8 to 10 years. Under these conditions there is nothing certain except change. These meetings are educational, as I have mentioned. They are designed to provide information to keep the plant propagator the key man in the ornamental plant business. As someone once said, the beauty of a rose starts with the vitality of its roots. As an organization, pledged to the dissemination of information and the provision for guidance and assistance in the field of plant propagation, we here assembled dedicate this meeting.

I have several appointments to make before we begin the sessions. These are as follows: to the nominating committee, the three immediate past presidents, Harvey Templeton, chairman; Bill Snyder and Martin Van Hof. To the auditing committee, Ralph Shugert, chairman and Leslie Hancock. The resolutions committee, J. S. Wells, chairman and Wayne Loveless. If you gentlemen will prepare statements for presentation at the annual business meeting Saturday afternoon, I will appreciate it. Now, if you will turn to your program you will see that Vice President and program chairman John Roller, has arranged, at your suggestion, a round table panel discussion. Before we break up, I might also announce that anyone interested in joining the Society and has properly completed the necessary forms, see Peter Vermeulen, who is chairman of the Membership committee.

[*Editor's Note*: The members separated into three round-table discussions; one, Storage and care of cuttings, grafts, and established nursery stock, J. P. Mahlstede, moderator, Jack Hill, recorder; two, Sanitation and propagation — methods and materials, James Wells, moderator, F. O. Lanphear, recorder; and three, Cost control in propagation — lowering costs, George Rose, moderator, Wayne Lovelace, recorder. Summaries of the round-table discussions were presented Thursday evening.]

PRESIDENT MAHLSTEDE: The first paper this morning will be presented by Mr. Dale E. Herman, a graduate student at Purdue University.

THE EFFECT OF ETIOLATION UPON THE ROOTING OF CUTTINGS

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I. Introduction

Etiolation is known to play a definite role in enhancing the rooting potential of many plants. A number of references attest to this fact in the literature, several of which will be cited below.

Sachs (1864) noted that adventitious roots formed in great abundance in darkness on portions of stems of a variety of plant species, but that this phenomenon would not occur in light(23).

Mevius (1931) found that light inhibited the rooting of cuttings of *Tradescantia* species (14). Gardner (1937) successfully rooted cuttings of McIntosh apple made with the basal cut in an etiolated area(3). Reid (1922) and Blackie, Graham, and Stewart (1926) used similar methods as Gardner to affectively root a difficult clone of camphor (21, 1). Smith (1924) found that etiolation enhanced rooting in the genus *Clematis*(25). Etiolation was proven very beneficial in rooting avocado cuttings, according to Frolich (1961) and Johnston and Frolich (1957) (2, 10).

The process of etiolation is practiced most extensively in the various layering methods of vegetative propagation, especially in relation to the stooling and etiolation methods used at the East Malling Research Station. The advantage obtained in the rooting of various fruit and ornamental species by these methods is borne out in references by Regel (20), Knight et al (11, 12, 13), Garner and Hatcher (4), and Sinha and Vyvyan (24). We probably unconsciously take advantage of etiolation when we stick cuttings into a medium to root.

Although it is well established that etiolation does exert a pronounced effect in the rooting process of many plants, little progress has been made in elucidating the actual physiological and anatomical basis of such an effect. Therefore, this investigation was started using four different approaches.

1. A rooting study to verify enhanced rooting as a direct result of etiolation.
2. An anatomical study to determine any differences in the cells or tissues of etiolated stems as opposed to nonetiolated stems.
3. An investigation of the extractable auxins from etiolated tissues as compared with nonetiolated tissues.
4. A study to determine the level of extractable rooting "cofactors" in etiolated as compared with nonetiolated tissues.

Etiolation is the development of plants or plant parts in the absence of light. In this study, in contrast to most previous discussions on etiolation, we were interested only in the light falling on the actual tissue from which root initiation was to occur. Thus, this was only a localized etiolation or a tissue blanching.

II. Root Initiation Study

A. Methods

Red Kidney Bean, *Phaseolus vulgaris* L., and Chinese Hibiscus, *Hibiscus rosasinensis* L., were selected as test plants for the differential rooting study as well as other investigations. Three varieties of *Hibiscus* were used: (1) Cornell Red, a relatively easy rooting variety, (2) Ruth Wilcox, intermediate in rooting ability, and (3) Wilson's White, a difficult to root variety. The letters CR, RW, and WW will serve to designate the respective varieties, and the letters RKB are used to designate red kidney bean.

The RKB's were planted in 4-inch plastic pots in a loamy clay soil mixed with one-third peat moss, 1 seed per pot. The etiolation treatment was begun an average of 18 days after the seeds were planted. By this time the first 2 unifoliate leaves were developed. The apical bud was pinched out of all plants to maintain a relatively equal photosynthetic surface on all plants.

Etiolation of the tissue was accomplished by wrapping the stems with black construction paper. The paper covered the tissue from the soil level to the second node, or the node from which the unifoliate leaves arise. Thus, the hypocotyl, cotyledonary or first node, and epicotyl tissue up to the second node were covered. One-half of the plants were left unwrapped as a control.

After an average of 3 weeks etiolation the black construction paper was removed and cuttings were taken slightly above the soil level. They were rooted in flats of perlite under intermittent mist without auxin treatment and the roots were counted at 4 and 8 day intervals. The average results of 7 replications are shown in Table I.

Table I — Effect of Etiolation Upon Root Initiation in Red Kidney Bean (*Phaseolus vulgaris*).

Rooting Period	Average Number of Roots per Cutting: Non Etiolated	Etiolated
4 days	3.0	16.3
8 days	19.4	36.0

As a final RKB rooting test, an auxin synergistic study was carried out. Forty etiolated and 40 nonetiolated cuttings were taken of which 20 from each group were treated with IBA using the concentrated dip method. Root counts were made at 4 and 6 day intervals and the results are shown in Table II.

Table II — The effect of Etiolation with and without Indolebutyric Acid (IBA) upon root initiation in Red Kidney Bean (*Phaseolus vulgaris*)

	Average Number of Roots per Cutting: Non Etiolated	Etiolated
Rooting Period 4 days		
Without IBA	4.2	31.0
With IBA*	1.4	125.4
Rooting Period 6 days		
Without IBA	27.3	39.4
With IBA	114.2	250.+

*IBA conc = 0 3gm in 100cc 50% ethanol, quick dip

Three experiments to study the effect of etiolation on the rooting of *Hibiscus* were conducted. Young, rather vigorous growing shoots were selected for etiolation, which was accomplished in the following manner. Except for the apical, primordial bud and adjacent unexpanded leaves, the 2 to 3 leaves were removed for an approximate distance of 4 inches below the bud. This area of the young shoot was then wrapped with black polyethylene plastic. After being wrapped for an average of 36 days, the new vegetative growth was several inches above the wrap. Cuttings were taken one-half inch above the base of the wrap and were treated with IBA, again using the concentrated dip method. The cuttings were placed in a plastic enclosed intermittent mist chamber and root counts made after an average of 26 days. Corresponding nonetiolated controls were taken the same day and in all respects treated the same. The average results from the 3 experiments with all 3 varieties are shown in Table III.

Table III — Effect of Etiolation upon Root Initiation in *Hibiscus rosasinensis* Varieties

Rooting Period-26 Days		Non Etiolated	Etiolated
Percent Rooting			
	Wilson's White	6.7	13.3
	Ruth Wilcox	88 3	93.3
	Cornell Red	77.0	97.0
Ave. No. of Roots per Cutting			
	Wilson's White	0.2	0.6
	Ruth Wilcox	10.0	18.2
	Cornell Red	6.1	10.5

B. Results and Discussion

The RKB results show conclusively that etiolation promotes root initiation. Table I shows that the rooting of the etiolated cuttings was over 5 times as great as that of the nonetiolated cuttings after 4 days rooting. After 8 days the rooting was still almost twice as great. Since few roots would be initiated after the 8th day, the 2:1 ratio would hold constant. Thus, etiolation renders a very prompt or initial response in the rooting process, which is evidenced in part by the much longer roots on the etiolated cuttings after 4 days. Etiolation not only strongly predisposes the plants to root formation, but root initials are actually formed prior to supplying of the conditions normally favorable for the rooting process. This was very evident as the wrap was removed, for the root primordia were already clearly visible on many of the cuttings.

Although the RKB generally roots to some extent even though no auxin or etiolation treatments are given, a final study was carried out to determine the response of etiolated and nonetiolated cuttings to treatment with auxin. The results, shown in Table II, demonstrate that etiolation dramatically enhances the effectiveness of an auxin. The rooting of the etiolated cuttings was over 89 times greater than that of the nonetiolated cuttings after 4 days rooting. This seems to definitely indicate that some factor other than higher levels of endogenous auxin is involved. A possible interpretation is that the etiolated tissues contain a higher level of auxin synergists than the nonetiolated tissues.

The *Hibiscus*, according to Table III, was somewhat less responsive as a test plant. This, however, may be due to the fact that herbaceous plants often root quicker and more prolifically, numerically speaking, than hardwood or softwood cuttings of woody plants.

The WW variety is one that may parallel Hartmann and Kester's third grouping of plants in relation to the presence of root-promoting materials (7). Thus, an exogenous application of auxin gives little or no response due to the lack of other as yet unidentified factors—hormonal or nutritional or both. Even after etiolation of the cuttings, there is only a very slight response. However, the slight rooting edge held by the etiolated cuttings is also borne out in the percentage of cuttings rooted after 26 days. After 40 days rooting, 30% more of the etiolated cuttings were rooted as compared with the nonetiolated cuttings.

