wood trial was different. In 1967 buds were easily inserted from 2nd June to 8th September with the exception of *R. corymbifera* (*R. d.*) 'Laxa' *R. c.* 'Superbe' and *R. c.* 'Succes' which were only moderately easy during a dry period. In 1968, almost all were easily buddable from 14th June until 9th August after which many began to deteriorate. The two *R. multiflora* stocks, 'Heinsohns Rekord', 'Pfander' and *R. canina* 'Inermis' were good until the end of September. 'Brogs', 'Schmids Ideal' and *R. micrantha* (*R. rubiginosa*) were slower in starting and *R. c.* 'Pollmers' began to dry up towards the end of July.

Precocity — Measurements of maiden growth were taken early in the season. Some rootstocks, such as *R. multiflora*, produce quicker growth than others and at the lower end of the scale, R. canina 'Superbe' was slowest. "Blow-outs" can be associated with precocious growth. *R. multiflora* is bad in this respect. There was an indication at Merrist Wood in 1968 from the weekly budding trial that the 1967 earliest-inserted buds were less prone to "blowing-out" as maidens. Where maiden growth is pinched when about 4 inches long, "blowing-out" is considerably reduced.

Suckers —

Table 3. Suckers per plant, 1968

	Luddington	Shardlow	Merrist Wood	Mean
R. c. 'Laxa	0.5	0.1	0.6	0.4
R. multiflora	0.9	0.3	2.5	1.2
R. c 'Pfander'	1.2	0.4	1.3	1.0
R. c. 'Heinsohns Rekord'	1.2	0.3	3.4	1.6
R. c. 'Superbe'	1.3	0.3	2.3	1.3
R. m. 'Inermis'	1.6	0.0	2.5	1.4
R. c. 'Inermis'	2.5	1.2	1.8	1.8
R. micrantha (*R. rubiginosa*)	3.3	0.8	7.0	3.7
R. c. 'Succes'	4.2	1.3	5.4	3.6
R. canina	4.3	1.0	4.4	3.2

The previous table shows the results of one year's study only; *R. canina, R. canina* 'Succes' and *R. micrantha* (*R. rubiginosa*) seem very liable to sucker while *R. c.* (*R. d.*) 'Laxa' is very free from suckering.

Flowers —

Table 4. Number of flowers: summer of maiden year

	Luddington	Shardlow	Merrist Wood	Mean
R. multiflora 'Inermis'	14	8	10	11
R. multiflora	14	7	8	10
R. c. 'Pfander'	11	6	5	7
R. c. 'Heinsohns Rekord'	11	6	8	8
R. c. 'Inermis'	11	7	7	8
R. c. 'Laxa'	10	6	5	7
R. c. 'Superbe'	10	6	6	7
R. micrantha (*R. rubiginiosa*)	10	6	7	8
R. c. 'Succes'	9	6	10	8
R. canina	8	5	5	6

In the middle of the summer of the maiden year, the two *R. multiflora* stocks were the most floriferous, whereas *R. canina* had fewest buds, flowers and dead flowers. It does not follow that the behaviour will remain the same after the maiden year, as the ultimate size of the bush will vary.

Number of shoots produced —

Table 5. Average number shoots at lifting time

	Merrist Wood	Luddington	Shardlow	Mean
R. multiflora	4.4	4.6	4.7	4.6
R. multiflora 'Inermis'	4.5	4.9	4.1	4.5
R. c. 'Heinsohns Rekord'	4.0	3.9	3.9	3.9
R. c. 'Inermis'	3.0	3.8	4.0	3.6
R. c. 'Superbe'	3.4	3.3	3.8	3.5
R. c. 'Plander'	3.1	3.6	3.7	3.5
R. micrantha (*R. rubiginosa*)	3.1	3.2	3.9	3.4
R. corymbifera 'Laxa'	3.2	3.3	3.7	34
R. canina	3.2	3.1	3.8	3.4
R. c. 'Succes'	2.7	2.8	3.3	2.9

Rosa canina 'Succes' gave the fewest number of shoots and therefore the poorest grade at all centres. The two *R. multiflora* stocks produced most branches and *R. c.* 'Heinsohns Rekord' also did well. *R. c.* 'Inermis' performed well at two centres but gave poor results at Merris Wood.

The two cultivars used were generally affected in a similar way by the various rootstocks although 'Peace' was ninth in vigour on *R. c.* 'Pfander' whereas 'Ena Harkness' was fourth on the same rootstock.

Table 6. Average height at lifting, inches

	Merrist Wood	Luddington	Shardlow	Mean
R. multiflora	26.7	28.9	24.7	26.8
R. m. 'Inermis'	25.5	28.0	24.4	25.9
R. c. 'Inermis'	24.6	28.1	24.1	25.6
R. c. 'Pfander'	23.7	28.8	24.2	25.6
R. c. 'Heinsons Rekord'	25.3	27.0	23.5	25.3
R. corymbifera 'Laxa'	22.6	27.4	23.6	24.5
R. c. 'Succes'	24.5	26.5	22.9	24.6
R. micrantha (*R. rubiginosa*)	24.9	25.1	22.8	24.2
R. c. 'Superbe'	24.0	24.3	23.0	23.8
R. canina	22.1	26.1	22.6	23.6

R. corymbifera 'Laxa' did less well at Merrist Wood than at other centres and there was far less uniformity of growth. In all trials, the two *multiflora* stocks produced the tallest plants.

SUMMARY —

With only the first of three nursery cycles completed, it would be wrong to draw definite conclusions but certain points are worth noting.

R. canina 'Succes'. Does not look at all promising. Difficult to handle and bud, large number of suckers. Comparatively few flowers. Susceptible to "blow-out". Insufficient numbers of grade 1 plants having three or more strong shoots.

R. micrantha (R. rubiginosa.) Very thorny and difficult. Numerous suckers. Does not appear to have sufficient good points to overcome the bad ones.

R. canina. This very popular stock has not performed very well in the first trial. It was one of the less vigorous stocks, produced rather a lot of suckers and few flowers in the first summer.

R. multiflora and *R. multiflora* 'Inermis'. The most vigorous stocks in the trial; produced most blooms in the first flush. Not many suckers but they have a comparatively short, fat neck and multi-branched head and tend to be surface rooting. These factors can hinder budding when 5-8 mm grade stocks are budded in July. Susceptible to "blow-out" unless maiden shoots are pinched. Not too easy to head-back due to thick, short neck.

R. corymbifera (*R. dumetorum*) 'Laxa'. An easy stock to bud giving reasonable vigour but growth was variable at Merrist Wood. Suckering was negligible. The number of flowers was a little below average for all the rootstocks in the trial. Easy to head-back; buds clearly visible and wood soft.

R. canina 'Inermis'. Virtually thornless and easy to bud. It graded well at Luddington and Shardlow but not so well at Merrist Wood. Flower number satisfactory. Fairly rapid growth in spring at Luddington and needs pinching to reduce "blowing-out". It has more suckers than some of the other *canina* selections.

R. canina 'Heinsohns Rekord'. The stock has rather a straggly habit but is comparatively easy to bud, even though the bark was rather thin in 1968. Produced a good number of shoots at all centres and would grade well. Suckering variable, being fairly high at Merrist Wood. Average number of flowers. The rootstock is very susceptible to mildew attack.

R. canina 'Pfander'. Few suckers; very susceptible to mildew. Fairly easy to bud. Average number of blooms but did not grade out quite as well as 'Heinsohns Rekord'. Some black spot disease on odd plants. Stock has an open habit and sends up tall shoots, somewhat arching.

R. canina 'Superbe'. Fewer than average flower number. Graded reasonably well but bushes below average height. Not many suckers. Early growth of stock tends to be a little straggly but later a bushy habit develops. An occasional leaf with black spot disease. Not particularly easy to head-back.

PETER VERMEULEN: Has anyone investigated the reasons why some seeds germinate in the first year whilst others take two years or longer?

A. R. CARTER: The pericarp of the seed contains an inhibitor which prevents germination. In some seeds this inhibitor disappears more quickly than in others; if you take the pericarp off you remove the inhibitor. Work is now in progress to attempt this by chemical means.

ROBERT GARNER: Have you tried washing the seed frequently in order to remove the inhibitor? For fruit seeds such as apple I have succeeded in getting germination within two or three weeks instead of having to wait a full season. This was done by dropping the seed into water which was changed daily for a week or ten days. It might even be possible to do this job in a washing machine on a larger scale though I have not attempted it.

A. R. CARTER: I have not tried that technique, but other workers have tried washing the seed.

JAMES WELLS: If seed is picked immaturely would it improve germination?

A. R. CARTER: We are trying different stages from green to deep red; we may have more information next year.

JAMES WELLS: I am surprised to hear that *R. multiflora* is not hardy. It is the basic understock in the USA, where temperatures are much lower than here.

A. R. CARTER (and other speakers) stressed that the depth of cane dormancy may depend upon autumn ripening and emphasized that it was the new growth that was damaged.

WORK FLOW IN THE PRODUCTION DEPARTMENT OF THE NURSERY

BRIAN E. HUMPHREY
Hillier & Sons,
Winchester, Hampshire, England

Before production efficiency and rationalisation can take place, a number of basic factors to any business must be considered. Production must be related to the type of business in which the nurseryman is engaged; for example, the requirements of a retail company might be quite different than those of a wholesale company and a company engaged in both wholesale and retail trading would again vary from the previous two. The basic marketing techniques of garden centres and mail orders may profoundly influence the approach towards production. It is scarcely necessary for me to expand further upon these major factors.

Production for our retail trade is geared towards the propagation of a vast range of plants, generally in fairly small numbers, whereas the wholesale grower is normally engaged in the production of a fairly small range of plants in vast numbers. If the business is entirely orientated towards a garden centre, or more than one garden centre, or if it is a wholesale business which is aiming to produce garden centre type products, then containerisation will be involved, resulting in a quite different production chain or flow pattern than that of an open ground plant. The production cycle in the nursery will be profoundly influenced by management policy towards production, whether or not home production is favoured or whether plants are purchased at some stage in their development.

The factors which I have mentioned so far mainly come under the jurisdiction of nursery management at its highest level; in other words, the owner or the directors. The question of management policy towards production, once the basic principles of the type of outlet have been settled, is often in-

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The factors which I have mentioned so far mainly come under the jurisdiction of nursery management at its highest level; in other words, the owner or the directors. The question of management policy towards production, once the basic principles of the type of outlet have been settled, is often influenced by the propagator and his department. If the propagator is able to convince management that he is a man of ability and is able to produce plants efficiently and economically, then obviously they will be more likely to give him the opportunity of producing more within the nursery. This means that the propagating department assumes considerable importance in the company; obviously, from the propagator's point of view, this is all to the good. There will be other factors which influence the attitude towards home production which are outside the control of the propagator and the management; for instance, the influence of seasonal labour variations and availability of labour may have a profound influence on the company's attitude towards home production. There might, for example, be a good in-flow of student labour in the summer months. There might be financial considerations which affect the availability or the use of labour; the cash flow position could have an effect here. In many mail order businesses there is a good in-flow of cash in late spring and summer which slowly reduces to a mere trickle in autumn and early winter. Often managements are unwilling to aggravate the cash position by increasing staff when the in-flow of money is small.

Having decided on the type of business and the general approach towards nursery production, it is necessary to get down to more precise details and to make decisions regarding the range of production which will be undertaken. It might be appropriate at this stage to characterise a few different types of production and their influence on the labour situation in the company.

Sometimes, a simple production set-up, often associated with wholesale nurseries, occurs where most of the plant material in the nursery has been bought in and the staff are used generally as planters, cultivators, lifters and packers. The company often undertakes simple propagation, such as hardwood cuttings, possibly root cuttings, and simple seed production of the large-seeded plants like oaks or maples. Usually, under this set up the nursery also produces some plants by budding and field grafting. The type of labour used for this is a general nursery worker and not strictly a propagator, and obviously this type of worker has his advantages and disadvantages. He is versatile, but not so specialised as the propagator, usually not so technically capable and he is unlikely to produce material of such great monetary value as the full-time propagator.

Another type of grouping occurs in many nurseries where the general workers, lifters, cultivators, etc. still frequently take on such operations as budding, but parallel with them is a production department of full-time propagating staff under one or more head propagators. The type of worker which you find in these departments is usually, though not always, of course, a more technical type of man; often he is the most competent craftsman type.

Generally speaking, many of the more highly trained horicultural nursery workers tend to gravitate towards the propagating units; whether this is always desirable is another matter, but it is a factor of the nursery world. Assuming that the right type of staff is available, the decision regarding the range of production will take the next step and this is very much a question of capitalisation, the availability of glasshouse space, of mist propagation facilities, and of the considerable capital involved in producing this type of facility.

One propagating house which we have in use at the moment cost no less than 30/- per square foot to erect in 1967 and 1968; it might rightly be argued that this figure is rather excessively high; with the use of cheaper structures, polythene houses etc., figures of something like 10/- or 12/- per square foot or less might be possible. Nevertheless, compared with £300. or £400. an acre for nursery land — all that is necessary for the production of hardwood cuttings — the capital investment and business risk in sophisticated propagating facilities have to be considered.

The factors which I have mentioned up to now — the availability of labour and the type of business — will, as I have said, profoundly affect decisions regarding the range of production. They will also affect the approach towards given pro- is more possible for us to have a fairly large labour force in the summer, our cash flow position is best at this time, and we are able to get good quantities of student labour who work for us during their summer holidays. In the winter we like to substantially reduce our staff, partly because we are anxious to conserve our funds, and also because we favour a low labour force during bad weather due to the problems of finding productive work for a heavy labour force under adverse weather conditions. Because of this labour situation, we have tended to be rather strong on propagation by summer cuttings and our production by hardwood cuttings has not figured very largely in our schedules; we do insert 30 or 40 thousand hardwood cuttings, but this, compared with our summer production of half a million or so cuttings, is obviously very small.

In order to make proper decisions regarding production range and the feasibility of carrying out production schedules, it is vitally important that data be collected. Available data is something which is lacking in most British nurseries, including our own; we are still far from satisfied with our data collecting.

Organization — Data collection forms into two major groups — firstly, the requirement of production and the data necessary to predict this requirement, and secondly, the assessment of the possible output from a given labour situation. Requirement predictions are obtained from the data collected by sales records and from questionnaires and also, of course, from personal visits to customers. We use all three of these techniques to obtain our predictions. An assessment questionnaire was circulated to over 250 public authorities this year, and one of the Directors and myself visited some 50 or 60 public authorities throughout the country, discussing with them their requirements.

An assessment of the output per labour unit (normally calculated as a 'man-hour') is obtained from the date collected over a number of years by the propagator or by a special staff in a work measurement section. Measurements of the number of cuttings collected per hour for a given type of plant, or the number of scions collected or the number of seeds collected, as appropriate, are required. The number of items processed per hour, grafted, stratified, prepared into cuttings, the number of cuttings struck and so on are all relevant and necessary to provide accurate schedules.

The production schedule needs to be broken down into numbers of separate components, normally the most convenient way of doing this is by dividing it into crops. There is often no need to split it into genera as items may be grouped together; for instance — a number of genera may form the sun frame crop or hardwood cutting crop. What is important is that groupings are made with genera which are treated in a similar manner. Sometimes it is more convenient to treat with a genus individually, for example, the rhododendron. In this example, however, it would be advisable to split these into three items — early, mid-season and late production from cuttings. Rhododendron grafting would need to be treated separately. I have circulated to you a sheet showing a possible break down of crops for a given period from May until September, giving some figures as examples (Example Sheets 1 and 2). Then I have carried out an exercise which is based mostly on our own data and our own predictions for labour output and I have shown you how this can then be calculated into the man-hours per month required. This was used as an assessment for a given labour situation on one of our production units.

If we look at the two sheets, you will see that the crops are itemised on the left, the total number of cuttings involved is shown in the next column, and the period of propagation and the method of propagation is also shown; from this data an assessment of the crop area taken up by the given figures can be made and this can be balanced against the availability of propagating facilities. By simple multiplication and division it will be seen that a figure for the number of man-hours required to collect and make a given crop is also calculated (labour assessment) for each particular item, and by adding these figures together, an overall labour assessment is made and planning of staffing levels can then take place (see Sheet 3).

The next phase of the job is to decide the flow pattern or sequence of events which go towards the final production of the crop. This pattern can profoundly influence the efficiency and the utilisation of labour so that an assessment can give a

Example — Sheet 1

NO. VII UNIT PRODUCTION SCHEDULE, JUNE — SEPTEMBER, 1968

CROP ANALYSIS

LABOUR ASSESSMENT IN MAN-HOURS

Crop		Quantity	Period	Position	Collecting	Making and inserting
Syringa vulgaris hybrids	0.75 [1]B C [2]B	2100	May	Glasshouse Mist	10	14
S. species	0.75 B C	2000	May	Glasshouse Mist	9	12
Azalea, deciduous	1.3 B B C	2000	May	Glasshouse Mist	7	8
Corylopsis	0.75 B C B	2000	June	Glasshouse Mist	10	23
Chaenomeles	0.75 B C B	3000	June	Glasshouse Mist	14	20
Cotinus coggyria	1.3 B C 1.3 B	10,000	June	Open Mist	25	40
Magnolia	0.5 B C 0.75 B	20,000	June/ July	Glasshouse Mist	40, June 95, July	50. June 120, July
Buddleia	0.75 B C B	4000	June/ July	Open Mist	14, June 5, July	20, June 7, July
Sun-frame cuttings	B C 1.3 B	91,000	June/ August	Open Mist	66, June 200, July 33, August	110, June 350, July 55, August
Cytisus	1.5 B C 1.5 B	8000	July	Open Mist	20	35
Elaeagnus	0.75 B C 0.75 B	2000	July/ August	Glasshouse Mist	2½, July 7½, August	5, July 15, August

[1]BC = basic collecting rate of 300 per hour

[2]B = basic making and inserting raate of 150 per hour

Example — Sheet 2.

CROP ANALYSIS

LABOUR ASSESSMENT, MAN-HOURS

Crop		Quantity	Period	Position	Collecting	Making and inserting
Cotoneaster	[1]B C [2]B	10,000	July/ August	Open Mist	23, July 10, August	46, July 20, August
Azalea, evergreen	1.3 B C 1.5 B	5,500	July/ August	Glasshouse Mist	25, July 2.5, August	25, July 2.5, August
Berberis, deciduous	B C 0.5 B	25,000	July/ August	Open Mist	23, July 60, August	94, July 240, August
Erica	1.5 B C 1.5 B	34,000	August	Heated Frame	75	170
Calluna	1.5 B C 1.5 B	6,000	August	Heated Frame	13	30
Hebe	B C 1.3	5,500	August	Heated Frame	18	22
Rhododendron	0.75 B C 1.2 B	60,000	August/ September	Glasshouse Mist	125, August 175, Sept.	120, August 170, Sept.
Ilex	0.75 B C 1.3 B	12,000	August/ September/ October.	Glasshouse Mist	60	48
Berberis, evergreen	B C 0.5 B	80,000	September/ October	Open Mist	200, Sept. 66, Oct.	800, Sept. 266, Oct.

[1] BC = basic collecting rate of 300 per hour

[2] B — basic making and inserting rate of 150 per hour

Example — Sheet 3.

NO. VII UNIT PRODUCTION SCHEDULE, JUNE - SEPTEMBER, 1968

STAFF ALLOCATION

	Total cuttings to insert per month.	No of working days per month	Total hrs collecting per month	[1]Staff allocation per day	Total hrs making, and sticking per month.	Staff allocation per day	Total hrs. collecting, making, and sticking per month.	Total staff per month
JUNE	44,000	19	169	[2]1 man @ 9 hours	263	2 men @ 7 hours	432	3 men
JULY	102,500	23	394	2 men @ 8 hours	682	4 men @ 7½ hours	1076	6 men
AUGUST	115,500	22	404	2 men @ 9 hours	722	4 men @ 8¼ Hours	1126	6-7 men
SEPTEMBER	95,000	20	375	2 men @ 9½ hours	970	6 men @ 8 hours	1345	8 men
TOTAL	357,000	84	1342		2637		3979	

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[1] For convenience the figures are rounded off

[2] Where hours per day exceed statutory hours, overtime is assumed.

Example Sheet 4.

PRODUCTION RECORD SHEET 19

Genus — Cytisus
General Remarks: —

Dept. ....

Propagation by ....

S (young stock); R (number required to produce); T (number of plants produced)

NAME	S	R	T	S	R	T	S	R	T	S	R	T
‘Burkwoodii’												
‘C. E. Pearson’												
‘Cornish Cream’												
‘Daisy Hill’												
x *dallimorei*												
‘Donard Seedling’												
‘Dorothy Walpole’												
‘Fulgens’												
‘Garden Magic’												
‘*Golden Sunlight*’												
etc. etc.												

high output per unit of labour or a low output, according to the pattern of work which is chosen. There are certain basic rules in any flow pattern which must be followed if efficiency is to be obtained.. The flow starts with a sales prediction, which is then related to the existing stock position for previous production schedules, and the period of saleability for the particular crop is taken into account — (for example, a *Buxus* might stay saleable for ten years, whereas, a *Buddleia* in a pot is saleable for, at the most, two or three years). These factors are balanced to arrive at an annual production requirement for a given plant in a given year. This is then transmitted to the propagator by some means or another, sometimes verbally or better, in my opinion, on paper. In our company we have a system of what we call “production record sheets”, copies of which I have circulated; I will describe one of these very briefly. In one column is the existing stock position, the middle column shows the requirements and the 'T' column shows the "takes", which are filled in by the propagator; he retains one copy and one copy is sent back to me for filing in the office. The "takes" column tends to become the stock position for the following year (see Sheet 4).

Having received his production record sheet, the propagator is then in a position to get on with the job and firstly, of course, decide how he is going to propagate the plant and the sequence of events which he is going to follow. We have a system in the company in connection with these production sheets, in that they are grouped into production methods. Peter Dummer or Graham Adcock will get from me the batch of production sheets for genera just before the time they will be propagating the plant.

The question of the sequence of events of production is a very difficult one. The responsibility of the propagator will vary; it may extend from rooting the cutting, grafting the plant, or sowing the seeds to the stage where the plant leaves the nursery as a saleable product.

It is most important that the propagator considers the sequence of events which take place in the production chain, and it is important to take the long term view regarding this, and not just the view which relates to the propagator's own sphere of activity. It is the responsibility of the propagaotr to provide the plant in the form required by the field cultivation department.

When deciding upon a particular flow pattern, the propagator should have in mind the final product, and how this may be most efficiently obtained with the labour at his command. There are, I believe, a few "golden rules" which should be observed.

If the item is to be container-grown, select a production flow which gets the item into a container as soon as possible. For example, if production is by cuttings, then consider rooting the cuttings in Multi-pots, Vaca-pots or Jiffys; if from seed, consider sowing the seeds individually in pots or Multipots; for grafting, graft onto potted stocks rather than bareroot or field stocks.

For field production the aim should be to get the crop into the field as quickly as possible; for example, root the cuttings in the field by using hardwood cuttings or by a "Phytotektor" type of system. If it is necessary to root under glass in boxes, or on the mist bench, as with difficult subjects, bed out the cuttings straight into the field rather than potting them first, if possible.

The propagator who wins in the profitability race is the one who cuts most corners; every production unit should experiment on corner-cutting with a small percentage of its crops each year. Missing out one transplanting or one potting sequence on a production schedule can mean a big cash saving, with a resultant increase in the profitability of the crop. The expertise in organisation of the staff will have a profound influence on the success of a given "corner cutting" scheme.

"Corner cutting" often leads to a greater saving in labour, but not generally to greater labour flexibility; for example, careful timing is necessary for a crop which is field-planted from the cutting beds and not potted. One must have labour available at the particular crucial time when field planting takes place. A production chain involving containers (that is, boxes or partitioned boxes, such as Vaca-pots, Multi-pots, Jiffys or some similar item), involves more capital, both of cash and labour, than a production chain concerned only with bare-rooted plants, but can give greater flexibility of labour use and a higher quality product, because it is possible to get better control of the environment.

It is possible to increase production considerably by thinking carefully about various factors in the production schedule. One of the major factors which has affected propagation in the last decade is mist propagation; this has brought many benefits, advantages, and gains in propagation techniques. Unfortunately, some features of mist are not so desirable. One of these is the concept of a fixed bench with a mist line above. From a management standpoint, the conventional glasshouse mist propagation layout with fixed equipment is rather inflexible. Crops must be brought into the glasshouse, subjected to mist until they are able to withstand a harsher environment, and then they must be moved out to make room for subsequent crops. In practice, most propagators insert cuttings into suitable containers to facilitate package handling and to speed up the number of crops which may be "run through" the misting process over a given period of time. For crops which have a low market value, such as *Weigelia, Deutzia, Physocarpus, Stephanandra, Berberis,* etc., the economics of production by this sophisticated means, involving high cost installations and frequent handlings, is questionable.

In an attempt to tackle the economics of production of the low price-reurn species, we reviewed alternative production methods. The traditional so-called "sun-frame technique" commends itself in many ways. With this system, low cost installation, such as simple temporary cold frames are used, this being coupled with rooting the cuttings directly onto the nursery bed. Using the sun-frame system, the cuttings, once rooted, are left to grow, *in situ,* and produce excellent liners for machine planting some 18 months from the time of insertion. An additional bonus is the suitable cutting material which may be collected from the beds of young plants approximately 12 months after the original cuttings were inserted.

All that was necessary was to up-date the sun-frame technique for acceptance under the present conditions prevailing at the nursery. After four years evolution, we have reached a point where our system closely resembles the "Phytotektor" system, I imagine still in popular use in the States. We use white opaque polythene stretched over wire hoops let into side planks of 96 inches x 8 inches x 1½ inches soft wood. Under the polythene tunnel a mist line is fixed in position and the cuttings are placed into a 2-inch deep layer of coarse sand which is put on top of the nursery soil. Once the cuttings are rooted, the mist line and polythene are removed for subsequent re-use the same season if conditions are suitable.

With this system we gain the advantage of mist and the advantage of sun-frame cuttings simultaneously and we are able, by correct spacing of our cuttings, to economically obtain an ideal liner. This system is by no means unique in this country and, of course, it is well established in the USA. It is an example of a system which has been obtained by thinking round the subject, deciding that mist is good, but the technique which has arisen as the result of the use of mist is not the most efficient way of producing the easily-rooted type of cutting.

Another crop worth discussing is the hardy hybrid rhododendron. Here we have used a number of "corner cutting" systems which have resulted in what is quite an efficient method of producing many such plants. These systems were slowly built up by trial and error.

Cuttings are cut to length from stock plant bushes with secateurs, and normally no further trimming is required. We ignore the presence of nodes, and do not make cuttings with a heel; the chosen length is simply what is convenient for our Dutch Tomato Tray containers.

With suitable varieties the lower leaves are torn off and not cut away with knife or secateurs. The remaining leaves are cut to a convenient length with secateurs. We do not give our rhododendron cuttings a heavy wound; this is because we are now using a rooting hormone, indolyl butyric acid dissolved in 50% methylated spirits, and our trials indicate that there is little effect by wounding on rooting percentage. The cuttings are inserted into Dutch Tomato Trays fitted with the rooting medium and then placed under mist.

The next item in the production flow for this crop is bedding out the rooted cuttings straight into open air beds in a woodland soil with a high organic matter content. There is no need to pot the rooted cuttings. Ideally the young plants should be bedded as the terminal bud is swelling — just before it breaks.

If conditions indicate irrigation of the cutting beds, this must be given priority and good cultivation is necessary. The young plants are bedded into raised beds at a plant density of 4 inches square and remain, *in situ*, for approximately one year. After this, the young plants are lifted from the beds and planted on raised beds at a distance of 22 inches square.

We are considering "cutting another corner" with our rhododendrons; we suspect our young rooted cuttings will stand full exposure provided adequate irrigation is available and we are going to try and bed a trial number of plants straight out into the final bed which, if successful, will save us several weeks work.

Unlike some nurseries, we grow ericas as bare-root plants and ball them in hessian for despatch. Our ericas are rooted in Dutch Tomato Trays, and because we use a fairly sandy rooting medium, we place a half-inch deep layer of peat on the bottom of the box with a slow-release fertiliser, such as Mag-Amp or En-Mag incorporated into it so that, once rooted, the roots are able to grow down into this layer and maintain the young plants in good health until the boxes of young plants are transported straight to the field and planted into final saleable positions from the cutting boxes.

These cuttings should be planted before the middle of June to ensure that they are large enough to over-winter in the open ground in the south of England; planting them in mid-August is too late as the young plants do not make sufficient growth to survive the winter. This year we planted in early July and the cuttings are doing well and by good cultivation, we shall successfully over-winter them, though not without some worry.

Another item which responds very favourably to open ground bedding, straight from the cutting boxes is holly (*Ilex aquifolium*). Here we root our cuttings in Dutch Tomato Trays, which are then taken to beds, planted in soil at 4 inches x 4 inches as done with rhododendrons. They are grown on in these beds for a year, and then machine-planted on our normal bed system at 22 inches x 15 inches.

I trust that the above comments will assist my fellow propagators in their attempts to increase efficiency by the consideration of "Work Flow Patterns."

RELATIONSHIPS BETWEEN STRUCTURE AND ADVENTITIOUS ROOTING

A. BERYL BEAKBANE
East Malling Research Station, East Malling,
Maidstone, Kent, England

A comparison of the anatomical structure of stems with their capacity to form adventitious roots has shown that a relationship exists between anatomy and rooting capacity in a wide range of species (1, 2, 4, 5, 6, 7, 8). In considering structure as it may affect rooting, it is important to have a clear, visual image of the location of the tissues that are chiefly concerned. They occur near to the outside of stems and include cork, cortex, and phloem. A sclerenchymatous sheath derived from the primary phloem is, for example, often present in plants that are difficult to root from cuttings (Fig. 1-*above*) and it may provide a physiological barrier to the initiation of roots, or a mechanical barrier to their emergence (1, 4). In contrast, only scattered groups of fibres (Fig. 1—*below*) are present in this zone in many free-rooting plants. In stems from shy— and free-rooting clones of pome fruits viewed at a higher magnification one can discern both individual fibre elements and parenchymatous cells composing the intervening zones of living tissue (Figs. 2 and 3). At a still higher degree of magnification, details of cell contents and of wall structure become visible as in Figures 4 and 5 depicting sections of growing stem tips. Groups of axially-orientated fibres are present in both clones. In the shy-rooting clone (Fig. 4), cells of the zone intervening between fibres have elongated periclinally and are in process of being transformed into thick-walled sclereids lacking living contents, while in the free-rooting clone (Fig. 5) thin-walled cells in a similar location show signs of recent division and they contain cytoplasm and organelles of which the nuclei are clearly visible.

In many free-rooting plants including those illustrated in Figures 1—*below*, 3, and 5, adventitious roots are not initiated in the living zones between fibre groups but they arise in the secondary phloem usually in association with a ray (Fig. 6). Such a ray would have contact at its distal end with living cells by means of cytoplasmic strands passing through the walls and it would not abut, as do most of the rays of shy-rooting plants, on fibres, sclereids, or other elements, without living protoplasts (Fig. 2).

Although a sclerenchymatous sheath blocking the distal ends of the rays is not the only anatomical feature apparently related to rooting capacity, it is the one most frequently recorded in shy-rooting varieties of hardy fruit plants grown at East Malling Research Station, and in samples of exceedingly shy-rooting plants received from many parts of the world. Such sheaths have, for example, been observed in the black wattle, *Acacia mearnsii* De Wild; an ornamental tree, *Brownea* x

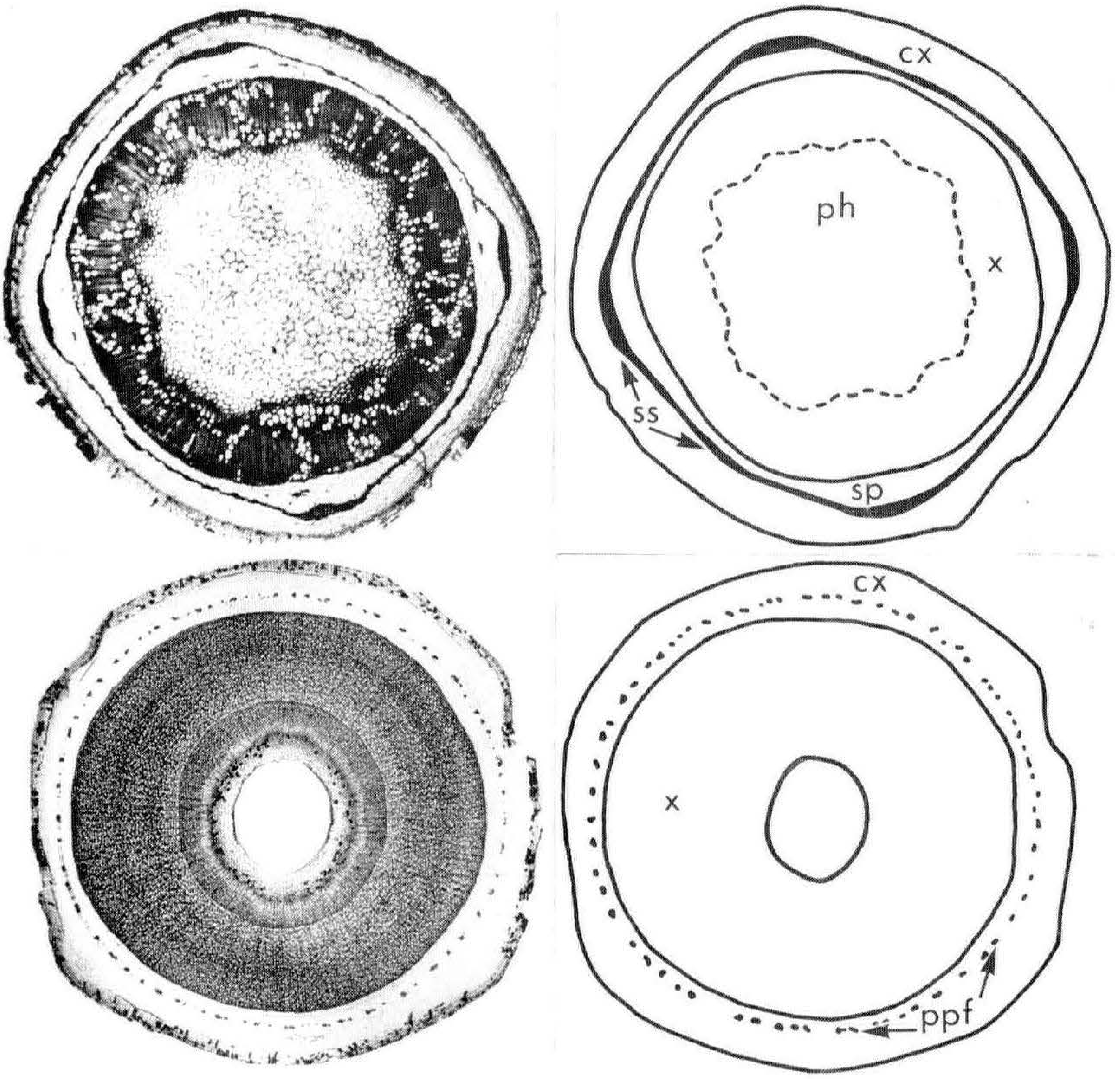

Figure 1. Transections of dormant, one-year-old stems of *Chimonanthus praecox* L. (*above*) and *Forsythia* x *intermedia*. (*below*).
cx, cortex; ph, pith; ppf, primary phloem fibre groups; sp, secondary phloem; ss, sclerenchymatous sheath of fibres and sclereids; x, xylem.

Crawfordii; cinnamon, *Cinnamomum zeylanicum* Blume; heaths, *Erica* spp.; beech, *Fagus sylvatica* L.; para rubber, *Hevea brasiliensis* (Willd.) Muell.-Arg.; an ornamental shrub, *Mahonia japonica* var. *bealei* Bean; oaks, *Quercus* spp.; and a sub-tropical legume, *Pueraria thunbergiana* (Sieb. & Zucc.) Benth. (= *P. hirsuta* Schneid.).

The pattern of development of sclerenchymatous sheaths varies among species and, in some instances, among genotypes within a species besides being subject to variations related to environmental conditions. The onset of tissue senescence in the primary phloem may be rapid, as in *Brownea* x *Crawfordii,* with the result that a fibrous sheath of elements without living contents occurs quite near to the stem tip. Such plants are usually exceedingly difficult to root even from soft, young shoots propagated under mist. In other species, such as *Acacia mearnsii,* lignification of the walls of cells derived

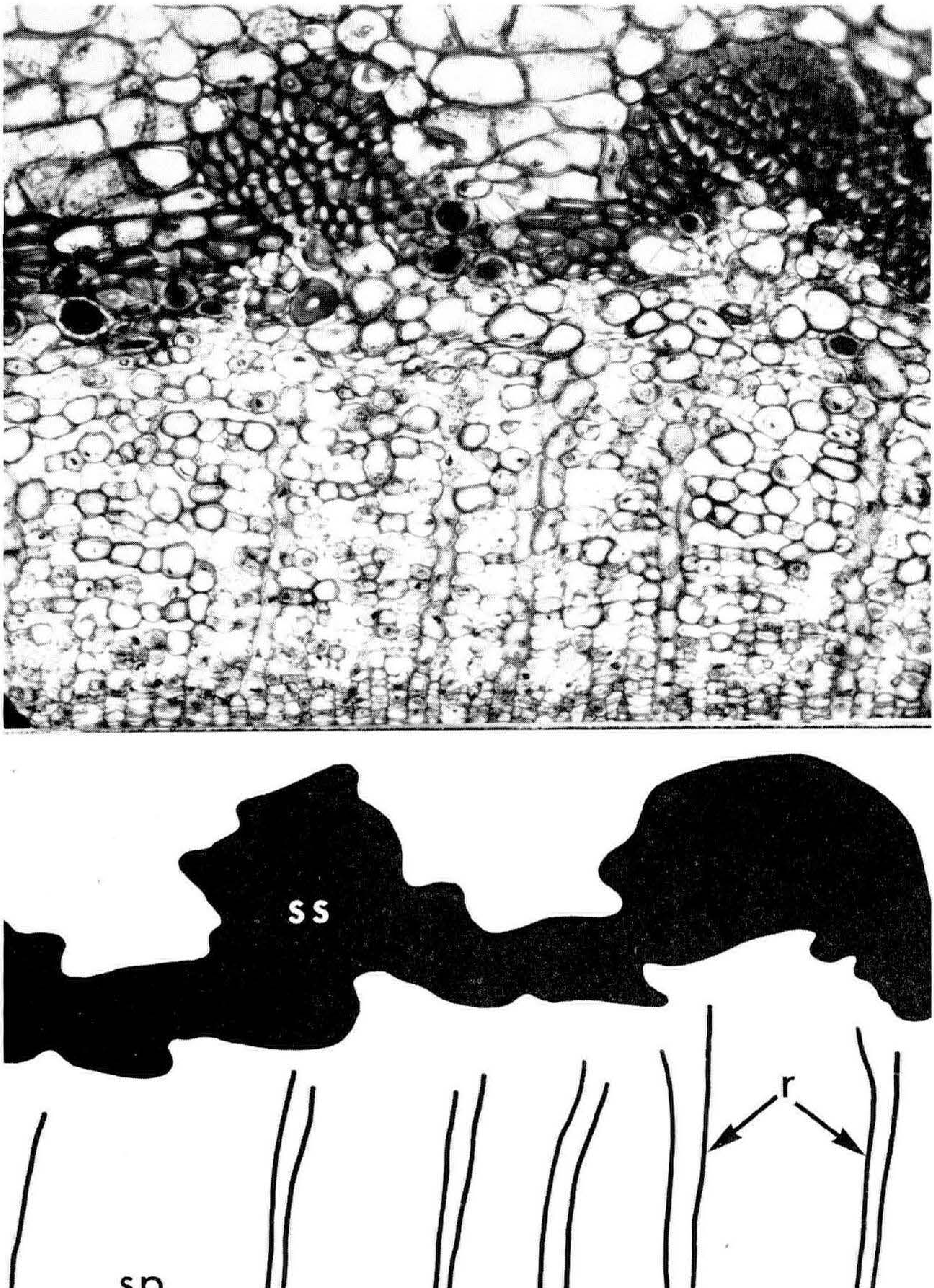

Figure 2. Transection of dormant one-year-old stem of Conference pear. r, rays; sp, secondary phloem; ss, sclerenchymatous sheath.

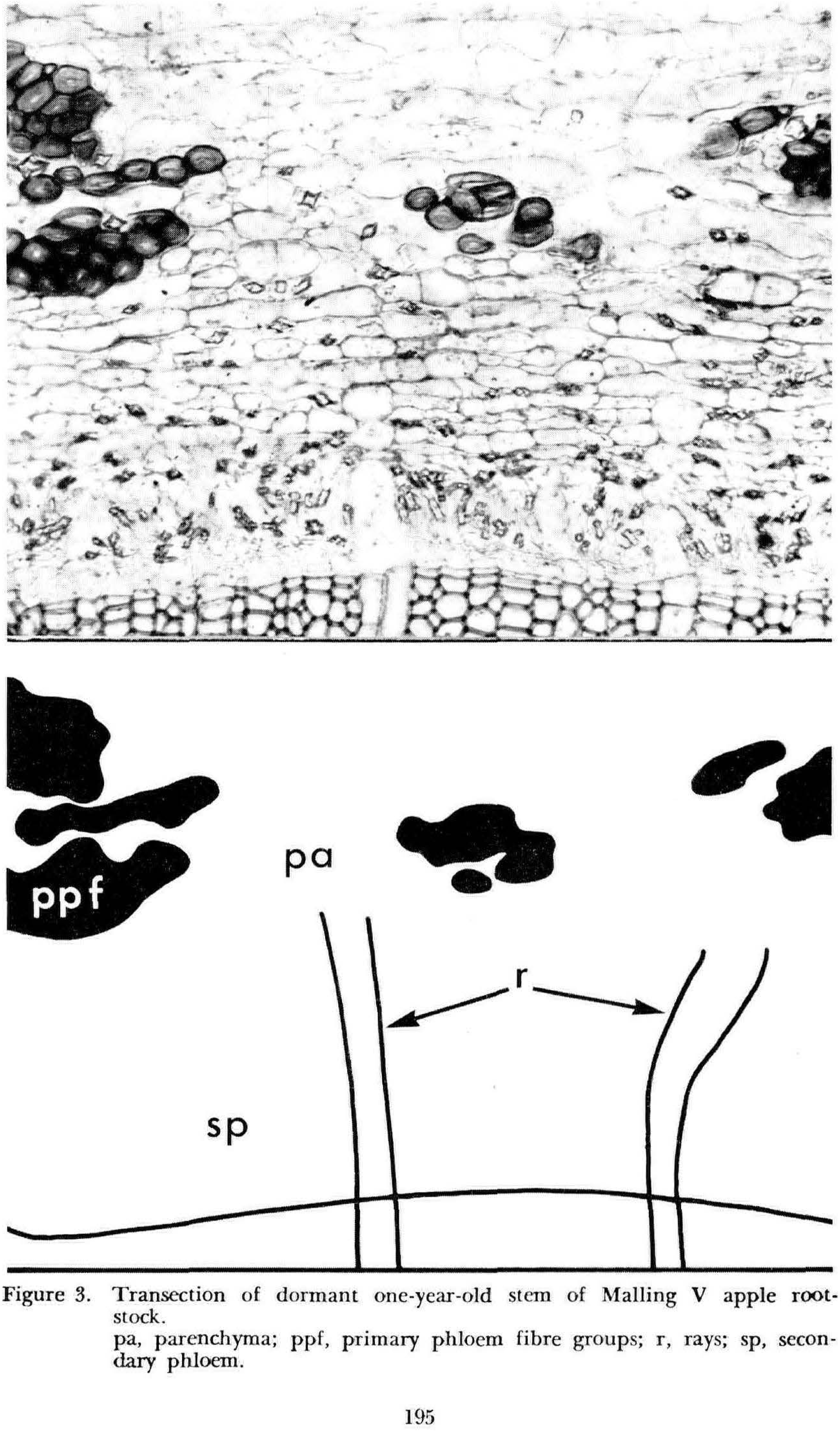

Figure 3. Transection of dormant one-year-old stem of Malling V apple rootstock.
pa, parenchyma; ppf, primary phloem fibre groups; r, rays; sp, secondary phloem.

from the primary phloem may take place some considerable time before these cells lose their living cytoplasmic contents. Specimens in this stage of development have been rooted under mist although the species is normally considered to be shy-rooting from cuttings. Sheaths may even be sloughed off soon after their formation, as in *Erica* where a phellogen is laid down on the inner side of a discontinuous sheath of fibres (Fig. 7). Subsequently a thick layer of cork is formed from the phellogen and it covers the distal ends of the rays with non-living cells in much the same way that a sclerenchymatous sheath of fibres and sclereids does in other shy-rooting plants. Thus, it may be significant that nurserymen usually propagate heaths from very young stem tips in which no cork has yet been formed.

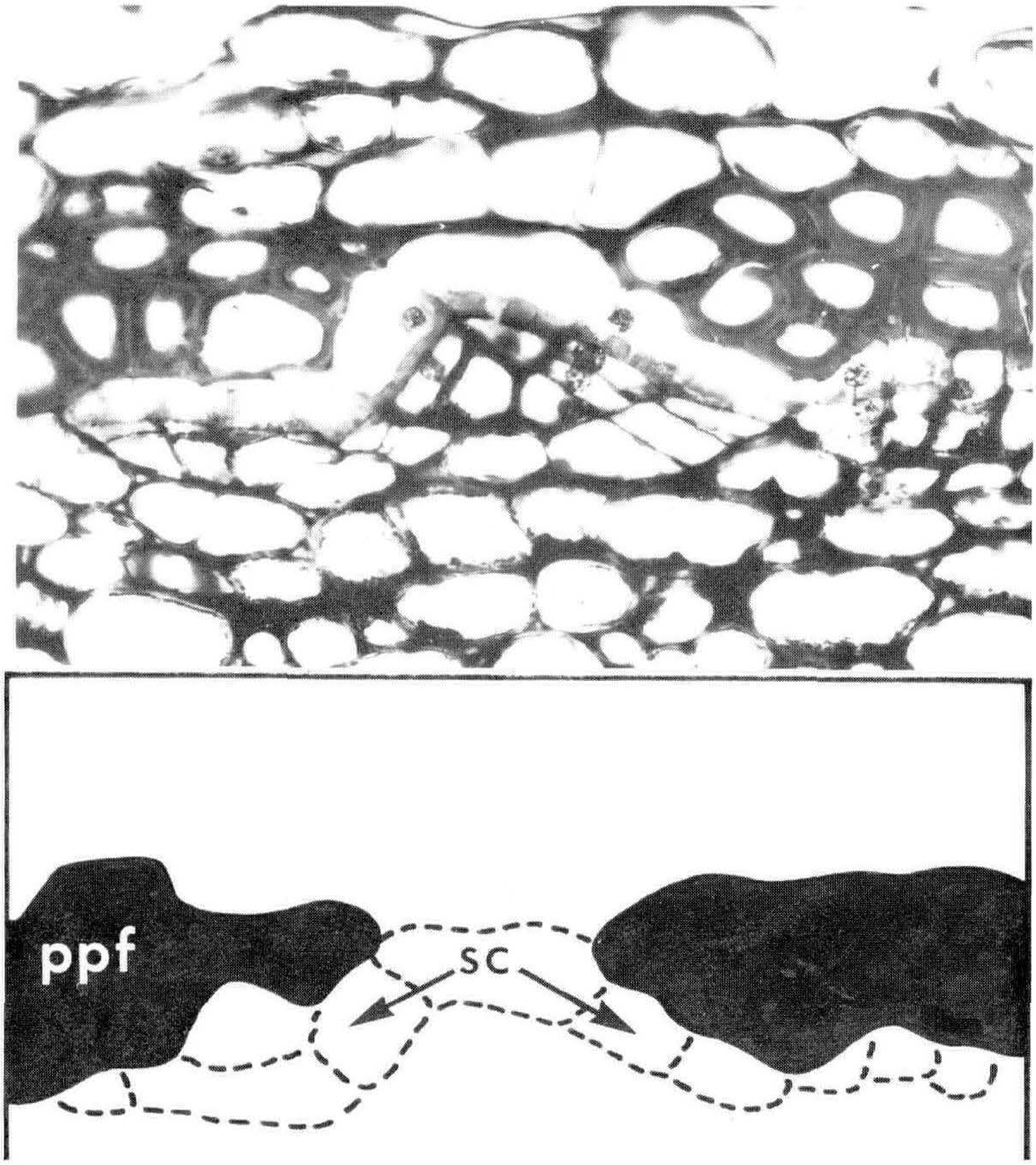

Figure 4. Transection of growing shoot tip of a shy-rooting clone of *Camellia sinensis* L.
ppf, primary phloem fibres; sc, sclereids differentiating from senescent cells of the primary phloem.

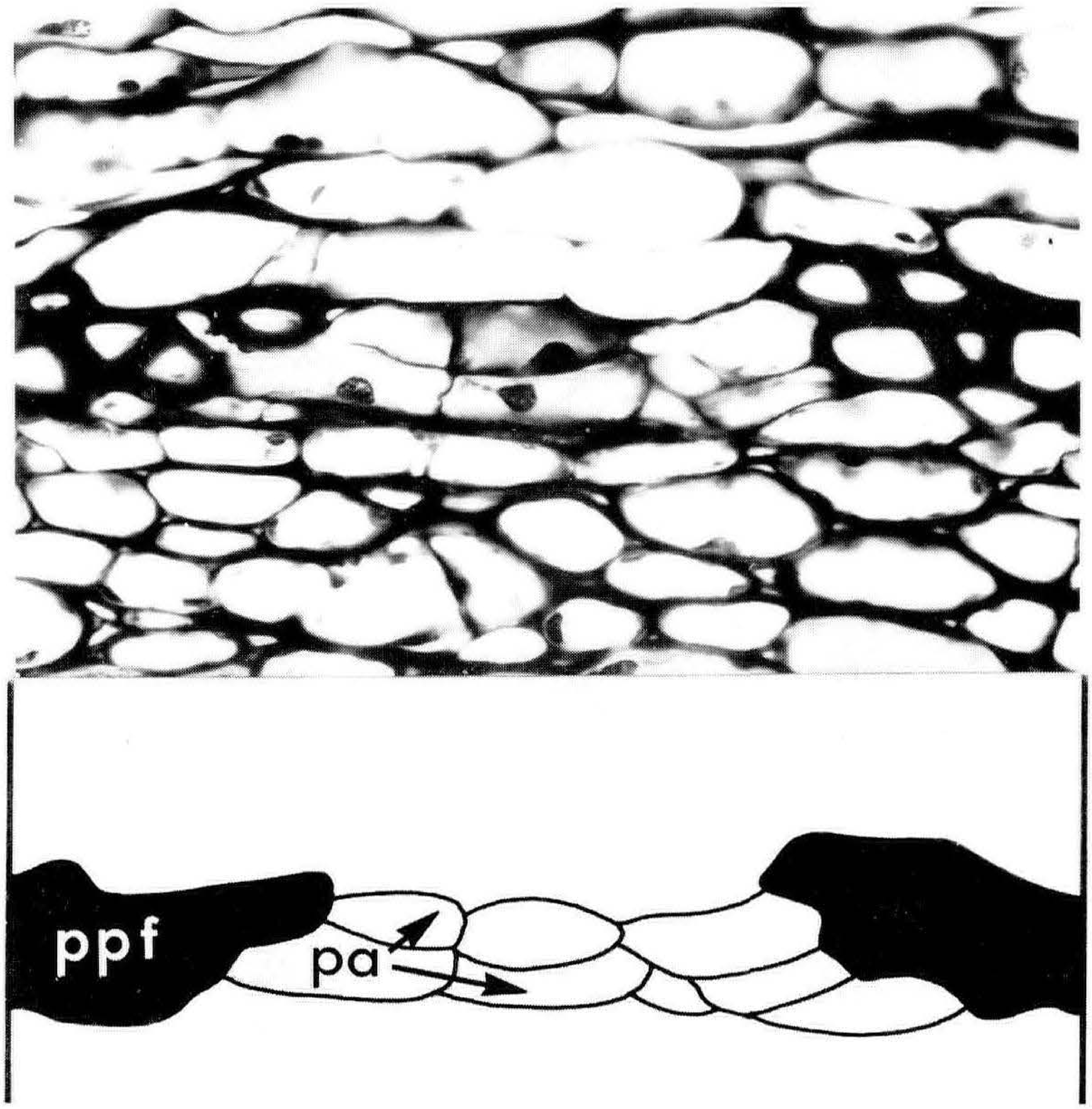

Figure 5. Transection of growing shoot tip of a free-rooting clone of *Camellia sinensis* L.
pa, parenchymatous cells in active division; ppf, primary phloem fibres.

In certain plants, as for example *Pittosporum,* secretory canals rather than fibres and sclereids develop in the primary phloem as it becomes senescent. The disruption of cells during the formation of the canals results in the breaking of many of the cytoplasmic connections with cells of the secondary phloem and cortex and, in this way, the canals may have a somewhat similar effect to that of a sheath of fibres and sclereids. In addition, cells at the distal ends of the rays may be bathed in the secretion released from the canals when the cutting is severed from the source plant.

Where anatomical features apparently inimical to adventitious rooting are likely to develop during the ageing of primary tissues, there are various courses of action that may be taken in order to obtain suitable material for propagation. Shoots from plants — or parts of plants — in the juvenile phase of growth may, for example, provide a source of free-rooting material. Differences in morphology observed between juvenile and adult shoots from ten-year-old seedling apple trees at East Malling Research Station were found to be associated with differences in anatomical structure (4). At the base, these trees produced shoots with a pose, leaf shape, and cell structure typical of the juvenile, free-rooting condition, while growths from the topmost branches, which were bearing fruit, resembled those of adult apple trees in outward form and in tissue structure. Where one is dealing with clones rather than seedlings, advantage may be taken of the fact that not all parts of plants age — in the physiological sense — at the same speed. Primary tissues derived from apical meristems may retain certain juvenile characters, including that of free-rooting, long after secondary tissues formed from lateral meristems, such as the vascular cambium, have lost these properties. In shy-rooting plants one may, therefore, be able to root shoots arising from sphaeroblasts — small nodules sometimes formed in the primary phloem, or cortex (3). Shoots of this type, grown from sphaeroblasts formed in the apple rootstock Crab C, rooted more readily (6) and possessed fewer primary phloem fibres than normal shoots (4).

Reference has been made on several occasions to the *inherent* rooting capacity of stems — that is their capacity to form roots under conditions approximating those occurring naturally. Some exceedingly shy-rooting plants — even some of the most unrootable among them, such as *Asparagus officinalis* L. — have been induced to produce roots when grown *in vitro* un-

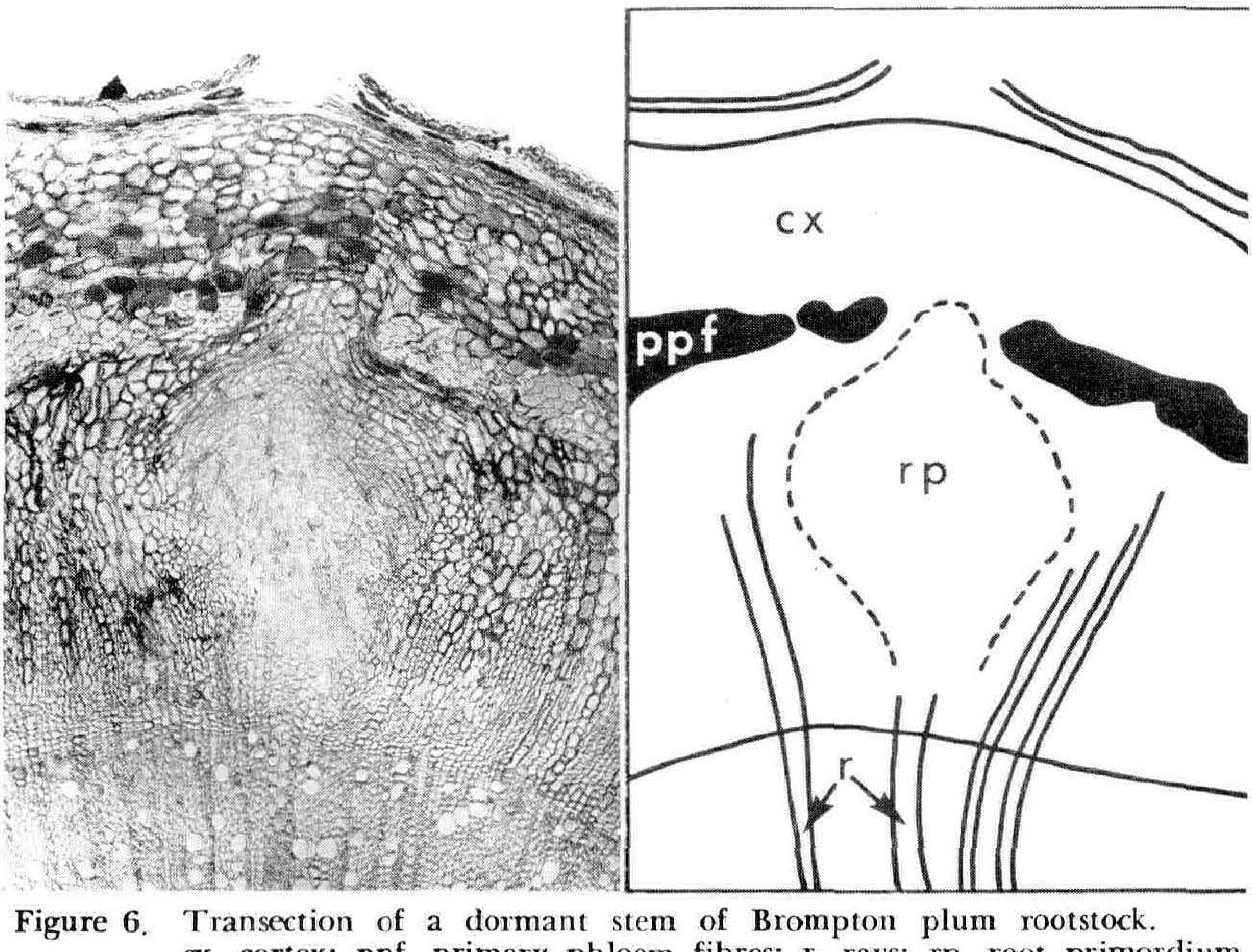

Figure 6. Transection of a dormant stem of Brompton plum rootstock. cx, cortex; ppf, primary phloem fibres; r, rays; rp, root primordium.

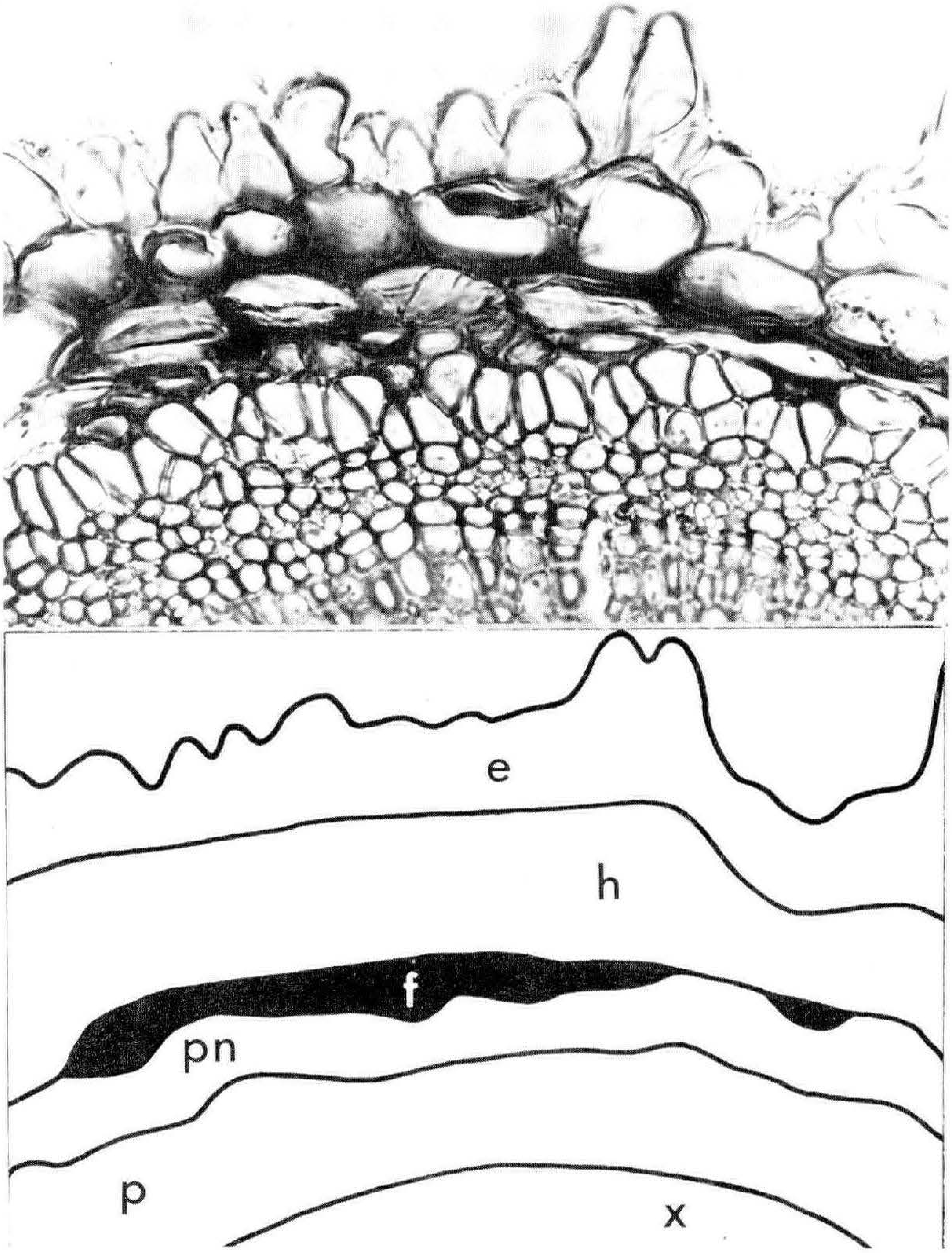

Figure 7. Transection of young shoot tip of *Erica arborea* L. var. *alpina* Bean. e, epidermis; f, fibres; h, hypodermis; p, phloem; pn, phellogen; x, xylem.

der aseptic conditions, and supplied with a nutrient medium and a growth factor supplement (5, 7, 8). Asparagus is, of course, a monocotyledon lacking a vascular cambium. The central ground tissue in which the vascular bundles are embedded, is surrounded by a massive sheath of fibres as shown in Figure 8. If a plant with such a tough peripheral structure can be rooted then, perhaps, there may be few plants that will not respond to techniques now being developed in the course of the present remarkable advances in the propagator's art.

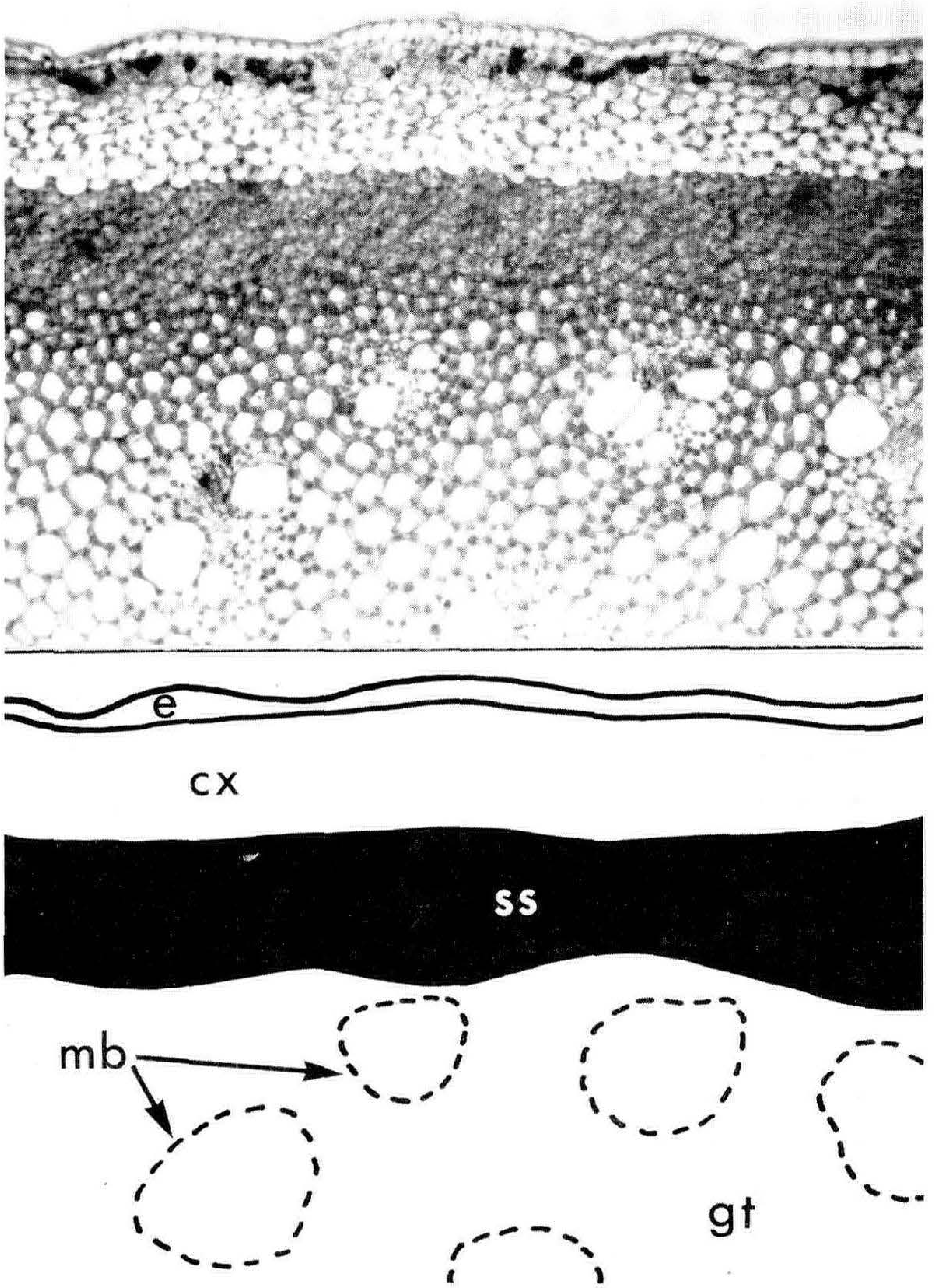

Figure 8. Transection of a mature stem of *Asparagus officinalis* L. cx, cortex; e, epidermis; gt, ground tissue; mb, medullary bundles; ss, sclerenchymatous sheath.

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FORGET NOT THE ESSENTIALS

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East Malling Research Station
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Dead plants cannot be propagated. Most of us accept this truth but we do not always behave as though we really believe it. Life being essential we should endeavor to maintain it.

Propagators spend much time 'multiplying by division', often into quite small pieces of parts of shoot, root or leaves, which they then place in situations where they grow to wholeness once again. There are many hazards in these processes and the greatest of these is desiccation or drying which, carried too far, is certain death. Herbaceous leafy cuttings are the chief sufferers but root cuttings are in the same danger, though the damage may not be immediately obvious. There is a tendency today to rely upon recovery under mist, but a wise man takes reasonable precautions. Moist-lined containers should be used for the collection of vulnerable cuttings. Polyethylene is suitable provided it is completely shaded whilst in use. Very full polybags may lead to suffocation of active cuttings; partial filling and ventilation helps. Young root pieces dry very quickly and may suffer severely in a few minutes if not protected.

The rate of drying varies with material and conditions. Whilst leafy cutting material left exposed may soon die, it may be safe when sprayed over and covered with a damp cloth. Leafless hardwood cuttings will also soon die on an open bench in a shed, yet be safe in a thin layer on a lawn. The washing of shoots or roots increases the rate of subsequent drying and calls for additional care.

Another neglected factor is aeration of the medium throughout the rooting period and beyond. The medium should stay aired even when it is very wet. This demands good drainage right through and material that does not become a soggy sponge during use. Our predecessors were so keen on aeration that they sometimes supported cuttings on the surface of a moist medium; a favourite dodge was to lay cuttings on top, or just nestling in, live sphagnum moss, using rain water to keep the sphagnum alive. Another trick was to push a cutting through the drainage hole of a pot inverted on moist material.

The temperatures used are important; control is simple with modern equipment. We would do well to remember that changing the temperature also changes conditions such as moisture and ventilation. If heat is applied below, the cutting base is the place for the thermostat. Yet propagators still place controls in strange positions; thermostats have been seen partly in draughty wall-cavities and even hanging in the free air above the cuttings.

Concerning the source or internal condition or quality of cuttings, when we collect a cutting we stand at the great divide.

Nothing we now do to that cutting can be more important than what has made it what it is. There are many factors associated with variety, strain, and culture to be considered. A factor too frequently ignored, and a major cause of inefficiency, is the *phase* of the cutting material. To possess the highest regenerative capacity (fast rooting), the shoot or root used for a cutting must have grown fast. Young seedlings have the maximum regenerative capacity but their vegetative propagation is no advantage. Adventitious shoots and roots propagate well. So do shoots or roots forced in warm glasshouses, or after severe pruning of well-established plants. In all these examples the tissues have been produced at high speed. Evidence of speedy growth is often revealed in changes in leaf-form, reminiscent of features commonly associated with juvenility, clearly seen in *Hedera, Ilex, Morus* and, indeed, many other genera. Incidentally, these fast growing parts may temporarily cease flowering, though non-flowering is not an essential property and obviously plays no part in root cuttings which also regenerate rapidly when grown fast on the source plant. For the production of good root cuttings cut the roots from the source plant and replant it again to produce fast-grown roots, a useful practice for some difficult-to-root subjects.

So, make your cutting-source grow *fast*. It does not matter how you do it, but hard cutting-over is one of the simplest ways. A warm glasshouse in spring will have much the same effect. So will the use of established vigorous rootstocks for slow-growing but valuable cultivars. Having obtained a really lively cutting, it deserves the best possible treatment and horticultural care.

SECOND SESSION

PLASTIC SHELTER CONSTRUCTION

A. D. WEGUELIN,
Barters Farm Nurseries,
Chapmanslade, Westbury, Wilts.

We have successfully constructed plastic covered shelters at our nursery using, principally, second-hand units from ex-Service Nissen Huts and wooden railway sleepers (ties).

The structure is built on the railway sleepers placed in two lines 17 feet apart, outside measurement. The curved Nissen hut irons, consisting of two 10-foot lengths, and one quarter-length of 2 feet, 6 inches, are welded together to form one arc of 22 feet, 6 inches. The angles on the irons are used to bolt to the sleepers with coach bolts.

These iron "ribs" are 6 feet apart and distance pieces of six-foot lengths of 2-inch by 1-inch timber keep them at this distance. Wires (10 gauge) are run the length of the house, threaded through the holes which are already in the centre of the irons. In the end irons an eye-bolt is used to strain the wire taut.

Nylon net is then stretched over the frames and secured to the sleepers by staples at the sides and ends. The plastic is then stretched over the frames and held down at the sides and ends with a 1½-inch x ¾-inch batten. The top net is then put on and secured to the sleepers with staples and telephone wire. The staples are not driven right home so they can be withdrawn easily when removing or replacing the plastic.

Wide doors are used at both ends to provide ventilation and the easy passage of tractors.

Originally, some trouble was encountered with chafing of the net where it crosses the irons and, to overcome this, cheap plastic hosepipe (⅜-inch diameter) is split and put over the protruding section of the irons.

The plastic is obtained from British Visqueen Ltd., Six Hills Way, Stevenage, Herts, and is 500 gauge with dimensions of 24 feet by 150 feet; it is advisable to obtain the "long-life" grade as this does not break down quickly.

Originally, the netting we used was No. 144 Nylon Black, six-inch square mesh, which was also 24 feet by 150 feet and was obtained from Bridport-Gundry Ltd., of Bridport, Dorset. We have now replaced this with No. 15/12 black polythene six-inch square mesh.

ROOTING DAPHNES FROM CUTTINGS

G. P. CHANDLER
Stewarts Nurseries,
Ferndown, Dorset

For this purpose I have split Daphnes into three groups:

Group 1. In this group I include the following species — *Daphne collina, D.* x *hybrida, D. odora* and its varieties, *D. retusa,* and *D. tangutica.*

The time for taking these cuttings is late July to the end of August but the all-important factor lies in taking them when they have reached the right degree of maturity. The cuttings should be of current season's growth. The length of cuttings should not be more than 3-inches but can be smaller according to the growth of respective species; cuttings may be a *joint* or a *heel* as long as the cutting taken does not exceed 3 inches. With *joint* cuttings it is a good tip to split them about ¼ inch at the base across the bud. This helps to form a good callus.

The cuttings are inserted into a mixture of 2-parts sharp sand and 1-part Irish peat moss. Pans or cutting trays may be used, with coarse chippings for drainage. After filling the tray with the cutting mixture, ¼ in. layer of sand is put on the surface. This, I find, prevents moss growing and a little sand trickles down to the base of the cutting when dibbled, which helps to form a good callus. Watering-in the cuttings is most important and must be very thorough.

Having completed this part of the operation, place the cuttings in a closed propagating frame with a temperature of around 50° - 60°F; shade fairly heavily and avoid over-watering until rooting takes place but, on the other hand, they must never be allowed to dry out.

All these species and varieties should be rooted and ready for potting off in about 6 or 7 weeks. Of course cuttings may be made the same way and rooted under mist, but I find with some of these varieties one does get quite a bit of "damping off".

Group 2. For Group 2 I have included *Daphne cneorum* and *Daphne* 'Somerset' (*D. x burkwoodii*). Let's start with *Daphne* 'Somerset'. This I find is the most easy to root of all the daphnes. One should have good stock plants, well established in 6 or 8-inch pots in the greenhouse, cutting fairly hard in the early spring to induce nice young healthy growth for the cuttings.

When this young growth is about two inches long and firming at the base this is the time to start taking the cuttings, which should be any time from June to early August. The treatment and mixture is the same as for cuttings in the previous group.

Stock plants of *Daphne cneorum* are best grown in the open ground, taking semi-mature cuttings 2 - 2½ inches long with, or without, a heel in late June or July. For this species cuttings seem to do much better if dibbled in a cold frame with double glazing, using a rooting mixture of 2 parts sand and 1 part peat moss. The cuttings should be dibbled fairly close together as this prevents drying out. Cuttings should be given a really good watering-in, which should last until they are rooted provided that the frames are shaded on bright days. Rooting should take place in about 6 to 8 weeks after which they should gradually be given air and more light. I like to leave the cuttings in the frame to grow on until the following spring before potting off or planting out into the beds in the open nursery.

Group 3 — Daphnes from root cuttings in December. For this group I recommend — *Daphne genkwa, D. mezereum* 'Grandiflora', and *D. mezereum 'Plena'*. This method provides the most saisfactory way of increasing *Daphne genkwa.*

Stock plants should be grown in pots plunged in the open ground during the summer and taken into a cold frame or cool greenhouse for the winter. For this type of propagation it is wise to have good stock plants growing on in succession for each year. It is better to strip all the roots possible from the plants being used to get the cuttings. Having collected the roots, cut them into ½-inch lengths, and place singly in large thumb pots or similar sized plastic pots. Fill the pots ⅔ full with compost of 2 parts peat, 1 part sand, and 1 part loam then lay the cuttings horizontally and just cover with silver sand; fill the pots with the compost and firm lightly. Plunge the pots up to the rims in ashes or grit in an open propagating bench, water in and cover with white paper. When rooting has taken place move the plants to a cool greenhouse.

PROBLEMS IN NORWAY MAPLE AND SYCAMORE-MAPLE PROPAGATION

STEPHEN HAINES
James Coles and Sons,
Thurnby, Leicester

I suppose that it must be the variation in leaf color that attracts me and many others to the *Acer platanoides* and *A. pseudoplatanus* varieties. Nothing is more satisfying than a good stand of 'Goldsworth Purple' contrasting with 'Drummondii' or 'Worleei' and of course there is no difficulty in selling them.

In common with many other growers, we have experienced great difficulty in obtaining a crop of these plants from buds. I can claim nothing original in the method now adopted which over the last few years has given us excellent crops. It is based on a study of successful growers' methods and of the growth pattern of the *Acer* species in question.

Our first requirement is a young rootstock with a fibrous root system. A two-year transplanted seedling, 8 - 10 mm size cuttings seem to do much better if dibbled in a cold frame with double glazing, using a rooting mixture of 2 parts sand and 1 part peat moss. The cuttings should be dibbled fairly close together as this prevents drying out. Cuttings should be given a really good watering-in, which should last until they are rooted provided that the frames are shaded on bright days. Rooting should take place in about 6 to 8 weeks after which they should gradually be given air and more light. I like to leave the cuttings in the frame to grow on until the following spring before potting off or planting out into the beds in the open nursery.

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Stephen Haines
James Coles and Sons,
Thurnby, Leicester

I suppose that it must be the variation in leaf color that attracts me and many others to the *Acer platanoides* and *A. pseudoplatanus* varieties. Nothing is more satisfying than a good stand of 'Goldsworth Purple' contrasting with 'Drummondii' or 'Worleei' and of course there is no difficulty in selling them.

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Our first requirement is a young rootstock with a fibrous root system. A two-year transplanted seedling, 8 - 10 mm size seems ideal; anything larger is usually coarse-barked at the level of bud insertion. These rootstocks should be cut back to 18 inches and planted in well-manured ground; it is essential that the stock grow vigorously throughout the summer.

Budding should take place as soon as buds are available and the stocks will open (mid-June). Day-length is important; it has been discovered that a substance produced by sycamore maples has an inhibiting effect on growth and induces dormancy in response to the stimulus of shorter days. When selecting the budwood, the buds should not be too succulent; lateral growth is often preferable to leader shoots. Sometimes the laterals provide only 4 to 6 buds, as the base "eyes" are too small and should not be used. The next requirement is that the bud should be encouraged into growth as soon as possible. Only when the bud has started growth can we consider ourselves to have the making of a crop. To promote this bud burst we cut back the growth on the stock to a handful of leaves. By removing all young growth the inhibiting effect of the terminal bud on the buds below it is abolished and the chance is increased of the bud bursting. By reducing the stock length before planting we have ensured maximum effect on the bud. It would seem that the dominance of the terminal bud is greater in 'Goldsworth Purple' than in 'Drummondii' and that the inhibiting effect on the lateral buds extends further down the shoot. This seems to be reflected in a greater reluctance on the part of 'Goldsworth Purple' to break into growth after stopping. We have tried applying a nitrogenous fertilizer after budding and this may be a worthwhile practice, as in certain plants dominance of the terminal bud almost disappears at high levels of nitrogen nutrition.

It is important to remove the petiole or leaf stem, especially in a wet season; if left this will decay and the bud with it. The petiole will ripen and be ready for removal a fortnight or so after budding, depending on the weather. Great care must be taken not to damage the bud or to force the petiole off too soon. In a wet season one should go over the stocks twice and remove as many petioles as possible each time.

We find that it pays to look over the buds after about three weeks and re-bud any failures. By this time the stock should be recovering and resuming growth and the bud will be plumping up and ready to burst.

The following February or March we head-off our stocks to the bud and paint the wound with fungicide. The maiden growth being staked from the start, this eliminates any chance of die-back from the snag and saves one operation.

PROPAGATION OF RHODODENDRONS AND AZALEAS AT KINSEALY

JAMES C. KELLY
The Agricultural Institute,
Kinsealy, Dublin, Eire

Studies on production of hybrid rhododendrons from stem cuttings commenced at Kinsealy in 1968. On October 30th cuttings were taken from four-year-old stock plants of Dutch origin. These cuttings were from four to six inches long, and taken as far as possible from the underside of the plants. In preparation, only four leaves were left on the cuttings, which were wounded heavily on both sides at their base and treated with a proprietary hormone powder (0.8% IBA). The cuttings were then inserted in a rooting medium of two parts peatmoss and one part washed river sand, then placed under mist. The bottom temperature was 70-75°F. As controls, small numbers of cuttings of the cultivars used in the trial were left unwounded or received no hormone treatment.

There was no advantage in re-inserting cuttings after the initial lifting, as very few additional cuttings rooted, whilst the remainder quickly degraded. The new plantlets were then potted into four-inch clay pots in a pure peatmoss medium with a range of nutrients added, excepting lime. From early Janu-

Table 1. Rooting results obtained after nine weeks.

Cultivars	Medium*	Hormone	No cuttings inserted	No well rooted	No lightly rooted	No unrooted	Total rooted
'Gomer Waterer'	P	0.8% IBA	10	7	2	1	9
'Gomer Watererer'	2P 1S	0.8% IBA	5	0	2	3	2
'Cynthia'	P	0.8% IBA	8	4	3	1	7
'Cynthia'	2P 1S	0.8% IBA	5	5	0	0	5
'Hugo Koster'	P	0.8% IBA	10	6	3	1	9
'Hugo Koster'	2P 1S	0.8% IBA	5	3	2	0	5
'Purple	P	None)	16	0	0	16	0
Splendour'		0.8% IBA)	16	11	4	1	15
'Purple	2$ 1S	None)	16	0	0	16	0
Splendour'		0.8% IBA)	16	7	2	7	9
'Doncaster'	P	0.8% IBA	5	0	2	3	2
'Doncaster	2P 1S	0.8% IBA	5	4	1	0	5
'Blue Peter'	P	0.8% IBA	6	5	0	1	5
'Blue Peter'	2P 1S	0.8% IBA	5	3	1	1	4
'Prof. Zaayer'	P	0.8% IBA	11	6	0	5	6
'Prof. Zaayer'	2P 1S	0 8% IBA	5	0	2	3	2
'Britannia'	P	0.8% IBA	32	6	0	26	6
'Britannia'	2P 1S	0.8% IBA	32	0	0	32	0

*P — pure peatmoss
2P IS — two parts peatmoss and one part washed river sand.

ary they were placed in a cold greenhouse, and kept watered as required. The survival rate was high and on April 20th, the plants were knocked out of the pots and planted into wood peat (pH 5.2) at the Peatland Experimental Station, Lullymore, Co. Kildare, as part of trials in progress there on nursery stock production on basin peat.

The plants were slow to break dormancy, and whilst still quite healthy it was not until mid-June that the buds began to grow. These plants are now growing quite strongly and with good cultural care should be saleable in two years.

The rooting of hybrid azaleas (Exbury and Mollis) commenced at Kinsealy in April, 1967. In that month and during May and June, the cultivars 'Balzac' and 'Honeysuckle' were tested for rooting in different composts and at different times. The cuttings used were from the apical portion of the stems, cut closely to the main stem so as to include a small piece of semi-mature tissue. All cuttings were treated with proprietary hormone powder (0.4% IBA) and inserted in four different media; i.e. pure peatmoss, two parts peatmoss and one part sand, two parts sand and one part peatmoss, and pure sand. 'Balzac' proved difficult to root (15 - 20%) even after three months under mist. 'Honeysuckle' showed high rooting percentages (85 - 95%) in two months. The best overall medium was pure peatmoss.

In 1968, nine cultivars of deciduous azalea were tested for rooting. Peatmoss alone was again the best overall medium, but two parts peatmoss and one part sand gave faster rooting. These cuttings were inserted on June 5th and lifted nine weeks later. Those cuttings unrooted were re-inserted for a further month. 'Berry Rose' (12 cuttings), 'Golden Girl' and 'Ballerina' gave comparatively poor results (50%, or fewer, rooted). 'Strawberry Ice", 'Klondyke' and 'Cecile' were intermediate (62-66% rooted). 'Gibraltar', 'Kathleen' and 'Gold Dust' rooted well (87-100%). 'Gibraltar' was notable for vigorous rooting. Cuttings of 'Strawberry Ice' and 'Cecile' inserted earlier gave poorer results (24% and 35%, respectively) but 'Klondyke' and 'Kathleen' responded well (75% and 87% rooted).

In the present season a trial is proceeding to establish the rooting times of the above nine cultivars. Two plants of each of the cultivars were:—

1. Brought into a glasshouse on April 8th and forced at 75-80°F.
2. Covered with polythene on April 8th for forcing in their outdoor beds.
3. Allowed to produce cuttings under natural conditions.

The aim of this experiment is to assess earliness of cuttings produced from each treatment consistent with high rooting percentages and thus establish the best forcing treatment for mother plants. It is our belief that the earlier cuttings can be taken, the faster the rooting, thus allowing several months for the first year's development of the plantlets. Over-wintering will also be assessed, as in trials in the preceding season some losses occurred in plantlets that developed flower buds after rooting and allowed to carry these into the winter.

The cuttings in the trial are being rooted in a mist unit, with bottom heat of 70-75°F. The medium used is two parts peatmoss and one part sand. The stock plants seem capable of yielding a large number of cuttings, and in the case of 'Gold Dust' the two bushes (four years old) gave up to 300 cuttings, whether forced under glass, polythene, or allowed to develop naturally. Cuttings were ready for collection by April 17th from bushes forced under glass, two weeks earlier than those forced under plastic which, in turn, were two weeks earlier than those allowed to develop naturally. The advantages of being able to take cuttings early is evident at the time of writing, as these are now growing strongly in the frames, whilst the later cuttings — still unrooted — show signs of deterioration in the propagation bench. In addition, the latter will have little time to grow on before they go into dormancy and leaf drop commences.

Some cultivars, e.g. 'Honeysuckle', 'Klondyke' and 'Balzac' do not appear to form flower buds during the summer after rooting and hence are not difficult to overwinter without special measures. At this stage in our trials an objective is to distinguish such cultivars from the more difficult kinds which will receive more detailed studies.

G. K. ARGLES: All plants need calcium. Is there sufficient in the peat?

JAMES KELLY: It may be necessary to add some at a later stage.

JAMES WELLS: Our medium consists of equal parts of peat and perlite. We find that a deep wound is advantageous and dibbling is unnecessary. The cuttings are distributed over the benches and struck in rapidly by hand. We have never limed the medium though it is worth thinking about. Perhaps gypsum would be best as this material is very effective on some stock plants. Excess mist is very harmful and this season we have had terrible weather conditions in New Jersey with many plants decaying in the lath houses. In my experience the calibre and vigour of the stock plant is perhaps the most important factor for success and the cuttings taken from the top of the plant are usually best.

ACERS FROM CUTTINGS

MISS J. M. ANSTEY
Coblands Nursery,
Sevenoaks, Kent

It seems ironical to me that such an acknowledged expert as Jim Wells can write a book in which he deals with a subject such as this and then you ask me to stand up and speak on the subject. Nevertheless, such is human nature that we had taken cuttings of *Acer palmatum* 'Atropurpureum' two years running before I thought of seeing what the experts had to say! Most of what I am going to say now concerns the difference between muddling through in our own way and learning from other people's mistakes.

Early in 1968 it was decided that we should try *Acer palmatum* 'Atropurpureum' from cuttings. Thirty-three stock plants were therefore taken under glass in February, bedded in a frame filled with peat and given regular doses of liquid feed throughout the growing season. The temperature was kept at a minimum of 45°F and, at the beginning of April, the first batch of cuttings were taken when the shoots were long enough and one pair of leaves had fully expanded. Cuttings were then taken at intervals until the beginning of May when the materials ran out and a long delay followed until more became available — from the same plants — in June.

The cuttings were made 3 to 4 inches long, some of them cut at a node in the usual manner, some cut at the base where the stipules leave a type of 'node' when they fall off. It didn't seem to make any difference one way or the other. All were treated with Seradix 1 and inserted in trays of 50/50 peat and sand then placed under mist where they rooted in three to four weeks. When they were potted in August, 65% had rooted. Most of these were potted in Arthur Bower's compost but some were put into 50% John Innes plus 50% peat and these were by far the best; most of those that survived the winter were from the latter batch. Overwintering, or encouraging them to grow on, is definitely the biggest problem, at least as far as we are concerned. Of the 900 or so plants potted, only 50 survived until spring, but even this was enough to encourage us to try again.

In the next trial the stock plants were left in the glasshouse. We didn't know whether we ought to leave them in or take them out but it does not seem to have done them any harm and they started into growth earlier in the year so that the cuttings could be taken over a much shorter period of time (in fact a fortnight instead of a month). They were treated as before — Seradix 1 and 50/50 peat and sand. They rooted in about a month and were potted during the second week of July. At this stage 50% had fairly good roots and these were potted. But those that were very poorly rooted and the ones that were not rooted at all were put back into the mist. Although Mr. Wells recommends this procedure it didn't really seem to be worthwhile in this case. Of the ones not already starting to root only 26% responded. But this did boost the total 'take' to 63% — or more or less the same as last year. So far we had repeated the previous year's results but this time the whole lot was potted into a peaty John Innes mix.

Sometime in June, however, I decided to see what Mr. Wells said on the subject and we found several discrepancies between his method and ours. I'll just repeat the relevant parts of his summary —

1. Take cuttings early in the season.
2. Take strong vigorous tip cuttings of fairly thick wood from actively growing plants and make cuttings 8 to 9 inches long if possible.
3. Wound with a heavy wound.
4. Treat with 2% IBA
5. Use a rooting medium containing 80 - 90% peat, the remainder being coarse grit.
6. Maintain conditions of high humidity; this, of course, is provided by the mist unit.

We followed these instructions as closely as possible, making only two amendments. Firstly, as the season was already fairly well advanced we took our cuttings on July 3rd — but as our plants were under glass and Mr. Wells's were in the open there may have been some compensation here. Secondly, we continued to use 50/50 peat and sand, as our mist unit tends to get very wet. These cuttings were weaned on July 25th and potted last week. The percentage take was 74 which is not as good as Mr. Wells' 80% but it is acceptable. The really amazing thing, however, was the difference in the quality of rooting. The early batch produced two or three thick, brittle "water" roots; the later batch had good, healthy, fibrous root systems. I think the size of the cutting, the heavy wounding and, above all, the strong hormone, were responsible for this and, undoubtedly, the cuttings could have been potted a lot earlier had we had the time.

Of course, we still have the problem of getting them into growth and overwintering them. I feel that with root systems such as these have there ought to be a far better chance of survival than previously. But is it the roots that count or the top growth? Some of the early batch have already produced extension growth, some have only produced a couple of new leaves, and in some the buds haven't attempted to burst yet. I would think that cuttings with extension growth are more likely to overwinter than those without, but I don't really know. None of the second batch has made any new growth at all so far, though they look strong and healthy.

Two more things we are trying this year. Firstly, we were told that when we pot the cuttings we ought to take off the old leaves to force the plant into growth. With the first batch we took some off and left some on but the ones left died and dropped within a day or two so it made little difference anyway. With this second batch the leaves look so healthy that I dislike removing any; nevertheless I have hardened my heart with some of them and wait now to see if it makes any difference.

Secondly, we are trying to encourage growth by the use of supplementary light; 200-watt lamps are suspended three feet above the plants and left on all night. And with this treatment goes a high potash feed. We hope by this means to overwinter a good batch of plants which will make the exercise worthwhile and also establish the routine to be followed next year. If anyone has any suggestions to make — particularly with regard to the problem of growing-on — we shall be very pleased to hear them.

MISS ANSTREY: Which type of rooted cutting overwinters best — plants with good root systems but no extension growth, or those which have made appreciable new growth?

BRIAN HUMPHREY: Why not leave them in the boxes until spring instead of potting them up? I would expect almost 100% survival this way without much difficulty.

C. E. SALTER: With long cuttings, take off the two top buds to get a break. Cuttings must be at least 3 nodes to be able to cut off the top and get good growth before winter.

PETER VERMEULEN: We use Jiffy pots under a plastic cover.

JIM WELLS: At Beltsville, Maryland, it has been shown that Acers react strongly to extra light. Never take the leaves off the cuttings and keep the plants at low temperatures overwinter.

PROBLEMS IN RAISING ORNAMENTAL STOCK FROM SEED

PETER DUMMER
Hillier & Sons,
Winchester

Over the past few years there has been an ever-increasing demand for large quantities of trees and shrubs and, as a result, we have had to change some of our methods of raising stock from seed.

Various reports, such as those of the I.P.P.S., and the Woody Plant Seed Manual (published by the Forestry Service of the U. S. Department of Agriculture) have been found particularly useful. This latter book is notable for its detailed work on the treatment of seeds with sulphuric acid. A visit a few years ago to the Forestry Commission Nursery at West Moors, near Ringwood in Hampshire, also provided us with ideas on different seed-raising techniques. These changed practices have increased the quality of the seedlings we have raised and reduced our production costs.

DORMANCY

In most cases dormancy originates in genetic conditions of the seed itself, or by improper handling of the seeds at harvest removing any; nevertheless I have hardened my heart with some of them and wait now to see if it makes any difference.

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DORMANCY

In most cases dormancy originates in genetic conditions of the seed itself, or by improper handling of the seeds at harvest time, such as allowing the seeds to become too dry before sowing or before stratification.

There are two main causes of seed dormancy:

1. An impermeable or hard seed coat which prevents water and oxygen from reaching the embryo and in some cases prevents the embryo from breaking through the seed coat.
2. Conditions of the embryo or stored food within the seed which prevent germination. Double dormancy exists in quite a number of species and is said to be caused by the combination of both a hard seed coat and internal conditions.

OVERCOMING SEED DORMANCY

Stratification. This is the usual method of breaking the internal dormancy of many seeds. The medium we like to use is a coarse potting grit and peat; the use of grit allows an adequate supply of oxygen to the seeds while the peat, which has a fairly low pH, aids in breaking down the seed coat and retains moisture which is vital for the well-being of the seeds. We like to use at least three times the amount of medium to seed in order to keep the seeds separated from each other. For small quantities of seed, hand mixing is practiced. For large quantities, a cement mixer is employed.

When stratified, the seeds are placed on the north side of a greenhouse in cubicles made from concrete blocks. The blocks are simply placed down and the cubicle made large enough to allow the seed to be turned occasionally. For small quantities of seed, a large pot or box is suitable.

Warm-to-cold stratification. Besides the usual method of stratification, we also practice the warm-to-cold technique using such species as the cotoneasters.

The seeds are picked as soon as ripe and are immediately macerated through a mincing machine, adapted from a household mincer; the pulp is then put into a large bath and filled with water. After a few minutes the water is poured off. A large number of seeds always float off with the water, but these can be ignored as they will be found to be infertile. Three or four rinses like this are required to obtain well-cleaned seeds.

After this treatment, the seeds are mixed with the peat and sand and placed in boxes or large pots and stood down in a *warm* greenhouse for about six to eight weeks. The use of a warm period for these stone-like seeds helps in breaking down the seed coat; the winter frosts which they will encounter when sown on the seed beds breaks embryo dormancy.

Acid treatment. The use of acid for the treatment of seeds is a comparatively new technique for us, which we started using only a few years ago. It has proved most satisfactory, especially with members of the legume family.

This year success has been attained using acid treatment on *Gymnocladus dioicus* (*G. canadensis*), a notoriously difficult tree to raise from seed. In the past, various treatments on *Gymnocladus* seed, such as using hot water, filing the seed, and the usual method of stratification have usually proved unsuccessful.

This year we tried a 4½-hour soak in concentrated sulphuric acid. After a thorough rinsing in running water, the seeds were stratified in the usual way then placed in a warm greenhouse. In a few days it was evident that the seeds were going to germinate for the sand in the stratification pot had risen several inches above the rim of the pot. Upon inspection, it was found that the seeds had swollen at least three times their original size and had started to germinate. They were then sown individually into 3-inch pots.

Listed below are several species whose seeds have been successfully treated with concentrated sulphuric acid, together with the duration of treatment.

SPECIES	DURATION OF TREATMENT
Cercis canadensis	½ hour
Cercis chinenensis	20 minutes
Cornus florida	3 hours
Cornus nuttallii	3 to 4 hours (depending on freshness of seed)
Gleditsia triacanthos	1½ hours
Gleditsia caspica	1 hour
Gleditsia sinensis	1 hour
Nyssa sylvatica	3 hours
Nyssa aquatica	3 hours
Robinia pseudoacacia	20 minutes

THIRD SESSION

THE RESPONSIBILITIES OF THE PROPAGATOR

D. M. DONOVAN
F. Toynbee, Ltd.,
Barnham, Sussex

The management of a nursery cannot be entirely separated in function from the propagator or other staff, as their interest is common, namely the production of plants or seeds of economic or ornamental merit for sale — albeit the one for profit and the other for livelihood. The management alone initially determines the type of enterprise to be capitalised although many influences in the course of time will alter the original concept, not least the advice of the propagation staff.

The present business of F. Toynbee, Ltd., comprises a wide and complex pattern of wholesale trade despatch, contract supply, landscaping and retail sales. The choice of plants grown here is partly determined by the advice of the propagator.

The management must decide wheather to grow an increasing number of different kinds of plants or reduce to a few hundred which have a guaranteed minimal annual sale. Whichever choice is made, an estimate of plant quantities is required, close to actual sales, and an acceptable limit of over-production must be determined. This is certainly hard work with a wide range of stock but it is essential for the proper survival of the business and to provide the propagator with a working level.

Another prerogative of management is capital expenditure, and its use provides tangible limits of production in land, buildings, machines and plant stock available, encompassing all the efforts of the enterprise. In other ways the propagator controls his employment as being the first active principle in the practicalities of nursery work. He must assume considerable responsibiltiy for maintaining successful methods of production, for the use of work-study principles to improve the efficiency of his operations, and he must be receptive to new techniques.

A vitally important part of the propagator's skill is his ability to recognise plant material and to identify his stock with the correct name, which he learns from close handling. Confusion in nomenclature abounds in many genera and groups of genera, furthered by extensive synonymity and a general haphazard attitude in many areas of the nursery world. Any trip around a general nursery will reveal discrepancies in names. A legal obligation now exists in the Trade Descriptions Act, 1968, to describe goods true to description. This cannot always be fulfilled perhaps, because of ignorance or unwittingness, but occasionally even blatant frauds may occur. A little more honesty is required in the frequent substitutions which occur and in catalogue descriptions.

The use of vegetative means of propagation is surely desirable when seedlings of some plants are noticeably diverse in quality, and when fine selections exist which are not excessively difficult to propagate vegetatively. For example, *Magnolia grandiflora* and *Chimonanthus praecox* are plants which are still frequently seed-grown but are far too variable for this method to be recommended. Likewise a clonal form of *Cercis siliquastrum* seems desirable. Trueness-to-name may be mentioned again and it is to be hoped that, by now, all nurseries have discarded *Hydrangea* listed only as pink, red or blue. Seedbeds and first planting-out rows must be scanned to rogue inferior plants and to select occasionally the outstanding plant, which may be set aside for several years for its qualities to be assessed; in this way improved clonal forms may be introduced into commercial channels. The work of the research stations in providing, and in propagating in the first instance, virus-free clonal material merits consideration here.

During the last few years some lines of imported material have declined in quality from past standards. Whatever the reason for this deterioration, and presumably demand is a major contributory cause, prices of first quality material are bound to rise owing to continued demand and to increased costs of production and transport. The increases must be passed on to the buyer so that, to maintain efforts at price stability at home, the nurseryman is increasingly likely to ask his propagator to further his propagation to include more of those plants previously bought in. The propagator's status will then be increased when his knowledge brings success.

Further co-operation between growers seems essential to reduce the over-production of the easier trees and shrubs. One nursery might easily grow a series of little-used plants for distribution to nearby nurseries without any increase of work during the initial propagation period; another propagator might raise larger numbers of common shrubs by agreement.

The position of propagators, like that of the nursery industry as a whole, would be enhanced if the gardening habits of the public were changed by inclination or persuasion towards less permanent garden design and more frequent replanting. The Horticultural Trades Association is the body to provide the persuasion on a national scale. Years of trade would come if the owners of four million untended gardens could be persuaded to take an interest, or if the numerous featureless gardens could have even the occasional tree to add immeasurably to their character and to the value of the site.

The industry should now become insistent upon evidence of some academic ability in its new entrants from school in the hope of sifting out the least suitable and raising the overall level of the quality of incoming staff. With the encouragement of further education facilities and given sound and broad training in the nursery, their understanding of plants and their basic skills will improve. Institutes, colleges and universities should raise their level of entry requirements and standards of attainment required for the overall benefit of the industry and for the art of propagation, which many graduates enter.

To summarise, the propagator is a responsible person in the management and practice of the nursery industry, possessing several skills, but essentially a committed person with a life-long task which cannot but satisfy.

THE PROPAGATION OF ALPINES

J. K. HULME
Botanic Gardens,
University of Liverpool

There are many snags in propagating alpine plants. Some of the high mountain species of *Androsace*, which produce tight rosettes of minute leaves, can only be raised from seed which is rarely produced in quantity and the seedlings grow very slowly.

Raising plants from seed is of considerable importance to the propagator of alpine plants who must be prepared to meet a range of spcialised requirements. *Primula whitei, P. edgeworthii* and *P. gracilipes* and their relatives of the Petiolaris section produce seeds which rapidly lose their viability. They must be sown as soon as they are ripe, with the seeds taken directly from capsule to seed-pan. Some people, however, have been led to the mistaken conclusion that all species of *Primula* should be so treated. In fact, the greater number of species respond far better to a spring-sowing programme; in this way they grow and develop and are ready to enter the normal resting period when winter arrives.

The seeds of *Gentiana verna* and *Lewisia cotyledon* hybrids benefit from a period of low temperatures under moist conditions without such treatment germination is likely to be sporadic and generally unsatisfactory. Seeds sown in containers in early March usually germinate freely when taken indoors into a heated glasshouse.

There are, however, many species of alpine plants which can be sown in a warm glasshouse in spring; e.g. *Aquilegia pyrenaica, Ramonda myconii* and the dwarf members of the Ericaceae.

Jankaea heldreichii can be propagated by separating offsets from the parent rosette; *Phlox nana* (*P. triovulata*) can be propagated by root-cuttings, but the rate at which these plants produce vegetative propagules, (to use an American term), is alarmingly low. Indeed, this is one of the major problems in raising a range of alpine plants for which the demand is greater than the supply. Most intelligent nurserymen use the plants of this category as bait for the considerable connoisseur custom which exists in this field.

It is perhaps in the next group of plants where real commercial possibilities exist. These are plants which offer some should raise their level of entry requirements and standards of attainment required for the overall benefit of the industry and for the art of propagation, which many graduates enter.

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Jankaea heldreichii can be propagated by separating offsets from the parent rosette; *Phlox nana* (*P. triovulata*) can be propagated by root-cuttings, but the rate at which these plants produce vegetative propagules, (to use an American term), is alarmingly low. Indeed, this is one of the major problems in raising a range of alpine plants for which the demand is greater than the supply. Most intelligent nurserymen use the plants of this category as bait for the considerable connoisseur custom which exists in this field.

It is perhaps in the next group of plants where real commercial possibilities exist. These are plants which offer some difficulties, but which may, however, be overcome if a few rules are observed. For example, plants of *Anchusa caespitosa,*[1] (as distinct from *A. angustissima,* which often masquerades under the name of *A. caespitosa*), have retailed over the last few seasons for prices ranging from 10s.6d. to 21s.0d. Yet it can be rooted with the ease and speed of plants which are retailed in the 3s.0d. to 4s.6d. bracket. A small area of stock bed consisting of well-drained media raised to an elevation of 15 inches above ground level is desirable. A garden frame can be used for the stock bed if convenient materials for a retaining wall for the bed are not available. The stock plants should be set at 18 inch intervals; a well-established stock plant can be expected to produce upwards of 50 cuttings in a season. The stock plants can be covered with frame lights in extremely cold or excessively wet weather in winter. Shoot cuttings are collected with a very short portion of stem below the rosettes of leaves and the cuttings can be expected to root at any time in the growing season. Much the best results are obtained from cuttings inserted in late April or early May as these will grow away without the check that later struck cuttings often experience. The use of IBA in talc seems to lead to a marginal improvement in rooting performance.

The timing of the preparation of quite a range of alpines is of very great importance. *Gentiana sino-ornata* and its hybrids are often propagated commercially by division of the roots in early spring. Further increases in stocks can be achieved by propagation from cuttings, which again will root over a long period in the growing season. Only those cuttings rooted earlier in the season, however, are likely to develop resting buds which are essential for the young plants to over-winter. Much the same is true of *Cyananthus lobatus* and *C. integar.* The question of timing is further illustrated because later-struck cuttings display a considerable impetus towards flower-bud production instead of making vegetative growth.

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[1] Ed. Note: *Anchusa caespitosa* Lam = *Pentaglottis caespitosz* (Lam) Tausch.
A. angustissima Koch = *A. ochreleuca*
A. angustissima Bourg. ex Nym. = *A. undulata*

PROPAGATION OF MINIATURE ROSES BY GRAFTING

D. Staton
Harry Wheatcroft and Sons,
Edwalton, Notts.

Preparation

Preparation for the grafting of miniature rose trees starts at the beginning of November. The second-grade miniature rose trees are pruned fairly hard, potted up into four-inch 'long toms' and placed into a cold frame or glasshouse where they are given a cold period for about four weeks.

The grafting pit is prepared in early December with about 9 inches of peat. We like to get the peat at a temperature of difficulties, but which may, however, be overcome if a few rules are observed. For example, plants of *Anchusa caespitosa,*[1] (as distinct from *A. angustissima,* which often masquerades under the name of *A. caespitosa*), have retailed over the last few seasons for prices ranging from 10s.6d. to 21s.0d. Yet it can be rooted with the ease and speed of plants which are retailed in the 3s.0d. to 4s.6d. bracket. A small area of stock bed consisting of well-drained media raised to an elevation of 15 inches above ground level is desirable. A garden frame can be used for the stock bed if convenient materials for a retaining wall for the bed are not available. The stock plants should be set at 18 inch intervals; a well-established stock plant can be expected to produce upwards of 50 cuttings in a season. The stock plants can be covered with frame lights in extremely cold or excessively wet weather in winter. Shoot cuttings are collected with a very short portion of stem below the rosettes of leaves and the cuttings can be expected to root at any time in the growing season. Much the best results are obtained from cuttings inserted in late April or early May as these will grow away without the check that later struck cuttings often experience. The use of IBA in talc seems to lead to a marginal improvement in rooting performance.

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The grafting pit is prepared in early December with about 9 inches of peat. We like to get the peat at a temperature of

80°F, with an air temperature of 72°F. The peat is watered to keep the inside of the grafting pit humid, care being taken to ensure that the peat is not so wet that excess water can be squeezed out by pressure. Air and soil thermometers should be placed in a convenient position in the pit in order to keep a regular check on temperature. Two dutch lights, one on top of the other, are placed the length of the grafting pit in order that the condensation particles which form on the glass are smaller thus preventing too much water from falling on the grafts. In mid-December the miniature plants are brought into the glasshouse to a temperature of 70° to 75°F. This alternating cold and hot treatment seems to stimulate more rapid growth.

The stocks used for miniature rose propagation are *R. multiflora* and *R. canina.* The stocks are left outside in a cold frame after being laid in rows and covered with sand just over the neck of the stock.

The scion material should be ready immediately after Christmas or early January. The material should be firm, showing a good bud at the top but not necessarily in colour. Then, provided the stocks are opening, grafting can begin.

Grafting

When the scion material is taken from the mother plant two or three leaves should be left on the mother plant in order to reduce the check to the plant and encourage it to produce more scion material. Care should be taken to bring in only the amount of material that the grafters can deal with at any one time.

The tops of the stocks are removed leaving the neck about 1 inch long. If the roots are long these can also be trimmed to about 4 or 5 inches in length. Then on the stock itself a cut is made on the neck of the stock, about ¾ inch long, opening the bark slightly to the left and right of the cut. A scion is then made from the scion material by making a cut, placing the knife above and behind the bud and bringing the knife through at about a 22° angle. The scion is then cut off from the rest of the material about ¼ inch above the bud. When inserting the scion the bud should be lower or just level with the top of the stock; also a "church window" should be clearly visible in order to give a stronger union. The scion is then tied on with either cotton or fine string. The grafts are laid in rows fairly close together in the grafting pit, the roots being covered to leave 1½ inches of the top of the stock showing. Before putting the double dutch lights in position over the grafts Captan is sprayed over the grafts to prevent fungus attack. This operation is repeated every other day until the grafts to prevent funtion is repeated every other day until the grafts have made union.

Care of grafts

All the grafts should have callused and united and the bud should have started to grow within seven days.

During this period the dead leaves should be picked off each morning. In the callusing period shading with hessian or newspaper should be done immediately in case of bright sunlight to prevent temperatures soaring. Air is put on the pit about the 8th day after callusing has taken place but only for two to three hours on the first day, increasing an hour each day for the next five days. After the 13th day the dutch lights can be taken away and the plants can be syringed down occasionally in case scorching should appear. At all times the glasshouse should be kept humid to prevent the plants scorching after the eight-day period within a humid atmosphere. The plants are then potted up into 4-inch "long toms" when the shoots are 1 to 1½ inches high. After two weeks growth these shoots can then be used for further scion material thus cutting down the number of mother plants needed.

BUD-GRAFTING MAGNOLIAS

D. KNUCKEY
Treseders' Nurseries (Truro) Ltd.,
Cornwall.

The idea of propagating magnolias by bud-grafting stemmed from five main sources:

1. Mr. Neil Treseder had started research on a comprehensive book on "Temperate Magnolias and Their Hybrids", and had commissioned an artist to paint a set of the best forms to use as illustrations.
2. We knew that a few grafted plants of selected clones of Asiatic magnolias existed, and that these had reached flowering maturity considerably sooner than seedling plants of the same type (e.g. *Magnolia campbellii* subsp. *mollicomata* convar. *williamsiana* 'Lanarth'.
3. Mr. Treseder anticipated that the coloured illustrations in his book would stimulte a world-wide demand for plants of selected clones.
4. Early in 1967 Mr. Treseder carried out investigations into the propagation of magnolias by bud-grafting, including methods used in America and Japan. He learned that Japanese nurserymen were achieving considerable success by direct budding onto two-year *M. kobus* seedlings in open field conditions whilst still in their seedling rows.
5. We knew that an unfulfilled demand existed for selected clones of the Asiatic magnolias and that we would be able to produce bud-wood from most of these after negotiations with their owners.

We therefore started by planting up some *M. sieboldii* in a prepared bed in a sunny greenhouse and proceeded to shield-bud these in August, 1967, tying the buds in and sealing with polythene strips, in order to copy Japanese procedures as closely as possible. The results were disastrous with only approximately 2% take.

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We therefore started by planting up some *M. sieboldii* in a prepared bed in a sunny greenhouse and proceeded to shield-bud these in August, 1967, tying the buds in and sealing with polythene strips, in order to copy Japanese procedures as closely as possible. The results were disastrous with only approximately 2% take.

Dismayed, yet undaunted, we decided to try again in September and October, 1967, using as understocks two-and three-year pot-grown seedlings of *M. campbellii* subsp. *mollicomata* and *M. sargentiana* var. *robusta.* Once more we shield-budded, but this time tied the buds in with cotton and placed the plants in a tent of thin 'breathing" polythene inside a sunny, unheated greenhouse. The results this time were promising with approximately 60% take, but with an overwinter loss of a further 10%.

More than a little encouraged we prepared for 1968, buying in seedling stocks from various sources and potting them in preparation for budding from August onwards. We turned one of our glasshouses over especially for the project, with benches soil-heated at 70°-75°F, overhead lighting with 25 watt tungsten filament bulbs at 3-feet intervals on battens that could easily be raised with the plants as they grew. The lighting was on a time switch set to give a twenty-hour daylength and to cut in at dusk, with an intermittent 2 seconds in 2 minutes timer; this was sufficient to keep the plants in growth and cut down electricity consumption. Being in a frost pocket we also installed a thermostatically-controlled warm air heater set at 55° - 60°F as insurance against frost damage.

We commenced budding again in August 1968, using both shield-budding and chip-budding methods, again tying with cotton, and keeping the plants in a polythene tent under glass, watering being kept to a minimum. Once more we had approximately a 60% take. We continued budding in September-October and November-December, using shield-budding, chip-budding and veneer-grafting of small well-ripened shoots, tying in with cotton, but this time waxing over the whole area of the buds and grafts. In some cases, especially with evergreen types, we left a triangle of leaf blade attached to the petiole and found that growth of the bud was induced sooner. The take by March. 1969, with very little overwinter loss, was between 75% and 95%, according to variety and material used.

Conclusions

1. There appears to be no incompatibility, even between evergreen and deciduous species. The Japanese successfully bud *M. grandiflora* onto *M. kobus.*
2. Budding from September to December, using well-ripened budwood has been more successful than earlier budding in August.
3. Keeping the budded area as dry as possible proved of prime importance. Polythene ties tended to trap moisture with subsequent bud decay.
4. Overwintering the plants under artificial light and heat cut down the winter loss, encouraged growth and will, we hope, promote earlier maturity.

HEATED BINS FOR ROOTING WOODY CUTTINGS

PETER HUTCHINSON
Hadlow College of Agriculture and Horticulture
Kent

Bins in the past have generally been associated with the propagation of fruit tree rootstocks. From simple beginnings in the early 1950's, when they were just utilized for storage, uses for them in rooting hardwood cuttings have developed, with the inclusion of soil warming procedures. Firstly, temperatures of 45° - 50°F were used, but more recently 70°F appears to be the optimum, especially for apple rootstocks.

Why use bins?

1. To increase the number of field liners over that which can be obtained from using more traditional methods such as hardwood cuttings in the open or in cold frames, e.g. *Cotoneaster x watereri.*
2. To propagate ornamental plants closely related to fruit tree rootstocks, e.g. *Prunus cerasifera* 'Nigra', *Malus* 'Profusion'.
3. To propagate ornamental plants not normally propagated by hardwood cuttings, e.g. *Crataegus* 'Paul's Scarlet', for use as a hedging plant. By simplifying, the cost of production can be reduced.

Siting. Ideally the bins should be placed on the north side of a building where the fluctuation of temperature is reduced to a minimum. Cooler air conditions on the north side help in reducing bud break. Some form of shelter over the bin helps in regulating the amount of water applied to the cuttings. In order to keep as even a temperature in the bin as possible a further insulating barrier of straw bales can be used round the outside of the bin.

Time of propagation. Following work carried out by Dr. Howard at East Malling Research Station (primarily with apple rootstocks), the 3rd week in February until early March appears to be the optimum time for taking the cuttings.

Source. The best cutting material is obtained from well-maintained hedges which have been pruned annually, thus giving good vegetative growth with high regenerative capacity.

Type of cutting. The basal portion of the one-year-old shoot makes the ideal cutting, prepared with secateurs to approximately 6-inches long, cut as closely to the previous season's wood as possible. Nodal cuttings are made if material from further up the stem is used.

Treatment. A quick-dip hormone of IBA. A selection from the following concentrations are used depending on the plant: 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, 3.0%.

Examples (3 concentrations used per plant):

2%, 2.5%, 3% have been used on *Malus* 'Profusion' as these concentrations were nearest to those recommended for apples.

0.5%, 1%, 1.5%	have been used on *Corlyus avellana* 'aurea', as lower concentrations are recommended for cobnuts.
1%, 2%, 3%,	have been used for plants where no information was available.

The basal ½-inch of the cuttings are dipped for 3 to 5 seconds and then allowed to dry. The cuttings are then packed into bundles of ten to minimise drying out in the centre of the bundle.

Temperature — soil warming. One each of three bins are set at 60°F, 70°F, and 80°F, 70°F being the generally recommended temperature. However some difficulty was experienced, due to the unreliability of the thermostats.

Insertion. The bundles of cuttings are buried to half their length in a peat/grit compost.

Watering. It is important not to allow the compost to dry out at the base of the cuttings. Watering should be reduced as soon as hardening off commences.

Summary: A considerable percentage of cuttings from a wide range of ornamental plants callused and rooted whilst in the bin. The subsequent check to these cuttings when removed and bedded out in a cold frame proved too much of a setback and generally, therefore, the final results were poor.

A close watch must be kept on the cuttings whilst in the bins, as callusing takes place rapidly at that period of the year, and a very close watch must be made on the moisture content of the compost at all times. Careful and gradual hardening-off is necessary in order to prepare the cuttings for lining or bedding out.

Bundling of the cuttings is not recommended as the cuttings callused into one another and as a result a large number decayed. We were, however, able to assess the plant's ability to callus.

We would have liked to have been more successful but we were sufficiently satisfied with the results to decide upon further trials in the coming season.

Plants used in our trials:

Tilia x euchlora *Tilia platyphyllos* 'Rubra' *Tilia petiolaris*	Callus and roots
Crataegus 'Paul's Scarlet'	100% callus
Crataegus arnoldiana	Callus
Corylus avellana 'Aurea' *Corylus avellana* 'Contorta' *Corylus maxima* 'Purpurea'	Callus and roots

Prunus spinosa 'Rosea' *Prunus cerasifera* 'Nigra' *Prunus serrulata* 'Sekiyama' ('Kanzan') *Prunus serrulata* 'Shirofugen' *Prunus* 'Accolade'	Callus and roots
Cotinus coggygria (*Rhus cotinus*) 'Folius purpureis' *Cotinus coggygria* (*Rhus cotinus*) 'Rubrifolius'	Callus and roots
Malus 'Profusion'	Callus and roots
Morus alba *Platanus x acerifolia* *Acer saccharinum* 'Pyramidale'	Callus

Materials required for building a 'Garner' Bin, with approximate cost:

SIZE OF BIN — INTERNAL DIMENSIONS — 10 feet x 4 feet x 2 feet, 3 inches. (40 sq. ft. of bin capable of holding 10,000 to 12,000 cuttings)

	£	s	d
13 sq. yds. Thermalite blocks at 13s.8d. per sq. yd.	8	17	8
2 gallons bitumastic paint	2	0	0
1 thermostat and soil warming cable	9	16	3
1 cwt. cement and sand		10	0
40 sq. ft. wirenetting, ½ inch mesh		15	10
Peat/grit compost		15	0
5 asbestos sheets 6 ft. x 2 ft. 6 inches x 3 inches	6	18	0
80 ft. timber, 2 inches x 2 inches @ 6d. per ft.	2	0	0
	£31.	12.	9.

Additional cost would include connection of the soil-warming cables to the mains supply.

Procedure:

Level site and cover with 2-inch layer of coarse gravel to give good drainage. Paint blocks required for base (42 blocks), allow to dry. Lay blocks for base close together; do not use cement, this allows for free drainage.

Build sides of bin using unpainted blocks; provide for damp course between bin and building and make sure that pointing is of a high standard. Keep blocks dry. When building is complete, paint all exposed surfaces with bitumastic paint.

Place 2 inches of grit in base of bin. Attach heating cable to piece of wire netting at correct spacing, this provides for easy removal of heating cables when clearing out the bin. Place 3 to 4 inches of compost (equal parts peat and ¼-inch grit) over heating cables. Drill hole in side of bin for insertion of the thermostat. This should be placed so that it is at the same level as the base of the hardwood cuttings. Build the shelter.

J. WELLS: Has anyone used pure sphagnum moss as a medium for these bins?

PETER HUTCHINSON: Not straight sphagnum, though sphagnum has been included in mixtures which have been used.