The most significant results from etiolation were shown by the intermediate rooting RW variety. The rooting obtained in the etiolated cuttings was nearly double that of the nonetiolated cuttings. One cannot fully account for the abnormally high rooting received in this variety. However, the high levels of auxin synergists which showed up in the RW tissues as indicated in the *Avena* first internode bioassays certainly adds positive evidence which may account for at least part of the response received. Reference will be made to this point in the discussion of the auxin synergistic study.

The CR variety tends to parallel Hartmann and Kester's second grouping of plants, in which the internal root-promoting substances of a hormonal or nutritional nature (suggested by Van Overbeek *et al.* for a red *Hibiscus rosasinensis* variety to be sugar and nitrogenous substances supplied by the leaves) (27) are present, but auxin is limiting. Thus, this variety roots well with an auxin application. One can note in Table III the consistently higher rooting obtained in the CR variety when etiolated. Also, significantly higher percentages of the etiolated as opposed to the nonetiolated cuttings of RW and CR were rooted after 26 days. An etiolation period of 36 days did not induce the production of root primordia visible to the naked eye, as in the RKB, but it certainly enhanced their rooting ability.

III. Anatomical Study

A. Methods

Microtechnique methods used in this study were based on those of Riker and Riker and Johansen (22, 9). One-half to one centimeter etiolated and nonetiolated stem sections were killed and fixed in formalin-aceto-alcohol (FFA) for 24 hours under partial vacuum. An ethyl alcohol-zylene dehydration schedule was used. After the tissues were embedded in paraffin blocks, they were softened in water and sectioned into 12 micron thick ribbons. Safranin and fast green were used to differentially stain the tissues. Individual stem cross-sections were then photographed.

B. Results and Discussion

The results of the anatomical study are illustrated in part by means of the photographs of nonetiolated and etiolated RKB

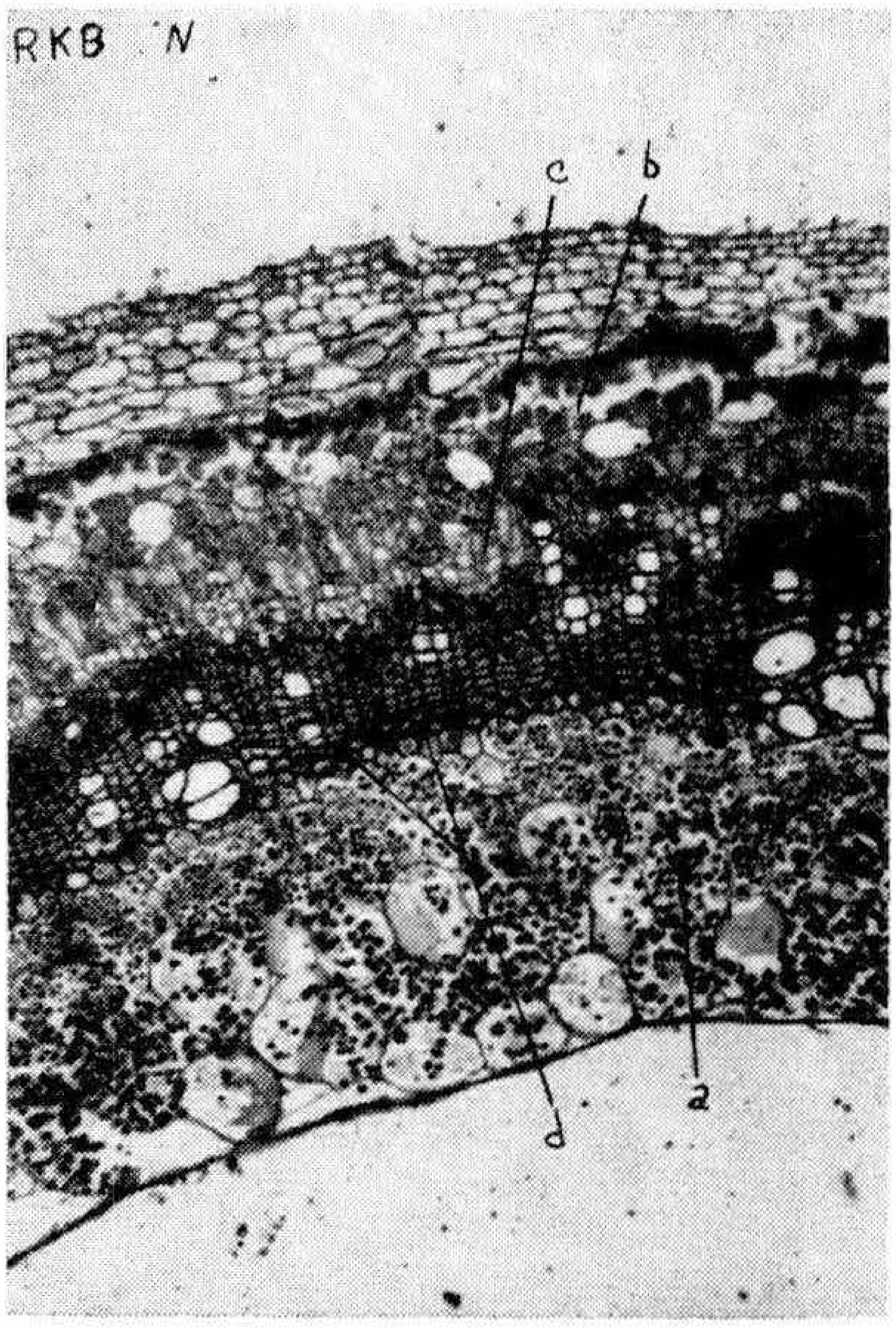

Figure 1. Cross section of a nonetiolated stem (hypocotyl) of *Phaseolus vulgaris*. Magnification — X 17, N — nonetiolated, RKB — Red Kidney Bean.

a. abundance of starch grains but a decrease in pith area and cell size.

b. pericycle fibers greater in number and slightly more lignified.

c. parenchyma cells less abundant and tissues more differentiated.

d. presence of increased amounts of cell wall deposits.

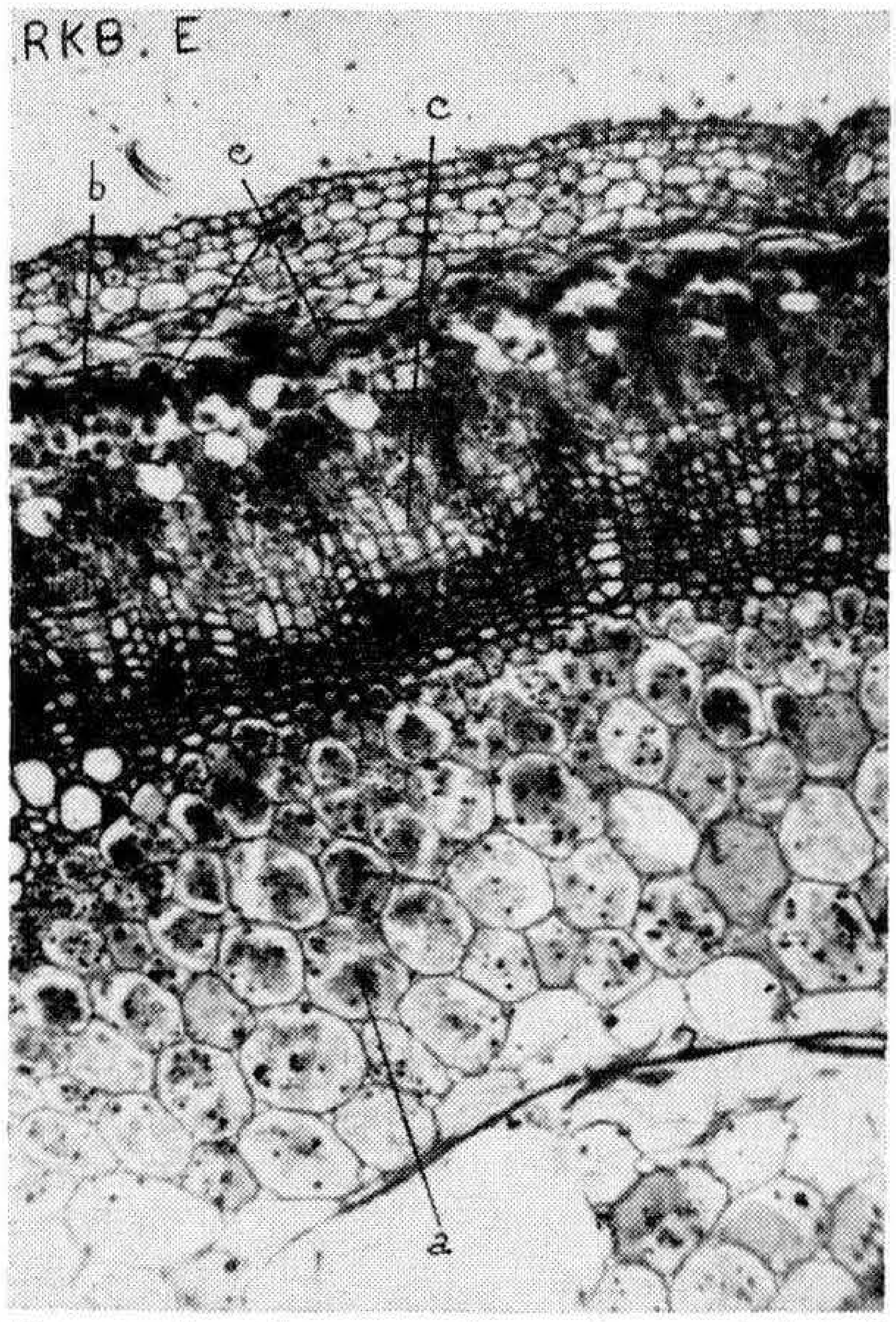

Figure 2. Cross section of an etiolated stem (hypocotyl) of *Phaseolus vulgaris*. Magnification — X 17, E — etiolated, RKB — Red Kidney Bean

a. reduction in quantity of starch grains but an increase in pith area and cell size.

b. pericycle fibers fewer in number and greater quantity of tissue and slightly less lignified.

c. abundance of parenchyma cells in a less differentiated condition.

d. reduction in amount of cell wall deposits.

e. indication of starch sheath.

and CR *Hibiscus* stem cross sections in Figures 1-2 and 3-4 respectively.

In reviewing the literature in relation to the anatomical basis of the effect of etiolation upon rooting, numerous papers by Priestley *et al.* cite evidence that a functional endodermis forms in etiolated shoots of various plants (17, 18, 19). Although this phenomenon was discussed in regard to totally etiolated plant tissues, as opposed to only a localized tissue etiolation in this study, it nevertheless warrants some attention. According to Priestley *et al.*, the secondary endodermis is characterized by the presence of the Casparian strip which becomes very suberized and impregnated with unsaturated fatty substances which harden as they oxidize. This suberin lamella renders the secondary endodermis relatively impermeable both to water and solutes. When the sap is retained within a functional endodermis only the parenchymatous tissues within that endodermis are capable of active growth. Since the endodermis completely retains the nutrient sap in the etiolated stem, it leads to an active formation of endogenous roots.

In young angiospermous stems the innermost layer of the cortex often contains abundant and large starch grains. Since it occupies the position where the endodermis would occur if it

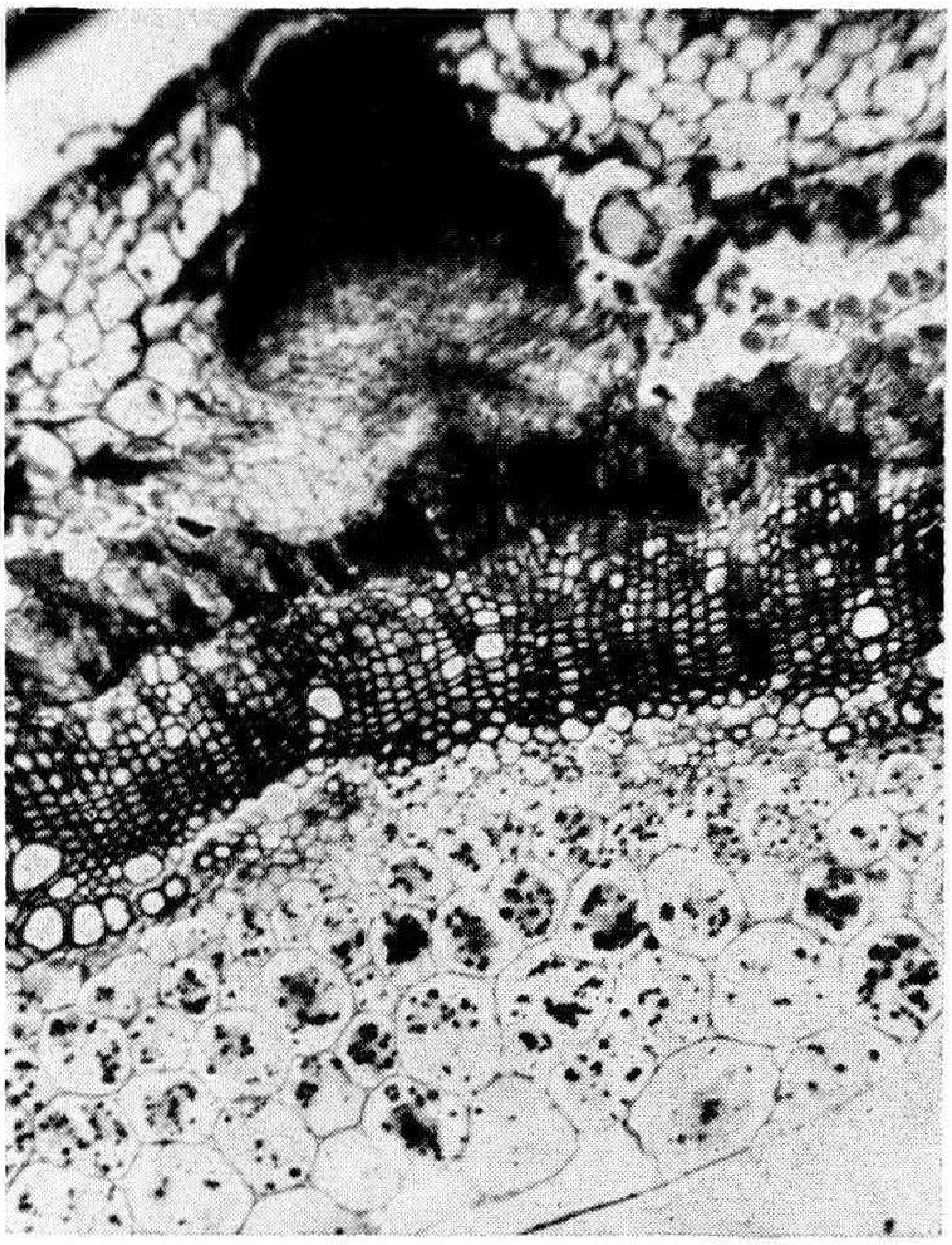

Figure 2a. Cross section of an etiolated stem of *Phaseolus vulgaris* showing an emerging adventitious root. Magnification — X 24, E — etiolated, RKB — Red Kidney Bean.

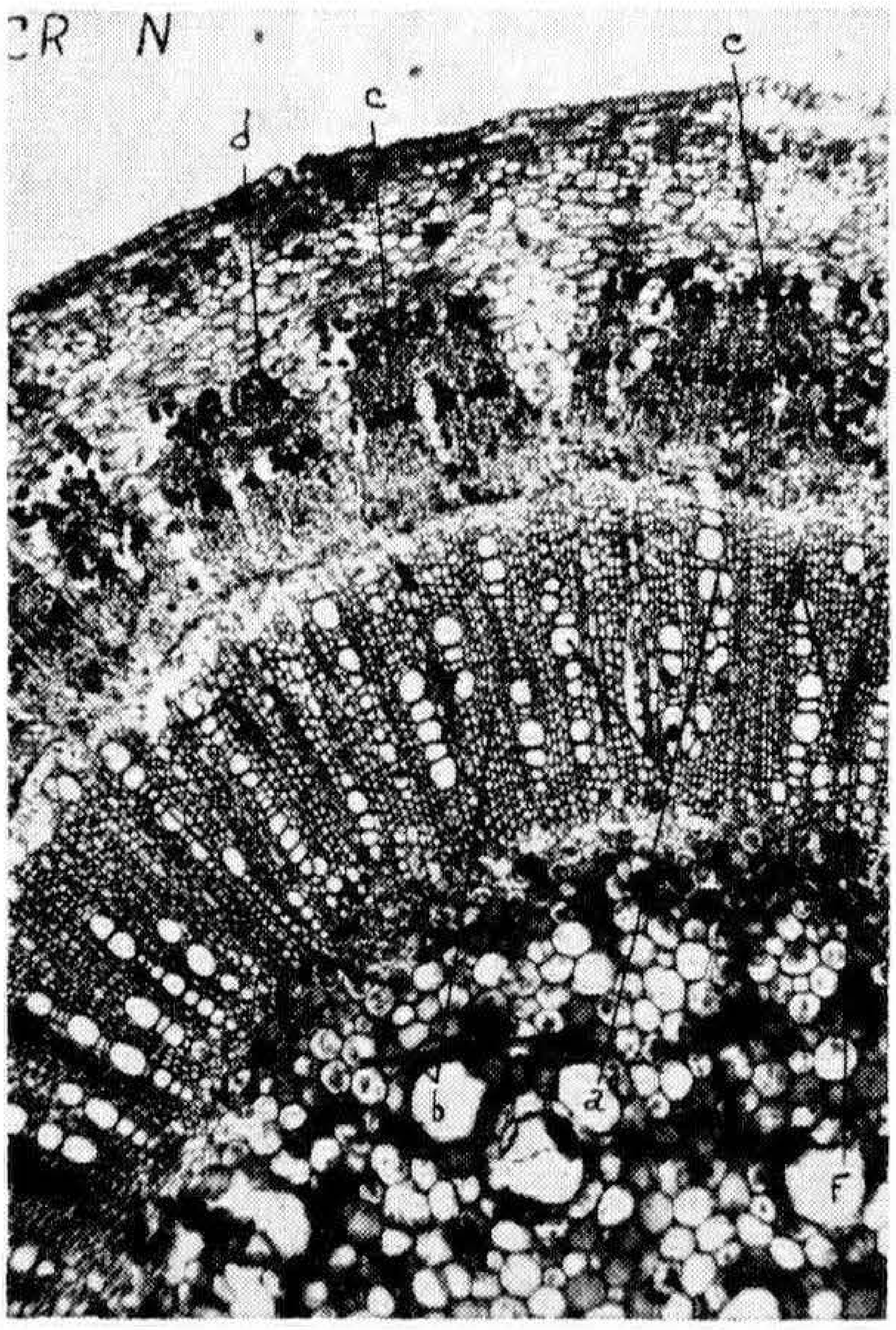

Figure 3. Cross section of a nonetiolated stem of CR variety of *Hibiscus rosasinensis*. Magnification — X 10, CR — Cornell Red, N — nonetiolated.

a. xylem more differentiated, vessels numerous.
b. vessels and other cells in xylem thicker walled.
c. *phloem fibers more lignified.*
d. pericycle fibers more lignified.
e. parenchyma cells less abundant and tissues more differentiated.
f. presence of increased amounts of cell wall deposits.