J. WELLS: I think that it would be worth trying pure sphagnum. We have found it to be successful with cuttings of such plants as *Thuja occidentalis,* taken in February and treated with hormones, then bundled and packed with their bases in sphagnum and kept in artificial light for six weeks in a cellar. These callus and begin to root and develop most successfully when placed in sand in frames, perhaps six weeks later. In this way we can extend the propagating season when conditions outside are severe. Sphagnum has also proved a very good medium for rooting *Chamaecyparis obtusa* 'Nana Gracilis'.

R. GARNER: With these problems we are, of course, concerned with sphagnum from the point of view of root development rather than root initiation.

B. H. HOWARD: The hardwood cutting bin was designed originally for long cuttings — 24 inches or so. Thus, when shorter cuttings are used and the compost reduced to about six inches there will understandably be greater fluctuations in temperature.

J. K. HULME: We have had some excellent rooting performances with these insulated bins though sometimes this has been followed by heavy losses subsequently. Our procedure has been to take cuttings from vigorous shoots when available, 7 to 12 inches long, depending on the species. The cuttings were prepared during the period from late February until the end of the third week of March. The cuttings were inserted in a 50/50 peat-sand mixture with a basal temperature of 70° to 73°F. Rooting generally took place quickly; in some cases good root formation occurred within 14 days. The cuttings were then lined out in nursery rows. The weather was colder than average in April, and May was excessively wet with a record rainfall for our site of over six inches.

Pterocarya fraxinifolia (*P. caucasica*) and *P. rehderiana* rooted well but 90% of the cuttings died in early summer. *Corylus avellana* rooted reasonably well but subsequently all died. The few *Alnus glutinosa* which rooted died. Only *Cornus alba,* 'Sibirica', and the common species of *Salix* and *Populus* continued to grow well; in all cases the species which did well can be rooted from hardwood cuttings without the aid of an insulated bin and high base temperatures. We shall be undertaking further trials in 1969-70.

PROPAGATION OF PLANTS FOR CONTAINERS

R. D. ANDERSON
Darby Nursery Stock, Ltd.,
Thetford, Norfolk

We are wholesale producers of container-grown plants and our object is to produce a plant which is well-grown and well-rooted in the container, attractive to the eye and easily transportable, as we feel a plant of this kind is best suited for self-service garden centre sale. These points need not apply to material produced for landscape work where larger plants are required.

There are two methods of producing a plant in a container:—

1. *Container-grown.* Plants are grown in containers throughout their life.
2. *Field-grown then containerised.* One-year liners or older plants are lifted from the field and potted into containers.

In order to achieve our objectives we use the "container-grown" method to produce all our plants, with the exception of trees and roses which, because of their method of propagation, do not fit easily into this system.

We chose this system for the following reasons:

1. We have more control over plant growth, which in turn leads to a more uniform produtc.
2. The plants in their pots receive no check and, therefore, suffer less from yellowing and loss of leaf.
3. The final potting into a 7-inch polythene container is much easier when dealing with a well-established plant in a Jiffy Pot than with a large bare-rooted plant.
4. We have no existing business in bare-rooted, linedout ornamenal stock.

Our system of propagation may be summarised as follows:—

1. All the cuttings obtained from stock beds or from young stock are inserted in trays and placed under mist. A few subjects are raised from seed by direct sowing into Jiffy Pots.
   Deciduous cuttings — May to September
   Evergreen cuttings — September to May.
2. (a) Cuttings rooted before the end of August are potted into 3-inch Jiffy Pots and packed in wire-mesh trays, 16 pots per tray.
   (b) Cuttings rooted after the end of August are left in cutting trays and overwintered in a frost-free greenhouse until spring and then potted up into 3-inch Jiffy Pots.
   (c) Evergreen cuttings rooted over-winter are potted in spring and early summer into 3-inch Jiffy Pots.

3. All plants in Jiffy Pots are over-wintered in either —
    i) hessian-covered shelters,
    ii) cold frames with hessian covers,
    iii) frost-free glasshouses.
4. Final potting of Jiffy-Potted plants takes place from April to June, and is carried out on a piece-work basis using female labour from our Marketing Company which conveniently has a slack period about this time of year. The Jiffy-Potted plants, having been trimmed over with a knife where necessary, are transported in their trays to our "growing-on" site, situated on an old aerodrome runway.

    Compost is mixed with a hired cement mixer and consists of a peat/sand mixture (3:1) with a base dressing of Plantasan added. The compost is transported into the potting shed by means of a conveyor belt, and the conveyor is serviced by a tractor using a front-mounted bucket lift.

    The potted plants in their final containers are transported out of the potting shed on trolleys and then the trolleys are towed down the runway which is laid out with a series of capillary beds. The plants are removed singly from the trolley and stood out on the beds, where they remain till they reach saleable size. Provision is made to cover certain subjects with Hessisian covers over winter.

    In certain cases, where propagating material is short and it is necessary to purchase from an outside source, we buy one of the following: —
    i) unrooted cuttings,
    ii) rooted cuttings,
    iii) young plants established in 3-inch pots,

    and by doing this we can conveniently absorb the material into our existing system.

The majority of deciduous plants are ready for sale towards the end of the summer following potting into final containers. Conifers and slow-growing evergreens usually require two growing seasons in the final pots before reaching saleable size.

This system is used for hardy nursery stock and any plant which will not fit into the system has to be discarded. Plants which require special treatment during propagation and which we wish to grow must be purchased from an outside source in an acceptable form. Alternatively, we must set up a special section in our propagating department to deal with the exceptions; we can only justify this step if the particular item is required in quantity and is difficult to obtain from a specialist producer at an economic price.

HOW HARD DO WE WORK?

THOMAS C. THURSFIELD
Light Oaks, Milton,
Stoke-on-Trent

With the introduction of modern herbicides and machinery is there more time to spare when the spring planting is over? On our nursery we have no mechanisation at all as the soil is moist, peaty and light, with no stones at all. We plant everything in beds by hand as you will see on the film and we crop the ground heavily. After shrub planting, as we have no container trade we decided to increase and extend our selling time by producing about 250 to 300 thousand spring and summer flowering border and herbaceous plants. We sell these on our two outdoor market stalls in local towns in the industrial Potteries area, which is a mainstay of our existence.

We operate our nursery as three small units. The smallest, operated by my father and two women part-time workers, produces from seed as many plants as possible in boxes of 60, for transplanting on to spare beds in the nursery. As we use farmyard manure regularly we find this good preparation for rotation of shrub planting.

The second unit of 4 acres is operated by my brother and one man. Here we grow our ornamentals and flowering trees from whips or young grafts, which we buy in. His empty beds are also filled with root plants.

The third and largest unit of 9 acres and increasing one acre every two years is operated by myself with two men and one student during summer holidays for picking off small plants. This unit is put over to mixed flowering shrubs, rhododendrons and conifers in variety of which we produce a great deal of our own stock from cuttings of various types and from layers. The empty beds here are also filled with herbaceous and border plants such as wallflowers, polyanthus, primulas, lupins, geums, delphiniums, golden ball, scabious, rock plants, etc. Planting starts about mid-June and continues until September. During this time we also have to keep the shrubs clean as we do not use any Simazine-type herbicides, only Paraquat if the season is wet and the weeds grow too quickly for hand control. We can carry on planting in dry weather as the soil is moist and does not dry out.

(*Editor's Note*: Readers who have not seen Mr. Thursfield's slides, which were shown at the Conference, will have difficulty in visualising he extraordinarily intensive cropping and high output from this nursery)

PLANT PROPAGATORS' QUESTION BOX[1]

FRANK WILLARD: Can I have comments from members on the quality of hardy hybrid rhododendrons when grown on their own roots? I understand that a well-known Dutch nursery has given up growing varieties of the 'Pink Pearl' type from cuttings because, though they root satisfactorily, they do not ball-up as well as grafted plants.

JIM WELLS: In the USA I gave up grafting on *R. ponticum* because of wilt disease. I would never go back to grafting. If a variety will not root from cuttings then we do not grow it. A few varieties do not produce satisfactory root systems.

A QUESTIONNER: Does *R. ponticum* rootstock produce a plant tolerant of a wide range of soil pH levels?

JIM WELLS: I do not think so.

BRIAN HUMPHREY: There is a tendency for varieties on their own roots to be less tolerant of poor drainage. Otherwise there are no ill effects as far as we can tell.

We find that quick-dip alone gives as good a result as wounding plus the use of hodmone powder. If we get much callus forming we consider this to mean we have used too low a hormone concentration.

We use four strengths of IBA on rhododendrons: —

(i) 0.25 gm IBA dissolved in 100 ml of 50% methylated spirits, for *R. cinnabarinum, R. griersonianum* and its hybrid progeny such as 'Elizabeth' and 'May Day'.

(ii) 0.5 gm IBA similarly dissolved. For certain of the hardy hybrids such as 'Alice,' and *R.* x *morelianum* Fatuosum Flore Pleno.

(iii) 1 gm IBA similarly dissolved for 'Pink Pearl', 'Hugh Koster' and 'Doncaster'.

(iv) 2 gm IBA dissolved in 100 ml of 60% methylated spirits, the extra strength being necessary to keep the IBA crystals in solution. This is used for a variety like 'Britannia'.

FRANK WILLARD: Has anybody succeeded in rooting *Hydrangea petiolaris* from cuttings?

A. P. D. MCMILLAN-BROWSE: It is not difficult to root the soft tips early in the season made into cuttings about 3 inches long. The difficulty lies in getting these rooted cuttings to grow.

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[1] **Editor's note.** An appreciable proportion of the time allocated to the "Question Box" was spent on discussion and questions concerning papers given earlier in the Conference and for which there was no time available for the purpose For the convenience of readers this information has been included at the end of the appropriate papers.

S. W. BOND: These plants develop easily from layers. Lay the shoots on a sandy soil in the open.

A QUESTIONNER: Any ideas, please, on the best method of propagating *Carpenteria californica?*

D. KNUCKEY: Cuttings will root easily enough early in the year in pure sand.

A QUESTIONNER: How can you get *Ceanothus impressus* to root and develop without decay?

JOHN GAGGINI: Cuttings with trimmed heels rooted in sharp sand under mist in August. Pot on after rooting and leave under glass over winter.

A QUESTIONNER: Any recommendations for *Azalea* 'Exbury hybrids'.

D. KNUCKEY: It is advisable to grow the stock plants under glass. We take cuttings in June and use 1% Rhizopon A.

FOURTH SESSION

THE PROPAGATION OF CONIFERS BY CUTTINGS

Ir. B.C.M. van Elk
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The propagation of conifers by cuttings in Boskoop differs a little from the methods used elsewhere in the world, though this does not mean that part of the research cannot be modified for use in other areas. It is rather difficult to translate the results gained in a cold double frame outside to a glasshouse, with or without mist equipment.

Cutting material used in England is quite different from ours. In Boskoop we usually take weak-growing side tips of young plants in full growth. It must be remembered that in Boskoop we have to send you small plants because of import taxes, transport costs, etc; so we have to take our cuttings from young plants, whilst you, perhaps, may take them from larger plants which we do not have.

Conifer cuttings are taken during autumn which, as I shall subsequently show you, is usually the best time. So far as I know the selection of the right time is largely by trial and error and with the art of "green fingers". The Adivsory Service takes it for granted that root formation is disminished if cuttings are taken during rainfall.

In Boskoop the length of the cuttings is 5 to 7 cm (2 to 3 inches), but there are some growers who take cuttings double or three times this size; by doing this they will obtain a saleable plant in a shorter time. Although the rooting time is the same the growth from the larger cutting is much better.

Most of the cuttings are placed in a mixture of 4 to 2, or 4 to 1, parts of brown peat and coarse river sand. These mixtures have a rather low pH, 4.5 down to 4.2, but this is excellent for rooting cuttings. Sand helps the aeration and the peat holds the moisture; these mixtures are rather sterile and are not rich in food. Of course, there have been experiments with perlite and with other sterile products beside peat but, in general, the results were either the same or a little less satisfactory than our standard mixtures, and the price of these other products is too high.

Looking ahead, I should say cutting production under pressure of rapidly changing production methods must be made in blocks of an artificial chemical compound which can be placed in other blocks and, in some cases, even into further blocks in which a saleable plant size is obtained. In Boskoop, the mixture is spread over the surface in a cold frame and pressed together a little. It can also be used in clay pots or in boxes which can be placed in a bed in a glasshouse or in a mist propagation house. In a frame the cutting will stand until September in the year following insertion. From the glasshouse the cuttings are placed in a cold frame, depending upon the time of rooting of the cuttings, for these houses are too expensive to use them only once during the year.

The use of Captan. Most cuttings are wounded by slicing the bark; after this they may be treated with rooting compounds, such as Seradix. We use mostly 0.1% NAA or 1% IBA. Very often the nurseryman starts with a 50/50 mixture of 10% Captan dust and a growth hormone dust of double concentration. He has the advantage of a good concentration of growth hormone and at the same time protection of the base of the cutting by Captan. The bases are simply dipped in the powder mixture. Alternatively, cuttings are stood in a hormone solution for 24 hours, dried for 15 minutes, then dipped in Captan dust to provide the same protection as for dust-treated cuttings. By using mixtures of a growth hormone and Captan you will see in the tables that the rooting percentages have been improved.

After insertion, the cuttings must be watered. This is done with a solution of 2 g/litre of Captan spray material (83%) to prevent the development of fungi in the frame or glasshouse. This treatment is different from the powdering of the base of the cutting; powder application raises the rooting percentages an average of about 20%.

Captan cannot always be used. When the cuttings are placed in a warm environment as, for instance, in mist during full summer conditions, they decay at the base when treated with a soluble growth hormone, or a combination of growth hormone and Captan. This warning follows research work carried out recently concerning the improvement of rooting by heating cold frames.

Table 1. Effect of IBA and Captan on rooting cuttings of two conifer clones.

Treatment	Percentage Rooted
Chamaecyparis lawsoniana 'Stewartii'	
(1) Not treated	0
(2) Treated with 25 mg/litre IBA only	16%
(3) Treated with Captan only	0
(4) Treated with 25 mg/litre IBA + Captan	84%
X *Cupressocyparis leylandii* 'Haggerston Grey'	
(1) Not treated	4%
(2) Treated with 100 mg/litre IBA only	40%
(3) Treated with Captan dust only	12%
(4) Treated with 100 mg/litre IBA + Captan dust	68%

Table 2. Effect of different hormone treatments on rooting percentage of *Chamaecyparis nootkatensis* 'Pendula'.

Growth hormone	Without Captan	With Captan
Not treated	16%	—
50 mg/litre IAA	32	66%
100 mg/l IAA	22	82
150 mg/l IAA	48	70
25 mg/l NAA	26	76
50 mg/l NAA	38	70
75 mg/l NAA	42	78
50 mg/l IBA	40	68
100 mg/l IBA	34	72
150 mg/l IBA	18	88

Temperature. In the 1963/64 season research was carried out wherein one-third of a batch of cuttings was treated in the normal way in a cold frame; a further third was given bottom heat at a temperautre of 15°C in the frame with an electric low tension cable from the time of insertion until the beginning of December, and again from the beginning of February until mid-May. The last third was only heated in the first year before winter, and the following year only after winter during the same times as for the previous group. In general, heating raised the rooting percentages by about 10%, but when the cuttings were also treated with Captan there was no difference.

Table 3. Rooting percentages obtained with 12 conifers in the year 1964/65.

Treatment	No heat	Heated before and aftei winter	Heated only after winter
Without Captan	42%	54%	42%
With Captan	60%	68%	63%

Table 4. Rooting percentages with 15 conifers from which cuttings had been made between September and mid-November, 1967.

Treatment	No heat	Heated before and after winter	Heated only after winter
Without Captan	43%	58%	39%
With Captan	64%	53%	44%

Table 5. Rooting percentages obtained with *Chamaecyparis* cuttings over two 2-year periods.

Temperature:	15°C		18°C	
Years:	1964 and 1965		1966 and 1967	
Captan:	—	+	—	+
Not heated	60%	82%	63%	81%
Before and after winter	71%	82%	52%	59%
Only after winter	63%	82%	48%	35%

It can be seen from Table 5 that raising the bottom temperature from 15°C to 18°C had a negative effect on rooting. At 15°C the use of Captan led to a uniformly good rooting percentage.

Table 6. Rooting percenttages obtained with *Juniperus* cuttings over two 2-year periods.

Temperature:	15°C		18°C	
Years:	1964 and 1965		1966 and 1967	
Captan	—	+	—	+
Not heated	43	60	44	74
Heated before and after winter	53	65	53	60
Heated only after winter	45	54	32	46

From Table 6 it is seen that the rooting percentage is higher at 15°C when the frame is heated before and after winter. There is the same tendency in *Juniperus* as in *Chamaecyparis* for the rooting percentages to be lower at 18°C than at 15°C and that there is, at this higher temperature, a lowering of the rooting percentage when treated with Captan.

However, good results can be obtained under mist in a warm glasshouse during the summer but, of course, the cuttings are then in a different stage of development.

Tsuga canadensis 'Pendula' reacts well to bottom heat. Cuttings rooted in a cold frame, as well as those rooted in a frame — heated both before and after winter — produced 84% rooting; in the latter treatment, however, the root system was three times the size as those on cuttings rooted in cold frames.

Juniperus chinensis 'Blaauw's Varietat' makes a lot of roots when cuttings are taken at the beginning of September and placed in a rather warm glasshouse. The roots are produced before winter. However, with this variety one can get total failure if the cuttings are not in the right condition.

When placed under mist, cuttings can be taken over a much longer period because it is possible to use material which can be either soft or hard. In general, however, too warm a glasshouse may lead to a total failure. We would not recommend large scale use of a growth hormone or Captan dust without the grower first having obtained experience in small trials.

Time of making cuttings. Table 7 explains some investigations we have carried out recently concerning the best time of taking the cuttings. Every 14 days 100 cuttings of the two chosen conifers were taken, treated, and placed in a cold frame for rooting. Until mid-September the *Chamaecyparis* cutting material was too soft for good rooting. After mid-October it was too late to root the *Juniperus* cultivar.

The investigations were extended to cover some other species and cutivars, as shown in Table 9.

Only with 'Grey Owl' is the seasonal rooting pattern constant. The other three conifers do not react uniformly. After four years we have come to the conclusion that, in general, best results are obtained by taking cuttings of these conifers between the beginning of September and early December.

Experiments with *x Cupressocyparis* over two years showed clearly that the best time for taking cuttings was before the end of October.

For rooting under mist the best advice that can be given is to make the cuttings as early as possible. Try to have a low

Table 7. Effect of timing on rooting obtained with two conifer clones.

Date	*Chamaecyparis obtusa* 'Nana Gracilis' No Rooted	*Juniperus virginiana* 'Grey Owl' No. Rooted
15 Aug.	49	98
29 Aug.	57	95
12 Sep.	54	96
26 Sep.	93	96
10 Oct.	90	68
24 Oct.	98	15
7 Nov.	99	23
21 Nov.	99	11
5 Dec.	100	3
19 Dec.	100	8
16 Jan.	99	38
30 Jan.	98	31
13 Feb.	99	10
27 Feb.	100	9
13 Mar.	98	4

Table 8. Effect of timing on rooting obtained with cuttings of two *Chamaecyparis* and two *Juniperus clones*. Number of cuttings rooted from 100 inserted.

Date	*Chamaecyparis*		*Juniperus*	
	lawsoniana 'Silver Queen'	nootkatensis 'Lutea'	squamata 'Meyeri'	virginiana 'Grey Owl'
28 Aug.	85	79	61	98
11 Sep.	69	80	26	100
25 Sep.	46	35	20	97
9 Oct.	84	55	44	85
23 Oct.	73	78	33	50
6 Nov.	74	38	39	1
20 Nov.	13	12	33	5
4 Dec.	52	30	30	1
18 Dec.	12	19	32	0
22 Jan.	71	43	33	14
5 Feb.	30	3	10	2
19 Feb.	17	18	19	9
4 Mar.	25	1	42	4
Mean	50	38	32	36

Table 9. Rooting percentages and root quality index for *Cupressocyparis* cuttings, as influenced by time of taking cuttings and by Captan applications.

Date cuttings taken	Rooting Percentages (with quality of root system)	
	Without Captan	With Captan
1965-66		
6 Sep.	66 (2.8)[1]	70 (2.4)[1]
5 Oct.	68 (2.4)	62 (2.5)
3 Nov.	16 (1.9)	32 (2.3)
2 Feb.	4 (2.0)	16 (2.3)
1966-67		
20 Sep.	57 (3.3)	76 (3.6)
9 Oct.	68 (3.4)	83 (3.6)
23 Oct.	72 (3.5)	73 (3.7)
6 Nov.	27 (2.5)	39 (2.5)
12 Feb.	21 (2.1)	50 (2.6)

[1] See discussion at end of paper for method of calculation.

temperature in the glasshouse and do not water the cuttings too much during winter. At that time it is better to water only when necessary, perhaps once a week, and to cover the beds with a sheet of plastic (0.02 mm thick) until the mist can be started again at the beginning of February.

Which growth hormone? New proprietary materials are introduced onto the market with clock-work regularity. Up to now they are all based on IBA, IAA, NAA or a combination of these, with or without a fungicide. These introductions provide a constant and time absorbing field of research.

In one series of experiments we compared the growth hormone according to the "Stekboek"* with Veratine, Jiffy Grow and two normal powders of NAA and IBA. Veratine, of which the base is unknown to us, requires the cuttings to be soaked for 15 minutes in a solution of 20 ml/litre. Jiffy Grow is a quick-dip product imported from America which can be used at full strength or at 1 in 9 water dilution.

Results with a number of subjects in 1966-67 are summarized in Table 10.

Table 10. Effect of several hormones on rooting obtained from cuttings of a number of conifer clones. 1966-67.

	Growth hormone "Stekboek"	Veratine	Jiffy Grow	NAA 0 2%	IBA 2%	Verapon
Captan	+	+	+	+	+	—
Chamaecyparis						
C. lawsoniana 'Naberi'	56	54	—	48	6	—
C. l. 'Silver Queen'	98	52	36	6	2	8
C. l. 'Stewartii'	98	98	14	56	50	58
C. l. 'Stewartii'[1]	100	98	32	100	70	84
C. l. 'Triomf van Boskoop'	90	90	72	76	46	38
C. l. 'Triomf van Boskoop'[1]	94	90	74	80	62	76
C. nootkanensis 'Glauca'	68	86	52	66	56	50
C. n. 'Lutea'	78	88	10	74	50	52
X Cupressocyparis						
C. leylandii 'Haggerston Grey'	60	12	—	0	12	—
Juniperus						
J. chinensis 'Blaauw Varietat'	46	94	—	98	100	94
J. c. 'Plumosa Aurea'	94	82	0	84	94	76
J. communis 'Repanda'	100	100	1	95	99	—
J. communis 'Suecica'	98	98	—	98	97	—
J. Scopulotum 'Spring Bank'	22	4	—	22	0	0
J. virginiana 'Skyrocket'	96	94	—	92	94	—
Taxus						
T. baccata 'Semperaurea'	76	72	—	66	32	—
Tsuga						
T. candensis 'Pendula'	96	90	8	12	—	—

[1] Cuttings taken from young plants.

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*The "Stekboek" recommendations mean treatment with 50, 100, 150 or 200 ppm of either IAA, IBA, or NAA, depending upon the cultivar.

It can be seen that "Stekboek" and Veratine have given very similar results. Sometimes it does not matter which hormone is used; in some cases these varieties will root satisfactorily without a growth hormone. When using an adapted growth hormone both the rooting percentage and the quality of rooting will be better. With a number of varieties there will be a difference of 20% from one year to another.

One thing can be noted. In the two cases in Table 10, where cuttings were taken both from older and from younger (4-yr.) plants, the reaction to some of the powder treatments was much better with the cuttings taken from the younger plants than from the older ones.

It can, therefore, be seen that the mean rooting percentages with "Stekboek" growth hormone, Veratine and 1/10 Jiffy Grow are more or less the same. Jiffy Grow at full concentration is too strong for almost any cutting; it causes them to rot at the base. Again the powdered cuttings rooted less satisfactorily than the soaked ones.

This experiment was repeated in 1968-69 and the results are summarised in Table 11, but even now we do not advise the use of these hormones, for a good advisory man in our country must be safe with his recommendations. Of course we pass on these results but we leave the decision on the use of the materials to the growers.

Finally, some results are given in Table 12 with four clones of *X Cupressocyparis leylandii.*

We have come to the conclusion that more experience is needed before the use of Veratine and the weak, quick-dip solutions of Jiffy Grow can be advised officially. With other well-known IAA, IBA and NAA preparations we already have 25 years experience.

Table 11. Effect of several hormones on rooting obtained from cuttings of a number of conifer clones. 1968-69.

	Growth hormone "Stekboek"	Veratine	Full Strength Jiffy Grow	1/10 Jiffy Grow	0.2% NAA
Captan	+	+	+	+	+
C. lawsoniana 'Forsteckensis'	98	100	8	100	100
Chamaecyparis					
C. l. 'Tharandtensis Caesia'	76	65	3	69	61
C. obtusa 'Filicoides'	70	60	0	72	48
Juniperus					
J. chinensis 'Keterleeri'	26	80	0	52	0
J. c. 'Pfitzeriana'	96	98	2	94	92
J. c. 'Plumosa Aurea'	81	55	0	52	18
J. virginiana 'Skyrocket'	85	74	0	92	82
Tsuga					
T. canadensis 'Pendula'	74	78	0	77	26
Mean	76	78	2	76	53

Table 12. Rooting percentages and root quality index of four clones of X *Cupressocyparis leylandii* as influenced by the auxin used and by Captan.

Clone	Rooting Percentages (with quality of root system)		
	IBA 100 mg/litre		NAA 0.2%
Captan	—	+	+
'Green Spire'	83 (4.2)[1]	93 (4.2)[1]	50 (3.2)[1]
'Haggerston Grey'	78 (4.4)	92 (4.1)	32 (3.1)
'Leighton Green	84 (4.0)	86 (3.9)	9 (2.3)
'Naylor's Blue'	55 (4.6)	95 (3.7)	0 (0)

[1] See discussion at end of paper for method of calculation.

JIM WELLS: Can the speaker explain how he arrives at the figures which relate to the quality of the rooting system and which were included in some of his rooting percentage tables?

B. C. M. VAN ELK: Yes, we grade our rooted cuttings on a five point scale, the grading taking into account both the quality and the quantity of the rooting system. Grade 1 is very light rooting; 2, light; 3, good or average; 4, heavy; 5, very heavy rooting. The number of cuttings in each grade is then counted. This number in each grade is then multiplied by the grade number itself, the numbers added together and the total divided by the number of cuttings. The resultant figure gives the quality assessment of the root system.

An example will show this more clearly: —

GRADE	1.	2.	3.	4.	5.	TOTAL
Number of cuttings in grades	10	10	30	40	10	100
Multiplying above number by grade number	10	20	90	160	50	330

Thus 330 divided by 100 gives 3.3, which is the quality grade assessment of the root system in this case.

BRIAN HUMPHREY: How do you obtain your 1/10 strength Jiffy Grow?

B. C. M. VAN ELK: Merely by diluting 10 ml of the product with 90 ml water.

BRIAN HUMPHREY: But is this, in fact, effective? A quick-dip technique requires an alcohol solution to ensure the rapid penetration. By diluting with this amount of water surely the material can no longer be effective as a quick-dip? For example, IBA in 50% alcohol is effective as a 5-second quick-dip, but the material in water requires soaking.

B. C. M. VAN ELK: We find it effective as a diluted quick-dip.

JIM WELLS: We have abandoned Jiffy Grow as we cannot get consistent results. However the material does, I believe, contain boron. We have used boron at 50 ppm, which has given good results when added to a hormone; it seems to increase the potency of the hormone.

B. C. M. VAN ELK: We have used boron widely without finding any significant results. But then we use cow manure at 70 tons per hectare every 2 or 3 years, so obviously our boron level is well maintained in the soil.

A. D. WEGUELIN: In France they are using CO_2 to hasten the rooting of cuttings. Has any work been done on this at Boskoop?

B. C. M. VAN ELK: Yes, but a 0.06% concentration gave no results. In the peat in which we place our azaleas we have CO_2 concentrations approaching 0.11%. We have not tried higher concentrations.

JAMES KELLY: At Kinsealy, a pilot trial has suggested that the illumination of cuttings in winter may give very good results. With *Chamaecyparis lawsoniana* 'Fraseri' and *Juniperus chinensis* 'Pfitzeriana', rooting occurred more quickly and thoroughly where the natural daylight was supplemented by mercury vapour lamps. We hope to continue our experiments and collect more substantial evidence.

LIGHTING — ITS EFFECT ON ROOTING AND ESTABLISHMENT OF CUTTINGS (A SHORT REVIEW)

A. B. MACDONALD
Glasshouse Crops Research Institute,
Littlehampton, Sussex

Searching through the literature, one finds that a considerable amount of research and experimentation has been carried out relative to this subject, particularly in the United States, U.S.S.R. and some European countries. Lighting has three main roles. These are —

1. *Rooting of cuttings.* This can be subdivided into —
   a) treatment of the stock plant;
   b) application to the cutting in the actual rooting bench.

2. *Establishment of rooted cuttings.* This can be interpreted as the continuation of growth to delay or prevent dormancy, with the aim of reducing losses of specific deciduous subjects during the winter.

3. *Breeding.* To speed up a breeding programme when plant breeders are anxious to see the results of their crosses earlier, e.g. *Rhododendron,* which has flowered after 3 years instead of 6 years. It may be practical with some subjects to

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3. *Breeding.* To speed up a breeding programme when plant breeders are anxious to see the results of their crosses earlier, e.g. *Rhododendron,* which has flowered after 3 years instead of 6 years. It may be practical with some subjects to

cause plants of early and late varieties to bloom simultaneously so that they can be hybridized.

I have purposely used the term "lighting" in this paper, as supplementary light has been used both to give photoperiodic and photosynthetic effects. It is most important to establish the difference between photoperiodic (daylength) and photosynthetic effects. Some of the literature can be misleading where supplementary light is discussed, as in most cases it is used mainly to control daylength.

Definition's to distinguish between the two are as follows:

Photoperiodic use — Extended daylength where low intensities of light are required; 5 to 50 foot candles. Here the light is at non-photosynthetic intensity.

Photosynthetic use — Actually supplementing the natural daylight, with the aim of increasing photosynthesis (building up carbohydrate reserves); approximately 400 foot candles or more are required. It is important to bear in mind, however, depending on the length of period it is given, that daylength can also be increased.

PHOTOPERIOD (daylength)

In the early 1920's Garner and Allard (1) showed the reason why some plants flower only in winter and not at all in summer. They found that this was dependent on the number of hours of daylight and darkness the plants received each day. The term given to this phenomenon was photoperiodism. This can be defined as a phenomenon in which relative lengths of light and darkness influence the development of plants, or alternatively, as the controlling action of the daily duration of light or dark on the flowering of some kinds of plants. They subsequently classified plants into three groups depending on their response. They are —

1. *Short-Day plants* — these only flower when the daily light period is less than a critical value; e.g. chrysanthemum.
2. *Long-Day plants* — these only flower when the daily light period is above a critical value; e.g. *Hibiscus syriacus.*
3. *Day-Neutral plants* — flowering of these plants shows no photoperiodic response; e.g. *Buddleia.*

This early work on photoperiodism was concerned entirely with flowering, but daylength can also control other plant processes. For example, dahlias — where a fibrous root system develops under long days and thicked storage organs in short days. Photoperiodism can also provide a survival mechanism. Plants which do not cease growing long before the arrival of early frost may be injured or killed outright. An example is the sycamore-maple, *Acer pseudo-platanus,* where new growth ceases by early July, immediately after the commencement of short days, thus helping to "condition" the plant for the winter.

Since the early 1920's, the physiologists' knowledge of photoperiodism has developed considerably. This knowledge has been applied to commericial horticulture, for what can best be described as "precision growing"; chrysanthemums, poinsettias and kalanchoes can be flowered at any time of the year by regulating the duration of the "light" and "dark" periods. Chrysanthemum "stools" naturally produce cuttings at specific times during the autumn and winter, but by controlling the daylength. they can be maintained in a vegetative condition throughout the year. This illustrates how one's knowledge of photoperiodism can improve management of a nursery.

STOCK PLANTS

In some species of woody plants the development of roots in cuttings has been found to be sensitive to daylength. Rooting is nearly always inhibited by S.D.; thus it has been found practical to produce artificial L.D. to encourage rooting in certain species.

A number of workers have found that the daylength to which the stock plant is subjected has an effect on subsequent rooting responses of cutting. Some of the earlier work was carried out in Russia by Moshkov and Kocherzenko (2) which showed that the photoperiodic treatment given the stock plant can affect the rooting of cuttings taken from it, as well as having a direct effect on the cuttings themselves. They found that when cuttings of *Salix undulata* were taken from stock plants in long-day conditions, they all rooted. At the same time, rooting did not occur with cuttings taken from stock plants which were held under short-day conditions. A rather similar response was found with other species of *Salix*. The importance of this is that it helps to explain seasonal variation in rooting and emphasies the importance of the time of year cuttings are taken.

This response was confirmed later by Waxman (3), working with *Cornus florida* 'Rubra.' He found that cuttings from plants held in short-day conditions for 45 days rooted only half as readily as those from plants in long-day conditions for the same period. The cuttings did not root if the short-days were extended for 125 days.

A rather different effect was found by Kelly (4) using *Ilex crenato* 'Hetzi'. Cuttings taken from plants receiving 30 and 40 short days rooted best, while cuttings from stock plants grown entirely in long days rooted least. A possible explanation given was that more growth regulating substances were produced under short days with this particular plant.

As short-day conditions bring about the cessation of extension growth and the formation of resting buds, the question arises whether buds which are dormant can be induced to resume growth by exposure to long-day conditions. Long-day treatment showed that resting buds of *Fagus sylvatica, Robinia pseudacacia* and *Larix decidua* could be induced to growth by exposure to long-days. It may be that this treatment could be used in rooting a number of important plants, so that the cuttings could be taken earlier in the year.

DIRECT RESPONSE OF CUTTINGS TO PHOTOPERIOD

This can best be described as the response of cuttings to the photoperiod in which they are rooted and only a limited number of investigations have been carried out in this field. In some species the development of roots on cuttings has been found to be sensitive to differing photoperiods, but it is apparent that a considerable variation in results has been obtained. Perhaps the plant which has been investigated the most is holly. Downs (5) undertook some experiments where terminal cuttings from male and female plants, using single clones, of 10 *Ilex* species and varieties, were rooted under mist in natural (winter) daylength and in L.D. conditions (obtained by interrupting the natural night for 3 hours with tungsten-filament bulbs). The results showed that long days encouraged earlier and better rooting; clones of *Ilex crenata* were the most responsive, while these of *Ilex aquifolium* and *Ilex opaca* were the least. He noticed that roots under long days were larger; there was also a marked difference in response by clones within the species.

Lanphear & Meahl (6) carried out some trials using 13 species of evergreen and semi-evergreen ornamental shrubs. They were rooted under 18-hour, 24-hour, and natural daylength. The results obtained were quite varied but they did show that with particular subjects there was a difference when rooting in long photoperiods in the autumn, compared with rooting in long photoperiods during the winter. During the winter, long photoperiods had no effect on rooting ability, although the number of cuttings rooted was reduced in the case of *J. horizontalis* 'Plumosa.' In autumn, however, only *Juniperus horizontalis* 'Plumosa' showed improved rooting percentages in long photoperiod, although the rooting quality of *Juniperus horizontalis, Ilex opaca* and *Rhododendron mucronatum* was improved.

Some investigations by Kamp and Van Drunen (7), working with *Taxus cuspidata* (*T. c. capitata*) were interesting. During October they took tip cuttings of the current season's growth, 8-10 inches long; subsequently some cuttings were placed under short days (natural daylength) and some were given a 4½-hour night break to provide a long-day effect. They found that rooting under short days was better than under long-day conditions.

ESTABLISHMENT

The primary objective here is to avoid "wastage" of valuable plant material. Some important deciduous subjects which are recorded as being difficult to overwinter, are *Cornus florida* 'Rubra', *Magnolia, Viburnum carlesii* and *Acer palma-*

tum cultivars. The propagator has no doubt gone to great lengths to root these subjects successfully in early summer, only to find after the winter that there have been serious losses. A reason given why *Viburnum carlesii* does not successfully over-winter is, firstly, because the young cutting has had insufficient time to build up a carbohydrate reserve and, secondly, the tissues have not hardened up sufficiently. Many propagators no doubt have their own methods of successfully over-wintering these subjects, but some experiments have been carried out to show that in many cases extension of daylength can assist.

Some early work has shown that under long-day conditions extra vegetative growth can be achieved on a number of woody plants after they have been rooted, for example, *Rhus typhina, Cornus nuttallii* and *Acer palmatum,* but this growth was only achieved when the surrounding temperature was in the region of 60°-65°F. In addition, considerable investigations have been carried out at the Experimental Station in Boskoop, Holland.

Waxman (8) carried out some interesting work with *Cornus florida* 'Rubra.' Cuttings were rooted under mist in early summer and were then subsequently exposed to 18-24 hour photoperiods. Significant extra growth was achieved when compared with the controls. Chances of survival were increased as leaf fall was delayed and additional buds were allowed to develop. He makes two very interesting and important remarks. Before the young plants can be over-wintered in a cold frame, they must be hardened off. This can be achieved by transferring the plants to short days from long days. However, if one wishes, one can keep the plants in long days throughout winter to produce new growth until the following spring and then they are placed outdoors. This can be expensive, due to the glasshouse space involved.

Deciduous azaleas have received some considerable attention where a major problem in their culture has been the losses which occur over the winter. Some investigations were carried out by March (9) at the U.S. National Arboretum with Ghent and Mollis type azaleas. He noticed that over-wintering proved difficult because the cuttings tended to become dormant after rooting and to die the following spring. He found that the use of articicial light from 8 p.m. to 6 p.m., given from the time of potting (around the 3rd week in July) until the 1st week in September, induced shoot growth immediately after rooting and enabled the plants to be over-wintered satisfactorily in a cold frame or cold greenhouse. Weiser (10) reported that the growth of young rooted plants of deciduous azaleas and dwarf rhododendrons was stimulated by being grown in continous light, using intensities of 35-50 foot candles.

SOURCES OF LIGHT

The cheapest and simplest source of light is the ordinary electric light bulb (tungsten-filament bulb). These are available in various forms. A point to remember is that ideally one should use reflectors around the bulb. There are three possible ways of applying this form of light; viz. by night-break, cyclic, or continuous over the 24- hour period. The method used largely depends on economics and the actual plant material.

When applying extended daylength to cuttings in the bench, Waxman (8) used for some of his work 75-watt bulbs with reflectors, which were spaced 3 feet apart and 3 feet above the cuttings. He suggests that the light intensity should be no lower than 30 foot-candles, with a minimum air temperature of 60°F. Elsewhere it is reported that for rooting *Rhododendron molle* (*Azalea molle*) 60-watt bulbs were spaced 3 feet apart and 20 inches above the cutting.

Lamps used for supplying supplementary light (e.g. mercury discharge lamps) have generally been found unsuitable for extended daylength purpose. They can provide light up to an intensity of 400 foot-candles, thus giving both a photosynthetic and a photoperiodic effect. They usually have a narrow spectral range, however, which is not so suited to photoperiodic control; their control gear is costly and also there is a "fall off" of intensity between the lamps. They could be useful when one wishes to rapidly build up carbohydrates as well as to give a photoperiodic effect.

CONCLUSIONS

On reflection, one could say that the knowledge of photoperiodic effects in trees is much less complete than that of herbaceous and annual plants which is, no doubt, due to the fact that such work with tree species is slow and sometimes difficult. One is dealing with a very wide range of clones and species whose responses are often totally different. Nitsch (11) illustrates this point very well. He gives three examples of the response of woody plants to long days:

a) A continuous growth response; e.g. *Viburnum carlesii, Cornus florida, Thuja occidentalis* and *Weigela.*

b) Growth in flushes; e.g. Scotch Pine, Red Oak.

c) Where the onset of dormancy cannot be prevented, but just slightly retarded; e.g. Lilac, *Viburnum prunifolium.*

Thus anyone wishing to use extended daylength must be prepared to experiment himself and a set of conditions suited to one subject will not necessarily suit another. The use of extended daylength does not seem practical for those plants which do not present any difficulty in their rooting or subsequent establishment. Also the propagator must be prepared to alter the subsequent management of his plants as indicated earlier.

Finally, the information the propagator requires is whether or not it is economically feasible to apply extended daylength to a particular subject. Also are there methods other than altering daylength which would more easily overcome the difficulty encountered in propagation and subsequent establishment? The propagator wants to know which plants respond to a given photoperiod, and what other factors, such as how much extended daylength, do particular subjects require.

It is known that a number of propagators in the U. K. used photoperiodic lighting with varying degrees of success; the aim of this short review is to give some background on the work already out in this field in different parts of the world. It is hoped that this will stimulate further interest in the U. K. and subsequently result in a lively session devoted to this topic at a future conference.

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MY APPROACH TO TEACHING PLANT PROPAGATION

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The teaching of plant propagation by any one person is, in essence, a personal philosophy of that particular individual, developed as a result of his experience in that field. It may well differ radically from the views of other teachers but I offer no apologies for this — my own approach. Basically this philosophy is a synthesis of three components. Firsthly, there is the influence of one's original teachers who must necessarily have the major effect for they are able to mould one's thinking; this component is thus the most telling as it is, perhaps, the most difficult to disregard. Secondly, the effect of the work and thinking of other teachers, researchers and practical propagators must have marked influences in developing one's ment? The propagator wants to know which plants respond to a given photoperiod, and what other factors, such as how much extended daylength, do particular subjects require.

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In my view the teaching of plant propagation is bedevilled by a great deal of traditional thinking especially in the light of the rapid advances which have been made in the technologies. One still sees in modern textbooks little attention to a logical appreciation of how the plant regenerates; for instance, propagation from cuttings (root, stem and leaves) is usually dealt with as one item followed subsequently, perhaps, by propagation by layering. Even an elementary knowledge of plant physiology should indicate that the regeneration in cuttings of roots, stems and leaves will probably require very different conditions but that the initiation of roots in stems, whether as cuttings or layers, is a function of ultimately the same stimuli. Hence in the teaching of plant propagation it seems logical when studying vegetative propagation to consider the regeneration of stems, leaves and roots as separate items. Thus plant propafation can be divided initially from the plant's point of view into propagation from: (1) seed; (2) roots; (3) stems; (4) leaves; (5) grafting, and (6) tissue and cell culture.

When we analyse any system of teaching there are two components — the "theoretical" and the "practical" — and plant propagation is no exception. It is first of all essential to understand the theoretical implications involved so that an ideal technique can be evolved for a particular piece of a particular plant; this can then be translated into practical terms with the consequent handling of plant material and familiarity with environmental control.

In considering the theory of plant propagation we can divide the various factors which influence plant regeneration into two basic groups. Firstly, there are those factors which influence the inherent ability of a piece of a plant to regenerate, i.e. the *capacity* of that piece of plant to regenerate; and secondly, those factors which influence whether or not it does regenerate once the piece of plant has been chosen, i.e. its *performance.*

The capacity of a particular piece of plant to regenerate is a function of two major groups of factors, *source* and *season.* The source factors represent the cultural influences which are affecting the stock plants providing the material; these chiefly are age, condition, nutrition, position and pathological conditions. In other words these factors are influencing regeneration even before the actual moment of propagation and will determine whether or not the piece of plant is capable of regeneration. The seasonal factor is a question of timing — this may well be critical. Hence from this knowledge we can theoretically determine the highest capacity of any piece of a plant at any given time.

Having achieved material of high capacity it is now necessary to ensure that its potential is realised. The factors which influence its performance can be divided broadly again into two groups. The factors which we can class as treatment are fairly simple, such as fungicide and hormone applications, wounding, maintenance of polarity, removal of leaves and buds, etc. and are all treatments carried out at the moment of propagation to ensure that any artificial aid which may ensure success does not limit performance. Finally, the *environment* will eventually determine performance; in other words, where the material is put at its moment of propagation. Basically, the environmental factors are those of the atmosphere and those of the medium; most important of these are temperature, light, humidity, air, etc. A knowledge of all these factors will enable the production of a performance so that the high capacity may be exhibited.

A knowledge of these theoretical considerations when applied practically provides the student with a chance to handle plant material in many forms and provides an opportunity to prove to himself that the theoretical predictions were reasonably accurate. It also provides an opportunity to familiarise him with various environments for propagation.

Finally, despite these considerations, we are concerned with a commercial atmosphere essentially; it is important that a reasonable and balanced approach to the techniques evolved is maintained and that the student realises the economic and managerial implications involved.

VISIT TO THE BOSKOOP RESEARCH STATION

Boskoop, Holland
Proefstation Voor De Boomwekerij
21st April, 1969

A party of 34 members (including a few guests) flew from Coventry airport to Rotterdam and thence went by coach to Boskoop where they spent 7 packed hours. The arrangements went like clockwork and not even the fact that the weather was bleak and wet throughout damped the enthusiasm of anyone; it was voted an excellent and most informative visit, a great value for the money and the officers of I.P.P.S. were encouraged to consider further possible short visits abroad.

The party visited the Research Station at Boskoop where they were greeted by the new Director, Dr. Roelofsen, himself an I.P.P.S. member. After an excellent 'koffietafel' at the Hotel Florida, four nurseries were visited —

Fa Th. Streng and Fa J. Streng (2 nurseries)
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Boskoop

As all nurserymen must know, Boskoop is the most important nursery centre in Holland, with 950 nurseries occupying a total area of about 1500 acres. This represents about one-sixth of the total nursery trade in the Netherlands, which exceeds 9,000 acres. The Director, Dr. Roelofsen, outlined the main areas and their specialisms, such as the 900 odd acres of rose stocks in Groningen, the forest and hedge plants on the sands at Zundert and the concentration of avenue trees at Oudenbosch. The total export value exceeds £8 million per year.

The Boskoop topsoil is not pure peat as many of us have popularly supposed but a mixture of about equal parts of peat, sand and clay with a pH between 4.5 and 5.5 and a water table that can be maintained about 2 feet below the surface. Beneath the surface is a 10 ft. layer of peat and a 30 ft. layer of peaty clay. It is a loosely compacted soil and we watched demonstrations of a cane being pushed six feet straight down the profile without any difficulty or undue pressure. There is a constant shrinkage of the soil due to drainage of the peat and a continuous loss of soil in the removal of the rootballs and we saw land being made up again by the addition of new soil from outside and from the dredgings of the canals. The looseness of the soil presents expensive problems when buildings or roads have to be constructed.

However often one visits Boskoop it never ceases to interest and amaze and the nurseryman will never come away without learning something. The shape of the holdings — perhaps a strip of land scarcely 100 feet wide and ¾ mile long as was the case with the first two nurseries visited — makes mechanisation exceedingly difficult. Indeed attempts to mechanise appear to be rather half-hearted, the essential requirement being the utmost intensive use of every available inch of land. Labour mostly takes one man to the acre and holdings have their own intensive propagation units — mist and double-frame techniques are to be seen side by side; grafting and layering complete the picture of intensive propagation techniques on nearly all the holdings. It is not only the intensity of the production but its complexity also that deters mechanical methods — so many kinds and cultivars are grown, and the careful selection of the right clonal stock is a characteristic of the Boskoop growers. Yet how long will rising labour costs enable these excellent standards to be maintained at a price the importing country will pay?

For Boskoop's life blood is the export market — over 90% of its products go abroad — and some of the exporters in Boskoop handle the production from other Dutch nursery districts. The Boskoop man sells his products — he travels to seek his market and is not satisfied to sit at home and wait for the orders to roll in.

The Experimental Station

This is an association, founded by nurserymen and governed by a representative Board of all Dutch nursery organisations. It is financed by subscription of members and by grants of the nursery organisation, the government and the municipal authorities. As with all Dutch research stations, research, advice and horticultural education is close knit and the Director is in charge of all three functions.

After a greeting from the Director and a brief summary of the nursery industry in the Netherlands the party was addressed by Mr. Van Elk of the Scientific Staff. He remained our guide throughout the remainder of the day.

The Station has some 15 acres of land of which part is planted up as an "Arboretum" — a collection of plants and selected clones, truly named and available for constant comparison. A coding scheme exists —

*** — Best variety for continental conditions.
** — Less good but acceptable.
* — Less good but acceptable.
S — Suitable for speciol purposes or markets only.
O — No good. Should not be propagated.

Students, we were told, during their 3 years of training at Boskoop must know all the generic names by the end of the first year, the specific names in their second year and the cultivars by the time they finish!

There was a long discussion with Mr. Van Elk on the use of herbicides in Boskoop. Simazine appears to be used widely. Very heavy dressings by our standards are often applied on the highly organic soils, but where the organic matter falls to 5%, the rates are similar to those in Britain (about 1½ lbs. active ingredient per acre). In the southern areas of the Netherlands, on the sandy soils, if the organic matter content falls below 3% growers are warned that they use Simazine at their own risk. Atrazine, still rather in the experimental stage, is less dependent on weather conditions than Simazine but they are looking to further work on its effect on newly-planted stock before making recommendations. Lenacil does not work as well as Simazine and is not much used. Rosaceous shrubs have been damaged by Dichlobenil and Chlorthiamid. Paraquat is used in very much the same way as in Great Britain. The party had a detailed tour of the glasshouses on the Station. Each member probably noted his own particular interest; it is indeed impossible to record in any brief report all the information that was made available on this occasion.

The work on rhododendrons was particularly interesting. Experiments are in progress to improve the techniques of propagation by cuttings instead of grafting. Some interesting hybridisation is being done with some 3,000 to 5,000 seedlings per year. By using artificial light (100 watts/m^2) they hope to cut down the breeding cycle from 7 to 3 years. Some new tender species have been introduced which they hope will provide a real breakthrough in new form when hybrided — we saw one such introduction, *R. leucogigas,* which had been collected 1700 m. up in Dutch Guiana. Interest was shown in deciduous azalea cuttings being taken very early from forced plants and illuminated at 100 watts/m^2.

Amongst the other points noted were: (1) Birch grafting — *Betula verrucosa* (*B. pendula*) and *B. v.* 'Laciniata' were both giving difficulty owing apparently to infection after the union had taken place. (2) *Malus* 'Katherine' grafted under glass; it appears that the ornamental Malus are grafted on apple seedling stocks, from seed obtained from the French cider industry. (3) *Cornus controversa* 'Variegata' grafted onto *C. alba* 'Argenteo-marginata' ('Elegantissima').

Nurseries of Fa. Th. Streng and Fa. J. Streng

Here were two of the typical small family nurseries — about a hectare each in a long strip of land rarely more than 30m wide. We looked at the propagation house used with mist in the summer months on conifer cuttings, but with a humidifier in winter; alternatively in very dull weather the cuttings were just cased over in plastic. The house had a wide range of *Chamaecyparis, Juniperus, Metasequoia* and *X Cupressocyparis leylandii.* A separate house was full of grafted material amongst which was a healthy batch of beech, grafted some weeks ago on to bare rootstocks and balled in peat moss before being plunged into the grafting beds. *Betula* had also been grafted but did not look so well, suffering from the same trouble as was noted at the Research Station. A good batch of *Juniperus virginiana* stocks had been brought in and were awaiting grafting. We noted also *Berberis linearifolia* 'Orange King' being taken out of the grafting house for the cold frames; it is apparently still impossible to root this successfully from cuttings. The third house we inspected was used for over-wintering small plants and we especially noted several varieties of *Acer* and *Pieris* which were now starting to grow away well.

The stocks of young *Abies, Acer* and various other plants potted up for grafting next summer and the following spring were of excellent quality. We were impressed, too, by the good range of *Rhododendron impeditum* and other similar dwarf forms. More unusual to British eyes was the very wide range of blueberries (*Vaccinium*) grown mainly for the German market.

On the nursery of J. Streng there was a house crammed with camellias. A very large number of small plants raised from leaf-bud cuttings and planted in Jiffy-Pots had been placed on high staging under which stood the stock plants — yet another example of Dutch intensive growing.

During a discussion at this nursery of the economics of the small producer in Boskoop, Mr. Van Elk made it clear that he did not consider that the financial remuneration was adequate and mechanisation would be difficult though it must come increasingly in the future. He thought both planting and potting machines would be used. An interesting and surprising piece of information forthcoming was that the water in the canals generally had too high a salt content to be used on container-grown plants.

G. Kooy and Zn.

This holding was unusual in that it specialised in herbaceous plants; the range of plants grown was wide but traditional for there seems to be little work done in the introduction of new herbaceous material. Again most of the operations were done by hand, with hand hoeing more widespread than herbicide application. We noted phlox propagated by root cuttings taken direct outside and planted out in early April. The most interesting aspect of this nursery was the extensive use of cold stores which enabled planting to be carried out in sequence almost the entire year through again ensuring maximum land usage. The stores are maintained at about 0° to 0.5°C and incorporate humidity control for an air humidity above 96% is required. All herbaceous plants which normally die down in winter can be stored for late planting when soil conditions are ideal; fast growing, leafy material does not store well.

F. J. Grootendorst

Here was a nursery with many modern features, and with a propagation and production area recently built. This comprised a 3-span propagating house, each span partitioned off from its neighbor. On the northern end of the propagating house was a working shed for grafting and potting which also acted as an access corridor to each of the three portions.

At the southern end was a double-span, growing-on house, which also acted as an access corridor to the propagating house.

The working shed was well equipped with ample fluorescent lighting and a well designed fixed bench, running the entire length. Swivel chairs adjustable for height and having a movable backrest were provided for the grafters.

The propagating house was constructed of western red cedar and incorporated the Boskoop system of double glazing. The inner layer of glass, consisting of sheets butted against each other and held by retaining laths some 5/8 ins. away from the outer conventional lapped sheets. The inner sheets could be fairly easily removed for cleaning by unscrewing the retaining laths, but this tiresome and time consuming job had not been carried out on most of the units we had visited. At Grootendorst's the glass had not yet been up sufficiently long to be very dirty.

The propagating house was shaded by rolled laths pulled up and down by pull wires. This system replaced the laborious method of manually rolling out laths as seen in some units including the Experimental Station. The propagating house had soil level and waist level benches, one portion being devoted to mist propagation, using a Danfos unit. The other two portions appeared to be equipped for closed cases. The size of each portion was approximately 20 ft. x 60 ft..

The two-span growing-on house was single-glazed, mainly constructed of metal; each span was approximately 15 ft. x 60 ft.

Crops

Chamaecyparis obtusa 'Nana Gracilis' was being grafted in the working shed.

The mist house contained many rhododendron cuttings; these were inserted into pure peat, given a heavy wound and treated with Rhizopon (powder formulation of rooting hormone). Rooting had not yet occurred in many cases, indicating that they were struck later than is normal in the U.K.

Other portions of the propagating house contained grafts, including *Juniperus* and *Quercus*. Potted-off *Juniperus virginiana* seedlings and *Juniperus chinensis* 'Hetzii' from cuttings were being used as understocks. The *Quercus* were all grafted on to bare-root stocks, the roots of which had previously been wrapped in sphagnum moss. The side graft was used. Types worked on *Q. robur* and *Q. coccinea* were seen.

The growing-on house contained potted plants of *Actinidia kolomikta* raised from cuttings taken in May or June and *Aristolochia sipho* propagated from grafts on own roots. With the latter method we were told that the polythene must be raised on wire hoops well above the grafts to avoid damping off. The pots used were plastic square pots giving good economy of space. An efficient staking system involving a 4 ft. cone supported by nylon strainer cords at the top was used.

Discussion with Tony Ogden, an ex-student from the West of Scotland College who had worked here two years, revealed that the potting composts were all brought in; one having a relatively low fertility level was favoured for understocks.

(Note: The Editor is grateful to the President, Vice-President, Secretary and to Mr. A. D. Weguelin for supplying most of the information on which this account is based)

SIMPLE CO-ORDINATED PROPAGATION EXPERIMENTS

At the Regional Annual General meeting at Hadlow in September, 1969, members expressed a wish to undertake among themselves simple propagation experiments, co-ordinated in such a way as to provide information on both general principles and specific details of technique. If successful, this venture could become a permanent and useful feature of the Society's work and could be geared to the particular needs of members.

Dr. B. H. Howard of the East Malling Research Station, Nr. Maidstone, Kent, has accepted the Region's invitation to

RESEARCH AT THE NURSERY LEVEL

BRUCE A. BRIGGS
Briggs Nursery
Olympia, Washington

I shall illustrate with slides some of the types of applied research which we as nurserymen can carry out in the course of our daily business. For those who are not in attendance at this meeting, a description of these projects will make up this article.

I feel that in order to upgrade the industry, basic research from institutions all over the world must be translated into applied research within the institutions and within the industry. A free exchange of information in detail amongst teacher and students, research scientists, and members of the industry is very important. A seemingly insignificant detail found in research may prove to be the missing link which may bring success to a practical plantsman. Or close daily observation in the field can bring to light valuable insights to be pursued further by the scientist or student.

The industry needs to cut down the lapse of time between research and practical application in the nursery. Organizations such as our International Plant Propagators' Society can help prevent this lapse of sometimes as much as thirty years between basic research and application. As nurserymen we cannot afford to wait, but should set up controlled research plots to check out problems which come up under our own conditions which may be a little different from those of our fellow nurseryman a few miles away, or from the basic research that was done under laboratory conditions.

ROOTING IN AIR

The rooting chamber which I described to you several years ago (1, 2) is now used in conjunction with a vacuum tank which we built to introduce various liquids into the cuttings. This rooting in air allows daily observation and may help to answer such questions as:

A. *How does wounding a cutting increase roots?* A review of this was given in 1962 by James Wells (3). A research project in The Netherlands (4) indicated that not only does wounding increase hormones in the plant, but may at that time, reduce the inhibitors being produced. By repeated trials, we found that the introduction of plain water by the vacuum system increased rooting. This also proved true of restuck cuttings of *Picea pungens* 'Glauca' and *Rhododendron.* Those which failed to root in the spring were retreated in a number of ways to find why the few remaining ones did not root like the others. Again, water forced into the cuttings was the best treatment. This would seem to point to the introduction of water as a major factor in the results obtained from wounding a cutting.

B. *What is the relationship between the location of the cutting wood on the stock plant and the concentration of hormone needed to obtain best rooting?*

C. *What are the best hormones for specific plants and what are the best concentrations to use?*

With the air chamber and vacuum tank, we have tried replacing the normal liquids in the cutting with hormones, plant food and other elements. We have also tried to bring about certain chemical reactions in the cutting with cold storage treatment.

A basic rule is that to get the same results each time, you must repeat the same procedure exactly as you did it before. As you can see, it is a wonder that we ever repeat our results in rooting, as we now have so little control over the factors involved. Maybe someday we will be able to work out details on all that is needed for optimum rooting of various species. Then perhaps we can produce an indicator by tissue color, or possibly by electricity, to measure the proper time to take the cutting and the proper way to treat the cuttings.

EXPERIMENTS WITH CHEMICALS

To compete in this mechanized age, nurserymen can well look into the possibilities of a greater use of chemicals to cut down labor. Chemicals can kill weeds, prune plants, improve sanitation, control pests and diseases, and retard or enhance growth, flowering, and fruiting.

We can sometimes borrow a chemical from another industry for a similar use in our own industry. However, we must use extreme caution to check out interreactions between different chemicals applied to the same plant, such as fertilizer, herbicide, insecticide, fungicide, etc. Bad reactions are apparently showing up in our area between ammounium sulphate and 16-20-0 fertilizers used with herbicides. Calcium nitrate used as a form of nitrogen together with chlorinated water, ties up the chlorine so that no free chlorine is available.