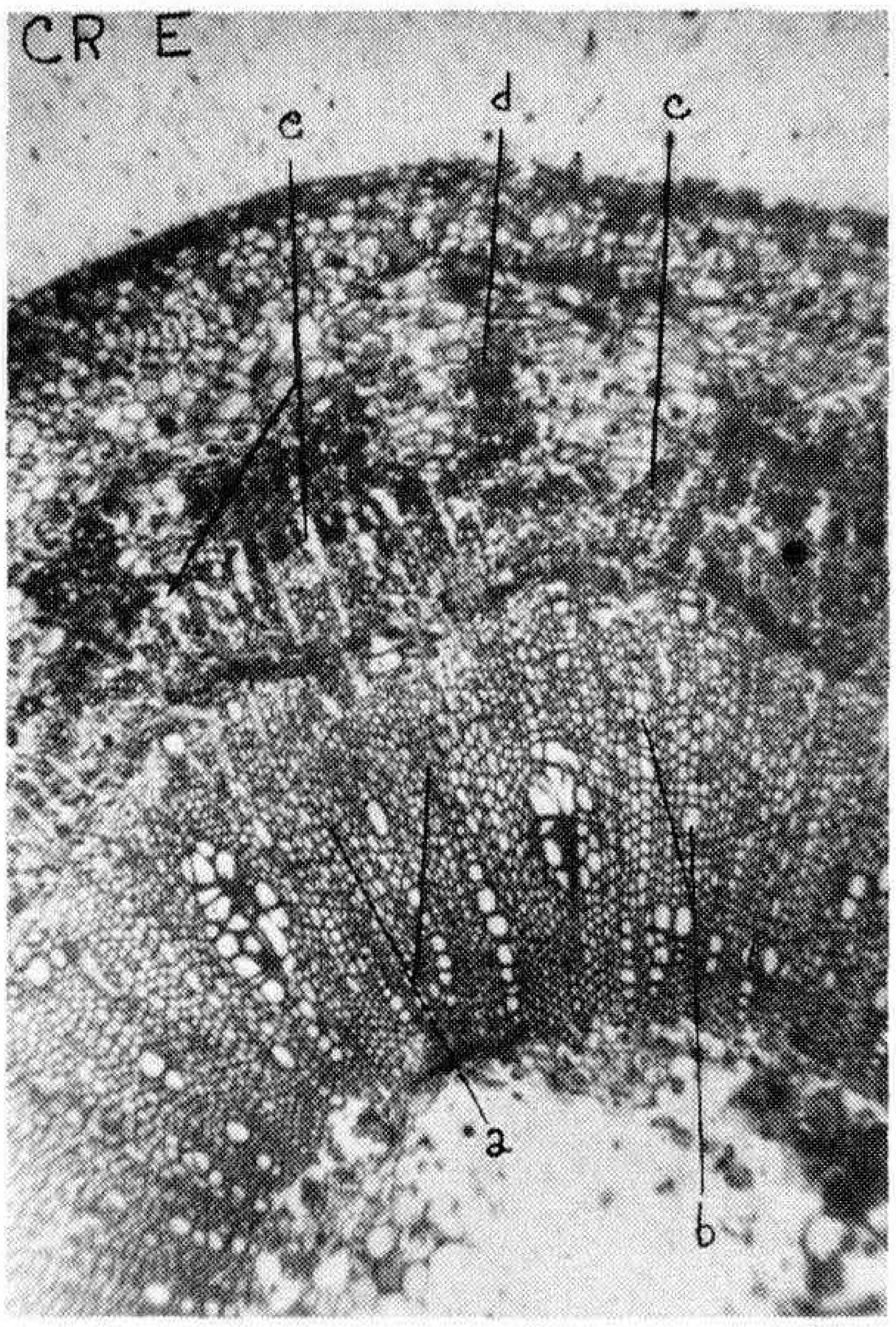

Figure 4. Cross section of an etiolated stem of CR variety of *Hibiscus rosasinensis*. Magnification — X 10, CR — Cornell Red, E — etiolated

a. xylem less differentiated, fewer vessels.
b. vessels and other cells in xylem thinner walled.
c. phloem fibers somewhat less lignified.
d. pericycle fibers somewhat less lignified.
e. parenchyma cells more abundant and greater quantity of tissue in less differentiated condition.

developed, the starch sheath, according to Guttenberg (6), is sometimes considered homologous with the endodermis.

The anatomical study revealed a number of differences in the etiolated as opposed to the nonetiolated cells and tissues and these are summarized below.

1. A substantial reduction in starch in the etiolated RKB tissues as opposed to the nonetiolated tissues.
2. An endodermis with Casparian strip was not observed in either etiolated or nonetiolated RKB or *Hibiscus* tissues; however, there was an indication of a starch sheath in both etiolated and nonetiolated RKB tissues.
3. Presence of root primordia in the etiolated RKB stem cross sections, with none observed in the nonetiolated tissues.
4. A reduction in development of mechanical strengthening tissue, and a decrease in lignification in cells, e.g., in the

phloem and pericycle fibers, in etiolated stems of RKB as well as *Hibiscus*. The presence of greater amounts of cell wall deposits, e.g., cellulose and hemicellulose, in nonetiolated stems.

5. Greater pith area with larger cells in the etiolated RKB stem as opposed to the nonetiolated stem.
6. An increase in content of parenchyma tissue in etiolated cross sections of both RKB and *Hibiscus*.
7. The presence of thinner walled cells in etiolated tissues, e.g., vessels and fibers in xylem of *Hibiscus*.
8. An overall reduction in cell and tissue differentiation, e.g., a slight reduction in differentiation and total amount of vascular tissue, in the etiolated cross sections of both RKB and *Hibiscus* as compared with the nonetiolated cross sections.

In conclusion, several hypotheses are suggested:

1. With the difference noted in starch content, it may be possible that there is an increase in the level of soluble sugars in etiolated tissues.
2. The presence of increased amounts of parenchyma cells and a greater quantity of cells in a less differentiated condition may be very advantageous as a potential source of enhanced meristematic activity leading to root initiation. Secondly, it may result in a more efficient utilization of endogenous IAA, as well as exogenous applications. The slightly higher endogenous level of IAA which appears to be present in etiolated tissues may thus be of added significance.
3. A reduction in mechanical strengthening cells and tissues may render the egress of root primordia easier, as Kuster has advocated (13).
4. Doubt is expressed that these anatomical differences are substantial enough to account for the highly significant difference in rooting encountered in etiolated versus nonetiolated cuttings. Thus, the possible accumulation of some other unknown substance or auxin synergist in the localized etiolated area is by no means eliminated.

IV. Auxin Study

A. Methods

The extraction and bioassay techniques used in the comparative investigation of the extractable auxins from etiolated and nonetiolated tissues were based on the methods of Nitsch (15) and Nitsch and Nitsch (16).

1. Extraction

Etiolated and nonetiolated cuttings were taken, placed in a container with dry ice, and then lyophilized. Prior to freezing, the outer bark — the tissues from the vascular cambium outward — was removed from the *Hibiscus* stems and only this outer bark cylinder, containing the phloem, was lyophilized. The entire RKB stem was lyophilized. A 0.5 gram sample of the dry, ground tissue was used for extraction with absolute methanol as the solvent. Three 40 minute extractions were made of each sample, and after each 40 minute period the extract was decanted and fresh solvent added to the tissue. For each extraction 25 cc. of methanol were used, giving a total of 75 cc. per sample. The extracts were then concentrated and evaporated just to the point of dryness and were taken up in 2 cc. of methanol, 1 cc. at a time.

2. Chromatography

The concentrated extracts were spotted on a 22½ x 18¼ inch sheet of number 3 Whatman chromatographic paper. The etiolated tissue was spotted on one-half and the nonetiolated on the adjacent half on a line across the width of the chromatogram 10 cm. from the top. The solvent system consisted of 8 parts isopropanol and 2 parts water (v/v). Using descending chromatography, the solvent was allowed to move down the paper for a distance of 30 cm. from the origin.

The chromatogram was prepared for bioassay by cutting 1-inch strips into 15 equal pieces, beginning at the origin or line of spotting and ending with the termination of the solvent front. A piece of the chromatogram which had been saturated with solvent and a piece taken from below the solvent front were used as controls. Each segment of chromatogram was placed in a corresponding test tube to which was added 2 cc. of citrate-K-phosphate buffer (pH 5.0) and 2% sucrose solution.

3. Bioassay

The straight growth tests described by Nitsch and Nitsch, (16) including the *Avena* coleoptile cylinder test and the *Avena* first internode (mesocotyl) test, were used for the bioassay of the auxins and inhibitors extracted from the stem tissues. Three days after planting variety Brighton oats, the coleoptile and first internode sections were approximately 2½ cm. in length and ready for use. Four mm. coleoptile sections were cut 3 mm. below the tip. In the first internode test the short coleoptiles produced on the dark grown seedlings were cut off at the node and discarded, and 4 mm. sections cut 2 mm. below the coleoptilar node.

In both tests 10 seedling sections were added to the tubes containing the chromatogram segments and incubation solution. After 20 to 24 hours incubation with rotation, the seedling sections were measured with a binocular microscope equipped with an ocular micrometer.

In addition to the usual straight growth tests, a test to determine the presence of auxin synergists was conducted. The procedure was the same as stated above with the addition that the incubation solution contained 1×10^{-8} M. IAA. This level of IAA was sufficient to stimulate growth but was considerably below the optimum.

B. Results and Discussion

The average results of 2 *Avena* coleoptile cylinder tests and 3 first internode (auxin synergistic) tests are expressed as histograms in Figures 5-8 and 13-16, respectively. Each column in the histograms represent the biological activity of one chromatogram section, starting with the base line of spotting on the left. The horizontal line across the histogram represents the growth of the controls. i.e., *Avena* sections in the buffer-sucrose solution with a piece of the chromatogram taken from above the solvent front and with one taken from the base which had been saturated with solvent. Columns above the control line indicate growth promotion, columns below the line indicate an inhibition of growth.

A comparative determination of the endogenous IAA auxin levels in etiolated as opposed to nonetiolated tissues was the primary objective at the onset of the investigation. Through color reaction or development of the "control" chromatograms, the R-f value for the synthetically prepared IAA extract was determined as approximately 0.79, or corresponding to chromatogram sections 12.0 to 13.7. This value corresponds very closely with the chromatographic position of the predominant growth promoting substance in the plant extracts, which occurs in the histograms from sections 11 to 13. The slight lag in the growth promotion or peak, which always occurred in section 12, is undoubtedly due to the plant extract, which tends to slow or hinder the movement of the auxin in the solvent system, compared to the movement of a synthetic preparation. Positive results were also received by spraying chromatograms of the native plant extracts with Salkowsky's reagent and also p-dimethylaminobenzaldehyde, but only after one gram samples of the tissue were used in extraction (5, 26). The color reactions specific for indole groups were verified by control chromatograms of synthetic IAA preparations. Thus, based on the above evidence, the predominant growth substance present in the plant extracts is probably IAA. However, its absolute identity was not finalized.

Histograms of the *Avena* coleoptile tests (Figures 5-8) show a striking correlation between the extracts of the growth

Figures 5 - 8 Histograms showing biological activity of chromatograms of etiolated and nonetiolated stem tissues of *Phaseolus vulgaris* and *Hibiscus rosasinensis*, var WW, RW, and CR 0.5 gram lyophilized tissue, extracted with methanol for 2 hours Extract chromatographed in isopropanol-water (8:2, v/v). Bioassay-*Avena* coleoptiles 4 mm long, taken 3 mm below tip Coleoptile control sections given concentrations 1 X 10-7 and 1 X 10-6 IAA grew to final lengths of 7.4 and 7.7 mm, respectively. Each histogram represents the average of 3 bioassays

E — etiolated
N — nonetiolated
RKB — red kidney bean
WW — Wilson's White
RW — Ruth Wilcox
CR — Cornell Red
IAA — indole-acetic acid