If we are to continue the unrestricted use of chemicals, we must obtain more information regarding their effectiveness, their safety, and their impact on the total environment. Even now as we are faced with increased controls or loss of the use of DDT, we may later be faced with increasing doubt as to the place of agricultural chemicals in our society. Individual research under widely varying conditions should help to produce some of the needed answers.

USE OF INDICATORS AS SAFETY MEASURES

Under our conditions with a heavily organic soil mix in containers, we found that all the chemical weed killers applied in the summer broke down or were tied up in 30 to 40 days, with the exception of Casoron. We used seeds of rye, lettuce, or radishes as indicators to determine when an additional application of the herbicide was needed and would be safe. Even

Atrazine applied at 5 lb/A to kill certain weeds, left no residue to damage rye planted 30 days later. This year almost all of our 500,000 containers as well as our fields were treated with chemical weed killers. Using these indicators put us in control — we could measure toxicity and keep plant damage to a minimum.

A NEW PROBLEM WITH WEED KILLERS

To have just one weed killer which does a good job is not enough. We find ourselves working with at least 10 different weed killers, using them for a special plant or condition at a given time. This year we encountered the one thing we have always feared — that of weeds building up an immunity to a certain chemical.

In 1958 we first used Simazine and until two years ago, it remained our basic chemical on some 80 acres of field stock. Then some fields were changed to Atrazine in an attempt to get better control of grasses in areas that we had intended to dig out. Groundsel began to appear last year in places, but we were not too concerned as Simazine was to be used again this spring for control. On new plantings as well as old, in the spring of 1969, Simazine up to 3 lb/A alone, and in combinations with other chemicals was used, with no control of groundsel.

To check further on this lack of control of groundsel, we set up a weed research block using some 10 varieties of plants in 1 gallon containers. We also attempted to test other factors such as effect of the time of the day and method of application, amount and method of applying water, granular versus liquid application, effect of liquid fertilizer and chlorination, and degree and length of control and toxicity.

On checking with the Western Washington Research and Experiment Station at Puyallup, Washington, we found that Simazine was still giving control over groundsel there. We began to suspect that we had developed a strain of groundsel resistant to Simazine. Dr. George Ryan at the Research Center obtained from us some seed of our form of groundsel to test against his form in a controlled research plot. From his programmed data, he found that his form of groundsel could be killed with ½ lb/A of active Simazine while our strain showed resistance to 16 lb/A (5). Further work on this problem is continuing.

ETHREL POTENTIAL

This last summer we experimented with applications of Ethrel (2-chloroethylphosphonic acid) to see if it might improve rooting of cuttings. When Ethrel was applied to corn to reduce the foliage for fungus control, roots appeared on the stalks of the plants. We ran many experiments with Ethrel alone and in combinations to try to produce roots on cuttings — all with very few results. Feeling that to produce roots, Ethrel should, perhaps, be applied to the stock plants, we tried it in late August (afternoon temperatures of 74°F) at the rate of ½%, wetting the tops of the plants. Under our conditions at this rate, both cotoneasters and heathers responded with a retarded growth, darker foliage, but no leaf abscission.

With these results, we then felt that perhaps Ethrel might have some merit as a growth regulator. From reports at the ASHS meetings at Pullman, Washington last summer (1969) there were mixed results on fruits and vegetables from the application of Ethrel and Alar, separately and in combination. No work was reported on ornamentals. However, it was reported that Alar would modify Ethrel-induced abscission.

Under our conditions, a 1% solution of Alar alone applied on actively growing azaleas and rhododendrons helped in bud formation, but did not adequately check two-vigorous vegetative growth. We plan to test further to see if a combination of Alar with Ethrel may produce the desired results of a good bud set and a more compact plant.

SANITATION

Sanitation at the nursery level still needs much attention in the way of better chemicals and improved methods.

Water is sometimes an unsuspected source of infection. The lake from which we pump our irrigation water appears very clear and the water tests show little chemical or salt content. However, we were noticing a loss of plants in the summer apparently from water molds, a root rot infection commonly due to *Phytophthora.* On the recommendation of O.A. Matkin of the Soil and Plant Laboratory, Orange, California, we tried chlorination of the irrigation water.

We installed a gas injector to chlorinate the water at 1 ppm at the lake, giving us ½ ppm at the sprinklers. This was enough to destroy the bacteria and fungi in the lake water and still give us ½ ppm of free chlorine. We were encouraged to find that plants already showing injury to the root system responded very well when transferred to an area being treated with chlorinated water. The chlorine seemed to retard further growth of the root rot.

We could find little data available on plant toxicity from chlorination, so we experimented with various strengths. In one test, we applied 10 ppm chlorine in irrigation water to the tops of gallon cans and found 1 ppm free chlorine in the water taken from the bottoms of the cans. The soil did not take away all of the active chlorine as the water moved downward. Some free chlorine appeared from the bottom of the containers even at the reduced rate of application of 5 ppm.

A sanitation program needs to be somewhat comprehensive to achieve noticeable results. Why fumigate a field or sterilize a soil mix and then later contaminate it with nematodes and harmful pathogens by the irrigation water? A complete sanitation system would include clean facilities, clean plants, soils treated with chemicals or aerated steam, and clean irrigation water. Ideally, it would prevent problems from developing. Why apply a certain fungicide to a pathogen, for example, some of our water molds, that can be killed only by heat? Fungicides, insecticides and other chemicals could be used to correct temporary problems which may still arise. It would seem, though, to be of doubtful value to use repeated applications of chemicals merely to hold down a condition of *Phytophthora*, only to grow plants dependent on the chemical for survival. Such a practice would seem to have merit mainly on plants sold for a short-lived use, on cut flowers, on food plants, or on rare plants or those in short supply needed for propagating stock.

THE FUTURE

In the future, we may look forward to improving sanitation through the principle of inoculation, such as have been used on humans by vaccination for many years. Dr. Kenneth F. Baker, of the University of California, Berkeley, has been working on this principle in Australia during this past year.

The future holds much promise for our industry. We have just begun to scratch the surface. The key to our future success lies in research. Let us as teacher, student, research scientist, and nurserymen continue to put basic and applied research together to unlock the potential of the now still unknown.

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CHARLES HESS: Bruce, thank you very much for a very inspiring talk. Our next speaker is Mr. J. D. Murphy from the University of Illinois and he is going to talk to us about direct rooting media.

COMPARISONS OF VARIOUS INDIVIDUAL MEDIA FOR DIRECT ROOTING OF CUTTINGS

JAMES D. MURPHY, JR., J. B. GARTNER AND M. M. MEYER[1]
Department of Horticulture
University of Illinois
Urbana-Champaign, Illinois

The vegetative propagation of ornamental plants presents many problems. Some problems result from the number of times cuttings must be handled. They must be taken, made up, and stuck into a rooting medium. After the cuttings have rooted, they must then be removed from the rooting medium,

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[1] Research Assistant, Professor and Assistant Professor, respectively, Division of Ornamental Horticulture, University of Illinois, Urbana, Illinois 61801.

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The vegetative propagation of ornamental plants presents many problems. Some problems result from the number of times cuttings must be handled. They must be taken, made up, and stuck into a rooting medium. After the cuttings have rooted, they must then be removed from the rooting medium,

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potted into a growing medium or packed for shipping. This process requires several handling steps which results in high labor costs. When cuttings are removed from the medium, roots have a tendency to become desiccated and break. This delays establishment of the cutting.

These problems may be overcome by using small units or pots filled with a propagating medium in which cuttings can be rooted, grown, or shipped without removal from the rooting medium. This process saves labor and cuttings may grow better than those removed from the rooting medium because chances for root desiccation, breakage, and infection are reduced. Several individual, direct-rooting media have been developed for use with ornamental plants. Examples of these media are Jiffy-7's, BR-8's, Jiffy Pots, and a recent introduction to this group, Quickee Sure Start. Jiffy-7's and Jiffy Pots are made of peat and the BR-8's are a polymerized kraft wood pulp. Quickee Sure Start[2] is a specially processed, expanded, phenol-formaldehyde plastic foam similar to the material which is used for holding cut flowers in containers. The foam is light in weight, strong, easily handled, sterile and ready for immediate use. It retains moisture satisfactorily and holds its shape very well when either wet or dry. It is very simple to cut into cubes of the desired sizes, and cuttings are easily inserted without the necessity of preformed holes.

The ideal propagation medium should be sterile, durable, well-aerated, and capable of retaining adequate moisture and of holding the cuttings in the proper orientation. The cuttings should grow normally for a short time after rooting in an ideal medium. Individual direct-rooting media, in addition to these characteristics, should be suitable for moving or shipping.

Each individual direct-rooting medium has advantages and disadvantages. The roots do not uniformly penetrate some media in all directions and thus produce a layering effect on rooting. Others are heavy and increase shipping costs. Certain media lack durability and break apart easily when handled. Some media require considerable time to fully soak up water. Growers often experience basal rot of cuttings in media that hold too much moisture due to an improper air-to-water relationship.

Since there have been several individual-unit propagation media developed, experiments were conducted to compare the rooting of several ornamentals in the various media. The following individual-unit propagation media were tested.

BR-8's	Acrylonitrile polymerized wood pulp molded into cakes of 12 units each.
Jiffy-7's	Compressed pellets of peat which expand when saturated with water.
Jiffy Pots	Pots made of peat filled with a 1:1:2 mixture of soil, peat and perlite.

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[2] Trade name of a phenol-formaldehyde foam distributed by Floralife, Inc., 4420 South Tripp Avenue, Chicago, Illinois 60632.

Quickee Sure-Start	A phenol-formaldehyde foam cut into the following cube sizes: 2¼", 2", 1¾", and 1½".

The foam cubes and BR-8's were soaked in a pan of water until saturated. The Jiffy-7's and Jiffy Pots were placed in flats and moistened by sprinkling. No additional fertilizer was added to any of the media used.

The following plant materials were used in the studies: *Poinsettia pulcherrina* Willd. 'Eckespoint C-1' and 'Paul Mikkelsen' *Chrysanthemum morifolium* Ramat. 'Golden Yellow Princess Anne', *Weigela florida* A. DC., Red-osier dogwood (*Cornus stolonifera* Michx.), Tartarian honeysuckle (*Lonicera tartarica* L.) and *Spiraea nipponica* Maxim.

The stems of the herbaceous poinsettia and chrysanthemum cuttings were dusted with Hormodin No. 1 rooting compound. The stems of the semi-hardwood woody ornamental cuttings were momentarily immersed in 1000 ppm 3-indolebutyric acid (IBA) in a 50:50 ethanol-water solution before being inserted into the various media. The individual units were then placed on steam-sterilized benches containing sharp sand. Cuttings were also rooted in the sand of the same bench. Mist was applied 5 seconds every minute during daylight hours for the first week. Then it was reduced to 5 seconds every 2 minutes until root initiation. Rooted cuttings were hardened off by misting 5 seconds every 15 minutes.

The degree of rooting was determined after roots had penetrated to the surface of the individual propagation media. Since the root system was difficult to remove from the Jiffy-7's, BR-8's and Sure Start media, the scale used to determine the extent of rooting was: *rooted, callused, unrooted* or *dead. Rooted* cuttings had roots penetrating the rooting medium or, in the case of sand, showed good root formation. *Callused* cuttings had developed callus tissue, but showed no rooting. *Dead* cuttings had lost their foliage and had black and rotted stems.

The effects of the rooting media on subsequent growth of the rooted cuttings was studied. Some of the cuttings were potted into a 1:1:1 mixture of soil, peat, and perlite. These were grown under long days (incandescent light supplied from 10:00 p.m. to 2:00 a.m.) to keep the cuttings in a vegetative state. The plants were measured after growing for several weeks.

The herbaceous cuttings rooted well in all the media tested and no visible differences were observed in rooting. The rooting observed with poinsettia cuttings is shown in Figure 1. These rooted cuttings were potted and grown to finished plants. There was little difference in their quality.

The influence of the various rooting media on the subsequent terminal growth of chrysanthemum is shown in Table 1. Cuttings rooted in Jiffy-7's, Jiffy Pots and foam cubes grew significantly better than cuttings rooted in sand or BR-8's. Cuttings rooted in Jiffy Pots grew significantly better than any of the others, but this may have been due to nutrients contain-

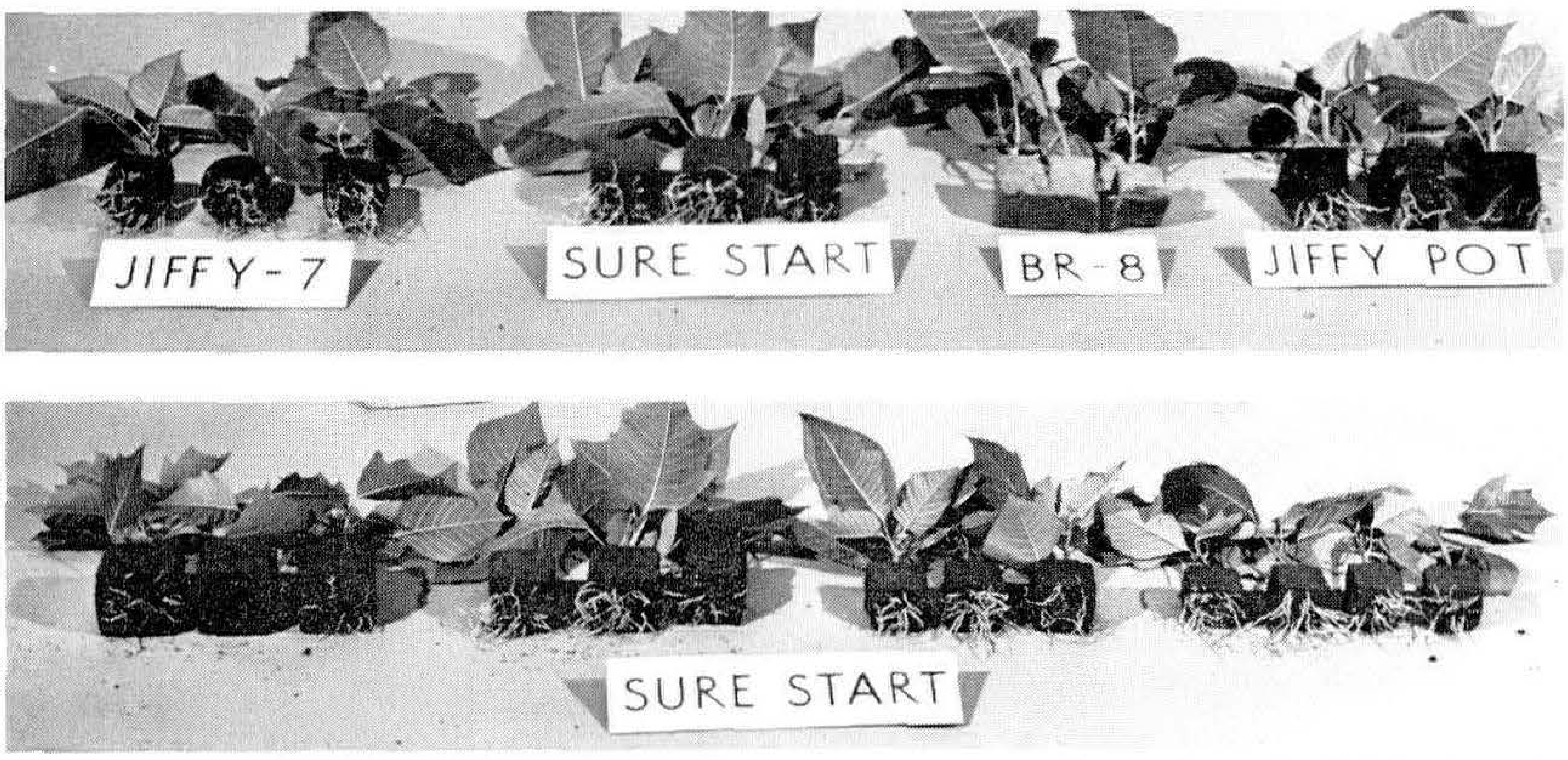

Fig. 1. Rooting of 'Paul Mikkelsen' poinsettia cuttings in various individual units media. *Top row*: Rooting in Jiffy-7s, Sure Start, BR-8 blocks, and Jiffy Pots. *Bottom row*: Rooting in various sizes of Sure Start foam — 2¼", 2", 1¾" and 1½"

ed in the soil, peat, perlite medium used to fill the Jiffy Pots.

Weigela cuttings, like the herbaceous cuttings, rooted well in all the media tested. The influence of the various rooting media on the vegetative growth after potting of weigela cuttings is shown in Table 1. It is evident that cuttings rooted in the foam material, Sure Start, grew better than any of the others. However, only the difference between cuttings in foam and Jiffy Pots is statistically significant.

Table 1. The influence of various individual unit propagation media on the terminal growth of chrysanthemum and weigela. Growth measured after three weeks under long days.

Plant	BR-8	Jiffy-7	Jiffy Pots	Start Sure	Sand	LSD at 5% level
		Length (cm)				
Chrysanthemum	9.88	12.27	14.16	12.31	9.71	1.26
Weigela	19.60	17.56	14.05	23.10	—	8.83

Cuttings of other woody plants were more difficult to root than those of the herbaceous cuttings, chrysanthemum and poinsettia, and took longer to root in many cases. Woody plants were also sensitive to timing, as the stock plants were grown out-of-doors. Therefore, difficulties were experienced with woody plants that did not appear with the herbaceous materials. However, there were some interesting results (Table 2). Red-osier dogwood cuttings stuck in the foam rooted better than those stuck in BR-8's, Jiffy-7's or Jiffy Pots, and the rooting was comparable to those stuck in sand. Honeysuckle cuttings rooted best in sand and about half as well in the individual unit media tested. Spiraea cuttings failed to root well in the individual unit media tested and did not root well in the sand. This may be due to the hardness of the cuttings and the poor performance of the foliage under the mist.

Table 2. The influence of various individual unit propagation media on the rooting of woody ornamentals. Cuttings stuck June 30, 1969. Data taken July 21, 1969. Basal portion of cuttings dipped in 1000 ppm IBA.

Plant	Media	Rooted	Callused	Unrooted	Dead
Cornus stolonifera	BR-8	7	—	2	3
Red-osier Dogwood	Jiffy Pot	6	—	—	6
	Jiffy-7	6	—	1	5
	Sand	12	—	—	—
	Sure Start	11	—	—	1
Spiraea nipponica	BR-8	2	—	10	—
	Jiffy Pot	3	—	8	—
	Jiffy-7		—	10	2
	Sand	5	—	7	—
	Sure Start	2	—	9	1
Lonicera tartarica	BR-8	6	—	6	—
Tartarian Honey-	Jiffy Pot	6	—	6	—
suckle	Jiffy-7	3	—	8	1
	Sand	12	—	—	—
	Sure Start	5	—	6	1

To summarize, several herbaceous and woody ornamental plants were rooted in various individual propagation media and compared to cuttings propagated in sand. Chrysanthemum and weigela rooted cuttings were potted and the growth of these was determined. The herbaceous materials were found to root well in all the individual unit media tested. Some difficulty was encountered with some of the woody plants, but some rooted fairly well in the individual media. Cuttings rooted in the individual unit propagation media did grow better after potting than those propagated in sand. There were also differences in growth noted among plants rooted in the different individual unit media.

The new phenol-formaldehyde plastic foam, Quickee Sure Start, performed as well as the other individual unit propagation media and sometimes better. This new material might be considered for trial by propagators of ornamental plants. Propagators could try unit propagation media as a method for reducing handling costs of cuttings. The labor saved may be more than enough to pay for the media, plus producing a high quality rooted cutting.

CHARLEY HESS: Very well done, Mr. Murphy. I would like to ask where the foam material which you used is available.

J. D. MURPHY: This material is available from the Floralife Corp., Chicago, Illinois. It's a new material which we have been testing and it looks promising.

VOICE: Is it advertised in the trade papers?

J. D. MURPHY: I don't think so.

CHARLEY HESS: This ends our morning session.

THURSDAY AFTERNOON SESSION

December 4, 1969

The afternoon session convened at 1:45 p.m. in the East Ballroom with Joe Cesarini serving as Moderator for the first section on *Propagation Techniques* and John Newhouse as Moderator for the second section on *Nutrition and Plant Growth.*

CHARLEY HESS: Before we begin this afternoon's program, I would like to recognize two Western Region members who were overlooked in the introductions this morning — Warren Berg and Ted Van Veen. Would you gentlemen please stand and be recognized? Thank you. We also have with us eight students from the Department of Horticulture at Niagara College, St. Catherines, Ontario who are accompanied by two of their instructors, Roger Gunthorpe and Ray Forester. Would you gentlemen stand and be recognized? Thank you. This afternoon's program is divided into two sections; the first, on propagation techniques, will have our old friend, Joe Cesarini, serving as Moderator.

MODERATOR CESARINI: Thank you, Charley. Our first speaker for this session on propagation techniques is an old friend of ours who really doesn't need an introduction, Mr. Al Fordham of Arnold Arboretum, who will talk to us on the production of juvenile shoots from root pieces.

PRODUCTION OF JUVENILE SHOOTS FROM ROOT PIECES

ALFRED J. FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

Physiological juvenility in plants has long been recognized and much has been published concerning it. Through the years a number of articles have appeared in the Proceedings of this society describing juvenility and its importance to the plant propagator.

When plants are grown from seeds, characteristics which appear on the young seedlings often differ greatly from those which are found later in the plant's life. In the case of pines, the first or juvenile shoots are gradually replaced by mature growth. This slide showing seedlings of *Pinus canariensis* illustrates the transition from the juvenile to the mature stage. The presence of juvenility at the lower portions of the plants is indicated by pliable stems bearing solitary leaves which are bluish-green in color and are of soft texture. Evidence of maturity is manifested in the upper portions by leaves that are borne in bundles of three, are grassy-green and of firm texture. The interval between the advent of maturity and time of flowering and fruiting has been termed the "adolescent phase." These stages represent the normal course of events in the development of conifers.

However, in some conifers, particularly in the genera *Chamaecyparis* and *Thuja,* the juvenile to adult transition may fail to take place and some plants remain in the juvenile phase. These have been termed "fixed juveniles." An outstanding example of how firmly fixed they can become is shown by this specimen of *Chaamaecyparis pisifera* 'Squarrosa' the Moss cypress growing at the Arnold Arboretum. It was set out in 1894 and has remained juvenile for over 75 years. Although fixed juveniles are usually dwarf in character, this one attains large size. Nearby is a specimen of the species, *C. pisifera,* planted in 1891; there is little difference in stature. Plants which become fixed juveniles also retain a trait associated with the seedling stage — the ability of cuttings to root readily.

Juveniles do not ordinarily flower and fruit, for the morphology which involves reproduction is associated with maturity. However, a fruiting tree of Moss cypress was discovered near Newport, Rhode Island, when our society met there. Seeds were germinated and the ensuing seedling population is of special interest. Eighty-seven plants are now about 2 to 3 feet tall. Forty-eight resemble the species (*Chamaecyparis pisifera*); twenty-two are juvenile, similar to the parent; four resemble *C. pisifera* 'Filifera', and thirteen resemble *C. pisifera* 'Plumosa'. The latter three are cultivars which were described during the last century.

Juvenile Shoots from Root Sections

Shoots that arise from roots are physiologically juvenile and will frequently root when made into cuttings despite the fact that stem cuttings from the parent plants will not. In 1967 while visiting Professor Elwyn M. Meader of Rochester, New Hampshire, we viewed two trees of *Picrasma quassioides,* the Korean Butter tree, which had been raised from seeds collected by him near Seoul, Korea. This rare tree was not present in the collection at the Arnold Arboretum so we were anxious to acquire it. His trees had not produced seeds and the question of how it should be propagated arose. *Picrasma* is a close relative of *Ailanthus* which propagates by root cuttings so it was decided to try that method. Professor Meader provided root sections which on November 14th were placed horizontally in flats of sandy soil and covered to a depth of one-half inch. By December 28th shoots started to appear and when large enough they were harvested and inserted as cuttings. Further shoots developed and they too were taken. Production of shoots has now continued for two years, and 86 have arisen from eight relatively small root pieces. It is astonishing that food reserves in the roots have been sufficient to support this activity for such a period of time. A crop of shoots is presently on the roots and it has been decided to let them remain and function in an effort to replenish food supplies. When they go dormant the flat will be transferred to our cold storage unit and later returned to the greenhouse. It will be of interest to see how long the production of shoots will continue.

Leaves on mature trees of *Picrasma* are pinnate—yet the first leaves which appeared on the shoots were trifoliate as is the case with newly germinated seedlings, and this would be evidence of juvenility. It should be added that when propagated under mist the cuttings showed leaching and some defoliated. Of these, many produced new leaves and later rooted. Under polyethylene plastic they rooted well.

Several years ago we conducted an experimental project to test the feasibility of producing juvenile shoots from roots in quantity. Root sections of large size were collected from a 47 year old tree of *Albizia julibrissin* and placed in flats as described above. This procedure worked well and from three root pieces one inch in diameter and 5 to 12 inches long a first crop of 52 shoots was obtained. The root pieces exhibited polarity and masses of shoots tended to develop near the proximal ends. Had the 12-inch piece been divided into two pieces, its shoot production might have been doubled.

Leaves on the *Albizia* shoots showed no evidence of juvenility — they were bipinnate as is typical of mature trees. But juvenility was present, for the cuttings rooted in eleven days even though stem cuttings from the parent plant cannot be rooted. Large root pieces of *Albizia* will also continue to produce juvenile shoots for at least 2 years.

Elliottia racemosa, the Georgia Plume, has presented propagation problems and despite the fact it was discovered over 160 years ago, it has remained rare in cultivation. Sound seed production is sparse and the seeds have proven difficult to germinate. At the Arnold Arboretum repeated attempts were made to root stem cuttings of *Elliottia* by using a variety of timings and an assortment of root-inducing substances, but with little success. The next effort was to test whether or not root pieces would produce multiple shoots. Root pieces were treated as previously described and in 26 days shoots began to appear. Polarity was again evident and clusters of shoots developed at the root ends which had been closest to the tree. Leaves on the shoots resembled those of the parent plant but evidence of juvenility was indicated by the fact that all cuttings which were taken rooted and did so quickly.

It seems reasonable to suppose that the juvenile factor would be present in all shoots that arise from roots and therefore they would root readily as cuttings. When dealing with plants such as *Albizia*, masses of easily-rooted shoots develop and provide a means by which stock can be propagated quickly. However, before collecting roots for this purpose one should make certain the plant is on its own roots and that it is not a periclinal chimera. Instances have been reported where periclinal chimeras have not duplicated the parent plant when roots have been used for propagation.

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MODERATOR CESARINI: Thank you, Mr. Fordham for a very informative talk. Our next speaker also needs no introduction to us because he is a past-president and is well known to all of us — Mr. Vince Bailey. Mr. Bailey is going to tell us how to root softwood cuttings outdoors.

OUTDOOR SOFTWOOD CUTTING PROPAGATION

VINCENT K. BAILEY
Horticultural Consultant
Newport, Minnesota

I should like to introduce the subject, "Outdoor Softwood Cutting Propagation", with a discussion of the need for something other than the conventional method in the greenhouse although your results, and ours at Bailey's, have been very satisfactory with various types of mist.

The past 15 or 18 years have produced many variations of the use of mist propagation systems. Many of you here have heard a number of them described and no doubt have used one or more of them. We, at Bailey's, are very happy with a circular bed. My nephew, Rodney Bailey, discussed this with you two years ago. We are even more sold on the system now.

All of us are familiar with the fine stands obtained with many varieties when greenhouses are used. You are all familiar with the cost of building a greenhouse as well as the rather high maintenance cost. We need a reason for considering going to any other method. The reason we at Bailey's have adopted the outdoor method is purely a matter of economics. We are producing a quality liner at a greatly reduced cost by getting away from the high capital investment.

We have tried a number of methods the past few years to reduce the overall costs of producing liners from softwoods. You are all familiar with the development of root-promoting hormones, which are a great help. Cheesecloth and other similar materials have been tried and I am sure are still used by some. At Bailey's we adopted the open area with misting, or rather a fine spray, as a partial substitute or supplement to the greenhouse. The greenhouses are still used to full capacity, but the open, outside, method is used for further expansion.

The description of our method is as follows: The area is plowed and worked smooth with a disc and harrow. We are now ready to make the beds. With a dump truck and a Melrose

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The description of our method is as follows: The area is plowed and worked smooth with a disc and harrow. We are now ready to make the beds. With a dump truck and a Melrose

"Bobcat" loader, we apply two to three inches of sand over a 22-foot diameter circle. A metal garden edging forms the outside of the bed. With two men and the proper equipment, this bed is made ready to plant in about one-half hour. Each bed will hold from 15,000 to 25,000 cuttings, depending upon the variety. Four of these beds are surrounded with snow fencing, and then a very fine spray or mist nozzle is located in the center of each 22-foot bed.

The mist is shut off completely before dark and turned on in the morning after daybreak. You are all aware that the mist can and must be reduced as rooting progresses. I mean only that the percent of time *on,* to time *off,* is decreased.

For simplicity of operation, all the time-clocks and solenoid valves are placed in one central location. The water is conveyed from the solenoid valve to its respective bed by a 5/8-inch rubber hose. By having all of the controls in one unit, we are able to completely dismantle the system each fall, store it inside over-winter, and reassemble it again in the spring with a minimum of plumbing and electrical connections to make. We merely connect the control system to our water supply and electric supply.

Each time-clock controls one solenoid valve which, in turn, controls the water for four separate beds. Although almost any rotary type lawn sprinkler will do an adequate job of misting, we prefer the Hardford spike sprinkler because it is easy to move from one part of the bed to another when adjustments must be made for windy conditions.

With normal weather conditions and newly-planted cuttings, the clocks will be on 5 times for about 6 seconds each, in every 12-minute cycle. This, of course, must be adjusted as the light, temperature, wind, and humidity conditions change. The 12-minute cycle clocks are controlled by a 24-hour clock that turns them on in the morning and off at night.

You can see from my description that the capital investment is very low. The controls are not expensive since one is used for four beds. They last a long, long time. The 4-foot snow fence is an inexpensive item and lasts many years. There is one thought I wish to express and that is, to be assured of good results, the person in charge must make adjustments when necessary. Unusual conditions may arise which may necessitate changes here and there at rather short notice. The machine is a great help but the answer to full success is the human element.

We have found that the following do very well with the above-described method:

Number of Cuttings Planted	Plants
28,000	*Acer ginnala* 'Compacta'
2,000	*Cornus alba siberica* 'Gouchaulti'
30,000	*Cornus alba* 'Elegantissima'
4,000	*Hydrangea arborescens* 'Grandiflora'
12,000	*Hydrangea paniculata* 'Grandiflora'
65,000	*Lonicera x xylosteoides* 'Claveyi'
9,000	*Lonicera xylosteum* 'Nana'
1,800	*Philadelphus lemoinei*
3,000	*Philadelphus lemoinei,* 'Sylviani'
8,000	*Philadelphus virginalis* O'Minnesota-Snowflake'
5,000	*Philadelphus virginalis*
8,000	*Physocarpus opulifolius* 'Luteus' ('Aurea')
13,500	*Physocarpus opulifolius* 'Nanus'
18,000	*Potentilla fruiticosa* 'Gold Drop'
33,000	*Potentilla fruiticosa* 'Katherine Dykes'
3,000	*Potentilla fruiticosa* 'Mount Everest'
11,000	*Potentilla fruiticosa* 'Vilmoriniana'
7,000	*Prunus glandulosa* 'Rosea'
12,000	*Spiraea* x *bumalda* 'Anthony Waterer'
9,000	*Spiraea* x *bumalda* 'Frobell'
10,000	*Spiraea nipponica* 'Snowmound'
2,000	*Spiraea thunbergii*
10,000	*Viburnum trilobum*
19,000	*Viburnum trilobum* 'Compactum'

We reserve greenhouse space for the harder-to-root items, such as the following:

Number of Cuttings Planted	Plants
4,200	*Euonymus alata* 'Compacta'
480	*Euonymus alata* 'Compacta #2'
85,000	*Philadelphus coronarius* 'Aureaus'
21,000	*Prunus* x *cistena*
24,000	*Prunus triloba*
25,000	*Prunus virginiana* 'Shubert"
260,000	*Ribes alpinum*
2,500	*Syringa velutina* (*S. palibiniana*)

The results are very satisfactory even if they are not 98 to 100 percent. Such a percent of success is something for us to feel proud of when we think back to that nice stand of some viburnums or some other item that looked so good. I like to have the foreman count and report the actual number of each variety planted and then the number rooted. These facts are much more meaningful to me than to hear a foreman tell me he had a beautiful stand of *Prunus* — it must have been about 100 per cent.

MODERATOR CESARINI: Thank you, Mr. Bailey; that was a very good paper and I'm sure everyone is interested in ways to save money. Our next speaker is a personal friend of mine and one of the most progressive young men in our organization. I look up to him but I also feel sorry for him because he is filling in the position which was last held by our good friend, Mr. Martin Van Hof. I feel sorry for him because he has a lot of room to fill. At this point I introduce to you Mr. Larry Carville.

PROPAGATION OF SOFTWOOD CUTTINGS UNDER POLYETHYLENE TENTS

LAWRENCE L. CARVILLE
The Rhode Island Nurseries, Inc.
Newport, Rhode Island

Propagation by softwood cuttings under poly tents is not a new technique but it is a topic which merits periodic review by this Society. Over the years, as experimentation gives way to new methods, and as improvements are made to accepted techniques, we have a responsibility to the membership of our Society to spread the Gospel and share in the wealth of new knowledge.

The method currently being used by The Rhode Island Nurseries was developed and perfected by a valued friend of mine: my predecessor and the Dean of American Propagators, Mr. Martin Van Hof. Previous references to this subject can be found in papers by Mr. Roger Coggeshall in the 1953 edition of the Proceedings and by Mr. A. R. Buckley in the 1955 edition of the Proceedings. Mr. Van Hof began his experimentation with this method in the early 1950's and it has been perfected over the years. In my brief association with The Rhode Island Nurseries I have found this method to be extremely simple and at the same time highly successful.

Materials Propagated. Perhaps a logical approach to this subject would be first to tell you what material we are propagating under poly tents and then to briefly explain the mechanics of outdoor propagation under polyethylene tents. At the present time, we are successfully propagating *Cornus alba* 'Argenteo-marginata', *Deutzia gracilis, Euonymus* 'Sarcoxie', peegee hydrangea, *Kolkwitzia amabilis, Pachysandra terminalis* and several varieties of each of *Hibiscus syriacus, Hydrangea hortensis,* forsythia, ligustrum and weigelia. This list in no way limits the kind of material which may be rooted under poly tents but merely indicates what species we are sticking under poly.

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Methods. Softwood cuttings are taken and prepared for sticking in the same manner as for mist propagation. We normally begin our poly tent propagation around July 15th, after we have completed all cuttings for the mist beds. All cuttings are taken early in the day and are treated with No. 3 Hormes powder prior to sticking.

The ground frames used in our operation are 32 feet long, 64 inches wide and have side boards which are 12 inches high. Frames are constructed on garden loam with a walkway of 24 inches between frames. The soil in the frame is tilled to a depth of 9 inches with a Howard Gem Rotavator, mixing in perlite at the rate of 24 cubic feet per frame during this initial operation. The rooting media is then raked smooth, tamped firmly and watered thoroughly. We are now ready to begin insertion of the cuttings.

Prepared cuttings are stuck with a dibble and are shaded and watered as the frame is filled. We find that placing a shade over the cuttings and placing wet burlap over the shade serves to maintain the cuttings in a turgid condition until the frame is covered with poly. It is of paramount importance to keep the cuttings as cool and moist as possible during this crucial period. A filled frame holds between 8,500 and 10,000 cuttings and with a crew of eight men, we are able to fill three frames every two days.

Covering the frame. When a frame is filled, the shades and burlap are removed. The cuttings are given a final heavy

Fig. 1. Frame filled with cuttings and ready for covering. Sideboards are 12 inches high. Center ridge, which will support the polyethylene, is a 1 x 2 nailed on 1 x 2 stakes.

Fig. 2. Frame is covered with 4 mil polyethylene, soil is tamped along the sideboards and metal "T" stakes are set in place preparatory to covering it with lath shade.

watering and preparations are made to cover the frame. One by two inch wooden vertical posts, 24 inches in length are driven into the soil to a depth of six inches down the middle of the frame from one end to the other. These posts will support the ridge board, a one-by-two inch strip which runs the entire length of the frame and which is nailed on top of the one-by-two inch posts. The distance from the top of the cuttings to the ridge is approximately 12 inches (Fig. 1). A trench four to five inches deep is now opened around the frame, approximately three inches from the bed boards and across the ends. This trench will secure the poly once it is stretched in place over the frame.

A roll of polyethylene, 4 mil in thickness and 10 feet wide is unrolled and cut to length. Using our eight man crew, the poly is pulled taut along the ridge, down over the side boards and is firmed in the trench. Soil is thrown into the trench and is tramped firmly. The poly over a completed frame should be tight, without sags and quite necessarily without tears. Any sags will have a tendency to collect rainwater and, if severe enough, could cause collapse of the frame.

At this point in the operation, shading becomes a critical factor since heat builds up very quickly in the closed frame. "T" irons 36 inches long are driven four feet apart in the walkways and across the ends of the frame to support the shades which are placed over the frame as quickly as possible. Initially we use a shade which gives 75% shading, with 1½ inch laths spaced ½ inch apart. Our shades are seven feet long and four feet wide and nine shades are used to cover each frame. This allows for an overhang on each end of the frame to protect the cuttings from direct sunlight (Fig. 2) The entire operation from the time we begin placing the one-by-two inch posts until we have completed covering the frame with shades takes approximately 15 minutes but requires a great amount of teamwork. We have found, through the use of a recording thermometer, that the temperature within the frame prior to the period when shades are added has reached 120° F so that time is of the greatest essence in completing each step of the operation.

Opening the frame. The frames remain unattended during the rooting period but after about four to five weeks, one end of the poly may be pulled open to allow inspection of the rooting progress. Normally after five weeks, both poly ends are opened and the cuttings are allowed to harden off for two to three days. After three days, the poly is completely removed but the 75% shades are left in place. Hand watering is now required since the cuttings no longer have the benefit of a 100% humidity environment. By the early part of September, double shades (75% shade) are replaced by single shades which are six feet long, four feet wide and have 1½-inch laths spaced 1¼ inches apart. These shades are left in place over the cuttings until late September at which time all shades are removed. The one-by-two inch vertical posts and the one-by-two inch ridge board may also be removed at this time.

Overwintering. Cuttings require little care during late summer aside from an occasional thorough watering. As the rooted cuttings mature and harden off, and after several hard frosts, marsh hay is spread over the cuttings. This operation normally takes place in mid-December when the ground has begun to retain frost during the day. No additional winter protection is afforded the cuttings and they remain in place in the frames until spring. During early April, the marsh hay is removed and cuttings are pulled, trimmed and heeled into the frames preparatory to field planting. *Hydrangea macrophylla* varieties remain undisturbed in the frames until buds break, at which time they are planted in beds. *Pachysandra terminalis* is also planted in beds during early spring. As soon as ground in the nursery is workable in April, cuttings are pulled from the frames and hand planted in field rows, 31 inches between rows and three inch spacing between plants in the row. Plants remain in the field for one season and are dug, graded and stored during late November.

Advantages of poly tents. The advantages of softwood propagation under polyethylene tents are obvious at this point. Cost of production per cutting under poly is considerably less than under mist even though the poly is used for only one season. No elaborate structures such as mist-lines, time-clocks and sand-beds are required and we have a simple, easily constructed dual purpose frame which requires little or no maintenance when constructed from redwood. One of the most outstanding features of this method is the lack of leaching of nutrients; such leaching may be one of the prime disadvantages of propagation under most mist systems.

Disadvantages of poly tents. I find one of the most frustrating drawbacks of propagation under poly tents is the fact that the cuttings cannot be readily observed. This may be merely a personal idiosyncrasy but I always prefer to have access to cuttings while they are in the rooting media. Closely allied to this first disadvantage is the fact that we have no convenient control of fungus infection which may develop during the rooting process. Since we have high humidity, no air circulation, and cuttings closely spaced in these frames, a fungus infection could cause a complete crop loss. We use no soil sterilants or fungicides on the soil prior to sticking cuttings and to date we have been fortunate. Another disadvantage is relative to weather conditions, since a prolonged period of cloudy, cool weather can delay rooting; in Newport, we often experience such prolonged periods of foggy, cool, weather during mid-August.

Summary. I would like to state, without reservation, that the advantages of propagation under poly tents more than outweigh the disadvantages. The cost of production per unit is substantially less than with most mist systems and no elaborate structures are required at any point during the operation. Presently, half of our entire softwood production is carried out under poly tents and we find this method completely satisfactory.

MODERATOR CESARINI: Thank you very much, Larry, for a very well presented paper. Sometimes I wonder what the nursery industry did before they invented polyethylene films. Our next speaker has been the propagator for the D. Hill Nursery Co. for over 4 years. At this point I introduce to you Mr. Peter Orum.

A PRACTICAL SYSTEM OF COLD-FRAME PROPAGATION

PETER ORUM
D. Hill Nursery Co., Inc.
Dundee, Illinois

Cold-frame propagation of ornamental woody plants has always been an accepted method. It has worked poorly and it has worked well, but seldom has it been very practical.

I once visited a large nursery in Germany. It was said to have several thousand glass-sashes in its propagation area. The amount of people needed to take care of this and carry sashes around ran almost into the hundreds.

Some years ago my close associate, John Wilde, and I started out with the goal of developing a practical system for dual purpose frame which requires little or no maintenance when constructed from redwood. One of the most outstanding features of this method is the lack of leaching of nutrients; such leaching may be one of the prime disadvantages of propagation under most mist systems.

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Some years ago my close associate, John Wilde, and I started out with the goal of developing a practical system for propagation in outdoor frames. Our three main premises were: (1) it had to be well adapted to the ornamentals we desired to grow; (2) it had to be economical; and (3) it had to be suited for large scale production. Through modification of methods used by other propagators and some new developments of our own we have come a long way toward this goal.

To paint the clearest picture for you, I have divided my subject into three subgroups:

I. Frame Construction
II. Propagation in the Frame
III. Adaptability

Frame Construction. This is of paramount importance. If we just looked at the plant propagator's side of the case, we would be satisfied as long as we built a frame in which the cuttings had a perfect environment. But since we, in the commercial part of this group, are managers too, we must look with an equally strong eye to the economic side. We must make money on our propagation, otherwise we will cease to exist as commercial propagators.

In the selection of an area, two things, especially, should be considered: drainage and wind protection. Although it is possible to prepare and build on almost any area, the cost will vary greatly.

To accomplish this type of propagation with an automatic mist system it is necessary to apply an excess of water at certain times. Also, since in most areas, there is an excess of rainfall during certain periods, — and cuttings, rooted or unrooted, standing with "wet feet" for any length of time will die, it is of utmost importance to provide good drainage.

The safest procedure is to lay a line of drain-tile down the middle of each frame then fill the trench with gravel. However, other methods will work, such as building the frames on a slope or on very sandy soil. It should be noted that these other methods need closer attention by the propagator. Since the mist is applied on the top of the cloth — up in the air — it is subject to drift. Overlapping of the water system takes care of part of this but real strong winds will take the mist away from the intended place. An area enclosed by natural windbreaks would be ideal, but snow-fence will do a fairly good job.

The basic layout consists of two frames separated by a waterline with risers for the nozzles. This mistline then covers the two frames.

An area can be layed out in two basic ways. Where space is available there should be a drive-way between each double-frame. This greatly facilitates transportation. Fork lifts and shelf-pallets can be used to transport plants to and from the frames. Hardly any walking is necessary and cost is cut substantially. If space is limited, a multiple frame system can be used. One frame is next to the other and there are no drive-ways in between — only alleys. In this case the frames should not be over 60 feet long and there should be a drive-way at each end. There would then be 30 feet walking distance from the middle. But the cost of this would have to be weighed against the better useage of the land.

Many different materials can be used for the frames: wood, steel, cement blocks or poured concrete — and for the water pipe: steel, aluminum or plastic. Again, the type of material to be used should be weighed against the length of life and the labor saved during construction and use.

Through several experiments we have developed a frame which we feel is very close to the ideal. We describe it as "Cement block—Frame Model 1965." This frame is built with cement blocks used in the building industry sold under the name of, "twelve-inch off-set cornerblock." A single row makes up the two outsides of the double-frame. A double row makes the center and works as an alley as well. The blocks are laid in a few inches of sand. Every three feet a steel ground-anchor is placed in the row so that the eye is just above the block. This is for fastening the tobacco-cloth in the summer and winter-covering in the fall.

Peagravel is filled in if the frames are to be used for cuttings in flats or trays. This is leveled to about two inches above the bottom of the blocks. If the cuttings are to be stuck directly, the frame is filled with a sterile rooting medium to about six inches above the bottom of the blocks. A sand-peat mix is satisfactory but some perlite mixed in might help in wet periods. The rooting medium is then dressed with a two-inch layer of coarse sand.

The water system consists of a water line lying in one side of the alley between the two frames. Every ten feet there is a two-foot high riser. We are using a rotary nozzle. This, of course, does not give an even water distribution, but it is even enough to produce a frame full of uniform cuttings and that is what counts. It is important that the mist line be level; otherwise, there will be a backflow of water to one end of the frame after the value is shut off.

On each mist line there is as electric valve. These are connected to time-clocks on a central control panel. Each electric valve is controlled by a 10-minute timer. A whole section, or group of sections, is controlled by a "day and night clock." It is advisable to use a 24-volt system as this saves quite a bit in cost of underground cable.

For covering of the frames a heavy galvanized arched wire is used — stuck down in the sides by the concrete blocks. This provides for very easy covering, be it with tobacco-cloth for propagation, or plastic for winter protection.

Propagation in the Frame. Through observation and experimentation we developed a simple theory for this undertaking. If cuttings are kept under moist cloth, which lets enough light through, they will have a favorable environment for rooting. Applying the water on the top of the cloth and not on the cuttings directly will cut down the leaching from the cuttings during the rooting period. This leaves the cuttings in better condition to root.

Some air movement is almost a necessity to keep down fungus diseases. Covering the cuttings with the light cotton material called "tobacco-cloth" provides for this. In a climate with a lot of bright sun in the summertime, a light shade is favorable, especially for rooting certain ground-covers and most variegated material. This, the tobacco-cloth provides for, too. Last, and sometimes most important, the tobacco-cloth gives some protection against failure. If the mist system fails because of human or technical error, the cloth gives a one to two hour tolerance, while uncovered new cuttings possibly would have only 20 to 30 minutes.

Propagation is started as early as material is available which will be, in our area, about the end of May. All cuttings are made in the field and brought to the frames for sticking without delay. They are stuck at the spacing found to work best with the particular variety. Spacing boards have been designed for this purpose. When stuck, the cuttings are soaked and covered with the tobacco-cloth. If the cuttings are to be in flats or trays they are normally stuck in a working shed, then transported from there to the frame.

The following two months is the critical time — the time when the propagator really has to be on the ball. In order to keep the cloth moist at all times the "day and night clock" must be set to turn on and off at the right times. And the 10-minute timers must be set to apply the right amount of water. This can be anywhere from two minutes on a real bright day to less than half a minute on a darker day. The 10-minute timer works so that the mist can be on or off for any length of time in the ten minute cycle, for instance, *on* for two minutes, then *off* for eight.

You will see that a judgment and calculation of the weather, the condition of the cuttings, and the setting of the clocks, is made by the propagator. We do not feel that time is ripe to make this much more automatic under general nursery conditions. There are too many variables that we do not yet control.

For a short period of rain, like a shower, there is no need to reset the clocks. But if prolonged periods of rain and cloudy weather occur, it is often advisable to cut the mist off completely. When the majority of the cuttings are rooted, a hardening-off is started. This is done partly by cutting down the amount of water applied and partly by opening up the cloth on the sides to give more air. This gives the propagator a lot of room in which to play things according to the need of the specific varieties. At the time the cuttings are well rooted, the mist is cut off completely. Shortly after, the cloth is removed from everything but certain groundcovers and variegated plants. From this point on the cuttings are treated as any other growing plants. Through the mist system they are irrigated when necessary, with fertilizer injected at all times.

Some kind of winter protection is needed in northern areas. This can be as simple as a thin layer of hay or straw on the more hardy plants. On less hardy plants it is advisable to cover with polyethylene. The covering is done fast and easily on our standard frame. Polyethylene is rolled out over the arched wire. On the sides, this is squeezed down between the wire and the concrete block, using a 1 x 2 inch wooden strip. Then, chicken netting is rolled on the top and tied to the ground anchors on the side. No wind, except maybe the hurricane "Camille" will move this.

The following spring most of the rooted cuttings are lifted and canned — or sold, in the case of groundcovers. Slower growing varieties are kept in the frame for a second growing season.

Obviously, cuttings with very different requirements should not be bunched together in the same set of frames. This could be labeled as a liability. Rather, I think, it is an asset, since it forces better planning, cuts labor costs and provides for better economy.

Adaptability. It would not do much good to design a system that, though it might be good, was not adaptable.

We have found, under our conditions, that many species of junipers and certain spruce clones, including 'Hilli' and as well as 'Glauca Koster' lend themselves to this method of propagation as well as nearly all ornamental deciduous shrubs and broadleaved groundcovers.

Not only must a system of propagation fit the plants to be propagated but it must, too, fit the overall operation of the nursery. For production of deciduous shrubs in June, and groundcovers from June to September, this system has worked extremely well. In increasing numbers, we are now producing junipers and spruce this way with equally good results. It is far more economical to produce cutting-grown understocks for juniper grafting by this method.

The system will not eliminate greenhouse propagation. Only 3 to 4 months are suited for propagation in outdoor frames in our climate. Because of availability of labor and cutting material it is not possible for a large nursery to do all its propagation in these few months. To even out the production, especially through the winter months, greenhouses are needed.

The cost and economy factor of the system is very favorable. It is, I dare to say, its real merit. Comparable costs, in production per unit and in overall costs, show a considerable advantage over operations in greenhouse bench areas. Total direct labor cost per rooted cutting has been brought down to 0.96 minute or 2.5c. This includes bench preparation, making the cutting, cultural care all the way through, plus lifting and grading. In comparison a 'Hetz' juniper for understock, cutting-made in the greenhouse, eats up 2.3 minutes of direct labor, or 7.3c.

Besides this distinct advantage in production economy, the system has the advantage of much lower initial investment than a greenhouse. The cost of construction is about one dollar per square foot of frame space. This includes everything, from grading of the land to the electric controls. I would guess that bench space in a greenhouse would cost about four times as much. The investment is less fixed, as it can be written off in a short time. The frames can be moved or even abandoned without great loss. These things are often advantages.

It is increasingly obvious that labor cost in propagation tends to make propagation of many ornamentals unprofitable. This is especially the case near industrial areas in the United States. Reduction of cost by propagating the best adapted varieties in outdoor frames seems to be one of the possibilities best suited to fit into the propagation operations in our area; that is, to produce liners at competitive and profitable prices.

At this time I wish to express my great appreciation to my tireless co-worker, John Wilde; also to the management of the D. Hill Nursery, who never shied away from exploring into the unknown, here especially remembering the late Jack Hill.

MODERATOR CESARINI: Thank you very much, Peter. We now have time for questions.

JIM WELLS: I'd like to ask Larry Carville why he sticks his cuttings with a dibble. Have you tried dispensing with the dibble?

LARRY CARVILLE: The only reason we are still using the dibble is that my men have very short fingers and by using the dibble they can get the cuttings properly inserted to the proper depth in the medium. We don't use a board, hammer or a slat. My predecessor used the dibble and I like it too; however, students today aren't being trained in the proper use of the dibble and we will no doubt have to change in the future, but at the present time it works very well for us.

HANS HESS: I'd like to ask Mr. Bailey why he puts *Euonymus alata* and *E. alata* 'Compacta' cuttings in the greenhouse and doesn't do these outside like the other softwood shrubs?

VINCE BAILEY: We have to put something in the greenhouse, Hans; but really it's because they are a little more difficult to root than some of the other things and we save the greenhouse space for those species we find to be a little more difficult to root.

ARIE RADDER: Mr. Orum, when are your junipers stuck in the frames?

PETER ORUM: From the first of June to about August 15; they shouldn't be stuck much later than this in our area.

CASE HOOGENDOORN: Do they still root if you stick them the 15th of August?

PETER ORUM: Yes, but that's not rooted by fall, that's rooted by next spring because they're covered with polyethylene during the winter.

JOHN ZELANKA: Mr. Orum, of the juniper cuttings which you stick, do varieties such as 'Maneyi' and other hard-to-root varieties root in one sticking or do you have to restick these in the greenhouse to finish them off?

PETER ORUM: We are still working with 'Maneyi" and do have some rather good results with our system, although the last couple of years we have had better results sticking 'Maneyi' in the greenhouse about the first of September.

MODERATOR CESARINI: That's all the time we have now; any other questions will have to go in the Question Box. I want to thank all the speakers again and you the audience, you've both been wonderful. Thank you very much.

CHARLEY HESS: The second half of this afternoon's program will be moderated by Mr. John Newhouse. It's a pleasure to have John take over the rest of this afternoon's program, John!

MODERATOR NEWHOUSE: We have a very good program for you on nutrition and plant growth but I ask that you hold all questions till the end of the program. Our first speaker is Martin Meyer from the University of Illinois.

EXTERNAL AND INTERNAL NUTRITION AND SPRING GROWTH OF WOODY ORNAMENTAL PLANTS

M. M. MEYER, JR.
Department of Horticulture
University of Illinois at Urbana-Champaign, Illinois

The exact response of woody ornamental plants to fertilizer applications is often difficult to measure. This is because of the nature of the growth of these plants. The growth to be considered here and of concern to ornamental horticulturists is shoot growth or, specifically, growth of terminal meristems of the shoots of woody plants. This growth controls the form of the plant, produces leaves and flowers, and gives interest and environmental modification to the landscape. The nature of this shoot growth and response of this growth to fertilizer applications at various times will be considered.

What is the nature of growth of woody plants in temperate regions? Woody plants break buds and initiate growth from preformed parts in the spring. This may constitute the total height growth for the season in some plants; however, in other plants it may not. The growth of woody plants can be divided into two basic patterns. The first of these patterns can be referred to as homophyllous which refers to one type of leaf being formed. This is the situation when spring growth is the total elongation of the shoot for the year. This growth con-

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What is the nature of growth of woody plants in temperate regions? Woody plants break buds and initiate growth from preformed parts in the spring. This may constitute the total height growth for the season in some plants; however, in other plants it may not. The growth of woody plants can be divided into two basic patterns. The first of these patterns can be referred to as homophyllous which refers to one type of leaf being formed. This is the situation when spring growth is the total elongation of the shoot for the year. This growth consists of the leaves or needles being entirely preformed in the bud and growing only by expansion during the spring, as shown by Sacher (7) to occur in various pine trees.

The second basic pattern has some leaves preformed in the bud, but after these expand and the shoots elongate, other leaves are capable of being initiated. This was found to be the case in *Betula* by Kozlowski and Clausen (2). They found this second group of leaves was somewhat different in shape from the early leaves, hence, they termed this type of growth heterophyllous. Thus the spring growth phase of all woody plants would appear to be important. In the first pattern of growth, spring growth forms the total height elongation and, in the second type, this growth forms a base for further growth.

Since growth in the spring occurs very rapidly and conditions for mineral uptake are unfavorable, considerable quantities of internal nutrients are needed. Meyer and Tukey (5) and Tukey and Meyer (8) have shown with taxus and forsythia that this growth is dependent on the stored nitrogen, phosphorus, and potassium reserves in the dormant tissue. Meyer and Splittstoesser (3, 4) have shown with lilace that the stored nitrogen is in the form of amino acids. Therefore, it is well documented that previous season's applications of nutrients result in increased internal nutrients during the dormant season and these result in increased growth the following spring.

What I would like to show here is how this internal nutrient level reacts with the external level during spring and early summer growth and whether this depends on the type of growth pattern of the particular plant in question.

The following results were obtained with two kinds of evergreen woody plants. *Taxus media* Rehd. 'Hicksii' (taxus) which follows a homophyllous growth pattern, and *Juniperus chinensis* 'Keteleeri' Cornman (juniper) which appears to have a heterophyllus type of growth. The plants were given varying levels of nitrogen and phosphorus applications during one summer. The following spring varying levels of these elements were superimposed on the previous season levels (see Tables 1 and 2).

'Keteleeri' juniper scions were grafted on *J. c.* 'Hetzii' rooted cuttings during January, 1967. These were potted in 3-quart plastic containers into a soil: peat: turface medium and fertilized every two weeks with NH_4NO_3 or KH_2PO_4 solutions starting July 1, 1967 (see Table 1). In the nitrogen treatments, phosphorus and potassium were applied every two weeks and in the phosphorus treatments, nitrogen and potassium were applied at the same intervals over the summer. The following spring the plants in the nitrogen treatments were fertilized every two weeks giving various spring-summer combinations (see Table 1). Since phosphorus moves slowly in the soil and forms insoluble compounds, the medium was washed free of the plants in the phosphorus treatments and these plants were raised by the solution culture methods of Hoagland and Arnon(1). The nitrogen-treated plants were harvested after eight weeks and the phosphorus-treated plants were harvested after six weeks of growth.

Table 1. Influence of nitrogen and phosphorus applied during two seasons on the growth and nutrient content of *Juniperus chinensis* 'Keteleeri'.

Nitrogen applied	Summer 1967	0	60mg	120mg
	(cm terminal growth)			
	Growth 1967	8.2	17.4	21.5
	% N	1.24	1.27	1.41
Spring 1968				
0	*Growth 1968*[1]	30.0	37.8	44.8
120mg		53.3	54.8	57.7
0	% N New Growth	1.19	1.23	1.21
120mg		2.42	2.24	2.33
	% N Old Tissue	0.92	0.96	1.03
120mg		1.97	1.80	1.82
Phosphorus applied	**Summer 1967**	**0**	**60mg**	
	Growth 1967[2]	53.0	56.0	
	% P	0.201	0.206	
Spring 1968				
0	*Growth 1968*[3]	48.0	53.0	
10^{-3}M		59.0	60.0	
0	% P New Growth	0.152	0.162	
10^{-3}M		0.265	0.280	

[1] Three longest shoots per plant due to branching
[2] g fresh wt measured after eight weeks.
[3] mg fresh wt/g fresh wt after six weeks

Junipers responded immediately to nitrogen applications with twice as much terminal growth during the summer of 1967 (Table 1). The foliage of plants in the higher nitrogen treatments also contained more nitrogen. There was some carryover of summer nitrogen to the following spring, as plants receiving no nitrogen during the spring, 1968, responded to the previous season application by increased growth (Table 1). There was considerable internal movement of nitrogen out of the older tissues into the new growth of the plants receiving no spring nitrogen. The percent nitrogen of the older tissues of plants receiving high summer nitrogen went from 1.41% to 1.03% during the spring and the new growth contained 1.21%. Nitrogen applied every two weeks at 120 mg per pot greatly stimulated the growth during the spring of 1968, regardless of the nitrogen applications the previous season. Nitrogen applied during the spring increased the nitrogen content of both old and new foliage and visual ratings showed the plants to be greener than those receiving no nitrogen during the spring.

Table 2. Influence of nitrogen and phosphorus applied during two seasons on the growth and nutrient content of *Taxus media* 'Hicksii'.