HISTOGRAMS SHOWING BIOLOGICAL ACTIVITY OF CHROMATOGRAMS OF STEM TISSUE

Bioassay - Avena Coleoptiles

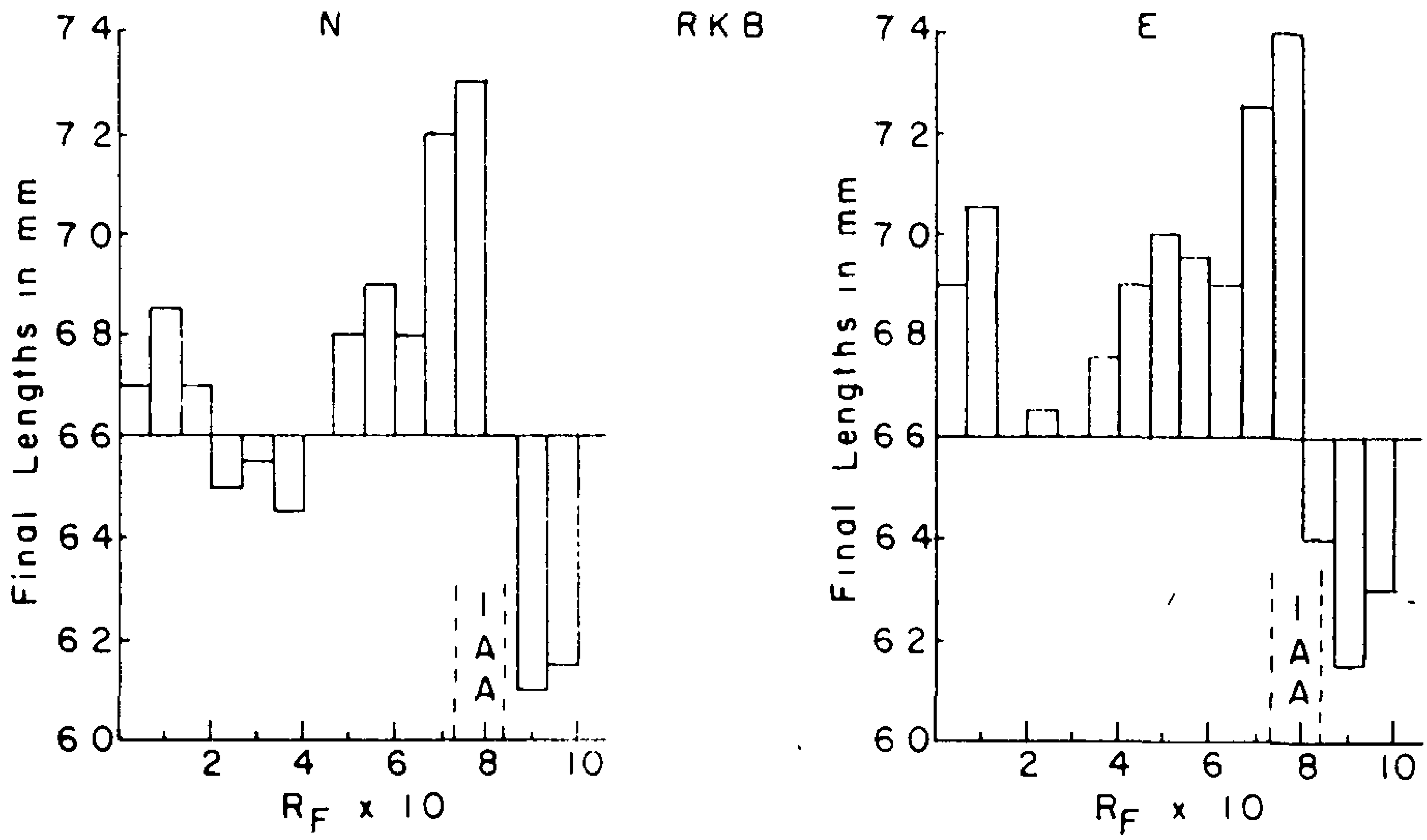

Figure 5

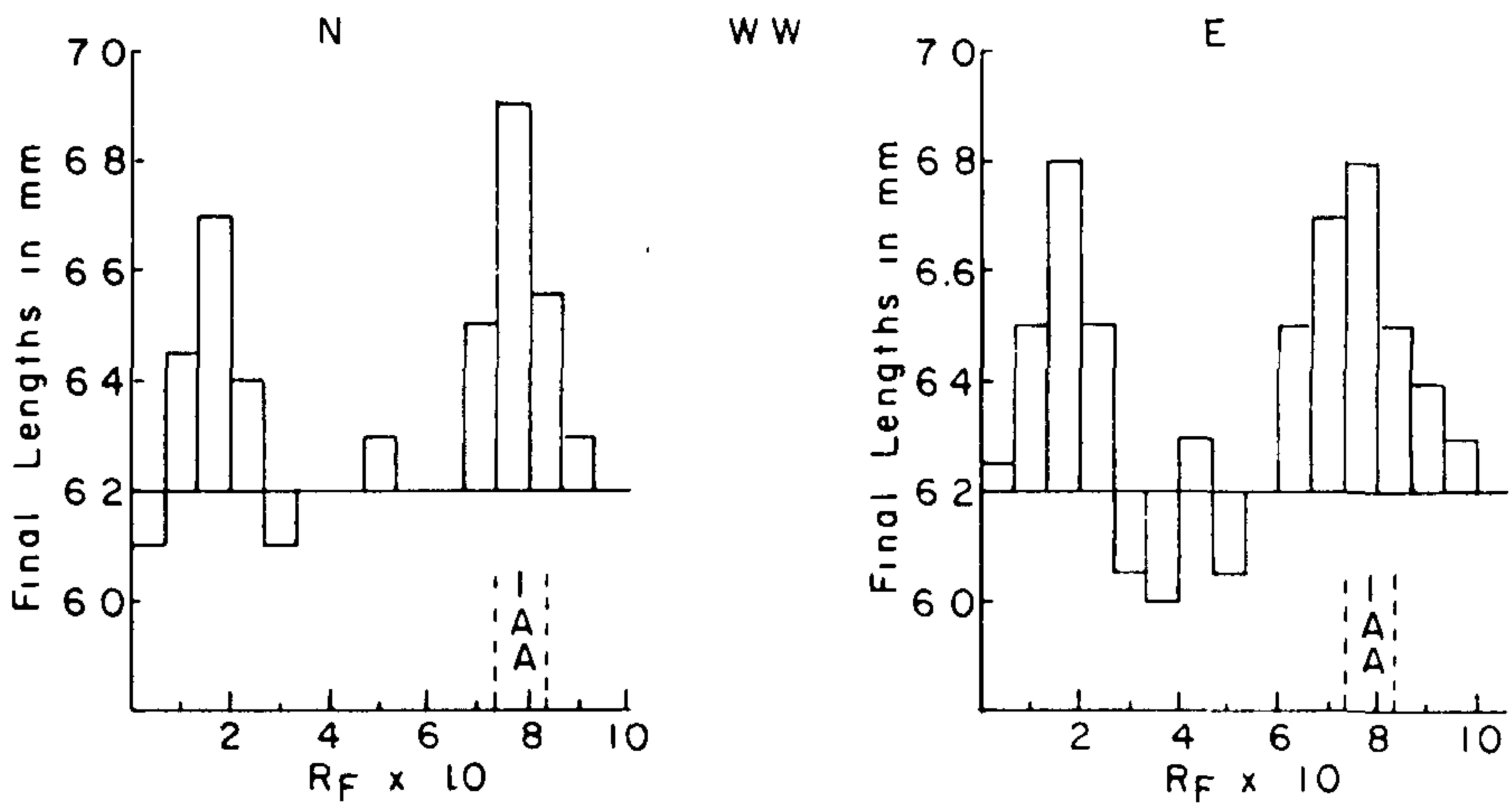

Figure 6

HISTOGRAMS SHOWING BIOLOGICAL ACTIVITY OF CHROMATOGRAMS OF STEM TISSUE

Bioassay - <u>Avena</u> Coleptiles

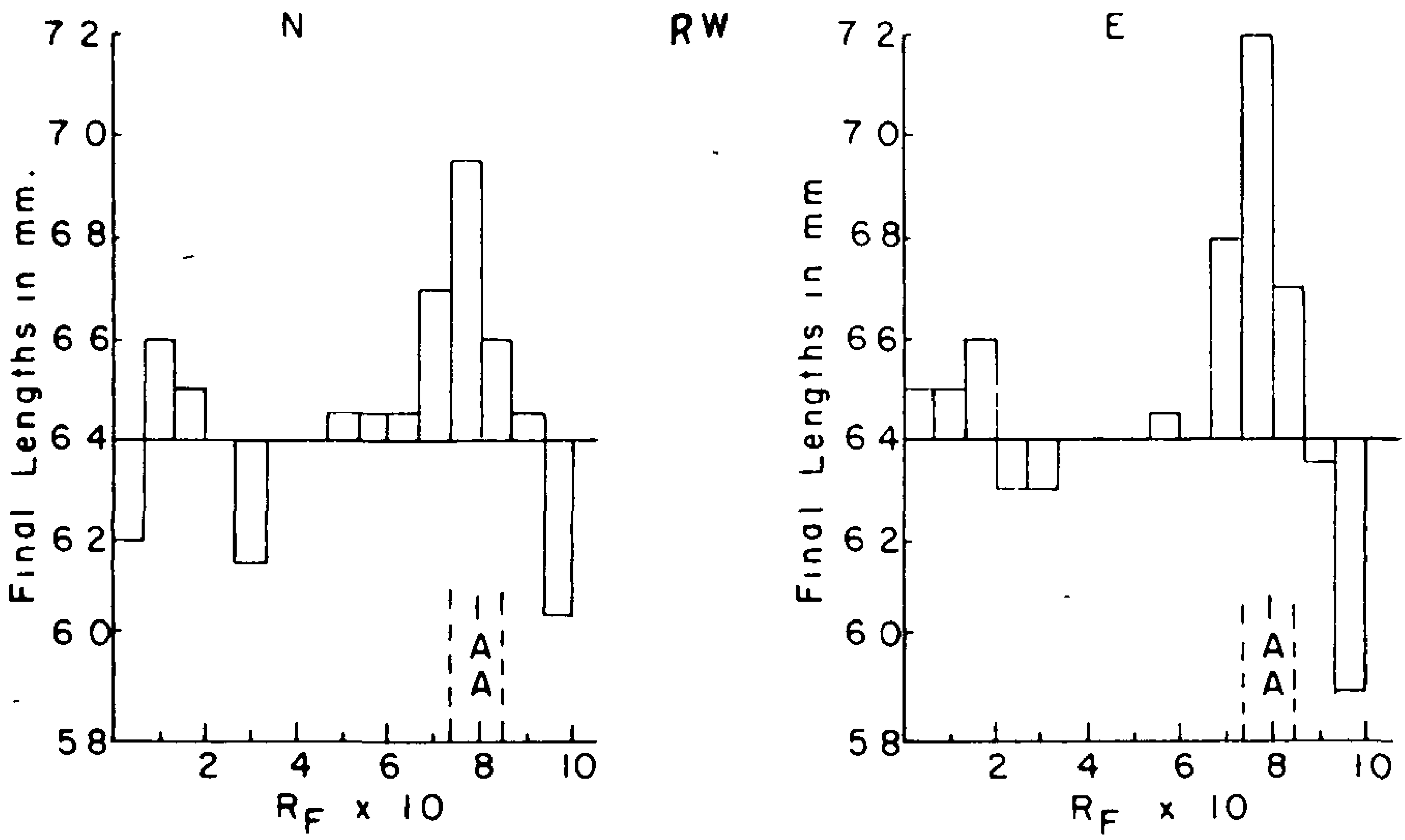

Figure 7

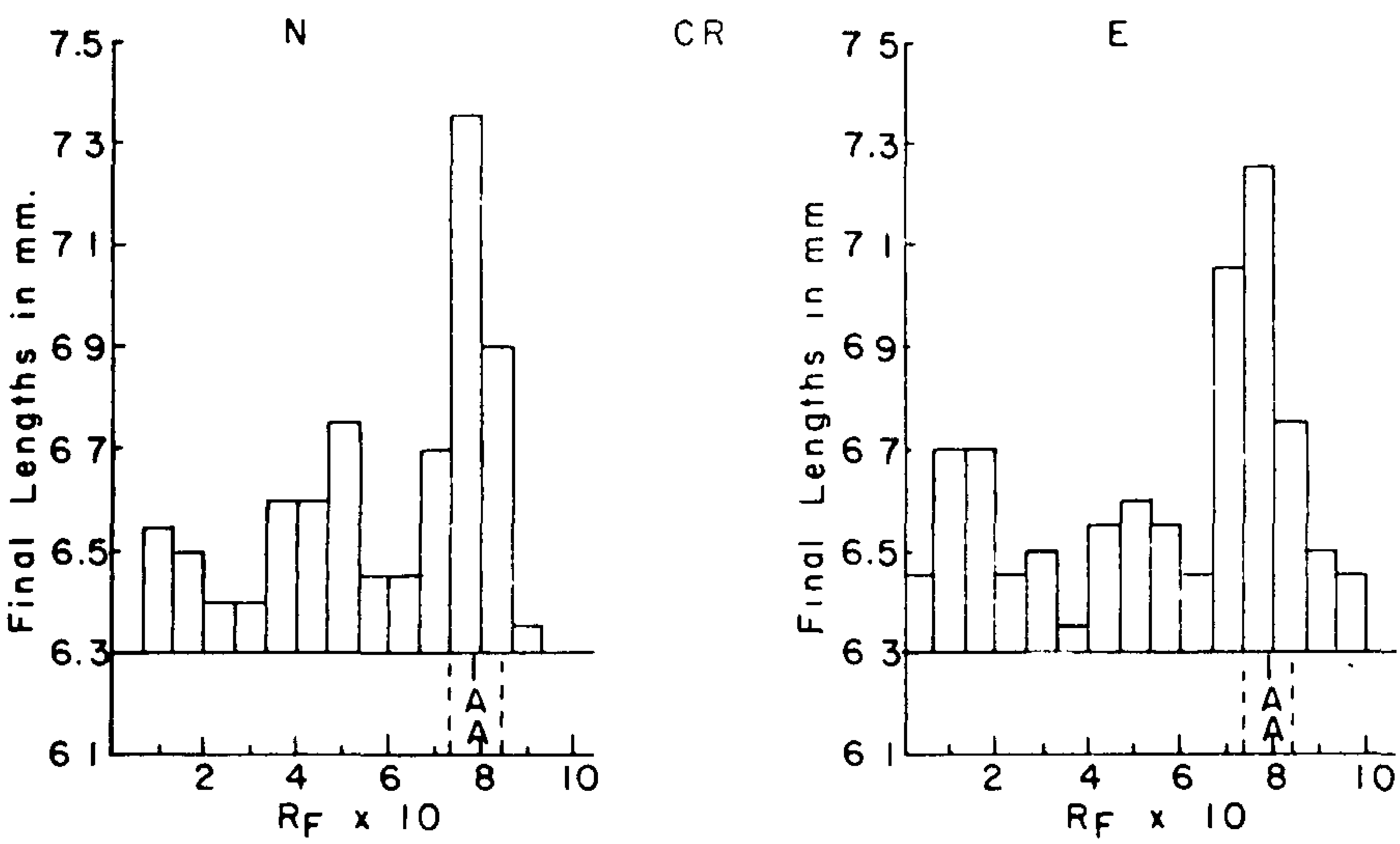

Figure 8

substances from the etiolated and nonetiolated stem tissues. However, growth promotion due to the presence of "IAA" is slightly greater in all cases from extracts of etiolated tissues. Thus, the endogenous concentration of "IAA" in etiolated tissues appears to be slightly higher than in the nonetiolated tissues.

At an R-f of approximately 0.05 to 0.15 (chromatogram sections 2 and 3) an unknown auxin occurs. As shown by the degree of growth promotion, this auxin also tends to be present in slightly higher concentrations in the etiolated tissues. Inhibitory substances do not appear to be present in highly significant quantities in the stem tissue extracts, except in sections 14 and 15 of the RKB, where they occur in approximately equal quantities in both the etiolated and nonetiolated tissues. A series of *Avena* first internode (mesocotyl) bioassays was also run in which the results coincided very closely with those reported in the *Avena* coleoptile tests.

Because the root initiation studies indicated the definite presence of auxin synergists, and also since a substantial difference in the level of endogenous auxins in etiolated as compared with nonetiolated tissue was not found, the growth response due to auxin synergists was studied. When analyzing the histograms in Figures 13-16, one must remember that the entire level of growth or elongation has been raised due to the addition of an exogenous IAA supply. Thus, the peaks from endogenous auxin promotion appear to be somewhat masked. Likewise, one may note that the growth peaks due to auxin synergists, e.g., rooting cofactors, are now greater than the growth peaks from auxin itself. This phenomenon would be expected since the synergistic response due to addition of an exogenous supply of IAA would undoubtedly be greater in those test tubes previously lacking in auxin than in one already containing an endogenous supply. This observation may especially be noted in relation to chromatogram section 12, and, in fact, may serve as indirect evidence that this growth substance is "IAA."