Nitrogen applied	Summer 1968	0	30mg	120mg
	Growth 1968	19.8	19.6	20.8
	% N	1.28	1.48	1.79
Spring 1968				
0	*Growth 1969*[2]	54.9	79.6	81.7
120mg		60.1	80.6	86.2
0	% N New Growth	2.16	2.09	1.85
120mg		2.33	2.22	2.24
0	% N Old Tissue	1.13	1.40	1.40
120mg		1.55	1.50	1.70
Phosphorus applied	Summer 1968	0	225mg	
	Growth 1968[1]	18.0	22.0	
	% P	0.095	0.256	
Spring 1969				
0	*Growth 1969*[2]	14.0	63.0	
10^{-3}M		26.0	65.0	
0		0.054	0.144	
10^{-3}M		0.562	0.216	

[1] g fresh wt
[2] mg dry wt/g fresh wt measured after six weeks.

The response of junipers to phosphorus was not as striking as the nitrogen response. There were slight increases in growth and percent phosphorus with the application of phosphorus during the summer of 1967 (Table 1). Plants receiving no phosphorus in 1968 were stimulated slightly in growth by the previous season's phosphorus application. An increase in phosphorus concentration around roots of the junipers during the spring caused a growth response regardless of the previous season's application. Again there was internal redistribution of phosphorus when none was applied in the spring, and spring applications resulted in a considerable increase in the phosphorus level in the new tissue.

Taxus plants were given treatments similar to those given the junipers. They were given varying levels of nitrogen and phosphorus every two weeks during the summer of 1968. The following spring varying levels were superimposed on the previous season's levels (Table 2). The plants were harvested after six weeks. In contrast to junipers, nitrogen applied to taxus resulted in little increased growth the season it was applied. The nitrogen content of the foliage tissue increased as the application of nitrogen was increased. This resulted in considerable growth differences the following spring even when no nitrogen was applied to the roots at this time (Table 2). The application of nitrogen during the spring did not result in the large growth increase in taxus that it caused with junipers. In taxus the internal nutrient content was more important than the external level during spring growth. This contrasts to junipers (Table 1) where nitrogen caused an immediate and large growth response when it was applied in the spring. However, nitrogen applied during the spring to taxus was incorporated into the new growth and maintained the nitrogen level of the old foliage (Table 2).

The amount of phosphorus applied every two weeks to taxus during the summer of 1968 (Table 2) was about 4 times that applied to junipers (Table 1), and was in the form of dry 20% superphosphate rather than a KH_2PO_4 solution. There was an increase in growth in 1968 resulting from high summer phosphorus application. This increase was primarily the result of buds on these young plants sprouting and growing during the summer. The phosphorus application during the summer resulted in a nearly three-fold increase in the foliage phosphorus level and this additional phosphorus resulted in over a three-fold increase in growth (Table 2) the following spring even when no further phosphorus was applied. Differences due to previous summer's growth were taken out by dividing the spring growth by the dormant fresh weight when making these comparisons. Phosphorus applied during the spring resulted in increased growth only when the phosphorus status of the plants was low. When the phosphorus in the tissue was high, due to the previous season's application, there was very little additional increase in growth. Tissue analysis showed that it was not the lack of phosphorus in the new tissue of plants receiving phosphorus in the spring that controlled growth. It may have been due to the lack of initiated primordia in the buds of these homophyllous plants.

Thus, the responses of woody plants to fertilizer applications differ according to the type of growth pattern. The heterophyllous type, junipers, respond quickly to fertilizer applications by increased growth. There is some carryover as stored material is used in spring growth, but the best growth is obtained by keeping them well fed. Another example of getting the most growth from this type of plant was shown at the Plant Propagators' meetings three years ago by Pinney and Poetter's (6) results with birch trees. These trees were never allowed to stop initiating new leaves or to stop growing until they were readied for winter or were marketed.

Taxus, a homophyllous type plant, on the other hand does not immediately respond to increased fertility except by breaking a bud here and there. Fertilizer applications in this case increased the tissue content and caused other metabolites to be stored, but massive growth responses must wait until the following spring. Therefore, fertilizer is not wasted by the plant but stored for future use. These differences in response and growth pattern should be kept in mind when evaluating the results of fertilizer applications. It is hoped that a grower of woody plants considering these results and realizing the type of plant and soil with which he is working might be better able to plan and evaluate his fertilizer program.

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MODERATOR NEWHOUSE: Thank you, Martin. Our next speaker has travelled a long way to talk to us this afternoon; he is Bob Ticknor from Aurora, Oregon.

INFLUENCE OF FERTILIZERS AND GROWTH REGULATORS ON FLOWER BUD PRODUCTION OF FIELD-GROWN RHODODENDRONS

ROBERT L. TICKNOR
Oregon State University
North Willamette Experiment Station
Aurora, Oregon

Phosphorus used in larger amounts than normal has been reported by McGuire (4), Myhre and Mortensen (5), Ryan (6) and Vanderbilt (9) to increase flower bud set in rhododendrons. This is particularly true for two— and three-year-old plants which, in some varieties, are difficult to bud.

Growth regulating chemicals also have been suggested as a means of increasing flowering of rhododendrons by Cathey and Taylor (1), Criley and Mastalerz (2), Crossley (3) and Ticknor (7) and Ticknor and Nance (8). Most of this work was done under greenhouse conditions, although the variety 'Roseum Elegans' growing in the field was used in some previous trials.

To test the relative merits of these two systems of increasing flowering of field-grown rhododendrons under Willamette Valley conditions, a trial was started in 1968. Five varieties— 'Elizabeth Hobbie', 'Princess Juliana', 'Pink Pearl', 'Roseum Elegans" and 'White Pearl'—known to vary in ease of budding were planted June 19, 1968. One month prior to planting, three inches of fir sawdust was worked into the upper six inches of the Willamette sandy loam soil. Ammonium nitrate to of plant and soil with which he is working might be better able to plan and evaluate his fertilizer program.

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Phosphorus used in larger amounts than normal has been reported by McGuire (4), Myhre and Mortensen (5), Ryan (6) and Vanderbilt (9) to increase flower bud set in rhododendrons. This is particularly true for two— and three-year-old plants which, in some varieties, are difficult to bud.

Growth regulating chemicals also have been suggested as a means of increasing flowering of rhododendrons by Cathey and Taylor (1), Criley and Mastalerz (2), Crossley (3) and Ticknor (7) and Ticknor and Nance (8). Most of this work was done under greenhouse conditions, although the variety 'Roseum Elegans' growing in the field was used in some previous trials.

To test the relative merits of these two systems of increasing flowering of field-grown rhododendrons under Willamette Valley conditions, a trial was started in 1968. Five varieties—'Elizabeth Hobbie', 'Princess Juliana', 'Pink Pearl', 'Roseum Elegans" and 'White Pearl'—known to vary in ease of budding were planted June 19, 1968. One month prior to planting, three inches of fir sawdust was worked into the upper six inches of the Willamette sandy loam soil. Ammonium nitrate to supply nitrogen at the rate of 80 pounds per acre was applied over the sawdust before working it into the soil. A soil sample taken before planting indicated a pH of 5.9 and a phosphorus content of 84.5 ppm. In November, 1969, the pH ranged from 5.4 to 5.7 and the phosphorus content from 175.0 to 262.5 ppm.

Treatments used were as follows:

1. Check.
2. Cycocel (2-chloroethyltrimethylammonium chloride) at 2000 ppm.
3. Broadcast phosphate (0-45-0) at 2000 lbs/A.
4. Broadcast phosphate (0-45-0) at 2000 lbs/A, plus chelated iron at 54.5 lbs/A.
5. Phosphate (0-45-0) at 1 tablespoon per plant.
6. Super FTE 504 (0-34-0) plus fritted trace elements at 4 teaspoons per plant.
7. Broadcast Super FTE 504 at 1000 lbs/A followed by 1244 lbs/A of 0-45-0 in April, 1969.
8. Ethrel (2-chloroethylphosphonic acid) at 4000 ppm.

Broadcast treatments were worked in prior to planting.

Following planting, all plants received 80 pounds of nitrogen. Where phosphorus was applied at planting, the plants were fertilized with ammonium sulfate. Where phosphorus was not applied at planting, a 16-20-0 fertilizer was applied. Urea to supply 20 pounds of nitrogen per acre was applied August 12, 1968.

Several applications of fertilizer have been made in 1969. The 80 lbs of nitrogen from 16-20-0 and from ammonium sulfate were repeated April 10. On June 11, K-Mag at a 320 lbs/A rate was used to supply magnesium, potassium and sulfur to all plots. Forty pounds of nitrogen/A from ammonium nitrate was applied July 2. Ammonium sulfate was used to supply an additional 30 pounds of nitrogen/A on November 19.

Cycocel at 2000 ppm and Ethrel at 4000 ppm were initially applied June 22, 1968, and follow-up applications were made July 8, 1968. The 1969 applications of these chemicals were made May 22 and June 5. The first application of the year was made when the new growth was about two-thirds expanded. The follow-up applications covered late emerging buds as they expanded.

Plots used were 26 feet wide and 15 feet long, containing one row of each of the five varieties spaced 4 feet apart. The plants were spaced 2 feet apart in the row, so that there were seven or eight plants of a variety per plot. For final record purposes, the five middle plants were used in this experiment, which was replicated three times.

Since only two years have elapsed of a three-year experiment, the results reported must be considered preliminary. Table 1 presents the measurements taken.

Results

It appears in this experiment that bud production of rhododendrons at an early age is controlled more by the internal plant system than by externally applied treatments. It is possible, however, to increase markedly the amount of flower bud formation on those varieties which normally bloom young by applied treatments.

Observations about each treatment are as follows:

1. The effect of variety on budding was most apparent in the check treatment where 65 percent of the 'Elizabeth Hobbie' and 'Roseum Elegans' budded, while there was no budding in the 'Princess Juliana' or 'Pink Pearl'.
2. Cycocel application resulted in increased flowering of 'Elizabeth Hobbie', 'Roseum Elegans' and 'White Pearl'. A reduction in plant height but little effect on width was noted.
3. Broadcast of 0-45-0 did not stimulate flowering except possibly in the case of 'Pink Pearl.' Plant size was similar to the check.
4. Broadcast of 0-45-0 plus chelated iron appeared to stimulate flower bud formation in 'Elizabeth Hobbie', 'Roseum Elegans' and White Pearl'. The only two out of 180 plants of 'Princess Juliana' which formed flower buds were growing in this treatment.
5. One tablespoon of 0-45-0 at planting has not stimulated flower bud formation in this trial. Plant size has not been appreciably affected.
6. Four teaspoons of 0-34-0 per plant resulted in marginal necrosis, particularly in 'Princess Juliana' and 'White Pearl' in 1968. Purple spotting of leaf margins of these varieties occurred in 1969-produced leaves. Plant size and flowering were depressed, apparently the result of minor element toxicity; but the leaves have not been analyzed to determine which element or elements in the fritted trace element mixture is responsible.
7. Purple spotting of leaves of 'Princess Juliana' occurred to a reduced degree when 0-34-0 was applied as a broadcast application as compared to application in the planting hole. Plant size and flower bud formation were reduced.
8. Ethrel tended to reduce flower bud formation without reducing plant size. Heavy budding the year following Ethrel application to 'Roseum Elegans' was reported in a previous paper (7). It remains to be seen whether these plants will set large numbers of flower buds in 1970. The other potential effect of Ethrel on stimulating axillary bud formation was not observed. Almost a "witch's broom" effect on 'Sappho' rhododendrons growing in containers followed four applications of Ethrel at 5000 ppm during spring and summer, 1969, in another experiment.

Conclusions

At present, Cycocel at 2000 ppm and 0-45-0 at 2000 lbs/A plus 54.5 lbs/A of chelated iron appear to be the most promis-

Table 1. Average plant size in inches and percentage with flower buds of five Rhododendron varieties following phosphorus fertilizer and growth regulator treatments.

		'Elizabeth Hobbie'			'Princess Juliana'			'Pink Pearl'			'Roseum Elegans'			'White Pearl'		
Tr. No	Material	Ht	Width	% With Flower Buds	Ht	Width	% With Flower Buds	Ht.	Width	% With Flower Buds	Ht	Width	% With Flower Buds	Ht	Width	% With Flower Buds
1	Check	7.5	12.9	65.0	17.8	18.1	0	14.5	15.7	0	19.0	18.5	65.2	17.0	20.7	52.2
2	Cycocel, 2000 ppm	7.3	12.4	80.0	16.6	18.1	0	13.8	16.6	8.7	14.6	17.3	91.3	16.9	20.8	60.9
3	Broadcast (0-45-0) at 2000 lbs/A	6.6	12.2	36.8	17.7	18.5	0	14.9	16.7	29.2	16.6	16.7	54.2	18.7	21.0	37.5
4	Broadcast (0-45-0) at 2000 lbs/A + chelated iron at 54.5 lbs/A	7.0	13.3	77.3	18.0	18.6	9.1	15.5	16.6	18.2	18.3	18.3	81.8	17.8	21.3	59.1
5	0-45-0 at 1 tblsp /plant	7.2	12.4	36.8	16.5	16.6	0	14.8	16.4	9.1	17.2	17.2	50.0	17.5	20.3	50.0
6	0-34-0 w/trace elements at 4 tsp/plant	6.4	11.6	31.6	16.9	17.3	0	14.5	14.9	18.2	14.7	14.0	18.2	15.8	19.2	31.8
7	0-34-0 at 1000 lbs /A + 0-45-0 at 1244 lbs/A	7.4	12.0	52.6	16.4	16.8	0	13.4	15.3	4.5	16.4	15.7	40.9	16.3	19.7	27.3
8	Ethrel, 4000 ppm	7.6	12.5	50.0	16.0	17.9	0	14.9	15.4	0	18.5	18.7	17.4	17.2	20.5	22.7

ing treatments for stimulating early and heavier budding in rhododendrons. Varieties which tend to bud early naturally were most responsive to these treatments. Not all varieties were responsive to phosphorus nor to growth regulator treatments under these conditions.

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MODERATOR NEWHOUSE: Thank you, Dr. Ticknor. We have had two excellent talks so far and the last one is to be given by Andrew Adams from Maryland.

USE OF CYCOCEL IN PREVENTING FALL LOW-TEMPERATURE DAMAGE TO AZALEAS

ANDREW N. ADAMS, JR.
Ten Oaks Nursery & Gardens, Inc.,
Clarksville, Maryland

For those of us who grow azaleas of the evergreen types, Kurume, Glenn Dale, Gable, Kaempferi and their hybrids, it is certainly discouraging every spring to find so many plants that are not saleable due to either bark split or bud damage. Most azalea damage, we have found over the years, occurs around the middle of October or the first part of November, after a long Indian summer with lush growing conditions — no frost, just warm rains. The growing season generally ends the first night with the temperature dropping to 23°F or so.

We have often said, and I know many of you folks have too, if we could only stop this growth the latter part of August or early September and be satisfied, instead of pushing our plants right up until the last good fall day. One method, which is time proven, of course, is to dig every plant around the middle of August and check its growth, but that went out with the depression when labor wages started skyrocketing.

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In 1963, Dr. Neil Stuart of the U. S. Department of Agriculture at Beltsville, Md. was working with a chemical called Cycocel or CCC (2-chloroethyl trimethylammonium chloride) which he discovered increased bud formation in greenhouse azaleas. With Dr. Stuart's encouragement we experimented at Ten Oaks with some of this material containing 11.8% active ingredient. After several years of burning foliage, stunting plants, etc. we found that one gallon of the 11.8% material mixed with 30 gallons of water, plus 2 cups detergent (Joy) added for spreader-sticker applied as a spray until run-off, did a good job of slowing growth. We also found, through further experimentation, that one application is not sufficient to stop growth with our usual wet August. In the Maryland area we found we need three weekly sprayings, startings on August 9th, spraying again on August 16th and then a final one on August 25th. If there is continued good growing weather through September, then a fourth spraying on September 25th, or one month later seems beneficial.

In conclusion I would like to say we have tried both the B-9 and Phosfon growth regulators and have not had the results we have had with CCC. Cycocel tends to yellow the foliage and give it that hard look which is fine for the landscape nurseryman but not for the florist, so care must be taken to add a generous amount of iron. We add 3 pounds Rayplex Iron per 30 gallons with our Cycocel spray mix to help eliminate this problem. The cost for 10/12″ and 12/15″ azaleas runs 4½c per plant for the three applications. I might add that when a plant reaches four years of age in the field, or when it stops putting out late shoots, we no longer treat them. This material is a great aid to horticulture even though not a cure-all. We are still looking for a better chemical, but to date have found none.

MODERATOR NEWHOUSE: I'd like to call the three speakers to the front table so that they can answer questions.

DICK VANDERBILT: Bob Ticknor, what age plants were you working with?

BOB TICKNOR: Part of them were what Ted Van Veen calls his spring liner and part we propagated in December.

DICK VANDERBILT: And you evaluated them 2 years later?

BOR TICKNOR: Yes.

VOICE: Andy Adams, would you give that formula again please?

ANDY ADAMS: We used the commercial mix of Cycocel which is 11.8%, adding 1 gallon to 30 gallons of water with 2 cups of Joy and 3 pounds of Rayplex Iron, available from Geiger Chemical Co. I use a backpack Sola sprayer with an open end, unscrew the nozzle on the end, and spray until complete runoff. The sprayer is turned up to about half volume.

JOE CESARINI: Dr. Ticknor, what is the name of the yellow dwarf rhododendron you showed?

BOB TICKNOR: That was 'Doubloon' and would probably be classed as an H-3; this would put it out of your area except for maybe some of the real mild areas on Long Island. It was originated in the Portland area.

CASE HOOGENDOORN: Bob, what is the proper time to use B-Nine for bud setting?

BOB TICKNOR: The proper time to apply most of these chemicals is to make the first application when your first flush of growth, that is the leaves, are about half expanded, wait 10 days and then apply again. This year we got good results in the field with B-Nine. Previously, however, we did not obtain very good results; I'm not sure what was different about this year, but we're still working with it.

LESTER FREELAND: Martin Meyer, you mentioned using nitrogen and phosphorous. Have you used any combinations with potash?

MARTIN MEYER: I have used potassium in previous studies but these were done only with nitrogen and phosphorus, but potassium was added to the plants at a constant amount to all of them.

JIM WELLS: Bob, have you used Cycocel just to reduce the vigor of the plant without dwarfing it?

BOB TICKNOR: No, we haven't; we've used only two levels, 2 and 4 oz of the 11.8% material. We did, at one time, use a 1 oz rate but we didn't get the budding response we wanted and discontinued it.

CHARLEY HESS: Martin, in your paper you described the application of fertilizer in summer with effects on growth the subsequent season. Would fall applications be metabolized so that you would have the effect on growth as your summer application?

MARTIN MEYER: I would assume that with plants that grow in the spring from parts that are preformed, that if you apply fertilizer in the fall the parts should be completely preformed and entering, or in, the resting condition; otherwise you may induce a flush of growth. Probably the greater response to fertilizer would be on those plants capable of initiating more leaf primordia after the first flush of leaves grows out in the spring; it is on this group of plants that the nurserymen notices the most fertilizer response from summer applications.

CHARLIE HESS: What do you mean by a summer application?

MARTIN MEYER: In these experiments, they were applications after the flush of growth was made in taxus. The experiments were started about the first of July and carried into fall (about the middle of September) then about the middle of April, when the plants started growing, we began applying the fertilizer for the second summer application.

CHARLEY HESS: Then you wouldn't get the same growth if these were applied in November?

MARTIN MEYER: I wouldn't think so with taxus, because of the preformed condition.

JOHN MCGUIRE: What was the medium used in your containers?

MARTIN MEYER: It's a 1:1:1 v/v soil, peat, turface mixture.

JOHN MCGUIRE: Dr. Ticknor, did you use any banded applications of high phosphorous?

BOB TICKNOR: No, it was either broadcast or put in the planting hole.

JOHN MCGUIRE: The reason I asked is that in Rhode Island we only got response when we used a ton per acre in a band; with broadcast we got no response either.

BRUCE BRIGGS: Bob, did you observe any frost protection by using Ethrel on the rhododendrons?

BOB TICKNOR: There was no damage on any of the plants, treated or untreated, last winter.

JOHN NEWHOUSE: If there are no further questions, I want to thank our speakers for an excellent program this afternoon.

FRIDAY MORNING SESSION

December 5, 1969

The Friday morning session convened at 8:30 a.m. in the Windsor Ballroom of the Commodore Hotel. Mr. William Flemer III served as moderator.

CHARLEY HESS: The moderator of this morning's session is Bill Flemer III, but he has been detained. In the interest of keeping our program on time, I'll start the morning session which deals with the propagation of specific plants with a pretty thorough discussion of *Prunus*. Some of the techniques to be discussed with respect to rooting such plants, which are ordinarily rather difficult to root, will hopefully be applicable to other plant species also. To lead off the discussion is Dr. Tehrani who will discuss, "Hardwood cutting propagation of different *Prunus* species."

PROPAGATION OF DIFFERENT PRUNUS SPECIES BY HARDWOOD CUTTINGS

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INTRODUCTION

Clonal propagation of some plum rootstocks by hardwood cuttings is more economical and less time consuming under English conditions than the coventional stooling and layering techniques (2, 4, 7). Garner (7) rooted plum rootstocks by collecting hardwood cuttings in the fall and storing them in insulated bins for the winter months at a basal temperature of 45°F. The cuttings were budded in the first growing season and produced satisfactory trees.

In Ontario, imported Myrobalan plum seedlings have been widely used as plum rootstocks. They were quite variable in vigor and there was no assurance that they were virus-free. Interest in propagating plum rootstocks in Canada has been increased by a recent embargo on the importation of nursery stock from Europe. The present investigation was undertaken to study the feasibility of clonal propagation of different plum and peach rootstocks under Ontario conditions.

METHODS AND MATERIALS

Rootstocks of 'Brompton', 'Myrobalan B', and 'St. Julien A' plum were used in 1967 and 1968, 'Black Damas C', 'Marianna' and 'Michaelmas' prune in 1968. These have previously been described (3, 8).

Sixteen-inch cuttings with a 3/16 inch minimum diameter were taken the last week of November from vigorous shoots

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[1] Respectively, Research Scientist and Agricultural Technician

of hedges of the above rootstock cultivars pruned annually (6). The mid-point diameter of the basal cuttings varied from 3/16 to 9/16 inch and the diameter of the thickest second cutting was 8/16 inch. However, higher percentages of basal cuttings had 5/16 to 8/16 inch diameters in comparison to the second cuttings, which were mainly 3/16 to 6/16 inch. Cuttings were put in the rooting medium during the last week of November. They were removed and planted in the nursery the first week in April. In 1967, six replicates of 10 basal cuttings each and, in 1968, three replicates of basal and of second cuttings were randomized when planted in the propagating frames. The base of the cuttings was momentarily dipped in a 500 ppm solution of indole-3-butyric acid (IBA) in 50% ethanol and then allowed to dry for half an hour before planting (1).

The propagating coldframes were prepared by excavating the soil to a depth of 12 inches. A four-inch layer of coarse gravel was laid at the bottom to facilitate drainage and covered with eight inches of a 1:1 peat-coarse sand rooting medium. The thermostatically controlled heating cables were laid on top of the coarse sand (2). To conserve heat the exterior walls of the coldframe were enclosed by fibre-glass insulation.

In 1967, minimum soil temperatures of 45°, 50° and 55°F were maintained in different compartments at the base of cuttings. In 1968, the thermostats were set at 45°, 55° and 65°F. However, from December to March actual temperatures at the base of the cuttings were 48°, 58° and 68°F in each of the corresponding sections of the coldframe. In the 1968 experiment the heat was turned off during the last week of March.

At the time of transfer from storage to nursery, the cuttings were rated from 0 to 5 according to degree of rooting at the base of cuttings. A rating of zero was given to cuttings with no visible roots at the base and a rating of 5 indicated complete coverage of the basal callus with roots.

The cuttings were planted six inches apart in the nursery at a depth of eight inches, in rows four feet apart. Complete randomized block design was used in the storage and in the nursery rows. The established rootstocks were budded in August at a height of five inches to different plum cultivars. The selection of buddable stocks was left up to the budder. After budding was completed, the number of cuttings of each rootstock budded was recorded. The following fall the number of one-year trees established in the nursery was counted.

RESULTS

Bottom temperatures of 50° and 55°F were equally effective in rooting of 'Brompton'. The highest percentage or 'St. Julien A' rooted at 50°F. The rooting response of basal cuttings of the rootstocks, 'Brompton', 'Myrobalan B' and 'St. Julien A' to the three bottom temperatures 45°, 50° and 55°F, is shown in Fig. 1. 'Myrobalan B' rooted very easily after all treatments. However, with this rootstock, there was a reduction in percentage of cuttings budded in August in comparison to the rooted cuttings at transference to the nursery.

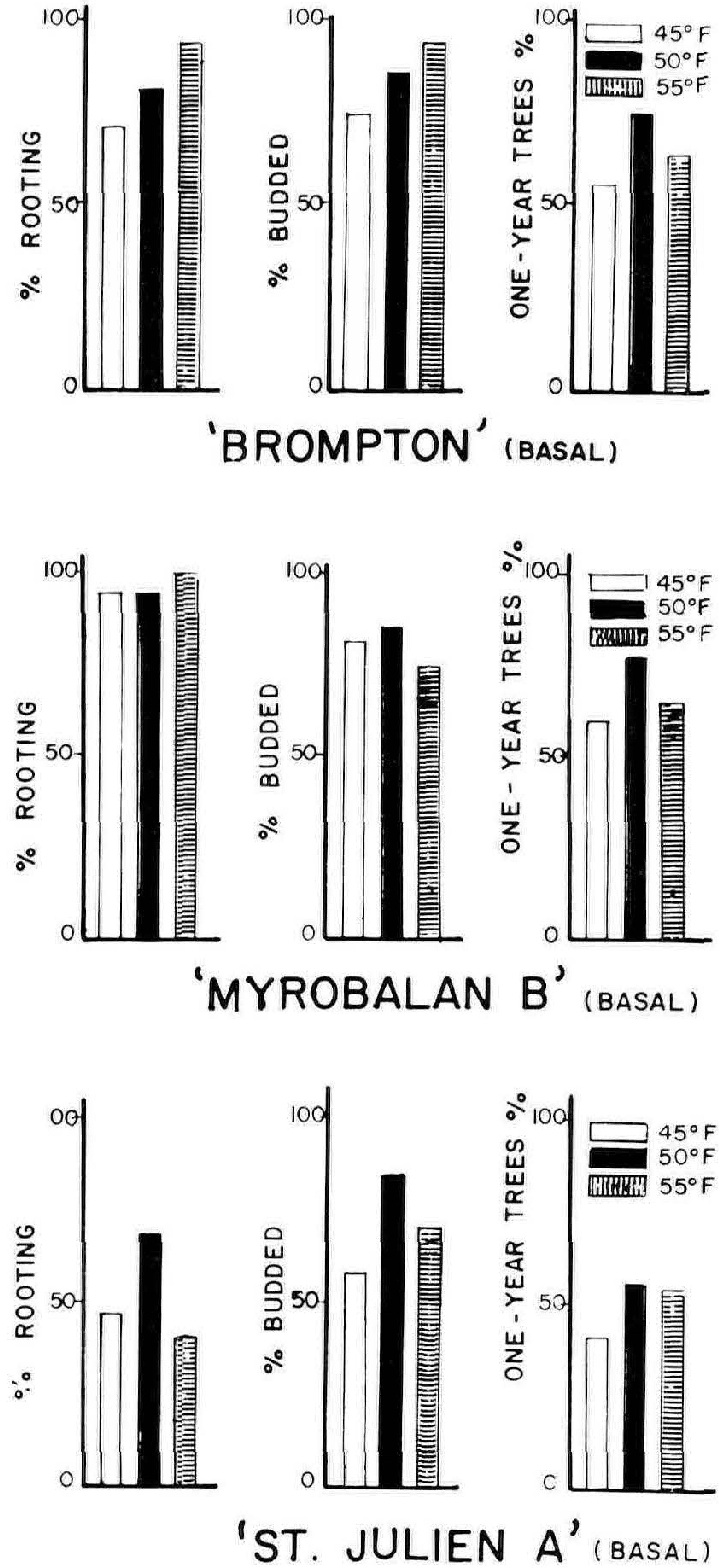

Fig. 1. The response of basal cuttings of three rootstocks to three bottom heat temperatures (1967)

At the end of the second growing season 56.6, 75.0 and 63.3 percent of the 'Brompton' cuttings receiving 45°, 50° and 55°F, respectively, produced one-year budded trees. The percentage of one-year-old trees on 'Myrobalan B' was very similar. However, with 'St. Julien A' the percentage only ranged from 40 to 55 percent.

The rooting response of the basal and second cuttings of 'Brompton', 'Damas C', 'Marianna', 'Michaelmas', 'Myrobalan B' and 'St. Julien A' to bottom heat treatments of 48°, 58° and 68°F, is shown in Fig. 2. No significant differences were observed in rooting of basal and second cuttings of 'Marianna', 'Michaelmas', 'Myrobalan B' and 'St. Julien A', irrespective of basal temperatures. However, 'Brompton' basal cuttings rooted better ($P<0.01$) at 48° and 58°F than at 68°F. The second

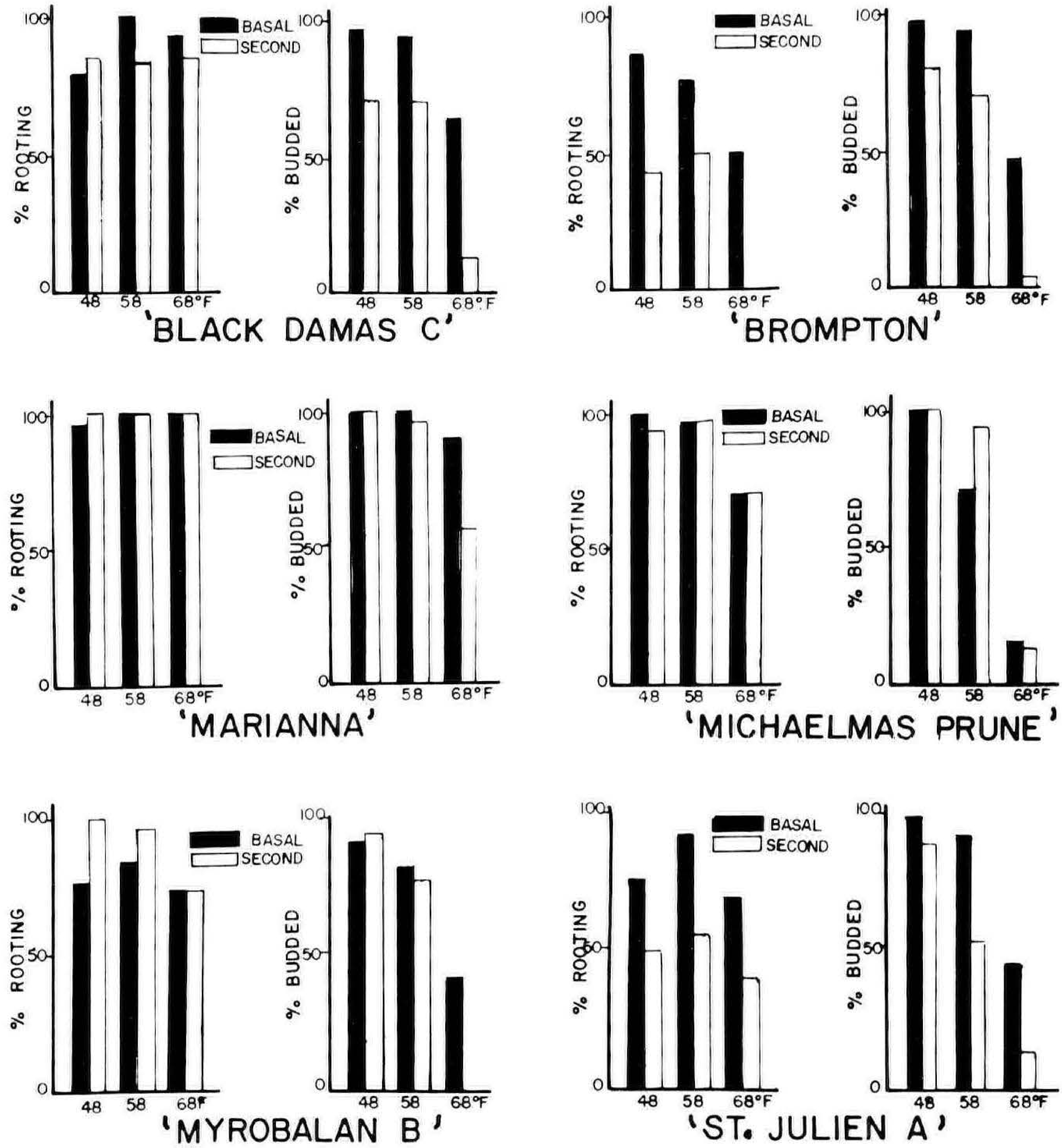

Fig. 2. The response of basal and second cuttings of six rootstocks to three bottom heat temperatures (1968).

cuttings of 'Brompton' rooted significantly less than basal ($P<0.01$) at 48° and 58°F and no rooting occurred at 68°F. The basal cuttings of 'Damas C' rooted better at 58° and 68° than at 48°F ($P<0.01$), but no differences attributable to temperatures were observed in second cuttings.

In general, rooting of the basal and second cuttings of rootstock cultivars at 68°F were inferior to other treatments; the only exceptions were the basal cuttings of 'Marianna' of which 90% were budded in August. At 48°F no differences were observed in any rootstock between the percentage of basal and second cuttings which were budded in August ($P<0.01$). The 58°F treatment of 'Damas C,' 'Marianna' and 'Michaelmas' prune were not statistically different from the 48°F treatment. However, the results with 'Myrobalan B' at 58°F were inferior to those at 48°F.

DISCUSSION

This study shows that clonal propagation of plum rootstocks by hardwood cutting is practical under Ontario conditions. Cuttings given basal temperature treatment during winter can be planted in the open nursery in the spring and budded during the first season of growth. Direct planting in the spring without such bottom heat treatment did not produce any rootstocks in the two years it was tried (unpublished).

All cuttings, irrespective of their thickness, were satisfactory for budding in August. The 16-inch cuttings used in this study provided an original stem adequate for budding. These long cuttings made it unnecessary to bud on secondary branches and avoided the risk of crooked stems.

Percentage of cuttings rooted at the time of transference to the nursery is not necessarily the best criterion for determining successful establishment of the cuttings in the nursery. Both 'Brompton' and 'St. Julien A' had a rather low percentage of cuttings striking root during storage. However, many of the unrooted cuttings struck root after being transplanted to the nursery and by August the percentage of cuttings suitable for budding exceeded the percentage which had roots on removal from storage.

It has been reported that one month of high basal temperatures in the spring (5) suffices to root some plum rootstocks. In this research, a bottom heat of 70°F caused the below ground portion of the cuttings to leaf out early in the spring. Such cuttings, even though they had rooted adequately could not be successfully transplanted to the nursery. Under Ontario conditions, a temperature of 45° to 50°F at the base of the hardwood cuttings was satisfactory for rooting, without encouraging early spring bud-burst. By starting the treatment in late November, a long period for root initiation is provided. At this temperature range, the thickness of the cutting and its location on the shoot were unimportant.

Recently it was reported (5) that 'Myrobalan B' and 'St. Julien A' rooted better when dipped in a 5,000 ppm solution of IBA and given a bottom heat of 70°F. This needs to be investigated further to see whether, at the temperature range of 45-50°F recommended here, the higher concentration of IBA will have any beneficial effects.

SUMMARY

Basal temperatures of 45-50°F in a coldframe was optimal for rooting of hardwood cuttings of 'Black Damas C', 'Marianna', 'Michaelmas' prune, 'Myrobalan B' and 'St. Julien A' plum, and peach rootstocks. Cuttings obtained in late November were successfully budded the next August and produced saleable trees the following year. When this optimum temperature was used both basal and second cuttings gave similar rooting and eventual establishment.

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Charley Hess: Are there any questions at this time?

Case Hoogendoorn: What are the advantages of raising these understocks from rooted cuttings rather than seedlings?

G. Tehrani: There is an embargo on these seedlings and they cannot be imported into Canada any longer. Also most of the important viruses of *Prunus* are seed transmitted and by taking cuttings from clean stock you get away from these viruses. Another point is that it takes 2 years to produce seedlings and we have had many problems with the germination of these seeds when giving the cold treatment in the field. I believe this is the surer way and cost studies have shown it to be cheaper.

Ed Mezitt: Do you leave these cuttings exposed to the weather outside?

G. Tehrani: Yes, the upper portion is completely exposed to the air temperature.

PETE VERMEULEN: At what point did you differentiate between basal and second cuttings?

G. TEHRANI: The basal cutting was taken directly from the main stem and the second was taken above this.

RALPH SHUGERT: Have you tried taking cuttings and sticking them directly in the field row?

G. TEHRANI: No, I haven't because of the wet soil conditions at the time we were taking the cuttings but I personally don't think they would root.

CHARLEY HESS: Thank you, Dr. Tehrani. I'd like now to introduce the moderator for this morning's session, Mr. Bill Flemer III, President of the American Nurserymen's Association.

MODERATOR FLEMER: Our next speaker of the morning is Dr. J. N. Cummins of Cornell University who will speak on, "Increased production of rooted *Prunus* cuttings with a preplanting soak of Benomyl."

INCREASED PRODUCTION OF ROOTED PRUNUS BESSEYI BAILEY SOFTWOOD CUTTINGS WITH PREPLANTING SOAK IN BENOMYL[1,2]

P. FIORINO[3,4], J. N. CUMMINS[4], AND J. GILPATRICK[5]
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Geneva, New York

INTRODUCTION

Decreasing damage caused by fungi and other microorganisms is among the principal means of improving methods of propagating woody plants by cuttings. Softwood cuttings under mist or in propagation boxes provide particularly favorable conditions for the growth and spread of fungus diseases. To produce important economic benefits, a fungicidal treatment should meet three conditions: (1) the treatment must appreciably reduce the incidence of disease; (2) the treatment must not be harmful to the plant material being propagated; and (3) the treatment must not interfere with the rooting/establishment process.

Under intermittent mist, cuttings of many species of *Prunus* are susceptible to *Botrytis cinerea* and a number of other pathogens. Selection and utilization of asexually propagated rootstocks for peach, plum, apricot and sweet and sour cherries depends in part on development of disease control systems.

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[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No 1751.

[2] Benomyl is the coined common name for 1-(butylcarbamoyl)-2-benzimidazole carbamic acid, methyl ester (duPont fungicide 1991 or Benlate). Appreciation is accorded the E.I duPont de Nemours & Co for providing the benomyl used in this work The technical assistance of Miss B. Oakes is gratefully acknowledged

[3] NATO Fellow on leave from Istituto di Coltivazioni Arboree, Universita di Pisa, Pisa, Italia

[4] Department of Pomology

[5] Department of Plant Pathology

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Three types of damage by fungi may be distinguished on many lots of *Prunus* cuttings under mist:

(1) Necrosis of the bark below the surface of the rooting medium, typically observed by the 3rd or 4th day under mist; this inevitably culminates in death of the cutting;

(2) Yellowing and/or browning of the leaves, with or without lesions, becomes discernible by the 3rd to 7th day under mist and is followed by leaf abscission during the 2nd or 3rd week.

(3) Necrotic patches on the lower stem are associated with root emergence, especially if a vertical "comb" of roots erupts.

A number of reports (cited below) suggested that benomyl might control a considerable range of fungi in the mist bed. The work reported here was intended to examine the effects of benomyl on rooting and establishment of *Prunus* cuttings under mist, using *P. besseyi* as the test subject.

REVIEW OF LITERATURE

Comparing intermittent mist with closed propagation boxes for rooting apple softwood cuttings, Singh *et al.* (8) concluded that rooting results were primarily dependent on survival, with either dessication or fungus infection capable of eliminating a planting. Many fungicides have yielded promising results when used on cuttings, and some commercial root-inducing preparations contain fungicides as well as regulators.

Doran (1) obtained promising results when he treated cuttings of *Magnolia virginiana* and other woody species with Phygon-XL. Klauss (5) found treatment with zineb dust to be very helpful with cuttings of begonia, chrysanthemum, pelargonium, and salvia. Tinley (10) working with several fungicides, obtained good establishment of *Hevea brasiliensis* using ferbam, Manzate, and Parzate. Tinley, as well as van der Kerk *et al.*(11) suggested the possibility that these related dithiocarbamate compounds might be growth-regulating substances as well as fungicides. Van Doesburg (12) found beneficial effects from captan dust on cuttings of several species of ornamentals. Smith and Evans (9) reported dichlofluanid the most promising of several chemicals for controlling grey mold on chrysanthemum cuttings.

Benomyl has been shown to be a most effective fungicide, controlling a wide range of fungi on many kinds of host plants. Erwin, *et al.* (3) demonstrated that benomyl applied as a soil drench controlled *Verticillium* wilt of cotton by systemic action. Engelhard (2) found benomyl sprays to have unusually long residual effectiveness against black spot of rose; he considered that this long residual activity might be indicative of systemic activity. Schroeder and Provvidenti (7) found that both soil drenches and pre-planting seed treatment with benomyl gave systemic control of powdery mildew of squash and cucumber.

Gilpatrick (4) reported that soil drenches effectively controlled powdery mildew of both apple and cherry but not apple scab and that the systemic activity is greater by root absorption than by foliar. He found no phytotoxicity at rates up to 100 mg/kg of dry soil. Benomyl was shown by Manning and Glickman (6) to give commercial control of *Botrytis cinerea* on geranium, whether applied as whole cutting dips, as sprays, or as drenches of the medium.

MATERIALS AND METHODS

We selected *Prunus besseyi* as a test subject because our past experience had indicated that the species had both a high capacity for rooting and an extreme susceptibility to damage by disease under mist.

Uniform, subterminal 3-node, 2-leaf softwood cuttings of several unnamed clones were taken from vigorous 10-year-old mother plants. After fungicide treatment, the fresh cuttings were air-dried for about 10 minutes; just before planting, the basal centimeter of each cutting was dipped for about 5 seconds into 1000 ppm IBA (3-indolebutyric acid) in 40% ethanol. Each flat was divided into four rectangular sections, each section receiving a different randomly distributed treatment (Fig. 1). In a shaded greenhouse bed, mist was applied intermittently for 2 seconds every minute, 14 hours a day, throughout the June 16 — August 4, 1969 experimental period.

Sterile media were obtained by autoclaving flats containing the chosen substrate. "Contaminated media" had been used in 1968 for mist propagation of apple, cherry, and geranium; disease had been a serious problem, and many particles of decayed plant tissue were dispersed throughout the substrate.

Evaluations were made 22 days after cuttings were treated, unless otherwise noted. Records taken included:

Survival (a cutting was considered as "surviving" only if the stem, callus tissue, and roots were free of superficially discernible infection),

Rooting (a cutting with any emergent root was considered "rooted". without regard to root size, number of roots, or survival status of the cutting),

Leaf retention (a leaf adhering to the stem was considered to be "retained" if its color was approximately normal and no decay was visible on either blade or petiole).

Trial 1: Benomyl and contaminated medium. — Fresh cuttings of the clones 'PB-10',-'17', and -'19' were soaked for 5 minutes in benomyl at 0, 330, 1000, or 3000 ppm concentration[1]. After IBA treatment, cuttings were stuck into flats containing a contaminated perlite/sand medium; each of the 12 plots contained 23 cuttings. Cuttings of 'PB-36' were similarly treated but were planted in sterile perlite-vermiculite substrate, 14 cuttings per plot.

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[1] All concentrations are expressed in terms of active chemical.

Trial 2: Whole cutting soaks in captan or benomyl. Cuttings of the clone 'PB-17' were soaked for 5 minutes in 1000, 3000, or 6000 ppm benomyl or captan, or in water. Cuttings were then treated with IBA and stuck in a heavily contaminated peat-perlite mixture. The experiment included two replicates, with 25 cuttings per treatment.

Trial 3: Interaction of whole cutting soaks and substrate drenches Fifteen cuttings of each of the clones 'PB-8', '-15', and -'17' were soaked for 5 minutes in 1000, 3000, or 6000 ppm benomyl or in water. After drying, the cuttings were stuck into a heavily contaminated peat-perlite medium which had been drenched with 5 grams per flat of either captan or benomyl.

Trial 4: Effect of whole cutting soaking time. 'PB-1', which had earlier showed an unusual susceptibility to fungus attack, was used to examine the effect of the period of soaking time on protection. Cuttings were dipped momentarily, soaked for 5 minutes, or soaked for 1 hour in 1000 ppm benomyl and were then immediately rinsed in tap water. After IBA treatment, they were planted in a contaminated peat/perlite medium. Four replications, 25 cuttings per plot were used.

Trial 5: Duration of residual effectiveness .The previous cuttage trials suggested that effectiveness was of short duration. Accordingly, we planted in contaminated media 100 cuttings soaked for 5 minutes in 1000 ppm benomyl and the same number of untreated cuttings. Weekly thereafter we evaluated these cuttings for leaf loss, petiole infection, death of cuttings, and root establishment.

Statistical treatments. Because so few proportionate data were at percentage extremes, we did not resort to arcsin transformation but rather performed analyses of variance directly on the data. Duncan's multiple range test was applied when significant differences were indicated.

RESULTS AND DISCUSSION

Striking effects of benomyl soaks on leaf retention, cutting survival, and rooting are shown in Tables 1 and 2 and Figs. 1 and 2. With cuttings in contaminated media (Table 1), the

Table 1. Effects of different concentrations of benomyl on cuttings of *Prunus besseyi* planted in contaminated rooting media.

Benomyl concentration (ppm)	No of healthy leaves per cutting (originally 2)[1]	Percentage of cuttings surviving after 22 days[1]	Percentage of cuttings rooted[1]
0	1.1a	50.9a	66.4a
330	1.4b	55.2a	74.2ab
1000	1.7c	80.2b	85.3bc
3000	1.8d	91.4b	98.1c

[1] In a given column, means followed by different letters are significantly different at the 5% level, as indicated by Duncan's multiple range test.

Table 2. Effects of benomyl concentration on cuttings of *P. besseyi* 'PB-10' planted in sterile perlite-vermiculite substrate.

Benomyl concentration (ppm)	No. of healthy leaves per cutting (originally 2)[1]	Percentage of cuttings surviving after 22 days[1]	Percentage of cuttings rooted[1]
0	0.93a	71.4a	49.9a
330	1.79b	85.7ab	57.0ab
1000	1.71b	92.9b	71.5c
3000	1.79b	92.9b	64.4bc

[1] In a given column, means followed by different letters are significantly different at the 5% level.

activity of the fungicide increased with concentration throughout the range used in this trial. In a sterile medium (Table 2) no concentration effect was observed, but the differences between treated and untreated cuttings was quite marked. There was no indication of phytotoxicity on any plot. Among the cuttings treated with 3000 ppm benomyl, almost all leaves appeared healthy and functional after 3 weeks under intermittent mist; more than 90% were free of visible symptoms of disease.

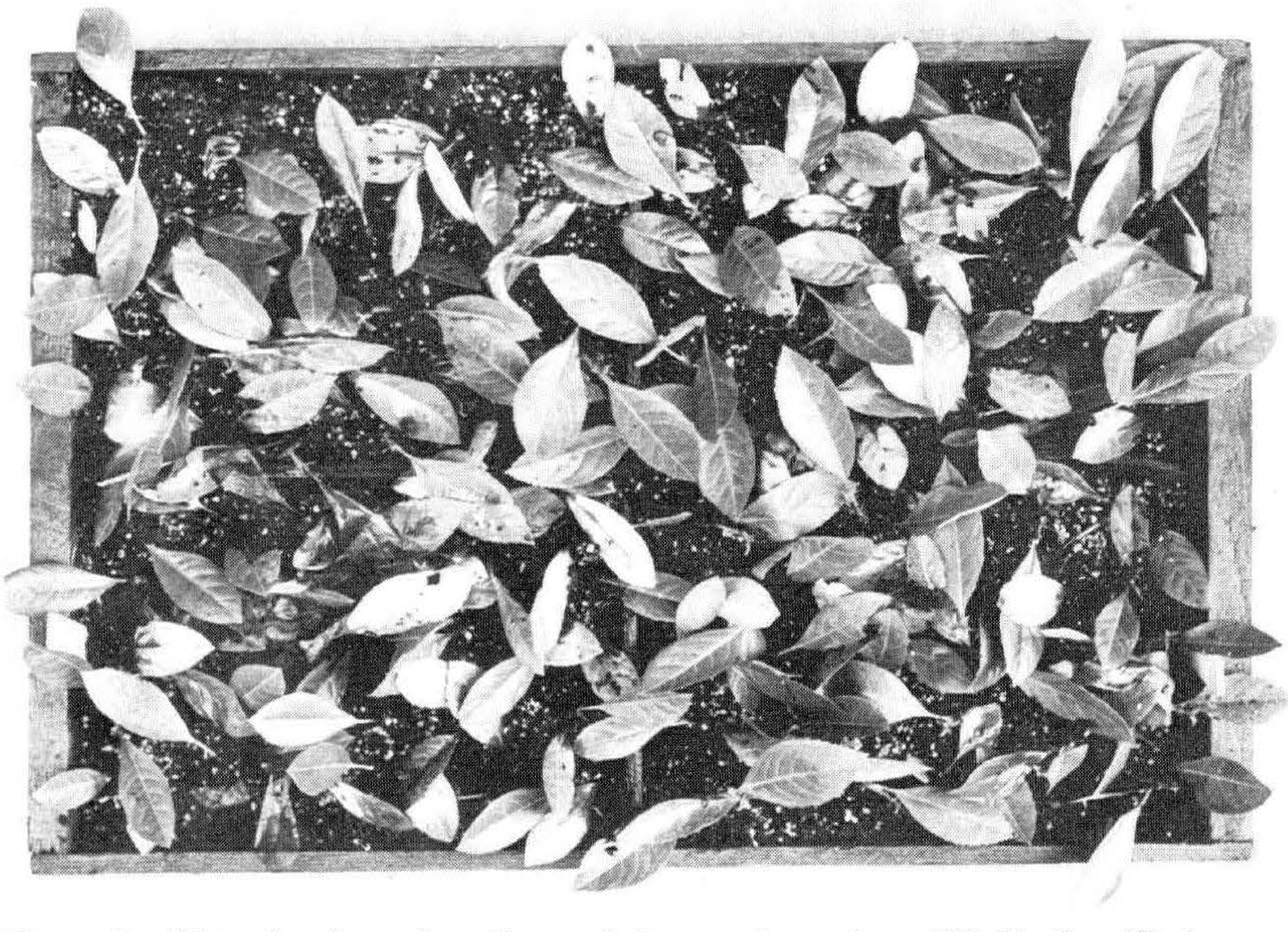

Figure 1. Flat of softwood cuttings of *Prunus besseyi* cv. 'PB-1' after 22 days under intermittent mist. The flat is divided into 4 rectangular quarters, each a treatment plot. Heavy leaf loss and large numbers of lesions on the leaves are shown on the check (*lower left*) and 330 ppm benomyl (*upper left*). Foliage in the 3000 ppm benomyl plot (*lower right*) is conspicuously healthy. 'PB-1' is highly susceptible to *Botrytis*.

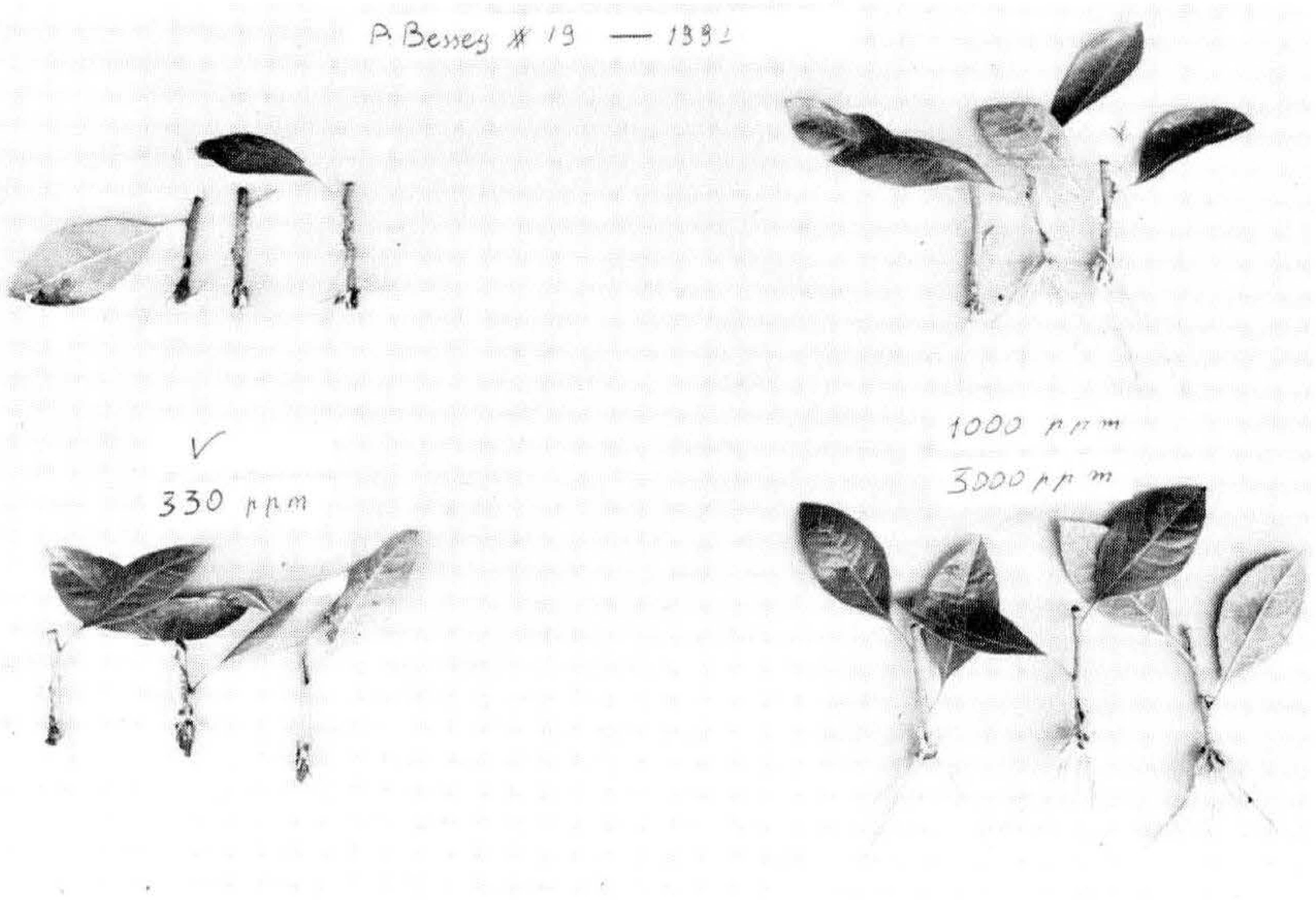

Figure 2. Typical cuttings of 'PB-19' rooted after 22 days under mist. Vigorous root growth, good leaf retention, and healthy stems of the 3000 ppm benomyl group (*lower right*) contrast with the less healthy appearance of the check (*upper left*) and 330 ppm benomyl samples (*lower left*).

Initial infection of cuttings was usually observed as a dark, slimy region at the extreme base of the cutting. With contaminated media, such infections were often observed as early as 3 days after planting. This initial infection usually took place at the basal excision wound. Later infections originated at the base or through leaf scars, through infected buds, or at wounds caused by eruption of roots.

Our observations indicated that the infection came from two sources: the medium itself, and the stock plants. In sterile media (Table 2), even the lowest concentration of benomyl appeared to be effective in disease control; this was probably due primarily to reduction of the inoculum originally on the cuttings. In contaminated media (Table 1), the concentration effect is a response to continuing attack by pathogens from the medium. Supposedly this concentration effect is related to variations in residual surface protection and/or to different amounts of benomyl initially absorbed by the cuttings.

Rooting was increased by fungicide treatments, but no conclusive evidence was obtained to distinguish whether this was due to a direct stimulation of root formation, to a higher rate of cutting survival during the rooting period, or to the number and quality of leaves retained. The data in Table 2 do not support the last hypothesis, although the data of Table 1 indicate that leaf retention is an important factor.

Captan and benomyl soaks compared. (Trial 2). On contaminated media, a five-minute soak in either captan or benomyl materially improved leaf retention, cutting survival, and rooting, as shown by the data of Table 3. There was no concentration effect with captan; even the lowest (1000 ppm) captan soak compared well with the two lower benomyl concentrations. The 6000 ppm benomyl soak was superior to any other treatment in all three criteria; no phytotoxicity was observed even at this extremely high concentration[1]. We infer that at this highest concentration enough benomyl was absorbed and/or adsorbed by the cutting to provide long residual protection. It should be noted that the differences in fungicide costs are negligible, since 5 gallons of suspension are adequate for treating many thousands of cuttings.

Interactions between drenches and whole cutting soaks (Trial 3). When used as substrate drenches at the 5 g per flat rate, captan appeared to be slightly superior to benomyl, as shown in Table 4. That both drenches were residually effec-

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[1] 6000 ppm benomyl is equivalent to 10 pounds of 50% wettable powder per 100 gallons of water.

Table 3. Comparison among 5 minute soakings in captan and benomyl (Trial 2). Under mist 21 days. Two replications using clone 'PB-17' only; 25 cuttings.

Fungicide and concentration (ppm)	No. of leaves retained per cutting (originally 2)[1]	Percentage of cuttings surviving[1]	Percentage of cuttings rooted[1]
Control	0.16a	28a	30a
Captan 1000	0.46b	72cde	50ab
Captan 3000	0.48b	60cd	36a
Captan 6000	0.42b	58bcd	48ab
Benomyl 1000	0.38b	36ab	44ab
Benomyl 3000	0.44b	52bc	60ab
Benomyl 6000	0.62c	84e	76b

[1] In a given column, means followed by different letters are significantly different at the 5% level.

Table 4. Interactions between substrate drenches using 5 g of benomyl or captan per flat and soaking cuttings in benomyl. Three clones ('PB-8', - '15', and -'17'); 45 cuttings total Contaminated media.

Concentration of benomyl used for 5 minute soak (ppm)	Number of funtional leaves retained per cutting (of 2)		Percentage of cuttings surviving[1]		Percentage of cuttings rooted[1]	
	Captan[1]	Benomyl[1]	Captan[1]	Benomyl[1]	Captan	Benomyl
Control	0.72ab	0.63a	82.2ab	64.6a	75.6	68.9
1000	1.44c	1.11bc	88.9b	91.1b	77.8	68.9
3000	1.54c	1.32c	100.0b	91.1b	77.8	80.0
6000	1.28bc	1.50c	87.8b	91.1b	75.6	77.8

[1] In a given column, means followed by different letters are significantly different at the 5% level.

Table 5. Effects of soaking period in 1000 ppm benomyl on leaf retention, cutting survival, and rooting of 'PB-1' in contaminated media.

Period of soaking in 1000 ppm benomyl	No. of leaves retained per cutting (originally 2)[1]	Percentage of cuttings surviving[1]	Percentage of cuttings rooted[1]
0	0.22a	38a	50a
Quick dip	1.10b	78b	78b
5 minutes	1.24bc	66b	76b
1 hour	1.44c	80b	84b

[1]In a given column, means followed by different letters are significantly different at the 5% level.

Table 6. Comparison of residual effects 1, 2, and 3 weeks after 5 minute preplanting soak in 1000 ppm benomyl. Cuttings set into contaminated media.

Week	Leaves retained per cutting		Petioles infected		Cuttings surviving (percentage)		Cuttings rooted (percentage)	
	Check[1]	Benomyl[1]	Check	Benomyl	Check[1]	Benomyl[1]	Check[1]	Benomyl[1]
1	1.56cd	1.88d	0.20	0.00	58b	90c	6a	10a
2	1.04bc	1.52cd	0.26	0.10	46b	84c	30b	38b
3	0.14a	0.46ab	0.14	0.44	20a	52b	40b	56c

[1]In a given column, means followed by different letters are significantly different at the 5% level.

tive on the media, rather than within the cuttings, is shown by the difference in leaf retention of cuttings soaked in benomyl and those not soaked in the fungicide.