Figures 13 - 16 Histograms showing biological activity of chromatograms of etiolated and nonetiolated stem tissues of *Phaseolus vulgaris*, and *Hibiscus rosasinensis*, var. WW, RW, and CR 0.5 gram lyophilized tissue, extracted with methanol for 2 hours Extract chromatographed in isopropanol-water (8:2, v/v) Bioassay-*Avena* first internodes 4 mm long, taken 2 mm. below the col*eopilar* node IAA, concentration 1×10^{-8}, was added to the sugar-buffer solution to study the growth promotion due to auxin synergism First internode control sections given concentrations 1×10^{-8} and 1×10^{-7} IAA grew to final lengths of 6.0 and 8.3 mm, respectively Each histogram represents the average of 3 bioassays

E — etiolated
N — nonetiolated
RKB — red kidney bean
WW — Wilson's White
RW — Ruth Wilcox
CR — Cornell Red
IAA — indole-acetic acid

HISTOGRAMS SHOWING BIOLOGICAL ACTIVITY OF CHROMATOGRAMS OF STEM TISSUE

Bioassay - Avena First Internodes
(Auxin Synergistic Tests)

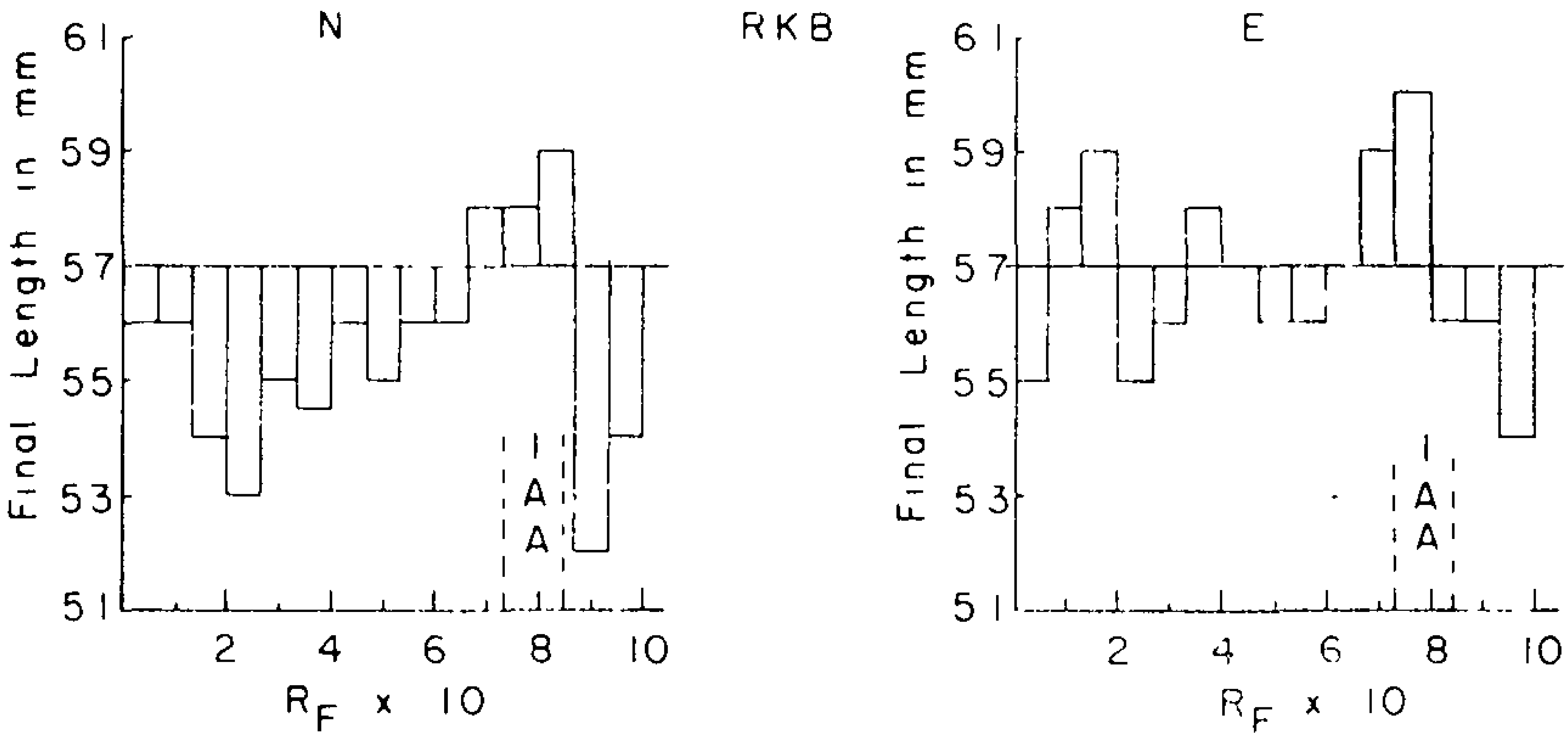

Figure 13

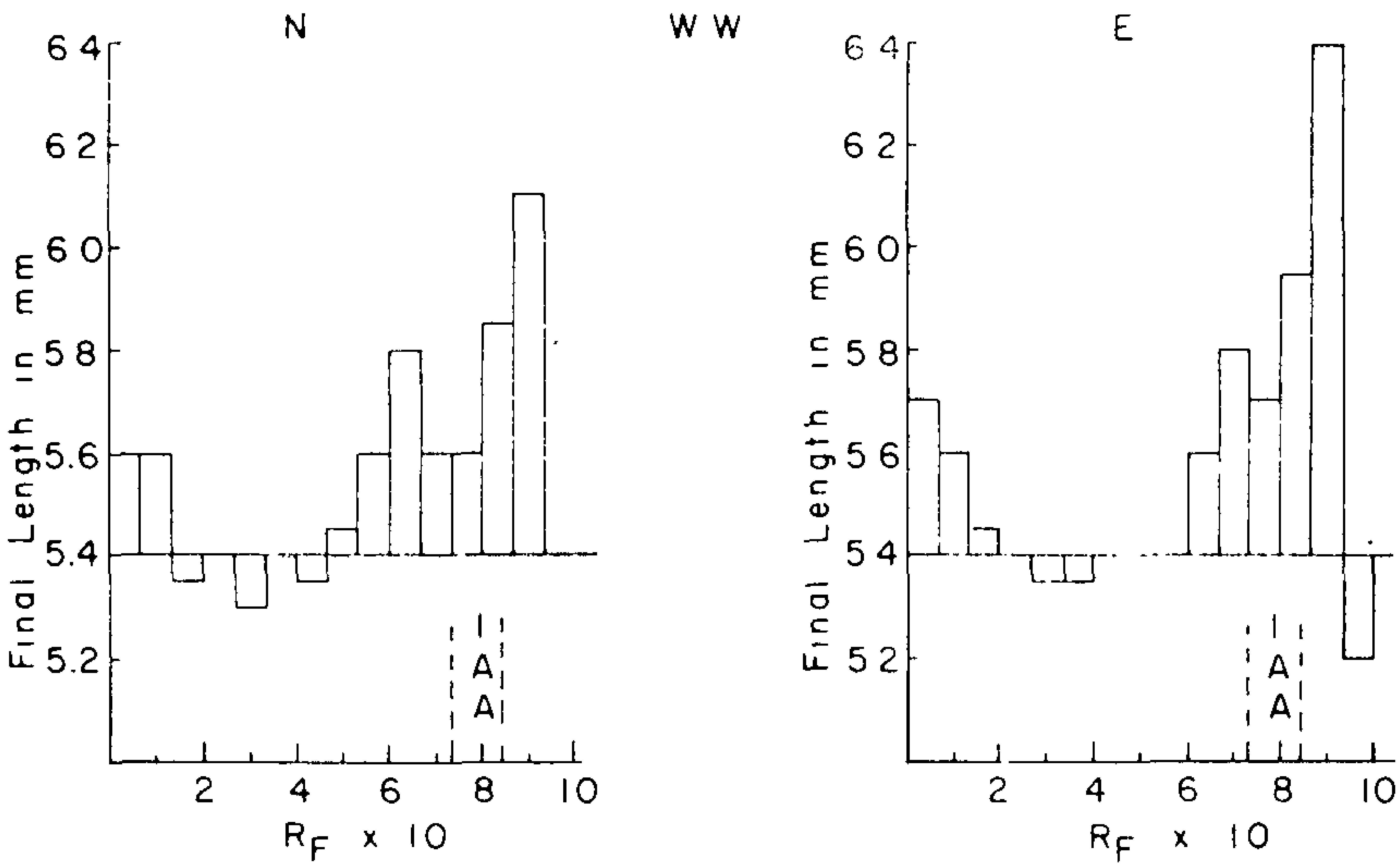

Figure 14

HISTOGRAMS SHOWING BIOLOGICAL ACTIVITY
OF CHROMATOGRAMS OF STEM TISSUE

Bioassay - Avena First Internodes
(Auxin Synergistic Tests)