With quick-rooting species such as *P. besseyi*, loss of leaves may have little direct influence on rooting. For slow-rooting plants, such as *P. domesica* cv. Brompton, retention of leaves appears almost essential for rooting.

Period of soak (Trial 4). A momentary dip in 1000 ppm benomyl gave surprisingly effective disease control (Table 5). Since these cuttings were rinsed immediately after treatment, a very rapid initial uptake and/or strong adsorption is indicated.

Residual effectiveness (Trial 5). The dramatic effect of treatment with benomyl in keeping the cutting healthy through the first critical period of rooting is shown in Table 6. In effect, the data indicate two waves of infection: the first occurs immediately after planting, the second some 10 to 14 days later. The 5 minute soak in 1000 ppm benomyl is effective for the first infection period, but its efficiency has been lost before the onset of the second wave of infection. Our observations suggested that the first infection probably came from inoculum on the mother trees and from the contaminated substrate, with entry being through excision wounds. For the second infection wave, 3 possibilities are suggested: (1) new production of inoculum, with subsequently high infection potential; (2) different parasites involved, one active immediately, the second, later, which may be resistant to benomyl; (3) development of new avenues of infection into the stem tissue, principally by eruption of roots and production of unsuberized callus at the basal cut, on leaf scars, and at lenticels.

CONCLUSIONS AND SUMMARY

The efficacy of benomyl soaks of *Prunus besseyi* softwood cuttings before setting under intermittent mist was clearly demonstrated. No phytoxicity was observed at concentrations of 1000, 3000, or 6000 ppm actual benomyl. The improved quality of rooted cuttings which had been pre-soaked in benomyl (Fig. 2) should result in improved performance of the plants when transplanted to the nursery. The pre-planting soak is suggested for commercial trial for propagation of *Prunus* and other genera as soon as label clearance is obtained. If the propagator is using contaminated media, drenching this substrate with captan before planting cuttings may be expected to improve disease control.

None of our observations suggest that benomyl in significant quantities is absorbed by the unrooted cutting from the substrate. When benomyl is applied in a whole cutting soak, its initial action may be to destroy the pathogen on or within the host plant. Factors influencing the residual effectiveness of benomyl include initial concentration, use of wetting agent, period of soaking, amount and nature of pathogen in the rooting substrate, inherent susceptibility of the cutting, and possibly extent of leaching of benomyl by the mist. Undoubtedly there are differences in rates of uptake of benomyl among various *Prunus* species and probably among clones within the same species. Although the effect may be expressed over a long period of time, the major action of benomyl appears to be in maintaining good plant health during the first 10 days in the propagation bench.

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FRED SERBIN: Do you know if the solvent for the benomyl is DMSO (*dimethylsulfoxide*)? If it is, the human toxic factor becomes important.

JIM CUMMINS: I can't speak with authority on this but I don't believe it is.

FRED SERBIN: Did you take any special precautions in handling this material?

JIM CUMMINS: No, we did not. This material has been worked with for 4 years now and there is no report of the kind of difficulty you suggest. I might add that we used no wetting agent with this material but there are reports of wetting agents being used with considerable increase in effectiveness of penetration. This could be used to cut costs in using this material.

CARMINE RAGONESI: Does this material have any inhibiting growth on the cuttings?

JIM CUMMINS: The only observation I can give is on *Prunus besseyi* and just the converse happened; treated plants developed rapidly and made better plants than untreated ones. We've also tried this material as a transplant solution and though it is expensive to use this way, we obtained excellent results with plants subjected to field fungi.

ANDY LEISER: Do you know the trade name under which this will be marketed and who is the manufacturer?

JIM CUMMINS: duPont manufactures it. It has been tested as Fungicide 1991 and will probably be marketed as Benomyl which is the official, coined, common name; it has also been called Benlate and it may come out under this name.

MODERATOR FLEMMER: We will have to cut off the questions now; any additional questions can go into the Question Box. Our next speaker is Dr. Robert Farmer who will speak about mist propagation of black cherry.

MIST PROPAGATION OF BLACK CHERRY CUTTINGS: SOME EARLY RESULTS AND PROSPECTS FOR USE IN FORESTRY

ROBERT E. FARMER, JR., AND GERALDINE C. HALL[1]
Division of Forestry, Fisheries, and Wildlife Development
Tennessee Valley Authority
Norris, Tennessee

Vegetative propagation of black cherry (*Prunus serotina* Ehrhart) is essential to currently expanding breeding programs designed to produce forest tree stock with genetic potential for superior growth rate, form, and pest resistance. At present, grafting is being used successfully to establish breeding arboretums of phenotypically superior selections from natural populations, the first step in breeding. It would be more desirable, however, to use rooted cuttings in this work in order to circumvent possible stock-scion problems. In this high-value species, genetically improved clonal stock might also be produced commercially via cuttings. Thus, methods of rooting cuttings are of considerable potential value. Mist propagation techniques have been developed for named varieties and clonal rootstocks of horticulturally useful cherries (2, 3, 4). However, we found no report of black cherry rooting in the literature, although Cech[2] has rooted cuttings taken from stump sprouts of mature trees. In this paper we will report rooting of black cherry as influenced by juvenility, chemical rooting stimulators, and collection time.

METHODS AND RESULTS

1968 Tests

Initial trials were designed to develop suitable media and chemical rooting treatments. In the first, completed in May, July, and August 1968, indolebutyric acid (IBA) treatments outlined in Table 1 were used. Physiologically juvenile cuttings came from small, field-grown, two to three-year-old seedlings, and mature cuttings from two- to three-year-old grafted stock. At least ten genotypes were represented in samples. Six-inch-long apical cuttings were taken after shoots were at least partially lignified. Leaves were pruned to one-half their original area before cuttings were treated and planted in a greenhouse misting bench. We used a commercially available device with which misting cycles are regulated by evaporation rate. The rooting medium was sand: peat (1:1). The design was a split plot with eight, five-cutting replicates of the eight sub-plot rooting treatments. Cutting sources were assigned to main plots.

At three weeks, rooting of juvenile material in Treatments 3, 4, 7, and 8 was about 50 percent for the May trial (Table 1). Cuttings in control and quick dip treatments rooted poorly or not at all. Average July rooting was considerably

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[1] Authors are, respectively, Plant Physiologist and Botanist. They are indebted to Sara Potts and Ruth Moore for statistical analyses and to Melanie Davis for technical aid.

[2] Personal communication with F. C. Cech, Department of Forestry, West Virginia University, Morgantown.

Table 1. Percent rooting of juvenile and mature black cherry cuttings from three collections as related to IBA treatment.

Treatment	May		July		August	
	Juvenile	Mature	Juvenile	Mature	Juvenile	Mature
1. Control	0	0	0	0	0	0
2. Control + Folpet[1]	0	0	0	0	0	0
3. Basal ends dipped talc-IBA (0.8%) mix	47	22	25	12	13	0
4. Treatment 3 + Folpet	52	30	16	19	6	3
5. Basal ends dipped in 2000 ppm IBA, 5 secs.	10	0	0	0	0	0
6. Treatment 5 + Folpet	10	0	0	0	0	0
7. Basal ends soaked in 50 ppm IBA, 25 hours	47	7	22	12	16	3
8. Treatment 7 + Folpet	47	26	56	9	3	0

[1] Thirty minutes immersion in a mixture of 1 tablespoon Folpet (50 percent WP) in one gallon of water

lower than in May but had the same pattern of treatment effects noted in the spring. August rooting was negligible. Folpet[3], which is reported to act synergistically with IBA in rooting other species (1), had no significant effect in this test.

In another May trial with juvenile cuttings, sand and sand:peat (1:1) were found to be equally good media; rooting in both was about 50 percent after IBA treatment.

1969 Tests

Observation of about 50 percent rooting in 1968 suggested that there might be considerable tree-to-tree variation in rooting potential. This variation was studied in 1969, using the IBA-talc treatment to promote rooting in a sand:peat (3:1) medium. Potted three-year-old seedling and grafted (physiologically mature) stock was brought into the greenhouse in March and forced to break dormancy. The five-to-seven-foot tall plants were growing in 8-gallon plastic pots. Twenty-one juvenile plants and all mature grafts (representing nine clones) were pruned back drastically to promote growth of latent buds. Fourteen juvenile plants were left unpruned. The several tests were conducted using material from these plants. In spring, cuttings were rooted in a greenhouse mist bed as in 1968. Summer trials were in an outdoor bed for which a timer supplied ten seconds of mist every three minutes during daylight hours. In both beds the rooting medium was maintained at a temperature of at least 70° F by thermostatically controlled heating cables.

Test No. 1. Trials with cuttings from juvenile, pruned trees were conducted in April, June, and late July. Each had from two to four replicates of four-cutting entries from each tree in a completely randomized design. Controls were used in enough trials to demonstrate that no rooting is obtained with-

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[3] N-(trichloromethylthio) phthalimide.

out IBA treatment. The rooting period was four weeks, after which time cuttings were washed out of the medium; the number of roots and the length of the longest root on each cutting were recorded.

Results are summarized in Table 2. April data are based on three trials started between April 7 and 28. Average rooting for individual trees varied significantly (0.05 level) from 0 to 100 percent; mean for the population was 66 percent. Rooted cuttings from most of the trees had abundant roots (10+), which were vigorously growing when trials were evaluated. Tree-to-tree variation in number of roots per cutting was statistically significant. Root length for trees also varied considerably, but differences were statistically non-significant due to wide within-tree variation.

Table 2. Rooting of juvenile black cherry cuttings as influenced by propagation date and tree.

Propagation Date	Rooting Percent		Roots per Cutting		Length of Longest Root, mm	
	Mean	Range[1]	Mean	Range[1]	Mean	Range[1]
April	66	0-100	15	1-23	43	20-70
June	52	0-100	9	1-18	23	6-35
July	17	0-100	11	7-20	27	10-42

[1] Range of tree means.

The June data are based on a single two-replicate trial in the outdoor mist bed. New shoots which had developed since April were the source of cuttings. Approximately one-third of the trees rooted as well as in April; the remainder exhibited an average decline in rooting of 29 percent. This decline was accompanied by a reduction in number and length of roots. With a few exceptions, ranking of individual trees with respect to rooting was approximately the same in April and June. A further reduction in rooting was exhibited in the July test, which was similar in design to that of June. Only four trees had rooting percent over 50, and most did not root at all.

Some basal necrosis was noted in many of the cuttings. This occasionally restricted root initiation to a portion of the stem immediately below the surface of the rooting medium.

Test No. 2. The second test was designed to compare rooting ability of apical cuttings from the following three sources:

(1) Physiologically mature scionwood grafted to juvenile stock and pruned back. All mature trees were field-selections being used in the TVA breeding program.
(2) Three-year-old pruned trees.
(3) Two-year-old unpruned trees.

On April 14, cuttings were treated with IBA (0.8 percent) in talc and planted in sand:peat in the indoor misting bed. The design was a randomized block with two four-cutting replicates of individual trees.

Results after a four-week rooting period are summarized in Table 3. Rooting percent of cuttings from pruned three-year-old trees was significantly (0.05 level) greater than that for cuttings from the other two sources. Cuttings from mature wood and two-year unpruned trees did not differ significantly in rooting. Root number and length were variable from tree to tree but did not differ significantly among cutting sources. Basal necrosis was again a problem with some cuttings developing roots only very near the soil surface.

Table 3. Rooting of black cherry cuttings as influenced by source of cutting material.

Source of Cuttings	Number of Trees Tested	Rooting Percent		Roots Per Cutting		Length of Longest Root	
		Mean	Range[1]	Mean	Range[1]	Mean	Range[1]
Grafted mature trees, pruned	9	19	0-50	13	1-21	32	15-45
Two-year-old trees, unpruned	14	9	0-63	10	1-21	21	6-60
Three-year-old trees, pruned	21	69	0-100	15	2-22	44	30-70

[1] Range of tree means

Test No. 3. Since basal necrosis reduced rooting surface of some cuttings in nearly all 1969 experiments, some preliminary trials were made to develop methods of reducing it. In the first, cuttings were soaked in a slurry of the fungicides, Folpet and Captan[4], then planted after an IBA treatment in untreated and Pan-O-Drench[5]-treated media. Neither Folpet, Captan, nor Pan-O-Drench significantly reduced basal necrosis which commonly affected 20 to 30 percent of the cuttings. Rooting percent was not increased by these substances.

In a second trial, Captan was mixed with the IBA-talc rooting compound (0.8 and 1.6 percent) at levels of 10 and 20 percent. While rooting percent was slightly higher and necrosis less at 0.8 percent than at 1.6 percent IBA, these differences were not statistically significant. Captan had no effect upon either rooting percentage or necrosis. However, the data suggested that high levels of IBA in talc may have some phytocidal effect.

Five juvenile and six mature trees were represented in these trials. While juvenile material rooted better (85 percent) than equivalent quality mature cuttings (59 percent), it is notable that as high as 91 percent rooting was obtained with cuttings from one mature tree.

Tests with Field-Collected Cuttings. In 1969, several tests with cuttings from field-grown trees were failures, in contrast

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[4] N-/(trichloromethyl) thio/-4-cyclohexene-1-2-dicarboximide

[5] Cyno (methylmercui) guanidine

to results noted above. In two of these trials, apical cuttings collected from three and four-year-old mature-wood grafts and seedlings were treated with IBA and planted in both outdoor and indoor mist beds. Rooting at four weeks was less than 5 percent, and severe basal necrosis was noted in some replicates. Following these tests, some four-year-old seedlings (7 to 10 feet high) were moderately pruned in May and resulting shoots were propagated. These also generally failed to root in both mist beds after IBA treatment.

Handling Rooted Cuttings:

In both 1968 and 1969, rooted cuttings were planted in clay pots filled with a loam potting soil. They were placed under intermittent mist for one week, then removed to a greenhouse bench. Survival of well-rooted cuttings in pots was over 90 percent.

Most cuttings rooted in the spring renewed shoot growth under long greenhouse photoperiods and were well-established plants by August. Some cuttings rooted later in the season did not respond to greenhouse conditions, but could be induced to renew growth by gibberellic acid (GA_3) treatments. GA_3 effects were formally tested in late August. Established cuttings which had set apical buds were paired according to clone and size. One member of each pair was sprayed once daily for three successive days with an aqueous solution of GA_3 (100 ppm); the other member of each pair was untreated. At 10 days after treatment, GA_3-treated plants in 25 out of 29 pairs renewed apical growth. No control plants renewed growth. Statistical analysis of these results using the nonparametric "sign test" indicated that the GA_3 effect was significant at the 0.01 level of probability. GA_3-stimulated apical growth was initially rapid (8 mm per day) and shoots were typically spindly. As the new shoots lignified they partly lost this appearance. During rapid growth the new shoots were especially susceptible to moisture stress, some exhibiting permanent damage under conditions which had no visible effect on older leaves.

In late May and mid-June, rooted cuttings from 17 juvenile and 8 mature clones were transplanted from pots into a nursery bed. One to eight ramets from each clone were planted at 1- by 1-foot spacing in a completely randomized design. The beds were irrigated bi-weekly during the summer and clean cultivated. Survival and height data taken on October 1, are summarized in Table 4. Juvenile cuttings exhibited greater survival and growth than mature ones, and there was statisti-

Table 4. Survival and height of rooted cuttings from pots transplanted into nursery beds.

	Survival Percentage		Height, cm	
	Mean	Clone Range	Mean	Clone Range
Juvenile clones	85	50-100	80	54-117
Mature clones	62	0-100	38	6- 67

cally significant variation among clones within physiological age categories.

DISCUSSION AND CONCLUSIONS

Results from these studies indicate that both juvenile (three-year-old) and grafted mature black cherry can be rooted via mist propagation. The most influential factors related to rooting success were IBA treatment, tree-to-tree variation in rooting potential, season of propagation and the origin of shoots from which cuttings were taken. Wide variation in rooting percentage was associated with all four of these variables.

Effective IBA treatments were similar to those now fairly standard for plants which root with difficulty. Some research attention should be given to the possibility of localized phytotoxicity associated with the IBA-talc treatment. The basal-soak method of treatment with dilute solutions may be more suitable if these effects exist.

Shoots resulting from pruning of potted greenhouse-grown stock exhibited the best rooting, with juvenile trees propagating generally better than grafted mature stock. Moderately pruned field-grown plants produced cuttings which rooted poorly, and field-grown, three-year-old unpruned trees were not successfully propagated. Pruning of potted stock appears to have resulted in reversion to juvenile rooting capability, although this reversion was not demonstrated with moderately pruned field plants. The basis of this differences in response is unknown, and a formal comparison will be necessary to further substantiate it.

Other than treatment and material conditions, the mist propagation procedures used are standard. Both outdoor and indoor beds equipped with bottom heat and different mist control systems were suitable. Sand and sand-peat media commonly used with other species were effective.

Considerable variation in rooting success with juvenile trees was associated with genotype and season of propagation. While spring and early summer trials resulted in much better overall rooting than later tests, it is notable that the tree-to-tree range in rooting percent was 0 to 100, even in April. Since trees were all handled similarly, it is likely that this variation is fundamentally related to genetic differences among trees. Seasonal environmental differences existed and may have caused some reduction in rooting, but most of the decrease is probably due to seasonal changes in the physiological condition of cuttings. Once cuttings were rooted, survival was good regardless of season. In late season, shoot growth could be renewed by spraying rooted cuttings with GA_3.

Survival and growth of rooted juvenile cuttings was good under nursery conditions. The stem form of these plants is similar to that of seedlings. Mature cuttings in the planted sample were on the average one-half as tall as juvenile plants. This difference may be at least partly due to the generally smaller root systems of the sample of mature cuttings which we planted. Further comparative observations will be necessary before conclusions on relative growth can be made.

While more research will be necessary to perfect the above system of black cherry propagation, success to date suggests that the method could be commercially feasible if genetically superior clones were used. This genetically valuable material would warrant propagation costs higher than for seedling production which is commonly used in forestry. Schreiner (5, 6) has long advocated the direct use of genetically improved clonal lines with high-value forest tree species. Given this goal, some breeding efforts could be aimed at developing suitable clones for such direct use. One system might consist of selecting trees with especially good juvenile performance (3-4 years) from progeny tests, screening them for rooting potential, and subsequently evaluating large numbers of good rooters in long-term clonal tests. Due to generally lower rooting capability, direct use of material from mature field-selections does not presently appear as potentially useful as the above system. However, rooting success with most mature wood tested indicates that the procedure may be suitable for seed orchard establishment.

SUMMARY

Softwood stem cuttings of black cherry were rooted under intermittent mist. Indolebutyric acid stimulated rooting of material propagated in spring and early summer; late season propagation was unsuccessful. Successfully rooted cuttings all came from juvenile and mature (grafts) plants which were grown in pots and pruned to promote formation of adventitious shoots. Wide tree-to-tree variation in rooting percent (0 to 100) was observed. Basal necrosis of cuttings reduced rooting in some trials. Gibberellic acid was used to promote renewed shoot growth after rooting. Rooted cuttings were established in nursery beds. The propagation technique is discussed in relation to breeding and production of genetically improved black cherry.

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MODERATOR FLEMER: Thank you very much, Bob, for a most interesting paper. We have time for just a few questions.

JIM WELLS: I was interested in this basal necrosis; have you any idea what causes it?

ROBERT FARMER: I'm not sure if there is a pathogen involved and, if there is, whether it is primary or secondary. Possibly it is an IBA herbicidal effect; if it is, the pathogens would be secondary.

JIM WELLS: Do you think it could be a lack of oxygen effect?

ROBERT FARMER: This is possible; I noticed that in plain sand we didn't get too much necrosis.

JIM WELLS: Many years ago Hitchcock advocated putting cuttings in on an angle so that the leaves were nearly lying on the medium. This may be a way of preventing rapid respiration losses because the leaves are close to the medium and you may have lower respiration. This necrosis is a problem I have all the time and I also think light intensity is involved— but you were outdoors weren't you?

ROBERT FARMER: Yes, but we noticed our worse basal necrosis on the indoor beds in late spring and early summer, just before we had to move out of the greenhouse.

ANDY LEISER: Do you know the specific chemical quality of your sand and your irrigation water? Was your sand a quartz sand, or did it have calcium carbonate in it?

ROBERT FARMER: Our sand does have some calcium in it.

ANDY LEISER: We did some work on the chemical constitution of the rooting medium and found that the basal necrosis in five species of woody plants was essentially eliminated when we added calcium to the rooting mix. In media that were acid and low in calcium all five species exhibited extensive necrosis.

MODERATOR FLEMER: We move from a search for rapidly growing forest trees to a consideration of the propagation of extremely dwarf and contorted witches' brooms. Our first speaker is Sid Waxman, who is going to discuss with us the variability in rooting and survival of cuttings from white pine witches' broom seedlings.

VARIABILITY IN ROOTING AND SURVIVAL OF CUTTINGS FROM WHITE PINE WITCHES' BROOM SEEDLINGS

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INTRODUCTION

I'm sure most of you know what a witches' broom is, but for the benefit of those who are in the dark, I'll first try to describe what witches' brooms are and why they hold such fascination to those of us who are collecting and experimenting with them.

A witches' broom is an abnormal shrub-like growth that occurs only occasionally on various species of woody plants. Most often, it occupies only a small part of the tree while the remainder consists of normal leaves and branches. The broom is considered abnormal because its structure usually differs quite sharply from that of the normal part of the tree. The development of the broom is not the result of a gradual change in structure, but is abrupt, and its point of origin is easily identified (Fig. 1).

I prefer to categorize brooms into two groups; 1) those that are caused by parasitic agents, such as dwarf mistletoe,

Figure 1. A witches' broom on a white pine.

viruses, mites, rusts and fungi, and 2) those that are mutations caused by factors, as yet, not understood. It is the latter group that I am most concerned with because grafts of such brooms usually retain the character of the broom and are not tree-like. The parasite-induced brooms, as one might expect, are often seen in groups, often many on the same tree, while the mutation brooms, which are rare, occur singly and are usually found miles apart.

Although brooms generally are shrub-like, they are not always similar to one another. Very often wide differences in stem and leaf structure occur from broom to broom. Needle length for example, can vary from ¾ inch to over 3 inches. Other interesting features in which brooms differ from one another are color of the needles, density of the branches, and size of the cones. As a consequence, even though the brooms look somewhat similar to the casual observer they are quite different from each other.

Variation that occurs among brooms is fortunate because it increases our chances of finding new and unusual evergreen plants. Brooms are of interest not only because they retain

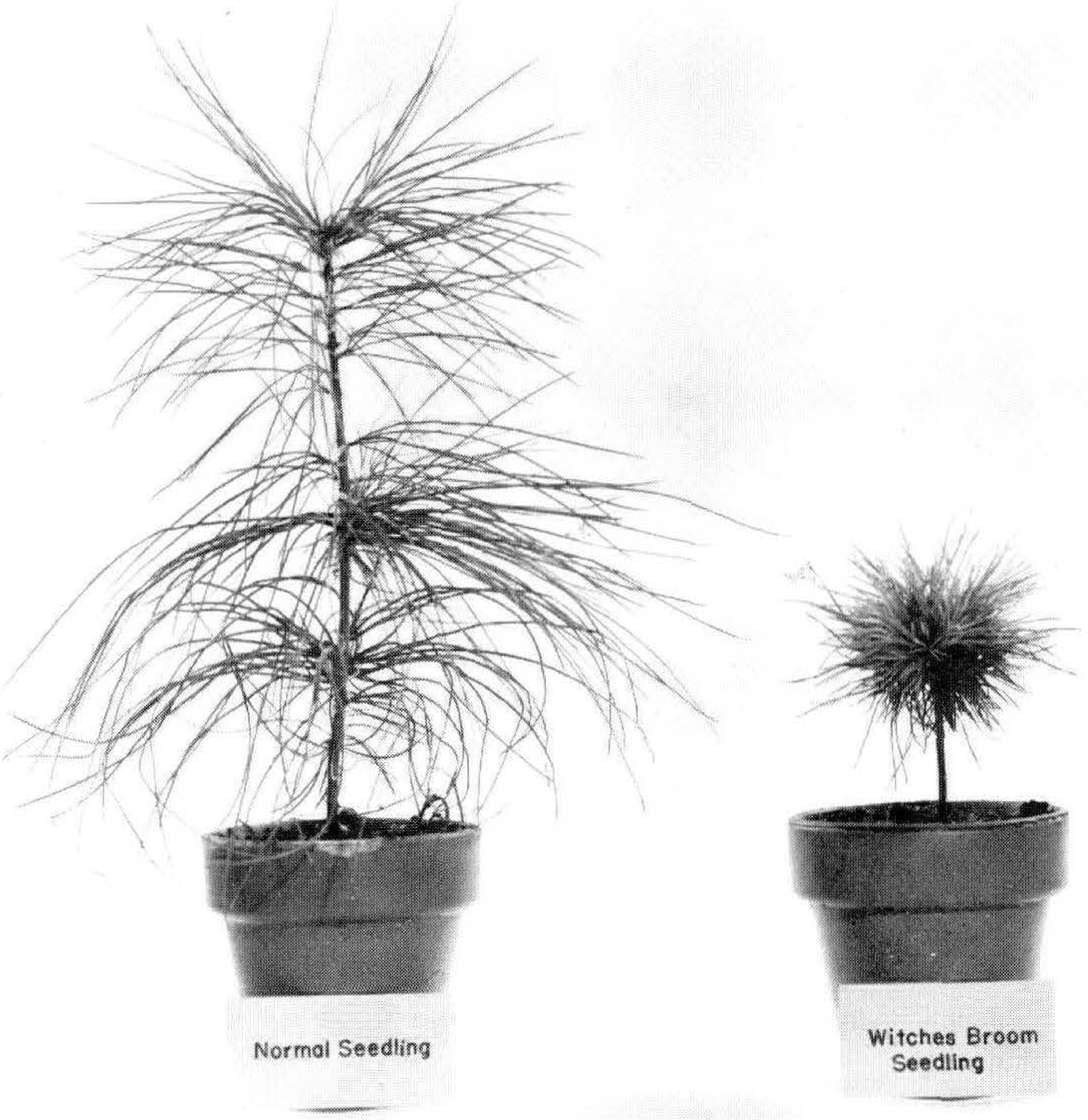

Figure 2. A normal and a witches' broom seedling of white pine.

their dwarf form when vegetatively propagated, but because the germination of seed obtained from brooms results in many unusual forms of shrubs. The fact that these abnormalities are carried over in the seed supports the concept that brooms are the result of mutations (Fig. 2).

To this date only female conelets have been found on brooms. Seed production can occur only by cross pollination from the normal part of the tree or adjacent trees having male catkins. Usually 50 percent of the seedling offspring are abnormal and 50 percent are normal. Of a seedling population from one broom, having a total of 741 plants, 368 were normal while 373 were dwarfed. In another progeny, 98 were normal and 104 were dwarfed. Similar witches' broom progenies have been previously reported by Fordham (3) and by Johnson, *et al.* (6). Both reported 1:1 ratios for normal and abnormal offspring.

In one group of white pine seedlings that are now five years old, considerable although subtle variation was found to occur (Fig. 3).

Figure 3. Examples of variability in form and texture among a group of seedlings obtained from a white pine witches' broom. All plants are 5 years old.

3 -> The vegetative propagation of witches' brooms is limited to grafting (7). Attempts to root cuttings of brooms have been unsuccessful except for one pitch pine cutting which rooted out of 25 taken. Grafting has been generally successful for most brooms except for one broom whose scions were found to grow very slowly. After four years these stunted grafts are still living, but seem to be suited more for a bonsai dish than for the field. For the majority of the brooms tried, grafting has proven successful.

In view of the fact that cuttings from brooms rarely root and because the odds in finding interesting forms among seedlings of brooms are much greater than from among the brooms themselves, an experiment was initiated to determine: 1) if cuttings taken from white pine witches' broom seedlings could be rooted; 2) if rooting varied among seedlings; and 3) if rooting varied according to the age of the plant. It is well known that white pine is not an easy-to-root species, but it has been reported that cuttings have rooted especially when taken from young plants (4).

METHODS AND MATERIALS

Seedlings obtained from a white pine witches' broom were grown in a greenhouse for 16 months under long photoperiods to hasten their rate of growth and were then lined out in the field and grown under natural conditions. After 4 years each plant was large enough to provide a limited number of cuttings. On March 28, 1968, 240 cuttings, four cuttings from each of 60 dwarf seedlings were taken, treated with Hormodin #3 and Captan 10:1 and then placed in coarse sand under mist. The following year, on April 18, 1969, the experiment was repeated using the same 60 plants except that five cuttings were taken per plant, providing a total of 300 cuttings. The frequency of the mist intervals was controlled by a light-operated interval switch (8) that responds to the intensity of the prevailing sunlight. The mist controller was adjusted to provide a minimum amount of water while maintaining a constant film of moisture over the foliage.

The small number of cuttings used per seedling was far from ideal, but in this instance the size of the dwarf seedlings, four and five years old, precluded the taking of a greater number of cuttings.

RESULTS

Of the 60 witches' broom seedlings used as stock plants in 1968, 61 percent had cuttings that rooted (Table 1, Fig. 4).

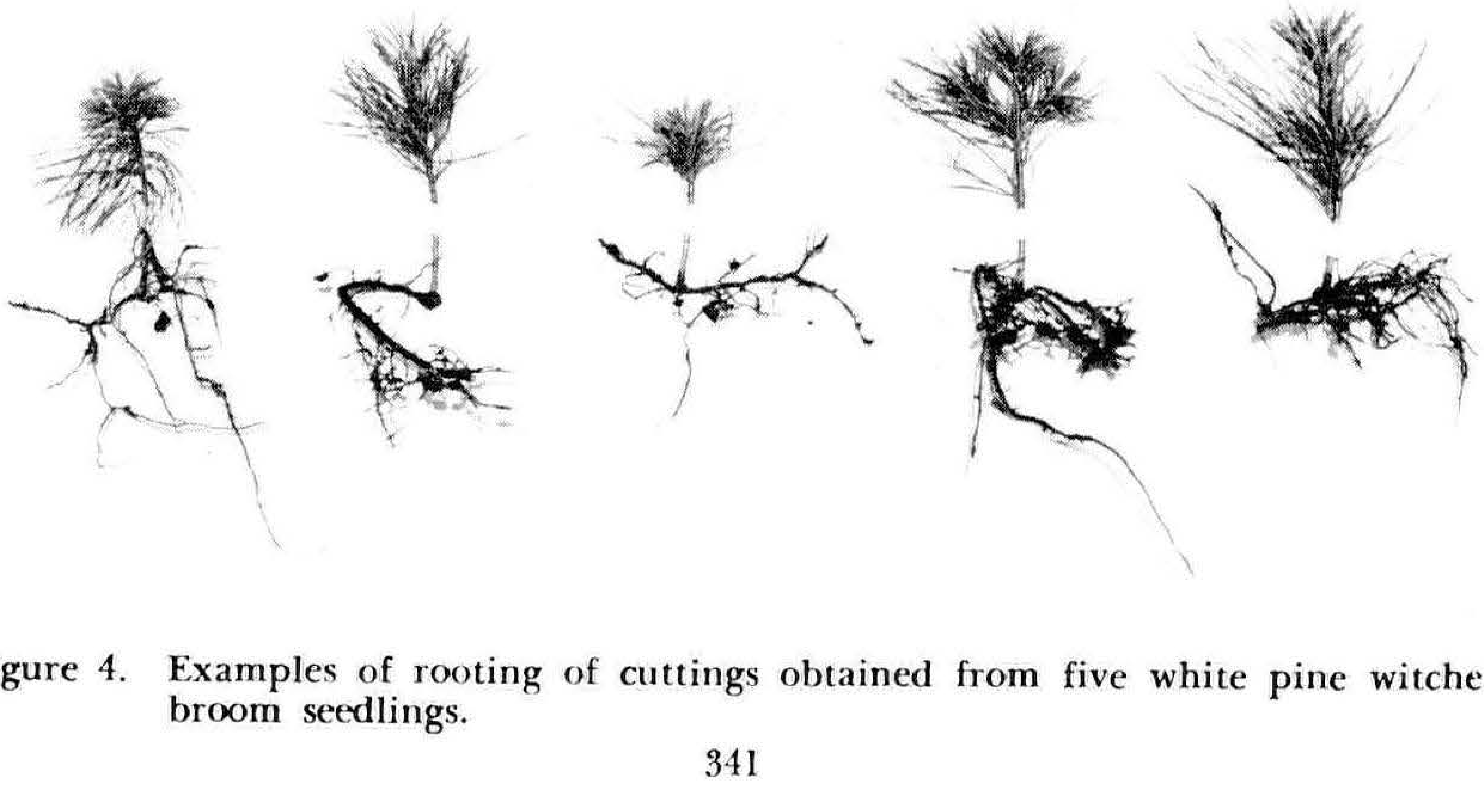

Figure 4. Examples of rooting of cuttings obtained from five white pine witches' broom seedlings.

Combining both years' results, 80% of the seedlings provided rooted cuttings. Considerable variability in rooting occurred among the seedlings. Twenty percent of the seedlings provided cuttings that did not root in 1968, nor in 1969, while 26 percent provided cuttings, all of which rooted. When considering only those seedlings whose cuttings rooted in 1968 and comparing the percent rooting with those rooted a year later, it was found that there was a highly significant decrease in rooting of cuttings taken in 1969 (Table 1). In other words, the percent rooting was significantly greater on cuttings from four-year-old (60.4%) than from five-year-old trees (29.4%).

Another example of a decrease in rooting with the increase in age of the tree was observed when cuttings were taken from a 10-year-old dwarf white pine that was found growing in the wild and which may have been of witches' broom origin (Table 2).

Table 1. Rooting of cuttings obtained from white pine witches' broom seedlings.

	Percent rooted			Percent rooted	
Seedling No.	1968	1969	Seedling No.	1968	1969
1.	0 -	0	31.	0	20
2.	0 -	0	32.	100	100
3.	0	40	33.	50	0
4.	0	100	34.	50	60
5.	25	40	35.	75	60
6.	0	80	36.	100	60
7.	0	60	37.	25	80
8.	50	60	38.	100	20
9.	0 -	0	39.	100	20
10.	0	100	40.	100	0
11.	25	0	41.	25	0
12.	25	40	42.	100	0
13.	50	20	43.	25	0
14.	0 -	0	44.	100	20
15.	50	20	45.	100	0
16.	0 -	0	46.	0	20
17.	25	80	47.	25	40
18.	25	20	48.	0 -	0
19.	0	80	49.	25	20
20.	0 -	0	50.	0	100
21.	0	100	51.	25	80
22.	25	20	52.	0 -	0
23.	50	40	53.	75	20
24.	100	60	54.	50	40
25.	100	20	55.	50	40
26.	0 -	0	56.	25	0
27.	0 -	0	57.	100	20
28.	0 -	0	58.	0 -	0
29.	0	40	59.	75	0
30.	50	0	60.	100	0

Table 2. Effect of age of stock plant on rooting of cuttings of dwarf white pine.

Date	Age (Yrs)	Rooting %	Date	Age (Yrs)	Rooting %
Apr. 1959	10	100	Apr. 1963	4	60
Apr. 1968	19	4	Apr. 1968	9	30

The percentage rooting was 100% in 1959 and only 4% in 1968, when the plant was 19 years old. The cuttings which had rooted in 1959 were grown on and in 1963 were used as an additional source of cuttings. At this time 60% of the cuttings rooted. Five years later, in 1968, the percentage rooted decreased to 30%.

DISCUSSION

Witches' brooms as well as seedlings from witches' brooms brooms are excellent sources of new and interesting dwarf evergreens (2, 3, 7, 9). There is enough variation in form, texture and rate of growth to justify the selection and propagation of choice clones. Propagation by cuttings can best be accomplished by selecting clones which are easy to root. Not all clones root equally well, however, and some were impossible to root.

Deuber (1) reported, in 1940, much variability in the rooting of cuttings taken from white pine clones even though all were of the same age.

The age of the pine seedling has considerable influence over its rooting potential. In these experiments one year's difference in age resulted in a significant decrease in rooting. The decline in rooting in only one year is not unusual. Gardner (4), in 1929, reported similar responses of one, two and three-year-old white pine seedlings whose cuttings rooted 98% from one-year-old seedlings, 51% from two-year-old seedlings and 12% from three-year-old seedlings.

The physiological changes that occur within plants from the juvenile to the mature stage and their concurrent decrease in rooting potential which was described by Hess (5) might serve to explain the decreased rooting of the witches' broom cuttings taken in 1969.

CONCLUSIONS

Seedlings obtained from witches' brooms offer a wide selection of unusual forms of slow growing evergreens. The rooting potential among the different clones varies quite markedly.

Propagation by grafting presents no problem, but cutting propagation may be limited to the easily rooted clones. With the increase in age of the seedling there may be a decline in the ease of root initiation.

The practice of taking cuttings from rooted cuttings of a particular clone may extend the period during which it could be rooted.

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MODERATOR FLEMER: Thank you, Sid for an interesting talk about an interesting group of plants. Any question?

ED MEZITT: Do you have any trouble with woolly aphids on these dwarf white pines?

SID WAXMAN: Not too much; we do have them out in the nursery on a few of the dwarfs.

JOE CESARINI: In separating the seeds from the cones have you ever tried to save the seeds from the lower, middle, and upper part of the cone separately and plant them this way?

SID WAXMAN: I know this is supposed to have some bearing on their potential growth but I have not tried it.

AL FORDHAM: We have separated the small seeds from the large seeds from witches' brooms cones and we got a higher percentage of dwarfism from the smaller seeds.

ROBERT FARMER: Have you checked the ploidy on these?

SID WAXMAN: No, I have not but I believe Arnold Arboretum has done this; am I right, Al?

AL FORDHAM: Yes, the chromosomes have been counted and they were found to be normal.

JOHN RODNEY: How can you tell a witches' broom is a gene mutation and not caused by a pathogen when they're up in the air?

SID WAXMAN: If you see only one broom in an area it's a pretty good indication that its a mutation. Also with white pine we know that it is not usually caused by a parasite.

JOE CESARINI: We find that some sections of these witches' brooms graft very easily and others are very hard to graft. Also, if we take our scions from the grafts our precentage of takes keeps increasing.

SID WAXMAN: So it works the same with grafts as with cuttings; cuttings root better from cuttings.

JOE CESARINI: I have also noticed that sometimes I have 15 or 20 grafts of a single broom, then all of a sudden the brooms will start to go bad, turning yellow and dying. If I happen to pass by the place from which the original broom was taken I notice it is dead too.

MODERATOR FLEMER: Thank you again, Sid, for an interesting talk. Our next speaker, Al Fordham, is going to discuss the propagation of one of the most interesting and valuable of the small size maples, the paper bark maple, *Acer griseum.*

ACER GRISEUM AND ITS PROPAGATION

ALFRED J. FORDHAM
Arnold Arboretum
Jamaica Plain, Massachusetts

Acer griseum, the paper bark maple, is a striking small tree with unique characteristics which lead to interest at all seasons of the year. In spring its newly developing trifoliate leaves are red-orange and when fully expanded they become green on their upper surfaces and conspicuously grey-green beneath. This greyish aspect is indicated by the specific name, *griseum*. In autumn its brilliant foliage is tinted from yellow through orange to deep red. Its outstanding feature, however, is dark reddish-orange bark whose outer layer peels away revealing orange bark beneath, which then darkens to resemble burnished bronze. During winter, when contrasted against snow, or when wetted by rain, the color of its bark is emphasized and *A. griseum* becomes truly magnificent.

This small tree has great popular appeal and many people are anxious to acquire it. However, owing to propagational difficulties, it has remained rare through the years and demand has exceeded supply.

Acer griseum was introduced to cultivation in the United States by the Arnold Arboretum. In 1907, Ernest H. Wilson, while collecting for the Arboretum in Western China, gathered seeds and shipped them to Boston. From these only one plant was raised and it later failed. He also collected a few seedlings which were successfully transported to the United States, and two of these are still alive. Our largest tree has developed from one of these. It has formed a round-headed specimen 26 feet tall and 31 feet broad with a trunk 7 feet in circumference when measured 18 inches above ground. The bark texture of the trunk on this older tree has undergone change — peeling no longer occurs and the bark now sheds in flakes.

PROPAGATION BY SEEDS

Each year during the past 12 years cut-tests of *Acer griseum* fruits were made and usually most have been void of seeds. However, in 1962, some trees had about 20% sound fruits and in 1968 the fruits proved to be about 80% filled. The 1968 testing was done in June when the seeds were partially developed, but by September when it came time to collect them, all had been taken by squirrels. The ground beneath the trees was littered with empty husks.

In 1958 we gathered a large number of seeds and processed them despite the fact that most were hollow. These were carried through various treatments and germination occurred over a period of several years. From this work enough information was acquired to conclude that the seeds showed double dormancy.

In recent years, *Acer griseum* seedling liners have been listed by Gulf Stream Nurseries, Inc., Wachapreague, Virginia, so this autumn we wrote to Jacques Legendre to find out how his seeds had behaved. He replied that the particular seed lot came from F. W. Schumacher, Sandwich, Massachusetts. Some seeds germinated two years after being sown while others took three, and total germination led to a very fine crop. Since that time his efforts to obtain good seeds have been futile. The original supplier has been unable to provide sound seeds and those obtained from England and various other sources have had poor germination. Ernest H. Wilson commented that even in China the tree does not bear fertile seeds each year.

Alfred Rehder in his *Manual of Cultivated Trees and Shrubs* describes four maples in the subsection *trifoliata.* All are native to Eastern Asia; they are: *Acer nikoense, A. triflorum, A. griseum* and *A. mandshuricum.* All four species are characterized by fruits that are usally hollow, seeds that exhibit double dormancy, and rarity in cultivation.

Acer triflorum is also a striking trifoliate maple. Its tawny-colored bark peels and curls as does that of *A. griseum.* In autumn its foliage turns bright orange-red. Plant Buyer's Guide shows *A. griseum* to be available from 1 Canadian, 3 European, and 3 U. S. nurseries[1]. *A. triflorum,* however, is carried by only 1 European and 1 domestic company.

PROPAGATION BY CUTTINGS

Root pieces from all four trifoliate maples were collected and processed to test whether or not they could be propagated from root cuttings and also to see if they might produce juvenile shoots which would root readily. In all cases shoots failed to develop.

As propagators know, cuttings taken from young plants of subjects difficult to propagate will frequently root, while those taken from older plants might not. With this fact in mind, softwood cuttings were taken from an older plant of *Acer griseum.* They were divided into three lots consisting of ten cuttings each.

Lot #1 was treated with a powder formulation of IBA at the rate of 8 mg per gram of talc with thiram added. None of these cuttings rooted.

Lot #2 was treated with a 5-second dip, using a combination of IBA + NAA at 2500 ppm each.

Lot #3 was treated with a 5-second dip using IBA + NAA at 5000 ppm each.

The cuttings were made on June 14 and placed under mist in plastic flats containing a medium of half-sand and half-perlite. On August 25, cuttings in lots #2 and #3 were removed from their flats, evaluated, placed in flats of sandy soil and immediately returned to mist. In lot #2 nine cuttings had rooted — 6 root systems were excellent and 3 were fair. Six cuttings with excellent roots were present in lot #3, while four had not rooted.

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[1] Since the publication of Plant Buyer's Guide, **Acer griseum** has appeared in the catalogues of two wholesale nursery firms.

Rooted cuttings of *A. griseum,* like those of many other plants, present a first-winter survival problem. They go into dormancy from which they never recover. Rooted cuttings of some such subjects will survive if induced to make new growth after they have rooted. This is done by providing supplementary lighting. In the case of *A. griseum* new growth has never appeared on cuttings during the rooting period and the use of lights after they have rooted has failed to stimulate growth. In many instances, first-winter loss can be avoided if the cuttings are not disturbed after rooting.

On November 27, the flats of undisturbed *Acer griseum* cuttings were transferred to our cold storage unit which is maintained at about 34°F. On February 9 they were returned to a warm greenhouse and by mid-March, cuttings that succeeded came into growth. Fifty percent of lot #2 recovered from dormancy and grew, while in lot #3, 60% started growth.

This slide shows rooted *A. griseum* cuttings which were taken from a six-year-old plant. Fourteen cuttings were divided into two lots. Lot #1 was treated with IBA + NAA at the rate of 2500 ppm each and lot #2 at 5000 ppm each. All are well-rooted, have been given a light feeding, and are ready to be transferred to cold storage as described above. However, a batch consisting of 86 cuttings were taken from young plants the same day and treated in a similar manner, have rooted at the rate of only 46%.

We conclude with the thought that if meristem culture or cell culture techniques become feasible for woody plants, *A. griseum* might be a good subject for consideration.

MODERATOR FLEMER: Thank you very much, Al, and while we're on the subject of *Acer griseum,* Case Hoogendoorn has been doing some rooting of this plant and has a few samples to show us.

CASE HOOGENDOORN: Last summer we made our first attempts in rooting *Acer griseum.* These cuttings were made June 23, treated with No. 3 Hormodin and set in flats of sand under fog in the greenhouse; they were potted on August 6. You'll notice the cuttings have a real good root system. We had about an 80% stand and they were all heavily rooted.

Ed. Note—The cuttings were taken from the tops of 1-year-old seedlings thus the use of juvenile wood is probably the main reason for the exceptional rooting obtained in this instance.

JOE CESARINI: We root mostly Japanese maples but we had a few of the *Acer griseum;* we root them right in the pot. We try to keep the temperature in the greenhouse at 31°F where the maples are. Has anyone tried grafting these on other maple understocks?

ROY NORDINE: I have grafted all of the 4 or 5 species of the trifoliate maples and have even grafted them on themselves and I found that they just won't graft. I also tried all different types of grafts and they just won't take.

AL FORDHAM: I have corresponded with the people at Boskoop. They have done quite a bit of work on these and have found that in some cases the combinations will succeed for two or three years but, in all instances, they finally die.

MODERATOR FLEMER: Our last paper this morning will be on *Hamamelis* propagation by Joerg Leiss.

HAMAMELIS PROPAGATION

JOERG LEISS
Sheridan Nurseries, Ltd.
Oakville, Ontario, Canada

Hamamelis or Witch-Hazels, as a group of plants, are probably known to most of you but are propagated and sold by only a few. I think that the unusual characteristics, such as the flowering period, fall and winter to early spring, warrant a much larger quantity to be propagated than there is now. The yellow, orange, and ruby, lacy flowers brighten an otherwise bleak winter scene, when no shrub shows any sign of life.

SEEDING

The six species, *Hamamelis japonica, H. mollis, H. vernalis, H. virginiana, H. macrophylla* and *H.* x *intermedia,* can be grown from seed which ripens in September-October in a two-seeded pod. It is best collected while the capsule is still soft (early September) as the seed, when ripe, is expelled as in *Buxus* and would be very hard to find on the ground. It scatters as far as 6 feet. We have found that seeds will not germinate the spring following if picked greener (August). If pure varieties are to be grown, seed has to be collected from pure stands, with the exception of *H.* x *intermedia,* which is a natural hybrid and varies.

We harvest our seed requirements during the early part of September. Squirrels and chipmunks are often there to pick their share at the same time. A bushel of seedpods yields about 2 pounds of clean seed. A pound of seeds has between 7,000 and 10,000 seeds for *H. virginiana,* which is our source of understock. After collecting. the unopened pods are placed in flats in the greenhouse, covered with a piece of glass. With light and heat the seed pods pop open very soon; the closed box prevents scattering. We then stratify the seed for one full year and sow the seed the following fall. Seed beds are mulched and shaded when germination occurs by the following spring. Seedlings are left for 1 year in the seed bed.

Our seed beds are treated with a nemacide-fungicide material (Vorlex) at 7 gal/A previous to seeding. We have experienced better germination and growth since we treat the soil. However, to obtain grafting-size plants we transplant for one more year, again on Vorlex-treated land. Understocks

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GRAFTING

Hamamelis varieties—and some species—are propagated by us by grafting on *H. virginiana*. We have grafted in the spring in the greenhouse on established understocks, but now prefer August-grafting in frames. The reason for this is that bottom heat does not seem to be beneficial at all. On one occasion we actually moved grafted stock out of a grafting case on to the cool greenhouse floor and found that plants healed and grew much better.

We use side grafting. We tie with rubber and remove the tip of the scion. No waxing is needed, just a tight frame. Grafting by the end of August gives enough time for healing before cool weather in the fall. Before planting out or canning the following spring, the understock is completely cut off. Deep planting is advisable, to prevent sucker growth. Any sucker showing has to be removed quickly to prevent the understock from overgrowing the scion.

CUTTINGS

We have tried cuttings on a number of occasions — semi-ripe wood under double-glass treated with 0.8% IBA — but had very little success so we have given this method up.

LAYERING

The branches are girdled or partly split and covered with a peaty soil, but roots will not be strong enough until the second season after layering for the layer to be taken off.

Hamamelis grows best in deep rich soil. We find *H. virginiana* on the edges of woods in light sandy soils with a high watertable, but it will grow on clay soils if not too heavy. The plants are long lived and there does not seem to be a disease or pest problem associated with any species. It will take 2 to 3 seasons to obtain a 2 to 3 ft. plant, but flowering will often commence right from grafting.

The following describes a number of slides:

H. virginiana has flowers which are pale yellow and flowers at leaf-drop, the same time the seeds are ripe. The leaves and bark have been used to make ointments for wound dressing. This plant grows to be 15 feet high and 15 feet wide.

H. mollis comes from Japan and flowers the latter part of winter. The flowers are not damaged by frost even as low as 0°F; however, they only open on sunny days and curl up when it gets cold. This is one of the old favourites; it grows 10 to 12 feet high and 8 feet wide.

H. j. flavo-purpurascens 'Adonis' Syn. ('Ruby Glow') has carmine flowers with narrow petals 1 inch long; it flowers in

March after *H. mollis*. It is a very broad spreading shrub and retains its dry leaves until spring.

H. x *intermedia* 'Jelena' has reddish-orange flowers. It has the largest flowers and petals, which are as much as 1½ inches long, very floriferous. In the fall the round, broad leaves turn reddish-orange with a yellow margin. This is the best fall-coloured clone.

H. x *intermedia* 'Arnold Promise' has flowers which are pale yellow with 1-inch long narrow petals. It reminds one of *H. j. zuccariniana* but has a broader spread and larger flowers. Flowering is from the end of March to April. It is the latest with us, and a good improvement on *H. j. 'zuccariniana'*.

Fothergilla. This is a plant which can be grafted on *H. virginiana* if seed is not available.

To really show them off during their early flowering period they should be planted near walkways so they can be appreciated as a most unusual plant. We are not growing the other species mentioned previously and I do not suggest that you grow even the 7 varieties I showed. *H. mollis* would be my choice for a starter.

MODERATOR FLEMER: Thank you very much, Joerg; that's really an interesting view of the various *Hamamelis*. They are unknown to most of the gardening public and with their nice fragrance, good fall color, and unusual time of blooming I think they have a promising future in the retail nursery trade. We have time for just a few questions.

VINCE BAILEY: What is the hardiness zone of the *Hamamelis?*

JOERG LEISS: There is some confusion about the hardiness zone now. On our Canadian map it would be No. 5; that would be No. 4 on your map. This would correspond to about -10°F. We know that they do not do well at Montreal.

RALPH SHUGERT: If I understood you properly, you stratify your seed for 12 months. Is this refrigerated stratification?

JOERG LEISS: No, this is outdoor stratification and actually, it's more than 12 months because we start stratification in the fall and sow the seeds outdoors the following fall. This gives an extra cold treatment which I believe is necessary; otherwise we get no germination even if we seed in the greenhouse after one year of stratification; that is, from one fall to the next.

RALPH SHUGERT: I was wondering if you had experimented with using refrigerated cold storage for the first year, then sowing in the fall of the second, to obtain seedlings the next spring.

JOERG LEISS: No, we haven't done this. Our method works and is convenient, so why change it?

MODERATOR FLEMER: Our experience with *H. vernalis* was that it could be sown in the fall as soon as the seed ripened and seeds would germinate the following spring. Do you find you also need 15 months for seeds of this species?

JOERG LEISS: We don't grow *H. vernalis* and have no experience with it.

MODERATOR FLEMER: *H. vernalis* is a southern species which, perhaps, accounts for the lack of such a long cold period requirement.

ED MEZITT: We obtained seedlings from Sheridan Nurseries about 15 years ago and these seedlings had some nice variations. From these we saved seeds and again found many interesting variations among the resulting seedlings. Some had larger flowers, some were fragrant, some were not; some had very green flowers, some with very small petals; some had beautiful fall colors, some would hold them and some would not. *H. mollis* was not very hardy for us; some of the newer ones are much hardier. *H. mollis* 'Brevipetala' is the most hardy for us. The newer ones coming out have many good qualities; they also root very well for us. I don't know which rooting powder we use but we give them bottom heat at 75°F and have had no trouble rooting them the last few years.

MODERATOR FLEMER: We'll have to cut off the questions now. I want to thank all of the speakers on this morning's session.

FRIDAY AFTERNOON SESSION

December 5, 1969

The session convened at 1:15 p.m. in the Windsor Ballroom, Commodore Hotel, with Mr. Thomas S. Pinney Jr. as moderator.

MODERATOR PINNEY: Our first talk this afternoon involves greenhouse and nursery cost analysis. Knox Henry had hoped to be able to make the meetings but at the last minute found he could not be here. However, he has supplied us with a tape of his talk so he will present his talk via a tape recorder.

GREENHOUSE AND NURSERY COST ANALYSIS

KNOX M. HENRY
Frank O. Reeves & Son, Limited
Pine Grove, Ontario

Mr. President, fellow members, guests: I find it difficult to express my disappointment at not being able to be with you in person today. The presence at the meeting of many of my fellow Canadians will attest to the fact that Canada is not so cold that I am frozen and thus unable to move. We moved our entire business to a new location during the past ten months, yet up until last Friday I had expected to be with you. I hope the taping of my talk will prove acceptable to you.

Our firm began as a market garden operation owned by the late Mr. Frank Reeves. Starting on the recently vacated premises in 1923 the business evolved from a position of solely growing vegetables to include a floriculture crop of chrysanthemums, snapdragons, etc. After Ken Reeves returned from the European theatre after World War II, he worked for a couple of years with his uncle, the late Cecil Delworth. Doubtless the experience he gained during his time with 'Uncle Cec' had a definite effect upon the future course of his father's business, for after he returned home to rejoin his father the floriculture end of the market garden operation began to increase and eventually surpass the cauliflowers and potatoes.

Youth easily becomes enthusiastic and Ken's realization that the bedding plants he was growing were a surer cash crop than vegetables induced him to be the first grower in Canada to grow and market the new hybrid petunias. The derisive scorn from his fellow growers did not deter him and very soon he became a leader in the Canadian bedding plant industry. His introduction of the self-serve concept, where each customer picks out their own plants while pulling around a wagon to carry their purchases, coupled with a "supermarket" type of cashier system is now copied by many garden centers.

Being a leader sometimes has dubious distinctions for he also realized that in spite of the prosperity of the business, which I must add still had a large greenhouse operation including chrysanthemums (potted and cut), poinsettias and geraniums, profits were rapidly decreasing.

In an effort to correct the downward trend the bookkeeping end of the business was completely revamped about 5 years ago about the time I joined the firm. The new system then instituted set up a more detailed purchase journal which would provide some indication of the extent of purchases for each crop and at the same time provide a monthly Profit & Loss statement.

The intention was admirable. Unfortunately this system had two main disadvantages; 1) it made no allowance for many overhead expenses, and 2) it was too slow for our size of business. Our Profit & Loss Reports were taking up to two months to prepare and the Purchase Journal represented about 15 hours of work per week.

About this time I was appointed manager of our Nursery and Garden Center and became involved in the office operation. The new system I am about to describe evolved over the past four years and while I am perhaps more familiar with it than anyone else in the firm, I am not the sole author of the procedures. I must acknowledge the contribution of our chartered accountant, our President, Ken Reeves, and others. My contribution has been one of continuity rather than all the ingenuity.

I learned of a new accounting system developed by the National Cash Register Company, known as their "Total System". This system naturally uses a cash register as the focal input for the system. All sales and bookkeeping transactions are entered on the cash register. The cash register, depending upon its design, produces either a punched paper tape or an N.O.F. tape. The latter is a tape of stylized type that can be optically scanned by a computer. Either system allows computer processing.

The punched paper tape has the advantage of being acceptable input for the greatest majority of computers so that one is not "married" solely to N.C.R.; the disadvaantage is that it is more difficult for the average person to learn to read.

The optical tape which, incidently, we use, is to my knowledge only acceptable as input by one other computer manufacturer besides the N.C.R. Data Centers. This limits you, should you wish to have a firm other than N.C.R. process your data. The one real advantage is that the optical tape is quite easy to learn to read.

At the end of each month we forward our tapes to the local or nearest N.C.R. Data Center. They process the data and return the monthly reports to our office usually within 5 days of date of our mailing. The actual processing of the tapes takes about 30 to 45 minutes. Most of the delay is in our "speedy" post office department.

For a total cost of approximately $60.00 per month we receive the following reports:

1. A Sales and Tax Report — showing our total cash sales and total charge sales.
2. A monthly Income Report or, as I refer to it, a Profit and Loss Statement — most important to any firm.
3. A monthly Balance Sheet.
4. A Cost Inventory Management Report.

This last report is most relevant to my discussion today for it, coupled with the Profit and Loss Report, forms the basis of our cost analysis system.

Every product we sell has its own individual code number. When a sale is made the 3-digit code number is entered on the cash register. Also when a purchase is made each purchase must be assigned a code number and then entered on the cash register. Likewise each expense is coded before it is entered on the cash register. Sales are entered on a daily basis as they are made. Purchases and expenses are usually entered twice a month.

I differentiate between purchases and expenses. Purchases are those items which are bought by us and resold directly or worked into a product which is later sold. Expenses are items which do not necessarily relate to any one particular crop, an example being electricity or insurance.

We have been able to develop a very simple and inexpensive cost analysis by, wherever possible, showing each item bought as a purchase to the individual crop. Many items which our government insists be shown as expenses are first "purchased" by the crop, then removed from the total monthly purchases, then entered as an expense. A classic example is wages. Each one is required to enter daily a breakdown of their hours. At the end of each pay week this information is translated into dollar value in the office. All the time sheets are entered on a summary sheet that has column headings for each crop. The columnar totals are entered into the cash register as a purchase for the crop concerned, then the total amount is shown as a negative purchase. Then the total wages are entered as an expense.

Each bookkeeping entry on the cash register involves a debit and a credit key. Thus each entry is self-balancing. We have one code number set up which — when the computer sees that particular number — it automatically registers a negative purchase. This allows us to avoid fictitiously inflating our expenses and purchases. Although the item of expense is entered twice, the first entry shows it as a purchase for the crop, but it is not included in the total merchandise purchases on the Profit and Loss Report. I hope I have made this clear.

The net result of the foregoing is that we are able to "purchase", so to speak, such expenses as: wages, fees, licenses, spoilage, advertising, travel, promotion, and uncollectable cheques.

The Inventory Report has several columns.

Column 1 shows the code numbers.
Column 2 shows the total dollar sales for the crop or code.
Column 3 shows the total percentage that crop is to the total of our sales.
Column 8 shows the total purchases accumulated by the crop up to the beginning of the particular month.
Column 9 shows the purchases for the month.
Column 11 shows the accumulation of purchases for the crop as of the end of the month.

This report, as well as the Profit and Loss Report and others, are received monthly by us from N.C.R.

To allocate our operating expenses each month, we use another different form with the following headings over columns across the top of the page: Column 1 is the code number for each expense item, followed by the name of the expense in Column 2. The column entitled "table" refers to a set of tables we have set up, breaking down by crop the expenses each month. I will come back to this later.

The total column is self-explanatory being the total of each expense. Next are a series of columns for each crop. Each crop column shows the percentage of each expense the crop must bear as well as the dollar value.

The columns are totalled after completion. May I add that the sheet does not show the breakdown for the Depreciation accounts, the Employer's share of Unemployment Insurance, or the Canada Pension Plan. These items plus one or two others are computed on a second operating expense sheet similar to the one just described.

After the totals have been calculated, it is a relatively simple operation to add the purchases and expenses for any one crop and equate these figures against the sales figures, thus producing a Profit and Loss figure for that crop.

In summary, may I make a few points: The foregoing system is costing us relatively little. On top of the approximately $60.00 per month N.C.R. charges us for the Data Processing and the four reports they furnish, we expend a total of about 6 to 8 hours per month to complete the cost analysis.

The Data Processing enables us to accumulate and categorize a great deal of information very quickly, easily and inexpensively.

The cost analysis system is based on the theory that all overhead and operating expenses incurred in the business can be charged to all the crops, providing one is persistant enough to believe there must be a way.

This brings up a point I earlier promised to enlarge upon for you. The weakness in this system lies in the area of the percentage of the overhead expenses that should be charged to each crop. This demands very careful consideration by senior management. It has taken Ken Reeves and myself four years to reach the point where we feel we are allocating these expenses correctly. The more diverse your business, the more difficult is the calculation. Briefly, think about the ramifications of vehicle expense. We have seven vehicles. How much of the expense relates to our nursery when any one of or all of three different vehicles may be utilized by that department at any one time? I won't go further on this — doubtless you see my point.

Those whose firms are using data processing will probably echo my comments when I say to those who are contemplating data processing in the future, allow yourselves at least a year to get the system 100% operational. In spite of the efforts of N.C.R., our chartered accountant, and with myself having had some previous data processing and accounting experience, our first six months was pretty rough.

The cost analysis system I have outlined can be used in a small business without dadta processing. It is also adaptable to other nurseries; one other nursery that has no greenhouse operation is using the system.

The system is not perfect, but I hope that by sharing our experiences with you, you may obtain ideas for your business. I would be most willing to go into more detail or answer any questions you may have if you contact me.

MODERATOR PINNEY: Our next speaker is Dr. John McGuire. His paper is entitled, "A Propagation Schedule for Container Plants".

A PROPAGATION SCHEDULE FOR CONTAINER PLANTS[1]

JOHN J. MCGUIRE
University of Rhode Island
Kingston, Rhode Island

Container plant production has been increasing in the Northeast for the past ten years. It has not yet developed to the levels found in the South or Far West but the rate of increase indicates it may one day be a major form of plant production in the Northeast. Growers in this area have been faced with problems not encountered in the milder climates. Specifically, the relatively short summer season requires a very efficient production program. This, and overwintering problems, have been the major reasons for slower development of this method of plant production in New England.

Most growers have now overcome the problem of overwinter storage by use of Quonset poly-houses. These houses are constructed over the plants in the growing areas, eliminating or reducing labor costs for moving plants. To make use of the short growing season, growers have also met the challenge by developing an efficient growing program. This parallels the

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[1] Contribution No 1342, Rhode Island Agriculture Experiment Station

to reach the point where we feel we are allocating these expenses correctly. The more diverse your business, the more difficult is the calculation. Briefly, think about the ramifications of vehicle expense. We have seven vehicles. How much of the expense relates to our nursery when any one of or all of three different vehicles may be utilized by that department at any one time? I won't go further on this — doubtless you see my point.

Those whose firms are using data processing will probably echo my comments when I say to those who are contemplating data processing in the future, allow yourselves at least a year to get the system 100% operational. In spite of the efforts of N.C.R., our chartered accountant, and with myself having had some previous data processing and accounting experience, our first six months was pretty rough.

The cost analysis system I have outlined can be used in a small business without dadta processing. It is also adaptable to other nurseries; one other nursery that has no greenhouse operation is using the system.

The system is not perfect, but I hope that by sharing our experiences with you, you may obtain ideas for your business. I would be most willing to go into more detail or answer any questions you may have if you contact me.

MODERATOR PINNEY: Our next speaker is Dr. John McGuire. His paper is entitled, "A Propagation Schedule for Container Plants".

A PROPAGATION SCHEDULE FOR CONTAINER PLANTS[1]

JOHN J. MCGUIRE
University of Rhode Island
Kingston, Rhode Island

Container plant production has been increasing in the Northeast for the past ten years. It has not yet developed to the levels found in the South or Far West but the rate of increase indicates it may one day be a major form of plant production in the Northeast. Growers in this area have been faced with problems not encountered in the milder climates. Specifically, the relatively short summer season requires a very efficient production program. This, and overwintering problems, have been the major reasons for slower development of this method of plant production in New England.

Most growers have now overcome the problem of overwinter storage by use of Quonset poly-houses. These houses are constructed over the plants in the growing areas, eliminating or reducing labor costs for moving plants. To make use of the short growing season, growers have also met the challenge by developing an efficient growing program. This parallels the

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year-round problems of the commercial florist. His problems are very much like those of the container grower. He is limited to growing his crops within the walls of his greenhouse and to make it profitable he must get as many crops as possible each year from the limited space. The container grower is limited to a short season while using an expensive method of production.

The problem of getting maximum growth, while not forsaking quality, has been solved by use of specialized media with good porosity and low exchange capacity and by using adequate irrigation and constant or frequent fertilization. Such practices have resulted in growth almost double that obtained in the field in the same locality.

There is one other step to maximize the short season completely. This is to time young plants, just as the flower grower does, to have them ready for planting at the right time.

In Rhode Island the canning season is usually from mid-May to the end of May. If plants are canned before that time, late cold weather often checks growth and hardens them, which offsets any advantage that may have been obtained from early planting. If canned much later, valuable days of the relatively short New England season are lost. Plant material used for containers must be more than a rooted cutting. They require some finishing after rooting. Young plants must be available in quantity in the right sizes. If they are not available in sufficient quantity the canning operation becomes overly expensive. If they are small the space they occupy in containers is not justified and they will require an extra year in the container to reach saleable size. If they are too large, efficient canning cannot be done and plants will be potbound before the end of the season. This will require additional potting in the middle of the season or a loss of quality if not potted.

It is obvious that not all plants can be handled the same way. Approximately 5 to 6 thousand plants are produced in containers each year for research purposes at the Rhode Island Agricultural Experiment Station. This paper will explain how these plants are produced each year so they are ready for canning over a ten-day period in mid-May.

This is a small operation by commercial standards but the principles should be the same. It must also be emphasized that the conditions are those experienced in Rhode Island and modifications would have to be made for other regions of the country.

Azaleas & Rhododendrons. Cuttings are made in late July and early August. They are removed from propagation beds in September, October and November. They are potted in 3″ plastic pots and grown under a light break (fluorescent lights from 11 p.m. to 2 a.m. at night temperatures of 65°F). Plants are pinched three or four times during the winter to develop branching. They are fairly well potbound by mid-May.

Azalea cuttings made in the earlier summer months

(June-July) are potted in July and grown on until fall. They are then overwintered in unheated plastic houses.

Other broadleaved evergreens (*Ilex, Buxus, Pyracantha, Euonymus, Cotoneaster*). Cuttings are made in late December. They are normally four inches or more in length and well-branched when taken. They are treated with a moderate growth regulator (1.6% IBA in talc). They are potted in February and placed under the light break as described above until spring. They are fertilized weekly with 20-20-20 (200 ppm N).

Narrow-leaved evergreens (*Juniperus, Chamaecyparis, Thuja*). Cuttings are made between December and January. Heavy, well-branched shoots four to six inches in length are selected. They are treated with 3 to 4.5% IBA in talc. They are potted in April and fertilized weekly.

Deciduous plants (*Forsythia, Viburnum, Ligustrum*). Hardwood cuttings 6″ long are made, in February and early March and placed in flats under mist. Leaves and roots develop simultaneously and when rooted they are moved in the flats to a bench without mist. They are fertilized weekly until canning time.

Seedlings (*Rhododendron, Azaleas, Pieris*). Seeds are sown in March under mist, potted in early summer, and maintained in the container area the first summer. They are then carried in the greenhouse under the light break the following winter. They are ready for canning the following spring.

With the exception of rhododenron, most plants are produced to canning size within a few months. This is done by pushing them under long days under a regime of moderate fertilization and optimum temperatures. One method tried this past summer was to propagate cuttings directly in a propagaing medium containing slowly-available fertilizer.

In summary, few new principles have been applied. When possible, large, sturdy cuttings have been used. Stock has been maintained under long-day photo periods by means of a light break during the night throughout the fall and winter. Plants have been fertilized from the earliest possible moment, at times when still under mist. Cuttings have been made as late as possible to reduce time under greenhouse care but early enough to produce a well-rooted plant suitable for putting in a container.

MODERATOR PINNEY: Thank you very much, John. This is certainly an interesting area and it can be a lot of fun. Sometimes we even tend to scare ourselves when we see what we can really do by efficient scheduling. Are there any questions?

HANS HESS: Do you know approximately what it costs per plant for supplemental light and maintaining the temperature at 65°F to get this maximum growth?

JOHN MCGUIRE: It would be fairly expensive under greenhouse conditions; the light would not be expensive but the heat certainly would be. We do not attempt to keep the plants under these conditions very long. Most of them are in the greenhouse for only a short time but with rhododendrons this is a rather expensive production.

HANS HESS: Have you used this "pill", that we've heard about, in your production and if so, what results have you had?

JOHN MCGUIRE: We have used the Agriform Plant Tablet; the results depend a lot on the irrigation program used in growing the plants. Our containers are getting ¾" to 1" of water per day and under this irrigation regime the tablets run out about early August. If you want to push the plants you would have to give them a shot of fertilizer at this time, but I don't — under our conditions I stop them right there. The best results we've had with slow-release fertilizers has been with MagAmp, with Osmocote running next.

MODERATOR PINNEY: Thank you again, John. We're going to have to move on now. Our next speaker will talk on "Mechanization at Medford Nursery". I am not personally acquainted with his nursery operation but I understand he is doing an excellent job and it is my pleasure at this time to introduce Mr. Earl Robinson to you.

MECHANIZATION AT MEDFORD NURSERY

EARL H. ROBINSON
Medford Nursery, Inc.
Medford, New Jersey

I would like to speak to you on mechanization at our nursery in five main categories: 1) Propagation, 2) Greenhouse Growing, 3) Field Growing, 4) Over-wintering and 5) Shipping.

PROPAGATION

Most of the plants we grow are produced from cuttings although we have grafts and a little seed production. Our cuttings are prepared in the customary way with one exception; that is, they are prepared in the "Propagation Room" and are stuck in the flats there in assembly line fashion. Approximately 100 cuttings are placed per flat. The hormone treatment varies with the plant and the timing of cutting. We wound our cuttings and after the cuttings are stuck, the flats are watered down with Aqua-Gro and Morsodren. The flats are then accumulated on racked carts and held there for moving to the propagating houses.

After being moved to the "Propagation House" on carts, they remain there until rooting is initiated. As soon as the cuttings are rooted, the flats are moved to the "Hardening-Off House", where the cuttings finish rooting and are hardened-off by hand syringing only.

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The main point then is that standard units (flats) of plants are moved mechanically (on carts) to keep our two propagating houses full at all times with a new crop every four to eight weeks. By this rotation of cuttings we are able to keep our propagation area to a minimum and yet keep our output high for the space used.

Our propagation and growing houses are all on one level — no stairs or ramps — so that carts can be used throughout. All aisles are 42 inches wide to accommodate carts or conveyors.

GREENHOUSE GROWING

Our azalea, *Ilex, Cotoneaster,* and *Pyracantha* are ready for potting some time in November or early December. We do most of our liner potting with the Quik-Pak machine and Royer's elevator and storage bin combination. One thing we have found is that it is necessary to standardize as much of the operation as possible. The pH of the potting medium, pot size, and root ball should be standard. When we have deviations from the established standard, there are problems and slow downs.

After the plants are potted, they are assembled in flats and moved to a growing house. They are moved by four-tiered carts to the greenhouse benches, the benches being a standard width to accommodate the flats. The growing houses have two layers of benches giving us double capacity. The lower layers, in some instances, are used for growing with fluorescent tubes. This is still on an experimental basis. The day-length remains at 13 hours and this area is used for low light intensity crops. Each greenhouse is heated by a propane gas-fired hot air heater and cooling is by Acme fan jet tube ventilation. By mid-May the plants are ready for field planting.

FIELD GROWING

This operation begins with the field layout and the efficient use of space as well as efficiently moving plants in or out of the field. Our field layout allows for future expansion but still enables us to use conveyor wagons and conveyors in the field.

Let us go back to the actual potting and follow through our procedure. Our soil mix is the U. C. mix and is prepared by a manure spreader, (Dick Vanderbilt's "patent"). It really works quite well. We have chosen to follow the "stationary potting" idea rather than a mobile field unit. We have tried both methods and feel it is more economical to pot one-gallon and two-gallon containers in one location having the soil mix, containers, mulch, and plants near at hand and move the finished plant to the field. We have also found that it is more feasible to recontainer; that is, move a one-or two-gallon plant to a five-gallon container in the field because of the weight and the bulk of handling the finished plant. Most of our help are women.

We have incorporated the Royer Soil Handling System with our potting machine. The potting machine used for one and two-gallon containering was made by a local machine shop. The main thing this machine does is set and maintain a constant pace, as well as firming the soil and centering the plant.

After the pot leaves the potting machine and moves down a belt, the plant is inserted and firmed, then mulched with sugar cane. At this point the plants are accumulated in small pallets (6 two-gallon plants to a pallet) and stored on conveyors or moved directly onto conveyorized wagons and moved to the field. The wagons are so built that they self-feed the pallets of plants by gravity to the man unloading. The flats are switched to another set of conveyors that store the plants for the man setting them out in the beds. By handling the plants in this manner, we have eliminated handling individual containers two times — once loading the wagon and once unloading and at the same time have kept fewer pieces of equipment tied up waiting to be loaded and unloaded. We are also keeping down the number of hands required at any one location.

In the actual field growing, we are going to the Chapin's "spaghetti" watering system as well as using proportioners to meter-in the fertilizer while watering. We are using two types of proportioners: 1) The Cameron "M", made in England — cost approximately $75 — and 2) The MP2, made in California — cost about $30. Both have their advantages.

After the plants are grown and are salable, moving them out in quantity is accomplished in the same manner as putting the plants into the beds — with conveyors.

OVER-WINTERING

In our part of the country, over-wintering is a major consideration for the container grower. Although it is not terribly costly per plant the initial outlay can become an expensive item.

Our structure is rather simple yet has answered our problem of over-wintering. A 24-inch piece of one-inch pipe is pre-drilled 6 inches from one end with a 3/16-inch hole. These pipes are driven into the ground 4 ft. apart with an air hammer. Then 1 x 4 boards are nailed onto one-inch pipe. Next 1½-inch galvanized pipe 21 ft. long is bent on a form and inserted into the one-inch pipe. We use stainless steel wire for the ridge, put ends in place, and cover with white poly. Saran tie-down strips are used to keep the poly from pounding. The only real mechanization in this phase is the air hammer which really does a terrific job for us. A four-man crew can hammer in 3100 one-inch pipes in 2 days with a little luck.

SHIPPING

For most of the industry the shipping is seasonal and concentrated in a relatively short period of time — at a time when labor is needed elsewhere. We have devoted a great deal of time researching, experimenting, and discussing with numerous growers our mechanization (and perhaps automation) of the entire shipping operation. Palletizing will definitely play an important part in this handling. We do feel our finished product will be unique and I will be most pleased at a later date to explain this entire phase of our operation.

In summarizing then — our idea is to eliminate hand labor wherever feasible. It may be hard to believe, but employee resistance to mechanization and automation is one of the bigger problems, especially with older employees. One of the phases we are working on now is to psychologically prepare our people for these changes, which will make their work easier and less costly for us. This can only be done through standardization and using as many machines or systems as is practical.

MODERATOR PINNEY: I'm sure all of you were as interested in this talk as I was and I'm sure Mr. Robinson will be having some visitors at his nursery in the near future. We are a little behind schedule and will not have any questions this time. Our next speaker is Dick Bosley. Dick has helped us in our nursery operations many times and it's a real pleasure to ask him to speak to us now.

WATER — FRIEND OR FOE?

RICHARD W. BOSLEY
Bosley Nursery
Mentor, Ohio

My paper will probably be one of the shortest ever given but I feel the message it contains can be very important to you.

At the Bosley Nursery we have been propagating a similar line of plant material under mist with the same water source for a number of years. We have never had as high a rooting percentage as others in this Society profess to achieve but then we didn't always tend to believe some of the figures we heard. In the 1968 summer and fall propagation season our results were even worse and it prompted us to have the mist water checked for agricultural suitability. We found the total soluble salt content to be moderately high for mist propagation of azaleas and rhododendrons. What was even more damaging was that the concentrations of both sodium and chloride were high for these sensitive crops.

The choice became: 1) find a new source of a better quality water; 2) install de-mineralizing equipment; or 3) stop growing those crops. We chose to install city water which is of much better quality. The results are that the crops no longer show the high salt type of injury and the rooting stands are now of an order equal to or higher than those which others boast about.

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The deterioration of our well water probably occurred gradually over a period of years thus not causing us to suspect it as the source of trouble. I would urge the States to establish water quality standards, if they have not already done so, and encourage growers to have their propagation water, in particular, checked if they are showing any salt injury on the leaves or roots of cuttings. The problem is severe under mist because of the nature of application. Most all of the salts in the water end up concentrated on the leaves due to evaporation, as there is little or no leaching, such as you would get under an irrigation system.

MODERATOR PINNEY: I imagine your paper will go on record as one of the shortest we have had but we appreciate the information very much. I know of one instance in Wisconsin in which a considerable amount of money was spent over a two year period trying to determine what was wrong and the trouble turned out to be the source of water. At this time I'd like to introduce the next speaker, Dr. Harold Pellet, who will speak on the relationship of rootstock to maturity and cold hardiness of the scion variety in apples.

RELATIONSHIP OF ROOTSTOCK IN THE APPLE TO MATURITY AND COLD HARDINESS OF THE SCION VARIETY

DAVID WILDUNG AND HAROLD PELLETT
Department of Horticultural Science
University of Minnesota
St. Paul, Minnesota

INTRODUCTION

Even though the art of graftage has been known and used in plant propagation for centuries relatively little is known about stock-scion relationships. There has been quite a bit of work done to study the influence of rootstock on plant growth and some on nutrition but very little work has been done to study the influence of rootstock-scion interactions as they might affect hardiness.

The rootstock could affect scion hardiness in one of several ways. Hardy rootstocks might induce hardier scions strictly through their use. The root system of certain rootstocks may have the ability to survive or escape root injury where other rootstocks cannot. In studies at Minnesota we have found that there is quite a range in hardiness capabilities of the various Malling and Malling-Merton stocks. Other workers have reported similar results (1, 2). Certain rootstocks may, due to earlier maturity or later bud-break, enable a scion variety to escape early and late winter injury by hardening earlier or dehardening later. The rootstock may enable the scion to develop greater hardiness than it could if grown on its own roots. Perhaps the rootstock does not influence the scion hardiness in

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MATERIALS AND METHODS

In order to study the influence of rootstock on scion hardiness in apple the following study was initiated at the University of Minnesota Horticultural Research Center in 1965.

The scion varieties, 'Delicious', 'Haralson', and 'Columbia Crab', were budded to 'East Malling 26' and *Malus robusta* '5' rootstocks. Throughout the remainder of this paper, 'East Malling 26' and *Malus robusta* '5' will be designated 'EM26' and 'MR5' respectively and grafts will be designated 'H/EM26' or 'D/MR5' to indicate 'Haralson' scion on 'East Malling 26' or 'Delicious' scion on *Malus robusta* '5', respectively. The scion varieties were selected to give a wide range in hardiness: 'Delicious' being tender, 'Columbia Crab' being extremely hardy, and 'Haralson' being one of the hardiest apple varieties grown in the upper Midwest. The rootstocks were chosen to give a comparison of hardy and tender rootstocks. 'MR5' is vigorous and hardy; 'EM26' is dwarfing and, at the time the study was initiated, was not really characterized for hardiness but was believed to be much less hardy than 'MR5'.

The hardiness of the current season's scion growth and roots of the rootstock was determined by controlled freezing tests at 5 times during the fall, winter, and spring of 1967-68 and 1968-69.

For the freezing test, small sections of stems or roots were placed in thermos bottles with a thermocouple to record temperature. The thermos bottles were placed in a freezer that was programmed to drop 3 degrees per hour. The thermos bottles were then removed at 3 degree intervals. The stem and root sections were kept in polyethylene bags at room temperatures for one week before rating; each sample was rated visually for damage using a 1 to 5 scale with 5 being no injury and 1 being dead. The mean injury ratings of 3 plants of each graft combination was used to plot the tables. A mean injury rating of less than 3 was felt to be too seriously damaged to survive.

Maturity was evaluated in three ways: date of terminal bud formation in the fall, percent leaf fall and rating of leaf color change in the fall, and date of bud break in the spring. In all cases evaluation was made at 4 to 8 day intervals in order to note the periodic changes that occurred, since the varieties varied greatly in all of these characteristics. Bud break in the spring was recorded at the time the leaves had emerged about ¼ inch. The date of bud-break is based on the average date of 12 different plants of each combination. Likewise, the mean percent leaf-fall data that is presented is the average leaf-fall of 12 different plants of each combination. Only the 1968-69 data are given since the results of the 1967-68 season were very similar.

I would like to compare each of the varieties separately to show how each reacted on the two different rootstocks. For each, I have plotted the mean percent leaf-fall as a gauge of maturity and the hardiness level of each combination during the period of leaf abscission. In the spring, I recorded the average date of bud-break, and the hardiness level of each combination after they had leafed out.

RESULTS AND DISCUSSION

'Haralson' on 'EM26' lost its leaves sooner than 'H/MR5'. There was about 4 days difference between 'H/EM26' and 'H/MR5' in the date fifty percent leaf fall occurred. This difference was apparent throughout the period of terminal bud formation and leaf fall (Fig.1).

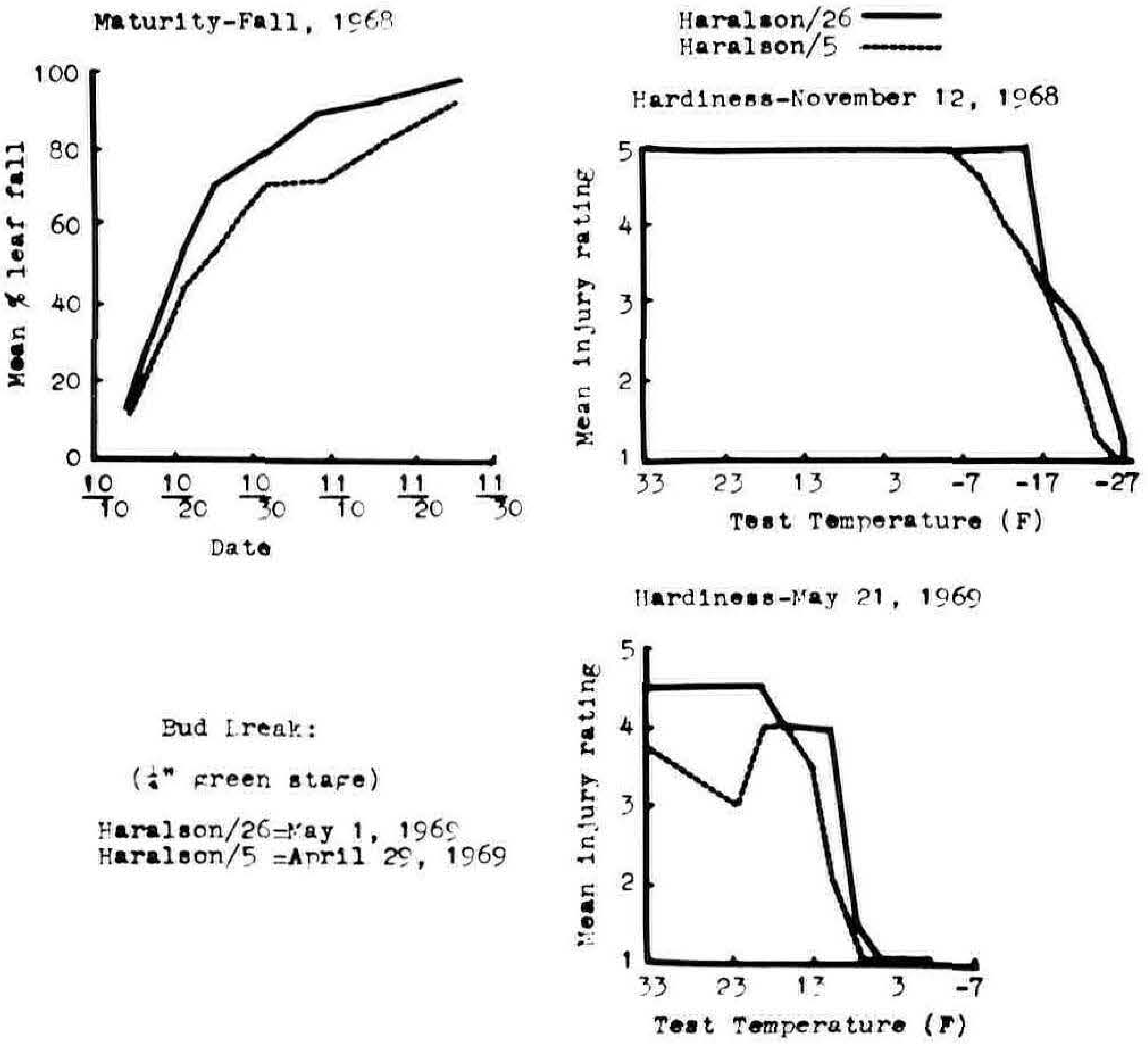


Fig. 1. Comparison of maturity and hardiness with 'Haralson' budded to 'EM 26' and *Malus robusta* '5'.

Earlier maturity of 'H/EM26' was also reflected in the mean injury ratings of hardiness on Nov. 12. 'H/EM26' showed no damage at -15° F whereas on 'MR5' it started to show some browning at -6°F. There was about 3 degrees difference in the killing point of 'Haralson' on the two rootstocks. Thus 'H/EM26' matured earlier and was also hardier in the fall than 'H/MR5'. In the spring 'H/EM26' broke bud about 2 days later than 'H/MR5'. This difference was reflected in a difference in the hardiness level between 'H/EM26' and 'H/MR5'. Because 'H/EM26' remained dormant slightly longer, it also apparently retained a higher level of cold resistance longer than 'H/MR5'. There was more field damage to 'H/MR5' than 'H/

EM26' on May 12 and there was about a 3 degree difference in the killing point of 'Haralson' on these rootstocks at this time. Thus, both in the spring and in the fall, maturity seemed to influence the hardiness of 'Haralson' budded to 'EM26' and 'MR5'.

With 'Delicious' the same trend was apparent although the differences were not as great. 'D/EM26' matured 2 to 3 days before 'D/MR5' and was 2 to 3 degrees hardier in the fall. In the spring 'D/EM26' was about 2 days slower to break bud than 'D/MR5' and was somewhat more hardy (Fig. 2).

'Columbia Crab' displayed the same characteristics in spring and fall as 'Haralson' and 'Delicious' (Fig. 3).

Next, we wanted to compare the unbudded rootstocks themselves for maturity and hardiness. It was found that while 'EM26 and 'MR5' started to lose their foliage about the same time, 'MR5' matured much more rapidly than 'EM26'. 'EM26' was earlier than 'MR5' in forming its terminal buds. This change in maturity is reflected in hardiness comparisons of the two rootstocks. In September, shoot growth of 'EM26' was slightly more hardy than 'MR5', but by Nov. 12 'MR5' was considerably more hardy (3 to 8 degrees difference) than 'EM26' and remained so throughout the winter (Fig. 4).

In the spring 'MR5' was extremely early in breaking bud, being about 12 days earlier than 'EM26'. Spring freezing tests also reflected the difference in ultimate hardiness and earli-

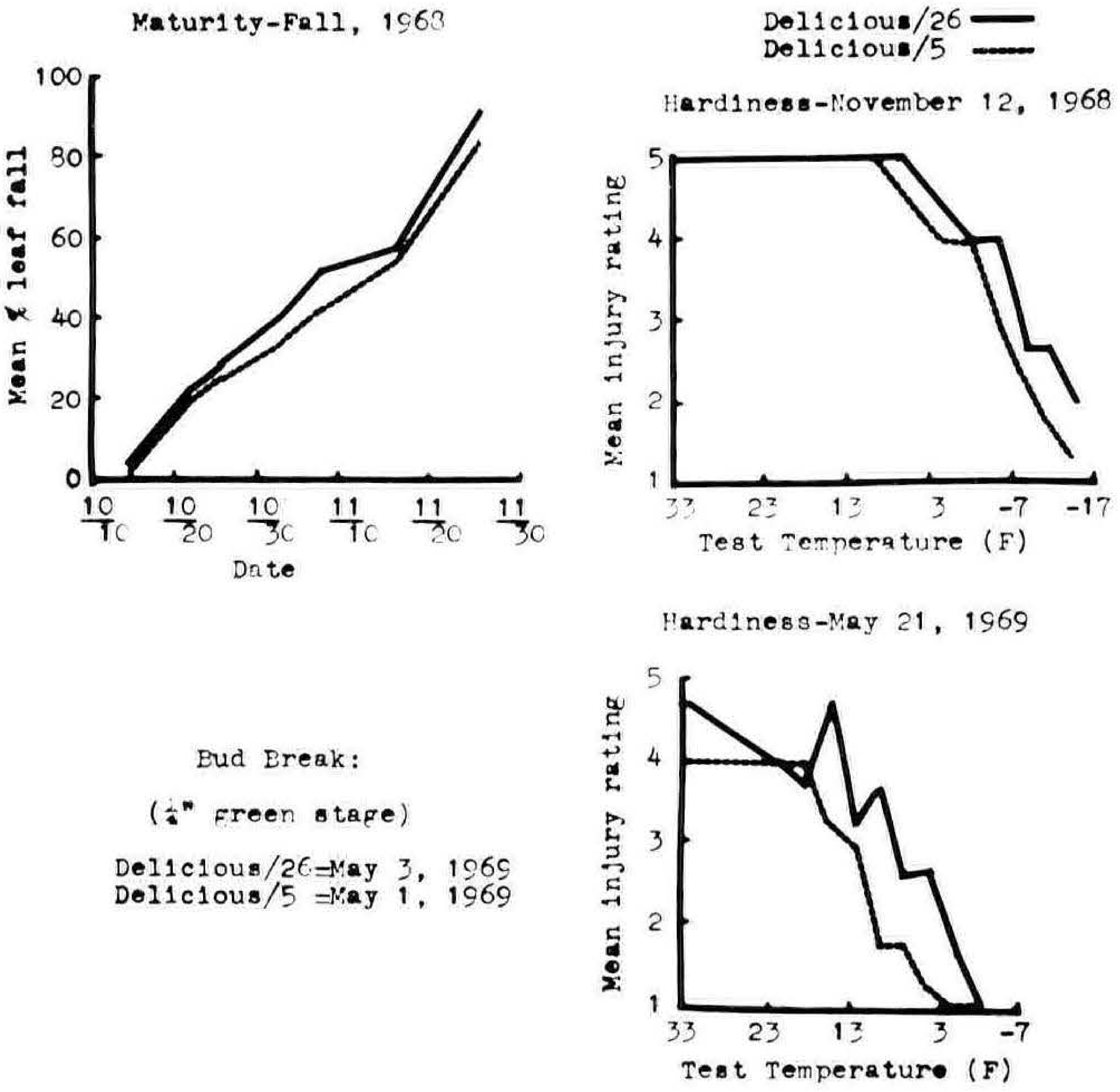


Fig. 2. Comparison of maturity and hardiness with 'Delicious' budded to 'EM 26' and *Malus robusta* '5'.

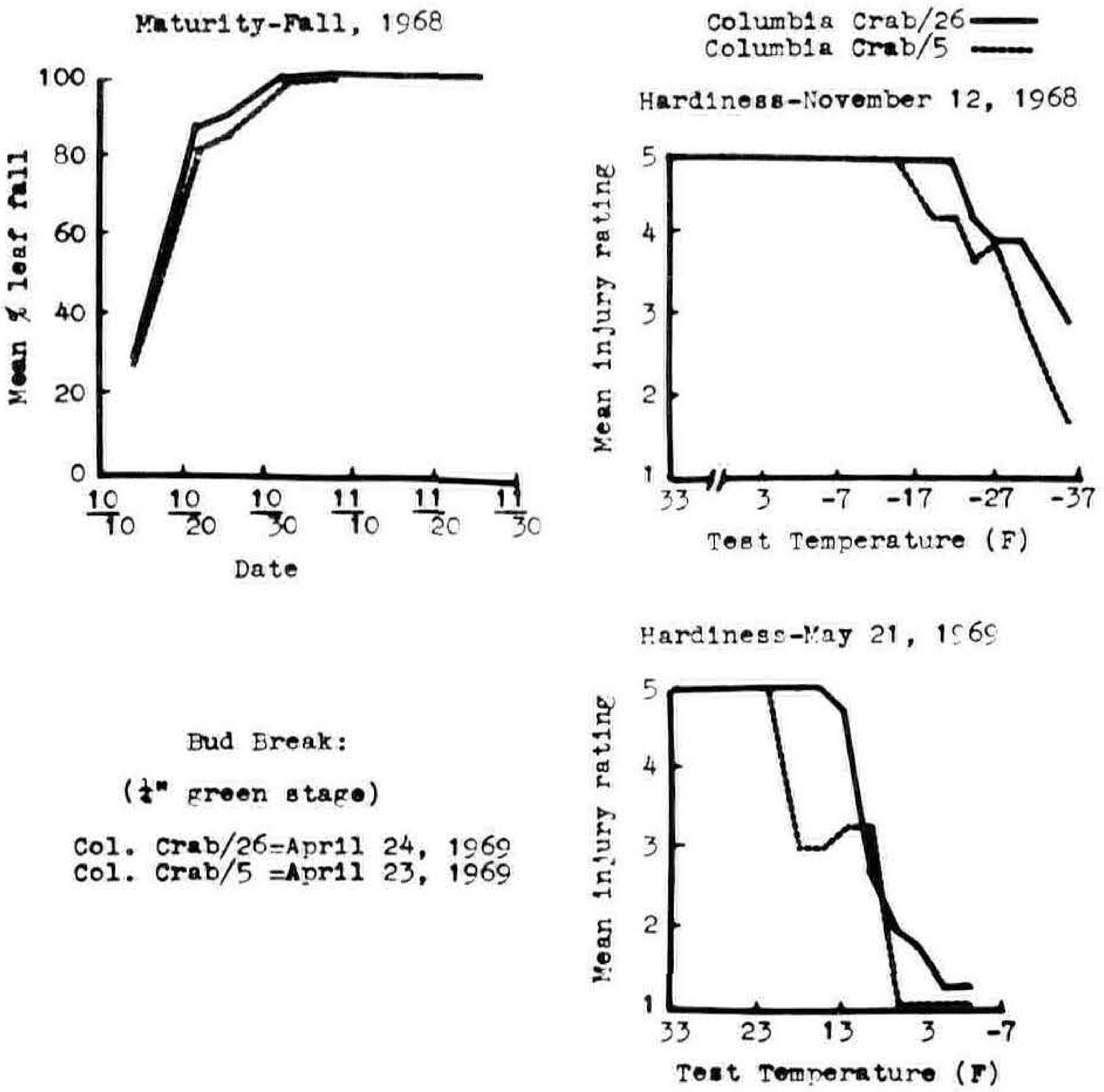
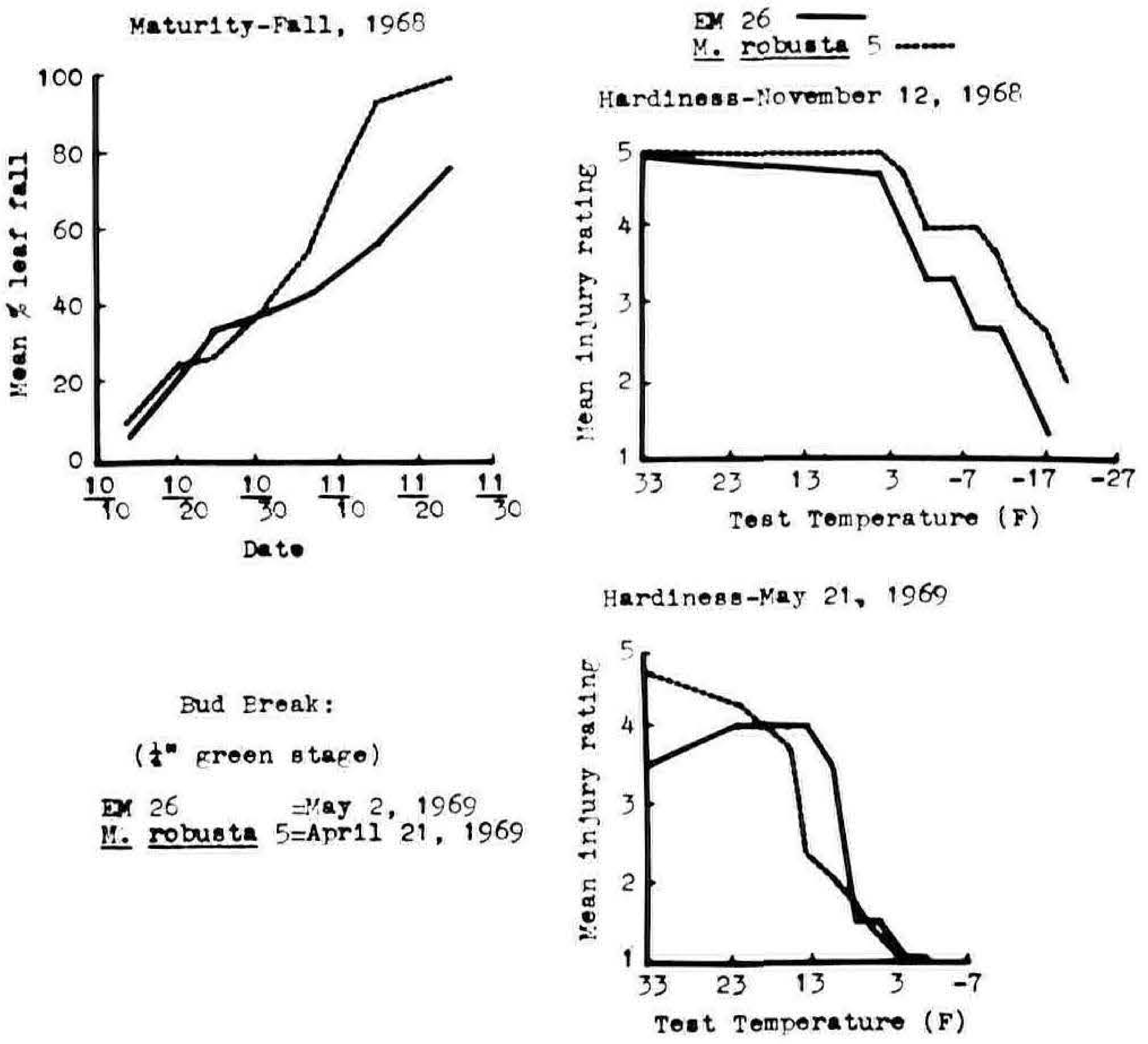


Fig. 3. Comparison of maturity and hardiness with 'Columbia Crab' budded to 'EM 26 and *Malus robusta* '5'.

ness to break bud. Field damage, as reflected by the 33°F, or check temperature, was greater on 'EM26' than on 'MR5', showing that 'MR5' was better able to withstand winter temperatures than 'EM26'. However, its level of hardiness on May 21 was not as great as 'EM26', reflecting the earlier bud break date of April 21 for 'MR5'.

Comparison of the rootstocks themselves thus shows that while shoot growth of 'MR5' is ultimately much more hardy than 'EM26', 'MR5' matures slightly behind 'EM26' early in the fall and then matures very rapidly later in the fall. This difference is reflected in the hardiness changes of the two rootstocks during the hardening cycle in the fall. Likewise, in the spring 'MR5' breaks bud extremely early and loses its cold resistance much faster than 'EM26'.

In every case, the earlier maturing combination was hardier than the later maturing combination. Likewise in the spring, the combination that remained dormant the longest also remained the most cold resistant. In order to determine if the increased hardiness of the budded combinations was due to the capacity of 'EM26' to mature earlier in the fall and break bud later in the spring, or if 'EM26' imparted some degree of hardiness to the scion varieties budded to it, we compared the hardiness of these varieties in mid-winter on both rootstocks.



Bud Break:

(¼" green stage)

EM 26 =May 2, 1969
M. robusta 5=April 21, 1969

Fig. 4. Comparison of maturity and hardiness of unbudded 'EM 26' and *Malus robusta* '5' rootstocks.

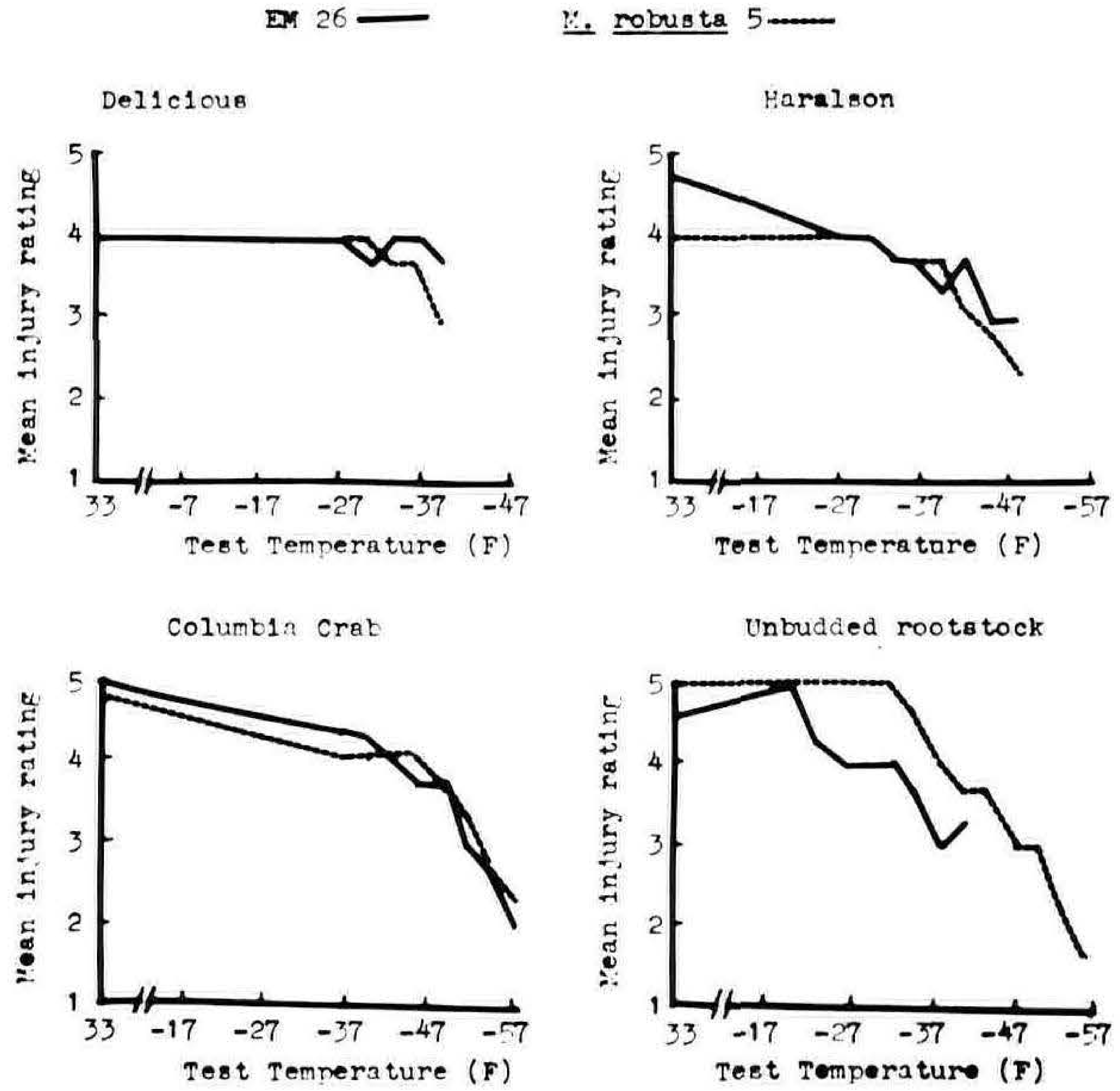


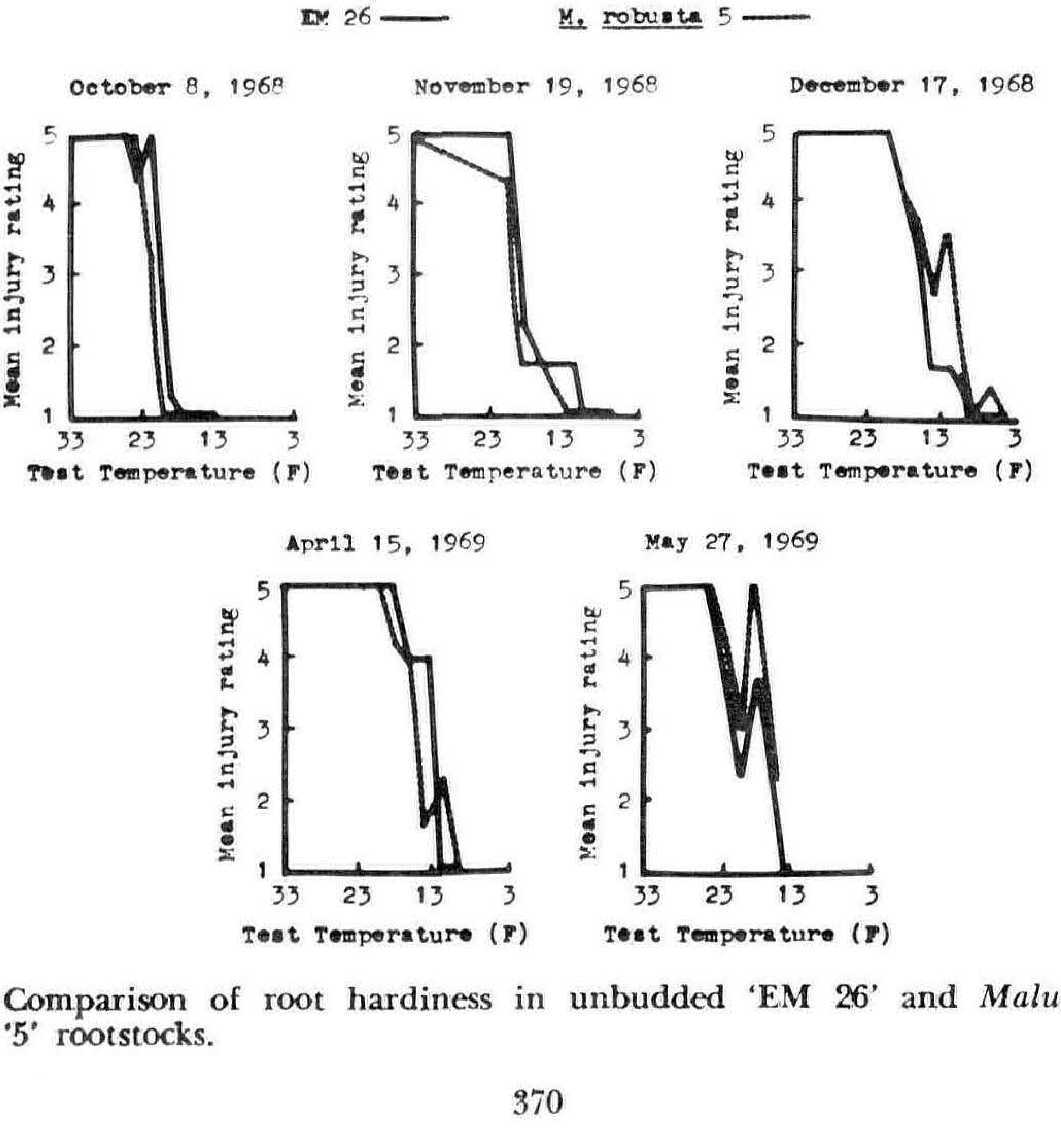
Fig. 5. Comparison of hardiness in mid-winter, 1968, with 'Delicious', 'Haralson', and 'Columbia Crab' budded to 'EM 26' and *Malus robusta* '5'.

In February, 1968, when this material was sampled, the differences in hardiness between the varieties on the two rootstocks was not apparent as it was in the fall and spring (Fig. 5.).

'Delicious', while suffering some field damage, was not killed at -39°F on either rootstock. 'Haralson' also suffered some field damage, slightly more on 'MR5' than on 'EM26', but was not killed at -48°F. 'Columbia' crab reacted the same way. Perhaps if lower test temperatures were used on these varieties, differences in the rootstocks would have become apparent, but for the temperatures tested, there was no difference in the hardiness of the variety on the two rootstocks. As in previous late fall and early winter tests, shoot growth of 'MR5' displayed the capacity to become more cold resistant than 'EM26' and was more hardy than 'EM26' in mid-winter.

Comparison of root hardiness between the two unbudded rootstocks reveals that the root hardiness was about the same at each date of sampling except in December, when 'MR5' was considerably more hardy than 'EM26'. The roots of 'MR5' apparently also have the capacity to harden to a greater degree than 'EM26' roots (Fig. 6).

Thus, while both shoot growth and root growth of 'MR5' have the capacity to become more cold resistant than 'EM26' in mid-winter, varieties budded to 'MR5' were no more hardy than when they are budded to 'EM26'. From this study, it appears that the rootstock can influence the hardiness of the


October 8, 1968

November 19, 1968

December 17, 1968

April 15, 1969

May 27, 1969

Fig. 6. Comparison of root hardiness in unbudded 'EM 26' and *Malus robusta* '5' rootstocks.

scion variety. Further, it appears the rootstock may exert its effect on scion hardiness by speeding maturity in the fall or by delaying bud break in the spring, as 'EM26' did, rather than by increasing scion hardiness by use of a rootstock which has the inherent capacity to become more cold resistant in midwinter.

LITERATURE CITED

1. Rollins, H. A. Jr., F. S. Howlett, and F. H. Emmert. 1962. Factors affecting apple hardiness and methods of measuring resistance of tissues to low temperature injury. *Ohio Agr. Exp. Sta. Res. Bull.* 901.
2. Stuart, N. W. 1940. Cold hardiness of Malling apple rootstock types as determined by freezing tests. *Proc. Amer. Soc. Hort. Sci.* 38:311-314.

MODERATOR PINNEY: Thank you very much, Harold. Are there any questions?

JOHN MCGUIRE: How long were the tissues held at the temperatures you mentioned?

HAROLD PELLET: They were just brought down to the temperature and then they were removed from the freezer. They were not held at this temperature.

CASE HOOGENDOORN: Are the dwarf rootstocks as hardy as your Minnesota seedlings?

HAROLD PELLET: No they are not, but 'EM 26' can be used quite successfully in Minnesota. 'EM 7' and 'EM 9' give us problems unless we mulch.

MODERATOR PINNEY: To continue this afternoon's program, we next have Dr. Elwin Orton who will speak to us on breeding woody ornamental plants.

HYBRIDIZING WOODY ORNAMENTALS

ELWIN R. ORTON, JR.
Rutgers University
New Brunswick, New Jersey

The development of new and superior cultivars is the primary objective of the breeding program with woody ornamentals at Rutgers University — The State University of New Jersey. For the most part, the improvements sought are increased winter hardiness, increased resistance to insect pests, and improved foliage and fruiting characteristics and, in some cases, decreased plant size. Work is also being devoted to the development of plants that exhibit characteristics quite novel for the plant material in question.

The plant species currently receiving most attention in the breeding program belong to the genera *Ilex* and *Cornus*. The starting point of the breeding project with each species has been the initiation and maintenance of a cultivar performance trials. Such trials are important as they make it possible scion variety. Further, it appears the rootstock may exert its effect on scion hardiness by speeding maturity in the fall or by delaying bud break in the spring, as 'EM26' did, rather than by increasing scion hardiness by use of a rootstock which has the inherent capacity to become more cold resistant in midwinter.

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The plant species currently receiving most attention in the breeding program belong to the genera *Ilex* and *Cornus*. The starting point of the breeding project with each species has been the initiation and maintenance of a cultivar performance trials. Such trials are important as they make it possible to evaluate plants of the currently available cultivars under reasonably uniform conditions at one planting site and, thus, to assess the variability present within the cultivated plants of each species. The performance trials also provide parent material for hybridization and provide various standards of comparison for evaluating the seedlings resulting from controlled matings.

American holly, *Ilex opaca,* was chosen for first consideration in the breeding program as a performance trial of more than 200 named cultivars and/or numbered selections of this species was available as parent material. This collection had been assembled by the late Dr. Charles Connors. Evaluation of this plant material revealed tremendous variability within the species for a wide range of plant characteristics. This variability was to be expected since plants of the genus *Ilex* are dioecious; thus, cross-pollination is the rule.

The dioecious nature of the species simplifies pollination techniques and small plants are readily manipulated in the greenhouse to obtain controlled crosses. Plants are merely caged in the greenhouse to exclude insects and the pollinations are made by hand. The objective of intraspecific hybridization with plants of *Ilex opaca* is to develop clones that make vigorous growth, that are reliably winter hardy in U.S.D.A. hardiness zone 6b, that possess a dense self-compacting habit, that have dark green, glossy foliage which remains attractive throughout the year and that possess brilliantly colored fruit, well displayed on the plant. To date, crosses have been accomplished with 40 select plants in 150 different parental combinations; approximately 40,000 seedlings have been acquired for evaluation under field conditions where they are planted at a spacing of 5′ x 5′.

Select seedlings from the first series of crosses are now approximately 12 feet in height, have been transplanted to the performance trials for further evaluation, and are being propagated for distribution to interested nurserymen.

Since it was felt that the ideal specimen-tree type of evergreen holly would be one which possessed a degree of winter hardiness equal to that of the better selections of American holly (*I. opaca*) in combination with the desirable foliage and fruiting characteristics of English holly (*I. aquifolium*), interspecific hybridization of plants of these species was initiated. Having obtained coincident periods of bloom of plants of the two species, thousands of hand-pollinations were accomplished using a select plant of *I. aquifolium* as the male parent. Female plants utilized in these crosses include the winter hardy cultivars, *I. opaca* 'Judge Brown', selected on the estate of the late Judge Thomas Brown of Locust, New Jersey, and *I. opaca* 'Hedgeholly', an excellent self-compacting, pyramidal type introduced by Mr. Paul Bosley of Bosley Nurseries, Mentor, Ohio. Despite the high degree of cross-incompatibility between plants of these species, flowering seedlings of the F_1

generation have been obtained. These plants are being utilized to obtain subsequent generations of seedlings which combine the desirable characteristics of both parent species.

Due to the seasonal publicity accorded English holly and American holly (*I. opaca*) during the Christmas season, plants of these species are very popular with the homeowner. However, plants of *I. crenata* undoubtedly constitute the hollies of most commercial importance in the Northeast. Intraspecific hybridization has been initiated with the objective of producing superior cultivars of various habits of growth that are reliably winter-hardy, that have dark green, glossy foliage which remains attractive throughout the year, and that possess mite resistance. A cultivar performance trial encompassing 5 plants each of 120 different named cultivars and/or numbered selections of this species has been field-planted. The plants are spaced 15′ x 15′ in order to provide sufficient room for each plant to develop its natural habit of growth.

One mating that has been accomplished on a large scale is that of *I. crenata* 'Convexa' x *I. crenata* 'Stokes'. Plants of the cultivar 'Convexa' have been very popular in the commercial trade due to their dark green, glossy, convex leaves and vigorous habit of growth; however, plants of this cultivar become too large for proper use in foundation plantings, develop brittle branches which break under the weight of a heavy snow, exhibit extreme discoloration of the foliage under heavy mite infestations or under the nutritional stress accompanying heavy fruiting, and are not reliably winter hardy in the colder areas of the Northeast. Plants of the male clone, 'Stokes', exhibit more hardiness than plants of 'Convexa' and develop a dense, self-compacting habit of growth, but the leaves are light green and lack gloss.

Approximately 21,000 seedlings resulting from a controlled mating of 'Convexa' x 'Stokes' were transplanted directly from 2¼″ peat pots to field beds at a spacing of 9″ x 9″. Two years later, the surviving plants (ca. 18,000) were dug and critically examined. Plants exhibiting any signs of winter injury, poor foliage characteristics, heavy mite infestation, or a poorly developed root system were discarded. More than 6000 seedlings were retained during this initial screening and were field-planted at a spacing of 5′ x 5′ to permit later evaluations under relatively exposed conditions. Each spring these plants are sprayed with Sevin to reduce the natural predators of mites, and thus encourage heavy infestations of mites as an aid in determining the relative susceptibility or resistance of the plants. More than 100 plants have been selected from this planting for further evaluation and possible selection for propagation and testing at other sites.

Interspecific hybridization is being utilized in work designed to replace the inconspicuous black fruit of *Ilex crenata* with brilliant red fruit that add to the landscape value of the plants. Female plants of *I. sugeroki* and *I. yunnanensis* develop red fruit and plants of both of these species are similar to certain cultivars of *I. crenata* in general foliage characteristics. Although neither of these red-fruited species is grown commercially, they are useful as a source of genes conditioning the red-fruit character. These species have been successfully hybridized with *I. crenata* as the first step in developing cultivars which possess the desirable characteristics of both parent species. A yellow-fruited clone of *I. crenata* which was introduced by the U.S.D.A. is being utilized in this work.

Both intraspecific and interspecific hybridization is being utilized to develop superior cultivars of *I. glabra*. The objective of intraspecific hybridization with plants of this species is to develop winter-hardy cultivars having a compact habit of growth with desirable evergreen foliage free from the purple mottling characteristic of many existing cultivars. Interspecitic into plants of *Ilex glabra* type.

Unlike the evergreen species, the deciduous hollies have received relatively little attention from nurserymen or plant breeders. A performance trial of cultivars of *I. verticillata, I. serrata,* and *I. decidua* is being assembled and both intra- and inter- specific hybridization is in progress. This work was initiated with crosses of *I. serrata* x *I. verticillata* and two cultivars resulting from this work have recently been introduced under the names 'Harvest Red' and 'Autumn Glow'. The original plants of these cultivars are intermediate to the parent plants with regard to such characteristics as number, size, and gloss of the fruit, exhibit attractive fall coloration of the foliage, have developed a symmetrical vase shape, and appear to be more dwarf than is typical for either parent species. These cultivars are being propagated for release to interested nurserymen.

The most recent work with the deciduous hollies includes plants of *I. decidua*. The characteristic of importance in this species is the retention of the fruit in an attractive appearance throughout the winter months; fruit of *I. verticillata* and *I. serrata* are seldom retained on the plant beyond late December in the Northeast. Many selections of *I. decidua* have been made available to the breeding program by Mr. J. Bon Hartline, Hartline's Holly Nursery, Anna, Illinois. As is true for all hollies, the genetic variability within the deciduous hollies is ample for the needs of the plant breeder. Thus, the outlook for the development of improved cultivars through hybridization and selection is very good.

Two species of flowering dogwood, *Cornus florida* and *C. kousa,* are now receiving attention in the breeding program at Rutgers University. A cultivar performance trial has been established and both intra- and inter- specific hybridization has been initiated. The objectives of this work are the development of winter hardy cultivars that exhibit different seasons of bloom and growth habit, that develop large showy bracts of long duration, and that possess resistance to attack by borers.

Vigorous F_1 seedlings resulting from crosses of *C. kousa* and *C. florida* have been obtained and are being grown for further evaluation. Should these F_1 hybrids prove to be fertile, they will be used in subsequent crosses to incorporate borer resistance in cultivars of *C. florida* type, as well as to obtain plants of *C. kousa* habit, and intermediate types, that exhibit the red-bract characteristic. To increase the efficiency of this work, initial efforts have been directed toward developing lines that breed true for the red-bract character. Many matings of pink- or red-bracted cultivars of *I. florida* have proven to be incompatible but several parental combinations utilized have been cross-fertile and, judging from seedling characteristics, all of the progeny from these matings will develop red or pink bracts.

Breeding work with woody ornamentals that have a generation cycle of 3 to 7 years is, by definition, a long-range program involving extensive field trials and years of evaluation. Thus, it is appropriate that such work be conducted at state and federally-supported institutions that can insure continuity of the program. The development of superior cultivars of woody ornamentals through formal programs of hybridization and selection is relatively new, but the prospects for success are very good.

MODERATOR PINNEY: Thank you very much, Dr. Orton. We do have time for a question or two.

CASE HOOGENDOORN: I occasionally see ads for self-pollinating hollies; is there such a thing?

ELWIN ORTON: Not to my knowledge. What they are referring to are ones which will set parthenocarpic fruit; that is, they'll set fruit without seed. These fruit are normally smaller and drop sooner and are usually less pigmented than fruit which contain viable seed. There are, however, no self-pollinating hollies; the sexes are separate.

BILL FLEMER: Can you cross *Ilex yunnanensis* and *I. crenata?*

ELWIN ORTON: Yes, we have hybrids of these. In fact, we're finding that many of the species which one would not expect to cross will do so. For example, I have hybrids of *I. glabra* and *I. serrata.*

VOICE: Have you done any work with *Ilex pedunculosa?* Plants of this species grow well for us in Canada.

ELWIN ORTON: No. We have not initiated intraspecific hybridization with *I. pedunculosa* as this is not commercially important in the Northeast. Plants of this species might be considered useful in interspecific hybridization since they exhibit considerable winter hardiness, but research by Dr. John L. Frierson indicates a somatic chromosome number of 110 for *I. pedunculosa,* whereas the commercially important species, such as *I. opaca, I. aquifolium, I. cornuta, I. pernyi,* and

I. crenata, reportedly possess 40 somatic chromosomes. Thus, it is unlikely that *I. pedunculosa* would be cross-compatible with any of these other species.

PETER VERMUELEN: Have you tried *Ilex rugosa*?

ELWIN ORTON: Yes, I have that crossed with *I.* x *aquipernyi* and have crossed it with plants that are hybrids of *I. cornuta* and *I. aquifolium* and several others. Most of the plants are not very vigorous however.

MODERATOR PINNEY: We thank you again, Dr. Orton. At this time I'd like to introduce Mr. Al Fordham of Arnold Arboretum who will take over the next segment of the program on new plant introductions.

AL FORDHAM: As Tom mentioned, we now come to that part of the program that deals with new plant introductions. I would like to remind you of the regulations dealing with the showing of new plant introductions; that is, each exhibitor shall be prepared to furnish propagating material at the proper time for each plant material to any member who makes a request. Commercial members will be allowed to sell plants to any interested member. At the end of the session there will be a few slides which Dr. Mehlquist and Mr. James Wells will show which are just for the opinions of the members with respect to identification, possibilities, etc. Our first exhibitor will be Mr. Joe McDaniel of the University of Illinois.

'GRIFFIN' EVERGREEN MAGNOLIA

J. C. MCDANIEL[1] AND SARA D. GROVES[2]
Department of Horticulture
University of Illinois
Urbana-Champaign, Illinois

Seedlings grown as *Magnolia grandiflora* are a variable complex. In the opinion of the first author, this variation is, so far as horticulturally superior forms are concerned, in large part associated with long-continued introgression of *M. grandiflora* by *M. virginiana australis* in areas of the southern U. S. coastal plains where their ranges overlap. A high proportion of the new and old select cultivars of *M. grandiflora*, including the 'Exmouth' which has been propagated for 230 years, have characteristics, particularly in their foliage, resembling those of indisputable hybrids such as 'Freeman' and others bred since 1930.

The distinctive clone now offered as 'Griffin' is believed to be the result of chance hybridization. It is probably a later-generation hybrid, which appears to be fully fertile, unlike the known F_1 hybrids between diploid *M. virginiana* and hexaploid *M. grandiflora*, which are often highly sterile.

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The original 'Griffin' plant, in a city park at Griffin, Georgia, is a multistemmed, compact, spreading tree, with leathery leaves having a glossy upper surface and brown indumentum, smaller and more acute at both apex and base than is usual for *M. grandiflora.* Its fragrant white flowers, freely produced over a long season, are large, and usually 12-petalled, borne on long peduncles which place them above the foliage. The red-coloring fruits, also well-displayed, are of smaller diameter and smoother than average for *M. grandiflora.* The abundant seeds have given somewhat variable seedlings with mostly better than usual *M. grandiflora* foliage. McDaniel finds its pollen compatible in a cross on deciduous *M. virginiana.*

Both authors had strong rooting (100% for Mrs. Groves) with IBA-treated 'Griffin' cuttings stuck in the greenhouse in early December. Mrs. Groves is a commercial propagator and has agreed to supply other propagators with cutting material. Its hardiness northward remains to be tested, but we can recommend 'Griffin' both as a superior evergreen and flowering cultivar for the areas where *M. grandiflora* now is generally grown, and as a select seed source.

NEW ORNAMENTAL TREE CULTIVARS OFFERED FROM ILLINOIS TO PROPAGATORS, 1969-70

J. C. McDANIEL
Department of Horticulture
University of Illinois
Urbana-Champaign, Illinois

Can you help us test some meritorious new ornamentals? We are planning to distribute to selected nursery propagators and some arboretums in early 1970, a few scions from two new hybrid magnolia cultivars originated here, and a self-fertile clone of *M. acuminata,* plus some other small flowering trees recently named, registered, and test propagated. I should like to hear from you soon if you are interested in initiating propagation of any one or more of the following items, none of which is patented.

1. *Magnolia* 'Ballerina' is a Loebner magnolia, seedling of *M.* x *loebneri* 'Spring Snow', possibly crossed with *M. stellata* 'Waterlily'. Of similar season to the well-known Loebner magnolia 'Merrill', this has considerably more double flowers (to 30+ petals), is slightly pink-blushed and more highly fragrant. Judged by its first twelve years growth, it apparently will mature as a smaller tree than 'Merrill', but larger than *M. stellata.* The 1969 tests showed a high percentage of strong rooting with May to July leafy cuttings stuck under mist after IBA dip. For grafting as cutting-source trees, I suggest either *M. soulangiana* or *M. acuminata* understocks, rather than *M. kobus,* whose foliage may be confusingly similar and could lead

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to later mixups, as have already occurred with 'Merrill'.

2. *M.* x *thompsoniana* 'Urbana' is a new hardy clone of this old hybrid, recreated in Urbana by crossing old local trees of *M. virginiana* x *M. tripetala.* Leaves and flowers are of intermediate size, but flowers have the good *M. virginiana* fragrance. It has been grafted on *M. tripetala* and *M. virginiana* stocks, and also rooted under mist in early summer.

3. *M. acuminata* 'Philo' is a large, nearly century-old tree of this species, exceptional among most of *M. acuminata* in setting heavy seed crops from its own pollen. It is suggested for propagation as a seed-source cultivar, since productive trees of this species are often hard to locate. The flowers are about average, but the red colored fruits are decorative in September. Grafted as a pollen source, it should also increase the seed production of any other *M. acuminata* tree in the immediate vicinity.

4. *Liriodendron tulipifera* 'Ardis' is a "compact model" tuliptree, with miniature foliage and about ⅓ the normal growth rate of the species. The original tree has not flowered much during its first 12 years, but has made a very decorative small tree. Flowers in 1969 yielded two fruits.

5. *Chionanthus virginicus* 'Floyd' like the preceding item, originated as a seedling on the Floyd Sonnemann farm near Vandalia, Illinois. This is notable for its narrow upright to slightly arching growth, much neater than the usual white fringetree. It has the large flower panicles typical of male fringetrees, but does produce a light scattering of fruit.

6. *Koelreuteria paniculata* 'September', whose original tree is on the Indiana University campus, Bloomington, Indiana, flowers two months later than typical trees of the species, or in very late August to September in this climate. Most, but perhaps not 100% of its seedlings are also the late flowering type. It seems to grow somewhat more vigorously than typical *K. paniculata,* and to have larger flower clusters and fruits. I have propagated it by leafy cuttings (old wood at the base) in May or June, and also from root cuttings started in vermiculite in spring. Either scions or root cuttings are available in limited quantities.

Our available material of some of these items is not large, so we may have to prorate them, or delay filling late requests. Enough scions should be available from item 3, and perhaps items 4 and 5, to supply all who request them.

AL FORDHAM: We next have Mr. Rodney Bailey who has a plant he would like to show.

RODNEY BAILEY: *Prunus virginiaan* 'Shubert' has the common name Canada red cherry. It was a seedling sport which originated in North Dakota several years ago. An interesting feature about it is that the new growth comes out green and then turns to a red as the leaves mature; in July the whole plant is red. It's completely hardy and appears to be disease and insect resistant. In our area its a good substitute for the red-leaved maple; it can be grown as a single stem or a multiple stem tree and attains a height of around 25 ft. It roots quite readily from softwood cuttings or can be grafted on *Prunus padus*. The fruit is a wine-red and is not messy since the birds will take it off as fast as it ripens.

AL FORDHAM: Thank you, Rodney. Next, we will hear from Mr. Roy Nordine.

ROY NORDINE: These are slides of the honeysuckle collection at the Morton Arboretum. This is a dwarf form of *Lonicera tatarica* called *L. tatarica* 'Nana'. It is pink-flowered and fruits like others but grows only half as high, going to a little less than 6 ft tall and about as broad. It's not at all leggy and makes an excellent appearance during its entire life.

Next is a plant derived from a witches' broom, *Acer ginnala* 'Durand Dwarf'. This particular plant is grafted on *Acer ginnala* and is 3 to 4 ft high and a little bit wider. It colors up typical of *Acer ginnala* in the fall of the year. It grafts readily on *Acer ginnala.*

This is a very dwarf form of a common plant in Europe, *Genista tinctoria;* its name is *Genista tinctoria* 'Hirsuta' because of the hairy leaves. Its mature height is less than 3 feet. It blooms at the end of the flowering season in the spring and is a brilliant yellow. It roots very easily from softwood cuttings.

At the Arboretum we propose the use of native American plants at every opportunity; here is one that attracts a great deal of attention. This is *Fothergilla major;* it has excellent fall color. There is a small one, *Fothergilla gardenii,* which is available in the trade.

Another plant to which I would like to call your attention is *Cladrastis lutea,* an American tree that belongs to the legume family. This family of plants, especially the trees, have not been overlooked but they have not been thoroughly looked into either. One of the advantages of these trees is that their roots do not compete with the grass. They are beautifully shaped strong shade trees and have excellent fall color. There is a pink flowered form called *Cladrastis lutea* 'Rosea'; this is a group of plants that I think that should be more available in the trade.

AL FORDHAM: Thank you, Roy. Dr. Mehlquist has some rhododendrens on which he would like to have your opinion.

GUS MEHLQUIST: These pictures were taken by some friends of mine in Lebanon last spring. When they returned they wanted to know what species it is and if it has any value. I'm not sure yet what species it is, but I certainly do think it ought to be introduced. You'll notice that it grows in a rather rocky habitat which I think drys out and gets very hot in the middle of summer.

AL FORDHAM: Mr. James Wells also has some slides he would like to show us.

JIM WELLS: We've been working with the deciduous azaleas for some time and I've been importing them from New Zealand. I took some seed from one called 'Williams' and this plant appeared among them. I rather like the looks of it and toyed with the idea of calling it 'Peachy Keen'. It roots readily. I do have a few plants but I primarily brought it along just to show and see what other people think of it. If you think it has merit we'll propagate them this year and any one who wants it can have some.

AL FORDHAM: That concludes the session on the plant introductions and I thank all of you who have brought slides to show.

CHARLEY HESS: I want to take this opportunity to thank Al Fordham for doing an excellent job of handling the plant introduction section of the program again this year and also to thank Tom Pinney for the job he did this afternoon in moderating the sessions. This concludes this afternoon's program and we will meet again at 7:30 for the Question Box Session.

FRIDAY EVENING SESSION

December 5, 1969

PLANT PROPAGATORS' QUESTION BOX

The Question Box session convened at 7:40 p.m. in the East Ballroom. Mr. Ralph Shugert served as moderator.

MODERATOR SHUGERT: Good evening, Ladies and Gentlemen; we shall now call the Question Box Session to order. For the benefit of those attending this session for the first time we ask all to participate. In order to have proper identity, we are asking everyone to do two things; wait for the microphone, and please give your name so it can be entered in the Proceedings. This can be very enlightening and interesting segment of the program if everyone will cooperate and participate. Thank you.

Now for the first question. Dr. Tehrani, how does your method of rooting hardwood cuttings work for ornamental varieties of cherries and flowering crabs?

G. TEHRANI: It does not seem to work too well with varieties of cherries; and I do not work with apples, so I have not tried this.

JOERG LEISS: The same type of treatment as Dr. Tehrani mentioned has been used on the *Malus* understocks of the EM type with good results. We have rooted *Prunus cistena* and *Prunus besseyi* by sticking them right in the field as hardwood cuttings; some years we have good results, others not. We make them in February and March and as soon as the frost is out of the ground — during the first part of April — we stick and shade them.

GERRY VERKADE: Do you cut and store, or cut and stick them?

JOERG LEISS: We store them but use no hormone treatment.

JIM LAW: We have tried the hardwood program on *Malus* 'MM 106' and had almost a complete failure. Accidentally, we took some semi-hardwood cuttings taken just before the leaves abscised and had excellent results with these. We are starting with our second full-year program and I would like to report further on this a year from now and see if we can repeat what we did a year ago. We have also rooted *P. cistena,* in a manner similar to what Joerg described, but we put them under mist keeping them just wet enough so they don't dessicate and had excellent results with it — but we want to try to repeat this also.

DICK CROSS: At our nursery we take hardwood cutting of *P. cistena* in late November, cut them and place them in the bench during December when we can maintain low temperatures. If we can store them at 40°-45°F till February and then raise the temperature we get much better results. We do use Hormodin No. 2; with No. 3 we got burning.

MARTIN VAN HOF: I think *P. cistena* is very easy to root. We take cuttings from growing plants in September and in 3 weeks they are rooted solidly.

MODERATOR SHUGERT: Andy Adams, I have the following questions addressed to you; does the fact that you did not use Cycocel this fall indicate that you are not completely sold on its merits; and did your azaleas bolt into flower the summer after its use?

ANDY ADAMS: We are completely sold on Cycocel. It was not necessary to apply it this fall because we had no rain during August and the plants were completely hardened off — there was no reason for using Cycocel. In answer to your second question, they bloomed at their normal time.

MODERATOR SHUGERT: Dr. Meyers, we have several questions addressed to you. There is a long standing use of the terms "determinate" and "indeterminate"; what advantage are there in the terms "homophyllus" and "heterophyllus"?

MARTIN MEYER: I used "heterophyllus" because it is the term Kozlowski, whom I cited, used and which I think best describes this type of growth; "homophyllous" is my term, which is opposed to heterophyllous.

MODERATOR SHUGERT: In view of the data on nutrient uptake in winter and of winter root activity of conifers and other woody plants, would Dr. Meyer comment on the best time to fertilize — between summer only or a constant maintenance of a good nutrient level?

MARTIN MEYER: Between Juniper and Taxus — I think it is important to maintain a constant level with Juniper because they respond all the time; with Taxus you would not have to be so critical in maintaining a constant maintenance level, but both plants would benefit from it.

MODERATOR SHUGERT: Sid Waxman, have you tried using high concentrations of IBA as a quick liquid dip on your pines and have you used Captan as a synergist?

SID WAXMAN: No I've only used Hormodin No. 3 and Captan as a fungicide; I don't know if it has any synergistic effect.

MODERATOR SHUGERT: Another question for you, Sid; have you done any work with witches' brooms other than pine and hemlock?

SID WAXMAN: No.

BRUCE BRIGGS: I assume it is generally held that hormones cause witches' brooms; this was reported at the International Botanical Congress in Seattle this year. Do you know of any tissue tests that have been made to determine if the tissue retains this original high hormone content in later growth?

SID WAXMAN: We tested it by the mung bean bioassay and found that the witches' broom seedling did have more biological activity. Also the growth on a witches' broom tends to be upright and I think this is related to auxin content as has been demonstrated for fruit trees.

GERRY VERKADE: Sid, someone told me they could root pines by sticking them in a potato, Is this possible and have you heard of it?

SID WAXMAN: Anything's possible, but I haven't heard of it.

CHARLEY HESS: I've heard of that but it was rose cuttings stuck into potatoes. Potatoes are high in phenolic compounds like iso-chlorogenic acid and there may be a far-out chance that it may play a role. It corresponds to the old Dutch treatment of splitting a cutting and placing a wheat grain in it and supposedly getting some stimulation, but it's not very promising commercially.

ROGER EWLINGER: You can stimulate rooting of some of the difficult to root pines, specifically *P. ponderosa,* by sticking the cutting into a germinating acorn.

MODERATOR SHUGERT: Larry Carville, in preparing your beds for softwood cuttings, how do you take care of the 4-inch strip that the Howard Rotovator does not get?

LARRY CARVILLE: We recently acquired a small front-tilling Model of Simplicity tractor which we use to trim up the sides.

MODERATOR SHUGERT: What are some up-to-date sources of information of plant culture work — procedures, media, etc.?

CHARLEY HESS: There were two papers on tissue culture of plant tissues given at the Western Region meetings which are in Volumes 16 of the Proceedings; one was by Tosh Murashige and another by Wes Hackett. Both of these have several references listed at the end of them (See Vol. 16:80-92). There is a book, *Proceedings International Conference on Tissue Culture,* edited by Philip White and published by McCutchen Publishing Corp. Berkeley, California in 1965 that has many articles with hundreds of references. A large number of articles which involve tissue culture methods are in various publications such as the American Journal of Botany, Plant Physiology, Physiologia Plantarum, and the Bulletin of the American Orchid Society.

MODERATOR SHUGERT: Joe Cessarini, why did you use 4 mil clear plastic rather than 6 mil white?

JOE CESARINI: I began covering them before I knew of the white plastic. The clear works, so why change it?

MODERATOR SHUGERT: Why do you pot your rooted Japanese maple cuttings in perlite and peat?

JOE CESARINI: We are not potting them, we are sticking directly into the pots for rooting. In potting, if you break any of the roots diseases get in and you lose them.

MODERATOR SHUGERT: We now have questions not directed to any particular person. Is there any indication that CO_2 enrichment of air aids rooting of cuttings?

BILL SNYDER: One of our students at Rutgers has been doing some work on CO_2 enrichment and the results, at best, were inconsistant.

PETER VERMEULEN: At Boskoop they found that CO_2 under poly was much higher than under glass frames.

BILL SNYDER: About 2 years ago there was a report from the West Coast concerning the CO_2 level in completely enclosed poly frames and they found that during the middle of the day, when the plants should be photosynthesizing the most rapidly, the CO_2 content in the cases was reduced to a level where probably little photosynthesis was going on.

CHARLEY HESS: There is also an article on carbonized mist in the last issue of the Proceedings.

MODERATOR SHUGERT: Has anyone tried Off-Shoot-O on azaleas and rhododendrons?

ANDY ADAMS: We used it on our entire azalea crop this year and it did a good job, using the recommended rate on the bottle for azaleas.

DICK BOSLEY: We used it on *R. kaempferi* this summer and it worked very well, but read the label and follow the directions. It will work on rhododendrons applied at about the time the new bud is just long enough so that the scales are just starting to open up. The stage of application is much more critical than for azaleas. It is seldom that they break uniformly enough and have enough of them at the same stage to make it practical to use.

MODERATOR SHUGERT: Someone asked what does it do?

BRUCE BRIGGS: It burns out the meristem and if the dilution is right there will be little or no burning of the other foliage. We hope in time to be able to pinch conifers and other broadleaves with it but a lot more work is needed.

JOE CESARINI: It does a wonderful job on cotoneaster.

MODERATOR SHUGERT: Has anyone working with Benlate noted any problems such as chlorosis which might indicate an accumulative toxicity?

DICK BOSLEY: We've used it on rhododendrons, incorporating it into the rooting powder at 2 and 4% actual, and as a "water on" material and have noticed no problems; this is our second year.

JIM CUMMINS: I reported using Benlate as high as 6000 ppm, which is about 10 times the recommended dosage; we have observed no post-application problems whatsoever.

MODERATOR SHUGERT: What causes necrotic damage to the ends of cuttings when a high level of hormone is used?

CHARLEY HESS: Some of the cells are killed; as the concentration is increased the roots come out higher on the stem instead of at the base; as it gets too high, the base of the cutting is killed and the roots come out higher up the stem.

MODERATOR SHUGERT: Does wounding increase IAA or are there other hormone actions from wounding?

CHARLEY HESS: I don't know of any evidence of an increase in IAA but there is evidence of a substance formed from wounding and this material does stimulate cell division. This work was done with bean pods and when the inside of the bean pod was scratched tissue proliferated. From this, traumatic acid was isolated and identified. I tried it on cuttings and it did not stimulate rooting. I talked to the people in Boskoop who tried it as a graft union stimulator and they found no response. So what goes on when you wound a cutting is still pretty much an unanswered question.

MODERATOR SHUGERT: What are the disadvantages of wounding Taxus cuttings?

JIM WELLS: Wounding of Taxus does not seem to improve rooting. You can "burst" roots out of the more difficult ones by treating them with the stronger hormones, like 2,4-D, but wounding is not necessary.

MODERATOR SHUGERT: What is the best understock for *Betula chinensis*?

JOERG LEISS: You can graft it on *Betula verrucosa* (*B. alba*), but we grow it from seed.

MODERATOR SHUGERT: Has anyone tried establishing a leader on grafted or cutting-grown blue spruce by continual pruning rather than by staking?

CASE HOOGENDOORN: There used to be an old Dutchman to whom I sold one-year grafts; what he did was to line them out and let them get established, then the next year he would cut them back. This would force buds — when you force buds you get a leader.

JOE CESARINI: The ability to establish a leader depends a lot on the scion you graft. I find that 'Hoopsi' is one of the best to form a leader.

MODERATOR SHUGERT: How compatible is *Cornus kousa* grafted on *Cornus florida?* The consensus of opinion in the room says it is compatible.

DON SHADOW: We have budded it for the past 8 to 10 years and have had no trouble at all.

PETE VERMUELEN: We have plants that have been grafted for 25 to 30 years and have never noticed any problem.

MODERATOR SHUGERT: Please give one or more positive ways to identify White Ash from Green Ash.

ROY NORDINE: It is difficult to determine when they are small but when the trees are older, Green Ash has an irregular branching habit, forming an irregularly shaped plant, while White Ash is very symetrical. In the fall of the year White Ash is the only one that turns purple; Green Ash turns yellow or brown.

TOM PINNEY: Is there a way of identifying them from the buds or seeds?

HARRY HOPPERTON: There are easy methods: buds on the Green Ash come to a point like a needle while those on White Ash are fat and round. Also Green Ash has a little longer and more pointed leaf than White Ash.

JOERG LEISS: The samara wing of Red and Green Ash both extend almost all along the edge of the seed while the samara wing, of White Ash only goes to about a quarter of the seed and is only half the size of that of Green or Red Ash.

MODERATOR SHUGERT: Last year Bill Curtis said that *Pinus contorta* could be used as an understock for all pine grafting. Did he really mean that? It's hard to believe that one species can be used as an understock for all pines.

BRUCE BRIGGS: One of our nurserymen, John Spawn, has used it on all of the pines I know of. There may be some he can't use it with but I'm not aware of these.

HARRY HOPPERTON: I have probably 30 pines grafted on *P. contorta* — some of them with almost 6-inch caliper; the grafts are a saddle and they're all perfect.

MODERATOR SHUGERT: How does one germinate *Cladrastis lutea* seed?

BILL FLEMER: Like other legumes it doesn't have an internal dormancy problem; it merely has a hard seed coat. We keep the seed dry over the winter and then put them in hot water, 120°F, until the seeds swell, usually 24 to 36 hours. They are taken out of the water and dried so they don't stick together, then are sown in nursery rows. We put double lath screen over them because the seedlings are susceptible to sun scald at their base. After they are up quite well we take one lath screen off.

CHARLEY HESS: Do you keep them in hot water, or is this just the starting temperature which gradually cools.

BILL FLEMER: This is just the starting temperature.

MODERATOR SHUGERT: When using a hot water treatment on any seed, try it on a small sample first — not the whole lot, because you can lose all your seed if the water is too hot.

LEN STOLTZ: Along with your suggestion Ralph, I'd suggest that several small lots of 100 or 200 seed be treated at different temperatures and times and then sown in a pot or flat in the greenhouse to determine which treatment gives the best germination percentage. This can be done a month or two ahead of the time you intend to sow them in the nursery.

MODERATOR SHUGERT: What is the required amount of water per week for maximum summer growth of plants in cans using a soil, sand, peat mix?

JOHN MCGUIRE: I don't think you can make a general rule since it will depend upon transpiration rate, temperatures, size and kind of plant in the can, wind velocity and other factors.

MODERATOR SHUGERT: Has anyone noticed any effect on rooting when stock plants have been treated with simazine or other herbicides?

JOHN EICHELSER: We've been taking cuttings from rhododendrons treated with Simazine for quite a few years and haven't noticed any decline in rooting from this cause.

PETER ORUM: We have been using simazine for a long time; we've used it on stock plants and have not seen any reduction in rooting percentage, but I don't advocate continuing to apply simazine indefinitely.

MODERATOR SHUGERT: What is the optimum pH to maintain the most desirable winter color of white pines?

TOM PINNEY: Our pH is not optimum — it is 8.0 with a dolomitic limestone base and it gives us problems. However, in the western and central parts of Wisconsin white pines grow very well and the pH is around 6.0 but there are more complications involved than just pH.

LESLIE HANCOCK: The pH level for white pine is extremely important; our pH runs about 6.0 and we have beautiful ones. It needs a medium-acid soil with good drainage.

HARVEY GRAY: I've checked into this a little and, as was pointed out, more than pH is involved. I think there is a correlation between the pH level and the micro-organisms of the soil which make the elements of nutrition available.

MODERATOR SHUGERT: Is ground hardwood bark comparable to pine bark as a container-growing medium?

MARTIN MEYER: We are beginning to study the use of hardwood bark, particularly beech and oak, and it does have a pH problem in that the pH is much higher than found with fir and pine bark.

MODERATOR SHUGERT: What is a fair price for unground hardwood bark per yard or ton and what type of grinder is suitable for grinding and what is the cost per yard for grinding?

MARTIN MEYER: The paper companies have tremendous quantities of this material available and it is ground a little because they shred it somewhat in stripping it off the logs. I don't know what a fair price would be.

DICK BOSLEY: We are using hardwood bark, but if I could get pine bark I would prefer it. As far as a fair price — they ought to pay you to take it away. We get ours free at the site but the trucking and handling charges are in the range of $3.00 per yard.

GERRY VERKADE: We've grown some sweetgum in hardwood bark at a pH of 7.2 and haven't had any chlorotic conditions. Freight on the bark costs us about $2.00 per yard in bulk; it is ground but we don't want much dust and fine particles. This also needs more work.

ANDY KNAUER: We paid $45.00 for a 15 to 18 yard load. To break it down you can use an ordinary wood chipper; one with a serrated blade works very well. You get considerable dust but also a tremendous amount of pathogens.

BILL FLEMER: Harold Nichol at the Green Leaf Nursery uses ground hardwood bark exclusively as the organic compound of their canning mix. I believe he said he paid 75c/yd delivered and grinding costs another 75c. They use a big W. W. grinder.

LEN STOLTZ: We intend working with this material at Kentucky and some of the problems we foresee is the fact that hardwood bark is almost always a mixture. Bark from hardwood logs shreds off when the bark slips giving a stringy product, difficult to grind. We want to look at the barks individually to determine if there are any inhibitive or promotive effects from their use.

MODERATOR SHUGERT: Who is using cost accounting, what are the results, and do you make more profit? Tom Pinney, this is addressed to you, sir.

TOM PINNEY: I believe most of the large nurseries are using it because they have got to know their costs. I know of several that I've talked to that are using it — some have it attached to computers. Ours is laboriously done by hand methods yet, but we are getting ready for data processing procedures. In our case it has positively increased profits.

MODERATOR SHUGERT: Another question, Tom, along these lines that you may wish to comment on. How large does the operation have to be for a cost analysis system to be feasible, and can it be readily adapted to a multi-phased nursery operation?

TOM PINNEY: In our case we are complicated by the fact that we are multi-phased. We are not large but we have found it feasible to separate them. I suspect it would be much easier to do a cost analysis system for a small operator. The problem in a medium-size nursery is to get your employees enthusiastic about it. I think the most important part of Knox Henry's talk was that he was talking in terms of a total system; you must look at all of the inputs and all of the outputs.

JIM LAW: I agree with Tom that it is probably easier to use on straight function nurseries. I think the important thing here is that it is another tool; it's a way of measuring what you are doing, where your labor cost is, where your material costs are, and what some of the other factors are.

MODERATOR SHUGERT: I've seen this system in operation for the past nine weeks both as a monthly cost analysis and, most important, as a weekly breakdown of plants sold to date, size, last year's sales, number of plants yet to sell, etc. It's amazing the amount of information immediately available. For those that have it, they wonder how they did without it —another excellent management tool.

MODERATOR SHUGERT: What is the best cover crop to rebuild old nursery land and why?

VINCE BAILEY: We have a 9-year rotation with 6 years in sod using brome-alfalfa because it opens up the soil down deep and gives good drainage to our heavy soils. We don't remove any of the crop but use a field chopper and plow it down in July of the third year. Then we add 20 tons of barnyard manure before planting each crop.

BRUCE BRIGGS: Has anyone used corn?

CASE HOOGENDOORN: Yes, I used silo corn just after the war to get land back into production. This grows about 8 feet tall and we had few weeds to pull. About the middle of August we chopped it and had about 3 inches of green manure, then we plowed it under and planted rye in September; this took care of our dog-grass problem and it improved the soil.

MODERATOR SHUGERT: That completes the Question Box Session for this year. Thank you for your very excellent participation.

SATURDAY MORNING SESSION

December 6, 1969

The Saturday morning session began at 8:30 a.m. in the East Ballroom of the Commodore Hotel. Harvey Gray served as moderator. Papers were presented after which the annual business meeting was held. The minutes of the business meeting appear at the beginning of the 'Business and Technical Session' of the Eastern Region.

HARVEY GRAY: Our first speaker on this morning's program recalls to mind the fungicide I have used for many years and have wondered as to it's merits in propagation. I've had a number of trials and tribulations with Captan and I'm never sure whether it worked advantageously or otherwise. I'm happy to see that we will have further commenting on this by our first speaker, Manuel Cabrita, who will tell us about Captan in the rooting medium.

CAPTAN IN THE ROOTING MEDIUM

MANUEL P. CABRITA
Barneyville Nurseries
North Swansea, Massachusetts

At the time Captan first came on the market I was having trouble rooting geranium cuttings. We lost about 70% of every batch of these cuttings with Black Leg. I decided to make the cuttings of geraniums, dip them into Captan and plant them directly into soil in 2½ inch pots. In 4½ weeks they were rooted right through the pots. We rooted 90% of the cuttings treated this way.

Later I decided to try it on some evergreen cuttings we were making. The ones we used were the following: *Thuja occidentalis* 'Nigra' *T. O. 'Fastigiata'* (syn., 'Pyramidalis') *Juniperus horizontalis* 'Plumosa Compacta', *J. chinensis* 'Hetzii', *Taxus* x *media* 'Hicks', *T.* x *m.* 'Hatfield', *T.* 'Densiformis' and *Buxus* 'Newport Blue'.

In preparing the bench, I white-washed it then laid polyethylene on the bottom of the bench and put in 6 inches of washed cement sand. The bench was then leveled off with a 2 x 4, much as you would do to float-off cement. I don't do any pounding of the sand to firm it; I just stick the cuttings into it. The cuttings were stuck 1¼" apart with 50 cuttings to a row on a bench that is 52 inches wide. The cuttings were thoroughly watered in after sticking was completed.

The cuttings are cut in the field and we don't make a fresh cut before we stick them — the cut that's made in the field is what we use. They're placed in plastic bags, stored at about 32°F and they may stay there for as much as 2 weeks. Prior to sticking we cut the top and strip the lower end, that's all. Using this method, one man can make, dip and stick 3300 cuttings in 7 hours.

In all instances the Captan gave better rooting than did Rootone. The root system with Captan was heavier, longer and usually whiter. The benches are open and a temperature of 60°F is kept in the greenhouse during rooting. (Slides were shown to illustrate the differences in the rooting.)

We buy 4 lbs of Captan for $2.95; Rootone costs about $8.00/lb. We feel there is a considerable saving in this.

MODERATOR GRAY: Thank you for that fine presentation. The next speaker is a young fellow who has worked at the University of Rhode Island on a study of the rooting cofactors in some of the easy and difficult-to-root clones of rhododendrons. This work was done as his Master of Science research problem under the direction of Dr. John McGuire. He is now at Cornell University working on his Ph.D. It gives me a great deal of pleasure to introduce to you Mr. Choong Lee who will present his paper to you.

THE RELATIONSHIP BETWEEN ROOTING COFACTORS OF EASY AND DIFFICULT-TO-ROOT CUTTINGS OF THREE CLONES OF RHODODENDRON[1]

CHOONG IL LEE[2]
Department of Horticulture
University of Rhode Island
Kingston, Rhode Island

Extremely poor rooting of cuttings of some clones of *Rhododendron* is one of the factors which decreases the production efficiency of rhododendron. Some endogenous rooting factors, other than auxin, which control rooting are believed to occur in easy-to-root cuttings of some genera, but to be present in a smaller amount or absent in the difficult-to-root ones (1,3,4,5,6). Hess (2) suggested that the presence of four root-promoting substances, named rooting cofactors, in extracts from stem tissues of the juvenile form of *Hedera helix* L. cuttings was responsible for its high rooting capacity. The rooting cofactors have also been found in other plants and were related to rooting ability (2,4,6). They have not previously been studied in *Rhododendron.*

Objective of this study was to determine the relationship between rooting cofactor or inhibitor level and the clonal and seasonal variation in rooting response of cuttings in three clones of rhododendron.

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[1] This work was carried out under the auspices of Dr. John J. McGuire, Department of Horticulture, University of Rhode Island. The material is a portion of a thesis submitted by the author to the Graduate School of the University of Rhode Island in partial fulfillment of the requirements for the Master of Science degree.

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to sticking we cut the top and strip the lower end, that's all. Using this method, one man can make, dip and stick 3300 cuttings in 7 hours.

In all instances the Captan gave better rooting than did Rootone. The root system with Captan was heavier, longer and usually whiter. The benches are open and a temperature of 60°F is kept in the greenhouse during rooting. (Slides were shown to illustrate the differences in the rooting.)

We buy 4 lbs of Captan for $2.95; Rootone costs about $8.00/lb. We feel there is a considerable saving in this.

MODERATOR GRAY: Thank you for that fine presentation. The next speaker is a young fellow who has worked at the University of Rhode Island on a study of the rooting cofactors in some of the easy and difficult-to-root clones of rhododendrons. This work was done as his Master of Science research problem under the direction of Dr. John McGuire. He is now at Cornell University working on his Ph.D. It gives me a great deal of pleasure to introduce to you Mr. Choong Lee who will present his paper to you.

THE RELATIONSHIP BETWEEN ROOTING COFACTORS OF EASY AND DIFFICULT-TO-ROOT CUTTINGS OF THREE CLONES OF RHODODENDRON[1]

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Extremely poor rooting of cuttings of some clones of *Rhododendron* is one of the factors which decreases the production efficiency of rhododendron. Some endogenous rooting factors, other than auxin, which control rooting are believed to occur in easy-to-root cuttings of some genera, but to be present in a smaller amount or absent in the difficult-to-root ones (1,3,4,5,6). Hess (2) suggested that the presence of four root-promoting substances, named rooting cofactors, in extracts from stem tissues of the juvenile form of *Hedera helix* L. cuttings was responsible for its high rooting capacity. The rooting cofactors have also been found in other plants and were related to rooting ability (2,4,6). They have not previously been studied in *Rhododendron.*

Objective of this study was to determine the relationship between rooting cofactor or inhibitor level and the clonal and seasonal variation in rooting response of cuttings in three clones of rhododendron.

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MATERIALS AND METHODS

Experiment I

An easy-to-root clone of *Rhododendron,* 'Cunningham's White', an intermediate-to-root clone, 'English Roseum', and difficult-to-root clone, 'Dr. H. C. Dresselhuys', grown under natural conditions were used in the study. Terminal stem cuttings with leaves were taken on July 10, September 15, and November 15, 1967. The stem and leaf tissue of the cuttings were frozen, lyophilized, and ground separately. One gram samples of ground tissue were extracted with anhydrous methanol at 0°C. The extracts were dried *in vacuo* at 35 ± 2°C and the residue was taken up in 4 ml of methanol. Re-dissolved extract of 0.25 ml was applied to a 5 cm wide strip of Whatmann No. 3 MM chromatographic paper. After streaking, the papers were immersed in a solvent system of isopropanol:water (8:2 v/v) for development at 2°C for reducing chlorophyll streaking. When the solvent front had ascended for 30 cm, the chromatograms were removed and dried in a hood for 2 hours. The chromatograms were cut into 15, 2-cm sections and a control section was cut from the paper above the solvent front. They were bioassayed to determine their root-promoting or inhibiting activity by the mung bean rooting test developed by Hess (3, 4).

Average number of roots initiated in the check vial and those at the regions of R_f 0.07-0.13, 0.27-0.33, 0.60-0.67, and 0.80-0.87, as reported by Hess (2) to be rooting cofactors 1, 2, 3, and 4, respectively, and also at the inhibitory region of R_f 0.00-0.07 were compared and the amount of each cofactor or inhibitor was determined. The mung bean bioassay was repeated three times at each of the three seasons.

Experiment II

Reciprocal side grafts were made to determine the effects of transmittable endogenous substances from scion to rootstock on rooting response of the cuttings in the three rhododendron clones.

Terminal 4-inch stem cuttings were taken on September 13, 1967. The lowest inch of stem and flower buds, if present, were removed. Each cutting contained five leaves. One-third to one-half of each leaf was removed depending on the leaf size. One of the leaves on the stem was replaced by a leaf and bud scion of another clone using the side graft method. The leaf of the scion was not shortened. All possible combinations of grafts among the three clones of *Rhododendron* 'Cunningham's White', 'English Roseum', and 'Dr. H. C. Dresselhuy's were made. Cuttings in each clone, without grafting, were used as controls.

All cuttings were wounded slightly and were dipped for 10 seconds in an auxin solution of 0.1% IBA, 0.1% NAA, and 50 ppm boron in ethanol. Cuttings were then planted in a randomized block design in a medium of sphagnum peat moss and perlite (1:1 v/v). Within a month the graft unions were healed. After three months the percentage of cuttings rooted and the diameter of the root ball on the cuttings were recorded.

RESULTS AND DISCUSSION

Experiment I

The root-promoting activity of extracts from stem and leaf tissues of the three rhododendron clones as indicated by number of roots initiated on mung bean cuttings, is shown in Figure 1, 2, and 3. The horizontal line in the histograms represents the average number of roots per cutting on the control. Columns above the horizontal line and below the horizontal line represent promotion and inhibition, respectively, of root initiation in comparison to controls.

(*A*) *July experiment* (*Fig. 1*). Extracts from stem tissue of 'Cunningham's White' contained four rooting cofactors located at the regions of R_f 0.1, 0.3, 0.63, and 0.83, respectively. Two rooting cofactors, 2 and 4, were found in extracts from stem tissue of 'English Roseum', and only cofactor 4 was found in stem tissue of 'Dr. H. C. Dresselhuys'. A rooting inhibitor was found in significant quantities at the region of R_f 0.03 in stem extracts of 'Cunningham's White' and 'English Roseum'. 'Dr. H. C. Dresselhuys' had the inhibitor present but not in a significant amount.

Leaf tissue of 'Cunningham's White' contained two cofactors, 2 and 4, and leaf tissue of 'English Roseum' had three

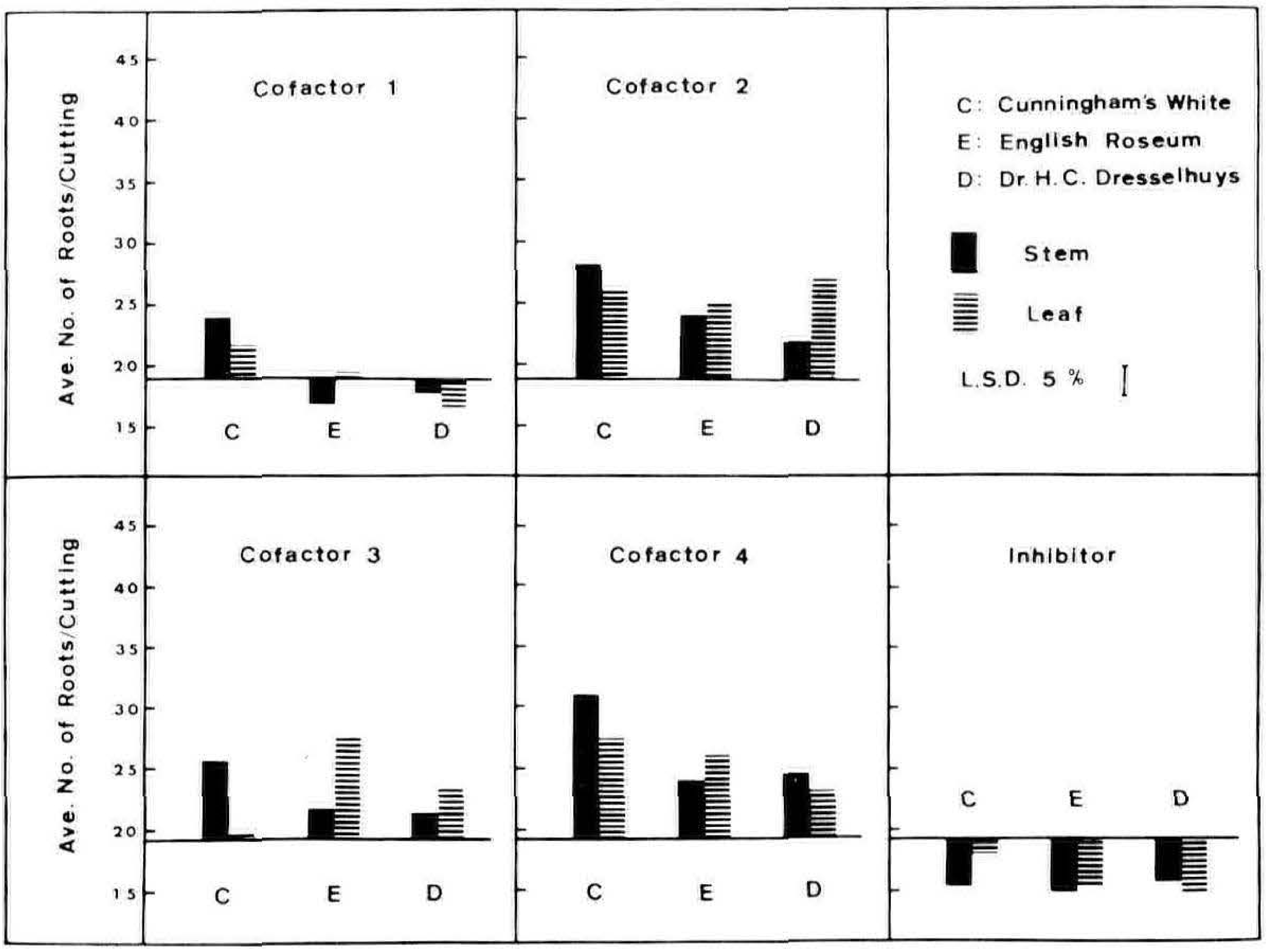

Fig. 1. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on July 10, 1967.

cofactors, 2, 3, and 4. Only cofactor 2 was present in leaf tissue of 'Dr. H. C. Dresselhuys'. No significant inhibiting effect was found in extracts from leaf tissue of 'Cunninghham's White' or 'English Roseum', but 'Dr. H. C. Dresselhuys' contained an inhibitor.

(*B*) *September experiment* (*Fig. 2*). A considerable increase in rooting cofactor levels, and a decrease in inhibiting activity, as measured by root initiation, was found in each clone, as compared to the July extracts. Extracts from stems of 'Cunningham's White' and 'English Roseum' contained four cofactors with no significant amount of inhibitor. Extract from 'Dr. H. C. Dresselhuys' stems had two rooting cofactors, 2 and 4, with no inhibiting activity. Extracts from leaf tissues exhibited similar trends in amounts of rooting cofactors and inhibitor with those in the extracts from stem tissues.

(*C*) *November experiment* (*Fig. 3*) The decrease of rooting cofactor level and reappearance of the inhibitor in November extracts was remarkable. 'Cunningham's White' and 'English Roseum' stems still contained all four cofactors with no inhibitor, but 'Dr. H. C. Dresselhuys' stem tissue had only cofactor 4 and the inhibitor in significant amounts.

Leaf tissue of 'Cunningham's White' and 'English Roseum' had all four rooting cofactors, whereas 'Dr. H. C. Dresselhuys' contained only two confactors, 2 and 4. The inhibitor was not found in significant amounts in the leaf tissue of any clone.

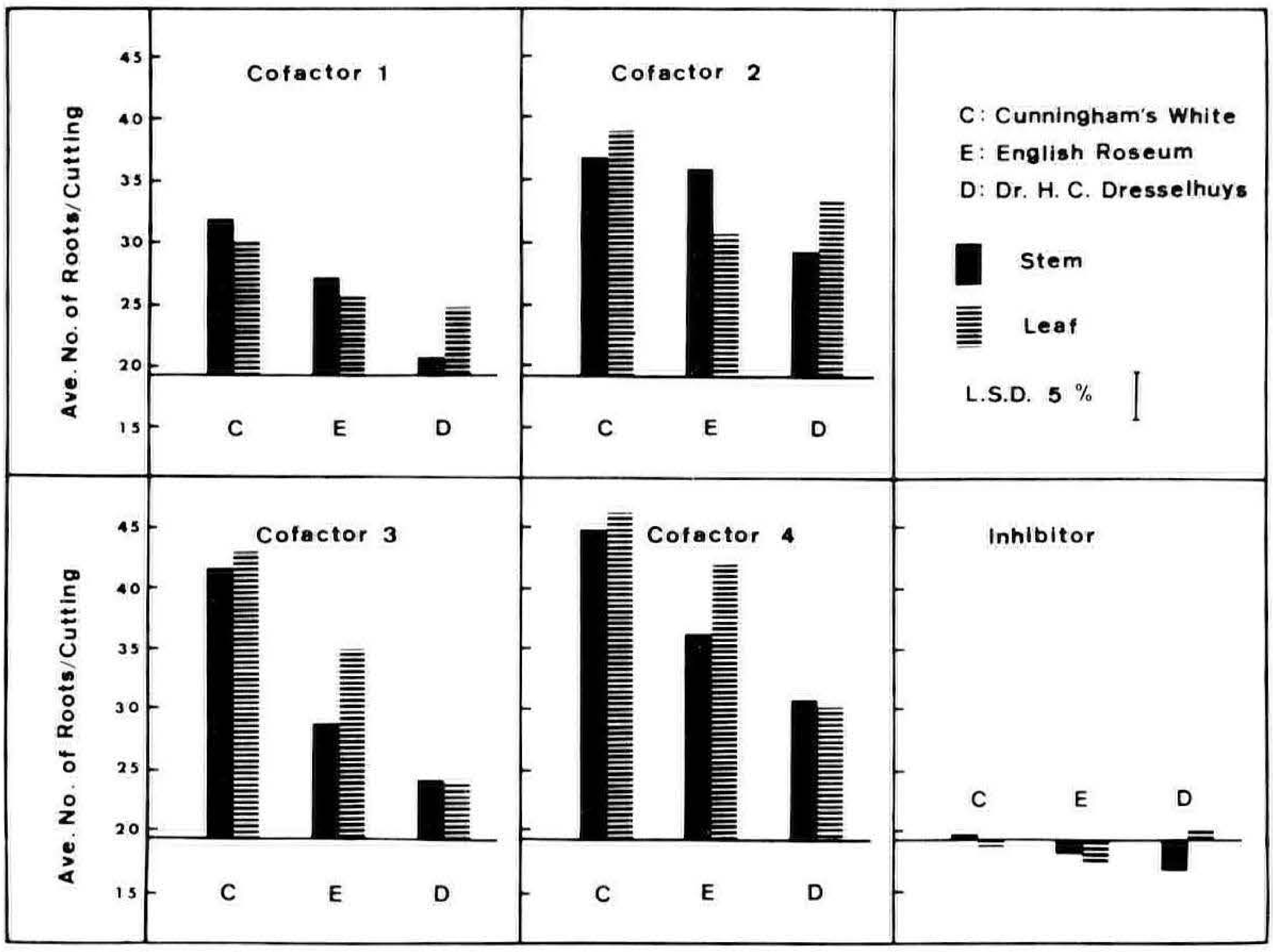

Fig. 2. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on September 15, 1967.

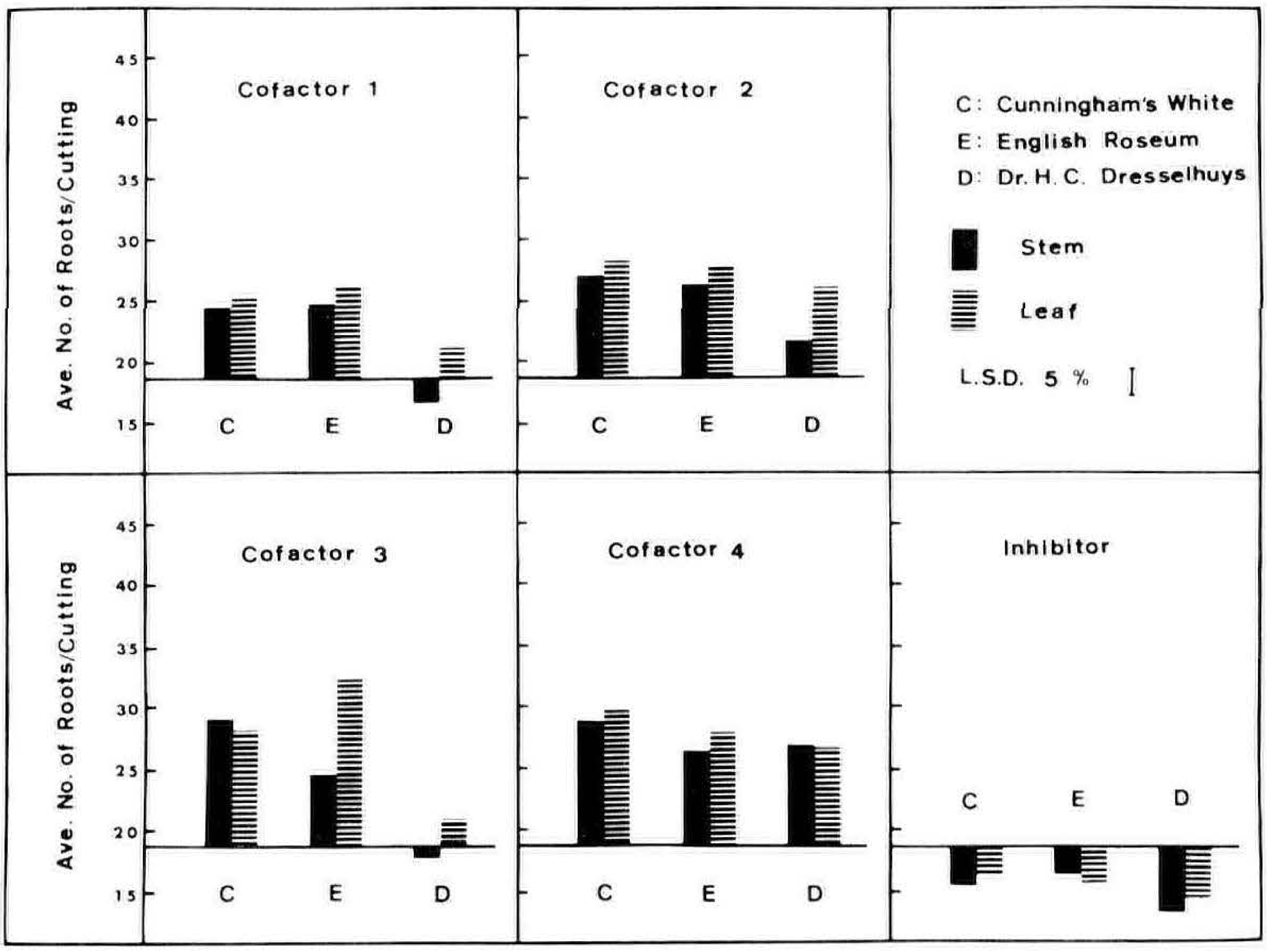

Fig. 3. Number of roots initiated per mung bean cutting treated with rooting cofactors and inhibitor extracted from rhododendron shoots collected on November 15, 1967.

These results generally showed that in every season the levels of endogenous rooting cofactors were greatest in 'Cuningham's White', followed in order by 'English Roseum' and 'Dr. H. C. Dresselhuys'. 'Cunningham's White' roots very easily with 100% rooting, 'English Roseum' shows intermediate rooting response of 71% rooting, and 'Dr. H. C. Dresselhuys' has 29% rooting (Table 1). These rooting percentages are similar to the number of rooting cofactors and it seems likely that differences between clones of rhododendron in rooting response may be related to the level of rooting cofactors contained in the cuttings. Other investigators (1, 3, 6) have previously reported a relationship between rooting ease and amount of endogenous root-promoting substances.

The effect of substances inhibitory to root initiation has been studied in many plants (1, 3, 6). In these experiments, more of the inhibitor was found in the July extracts from stem tissues of 'Cunningham's White' and 'English Roseum' than 'Dr. H. C. Dresselhuys'. In September extracts neither stem nor leaf tissues of any clone contained inhibitor, in spite of definite differences between clones in rooting response (Table 1). These facts indicate that rooting cofactors may be more responsible for the rooting ability of rhododendron cuttings than is the inhibitor.

Rooting cofactor levels contained in the stem tissue of 'Cunningham's White' were not less than those in the leaf tissue. In contrast, cofactor levels present in the stem tissue of 'English Roseum' and 'Dr. H. C. Dresselhuys' were less than those in the leaf tissues. These indicate that rooting cofactors contained in poorer rooting clones may be less translocatable and this characteristic may be one of the reasons causing difficulty in rooting of the cuttings.

Root inducing activities and amount of rooting cofactors were increased considerably in September and decreased again in November to the level of July extracts. Conversely, the inhibitor found in the July extracts disappeared in the September and reappeared in November extracts. These results may be associated with the fact that better rooting response can be obtained in late summer or fall than in any other season.

Experiment II

Table 1 shows the effect of different scions on size of root ball and the percent of cuttings rooted for three *Rhododendron* clones. A leaf and bud scion of 'Cunningham's White' significantly improved both rooting percentages and root ball size of cuttings of 'Dr. H. C. Dresselhuys'. Similar scions did not significantly increase rooting of the intermediate-to-root 'English Roseum' cuttings, but the tendency for increased rooting capacity could be found.

The rooting capacity of 'Cunningham's White' or Dr. H. C. Dresselhuy's was not appreciably affected by a leaf and bud scion of 'English Roseum'.

Scions of 'Dr. H. C. Dresselhuys' reduced rooting response of 'Cunningham's White' cuttings. The scion did not influence the rooting capacity of 'English Roseum' cuttings. Other investigators (6, 7) have found that rooting of some difficult-to-root cuttings could be increased by grafting onto the cutting a leaf and bud scion from an easy-to-root cultivar.

Table 1. Effect of different scions on size of root ball and percent of cuttings rooted for three *Rhododendron* clones.

Group	Stock[1]	Scion[1]	Diameter of root ball (inches)	Percent rooted
I	C	none	2.88	100
	C	E	1.95	92
	C	D	1.56	88
II	E	none	1.36	71
	E	C	1.68	92
	E	D	1.39	84
III	D	none	0.22	29
	D	C	1.36	96
	D	E	0.87	51

[1] C = **Rhododendron** 'Cunningham's White'
E = **Rhododendron** 'English Roseum'
D = **Rhododendron** 'Dr. H C Dresselhuys'

L.S D. at 5% level for root ball diameter: Group I = 0 96, Group II = N.S., Group III = 0.86.

L.S.D. at 5% level for % rooted Group I = 7.60, Group II = N.S., Group III = 42.00.

Results in this experiment indicate the presence of transmittable endogenous root-promoting substances in scions and it shows a clonal variation in amount of these substances. It seems likely that improving rooting capacity of 'Dr. H. C. Dresselhuys' may be due primarily to the increase of total endogenous root-inducing substances translocated from the scion of 'Cunningham's White', which was a rich source of the promotive substances. On the other hand, reducing rooting response of 'Cunningham's White' cuttings with the scion of 'Dr. H. C. Dresselhuys' may be attributed to the decreasing content of root-promoting substances rather than inhibitor from the scion which contained the least amounts of rooting cofactors.

SUMMARY

The level of endogenous root-promoting and inhibiting-substances in the three clones of rhododendron were compared at seasonal intervals in order to study the clonal and seasonal variation in rooting response of cuttings. The highest levels of four rooting cofactors in any season were found in both stem and leaf tissue of the easily-rooted clone of *Rhododendron* 'Cunningham's White' and followed by the intermediate-to-root clone of *Rhododendron* 'English Roseum'. The difficult-to-root clone of *Rhododendron* 'Dr. H. C. Dresselhuys' contained the least amount of the rooting cofactors. An inhibitor was often found in all clones, but it appeared less responsible for clonal differences in rooting response than variation in levels of the rooting cofactors. The promoting activity of rooting cofactors in all tissues of the clones increased in September and decreased again in November to the level of July extracts. Inhibitor found in the July extract disappeared in September and reappeared in November.

Rooting response of cuttings of 'Dr. H. C. Dresselhuys' was significantly improved by grafting a leaf and bud scion of 'Cunningham's White'. On the other hand, scions of 'Dr. H. C. Dresselhuys' resulted in decreased rooting of cuttings of 'Cunningham's White'. Rooting capacity of 'English Roseum' was less affected by a scion of other clones of rhododendron.

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MODERATOR GRAY: Congratulations on your presentation, but most of all, on your diligence in this particular study. I feel you will do well in the field of plant propagation. The next speaker on the program really needs no introduction, Mr. Peter Vermeulen.

EDITORS NOTE: International President, Mr. Peter Vermeulen, gave a brief review of the talks presented at the meeting of the Region of Great Britain and Ireland in September, 1969. These talks and the Business Meeting report are printed in their entirety in this volume of the Proceedings and therefore his review of the papers is not presented here.