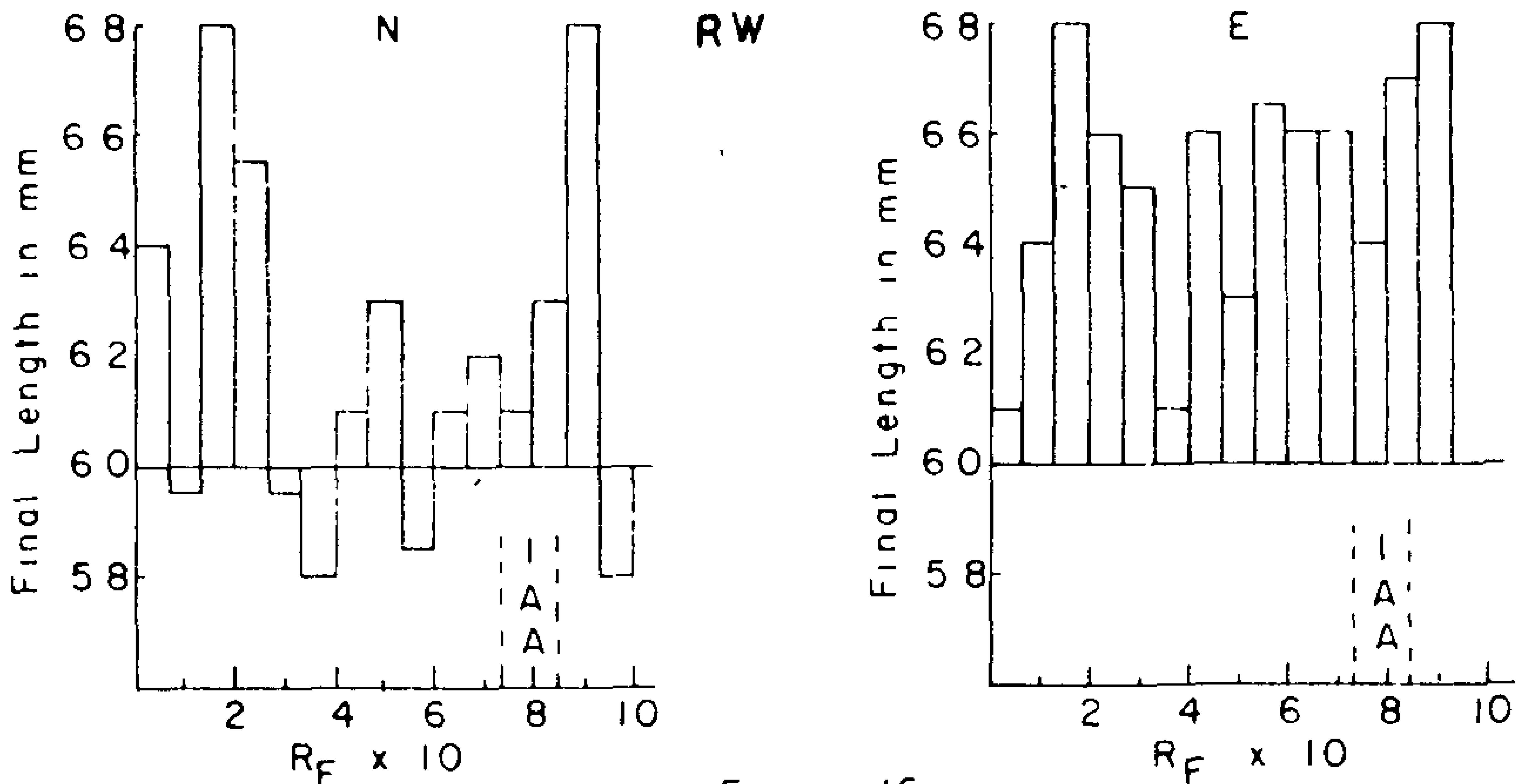

Figure 15

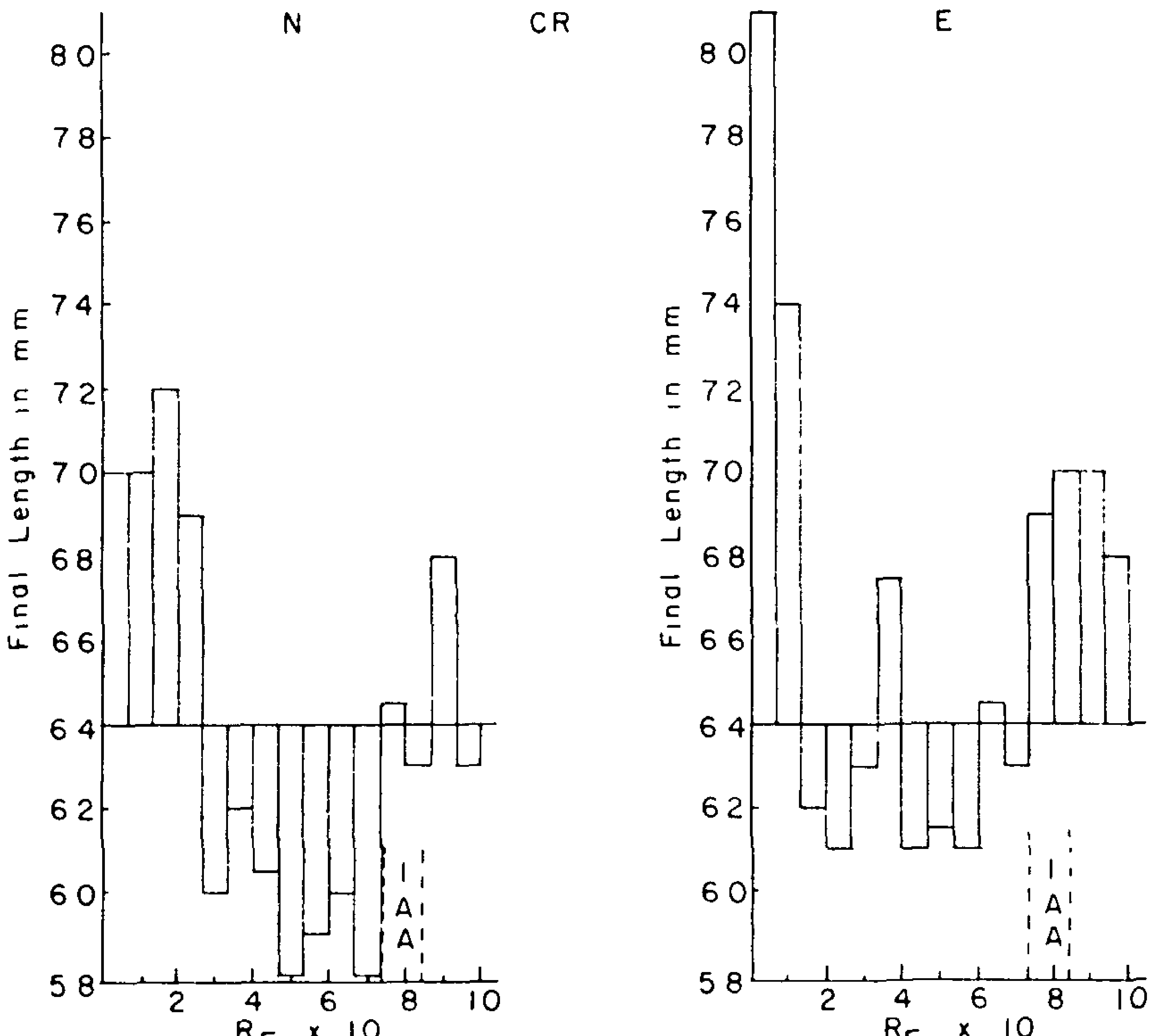

Figure 16

With the addition of an exogenous supply of IAA, the factors or variables involved have now been increased, and the data are indeed difficult to analyze. However, one can still note a significant correlation between the biological activity of the etiolated and nonetiolated tissue. There does appear to be slightly higher levels of auxin synergists present in the etiolated RKB and WW *Hibiscus* tissues as opposed to the nonetiolated tissues. In the RW variety, very high levels of auxin synergists are noted, which, as stated previously, may at least in part account for the very high rooting received in this variety. Significantly higher levels of auxin synergists are again evident in the etiolated tissues, which also holds true for the CR variety, where activity is very pronounced in the area of rooting cofactor 1.

V. Rooting "Cofactor" Study

A. Methods

Extraction and chromatography techniques used in this study of the extractable rooting "cofactors" from etiolated and nonetiolated tissues were similar to those used in the auxin study and will not be repeated.

In 1960 Hess developed a light grown mung bean rooting bioassay for the detection of the rooting "cofactors" (8). This bioassay is based on the initiation of adventitious roots in cuttings taken from mung bean (*Phaseolus aureus* Roxb.) seedlings. The seedlings are germinated and grown in vermiculite in the light chamber, and are ready for use in 9 days. Cuttings consist of the trifoliate bud, primary leaves, epicotyl, and 3 cm. of the hypocotyl. This light grown mung bean bioassay was selected for this study.

Ten cuttings were placed in each shell vial containing a chromatogram section and assayed with 4 cc. of a 5×10^{-6} M. solution of IAA. This solution was taken up by the cuttings in 24 hours and was then replaced with double distilled water. Roots were long enough to count in 5 days.

IAA, the natural plant auxin, is used because these root promoting substances, although unrelated to IAA, require its presence for maximum activity or expression. Thus, the root promoting substances apparently serve as cofactors of IAA.

Figures 17 - 18 Histograms showing biological activity of chromatograms of etiolated and nonetiolated stem tissues of *Phaseolus vulgaris* and *Hibiscus rosasinensis*, var WW. 0.5 gram lyophilized tissues, extracted with methanol for 2 hours Extract chromatographed in isopropanol-water (8.2, v/v). Bioassay-cuttings of light grown mung bean (*Phaseolus aureus*) seedlings. Cuttings consisted of the trifoliate bud, primary leaves, epicotyl, and 3 cm of the hypocotyl Average number of roots per cutting in the double distilled water control was 9.0 The hisotgrams represent the average results of 5 bioassay rooting tests.

E — etiolated
N — nonetiolated
RKB — red kidney bean
WW — Wilson's White
IAA — indole-acetic acid

HISTOGRAMS SHOWING BIOLOGICAL ACTIVITY
OF CHROMATOGRAMS OF STEM TISSUES
Using 0.5 Gram in Extraction

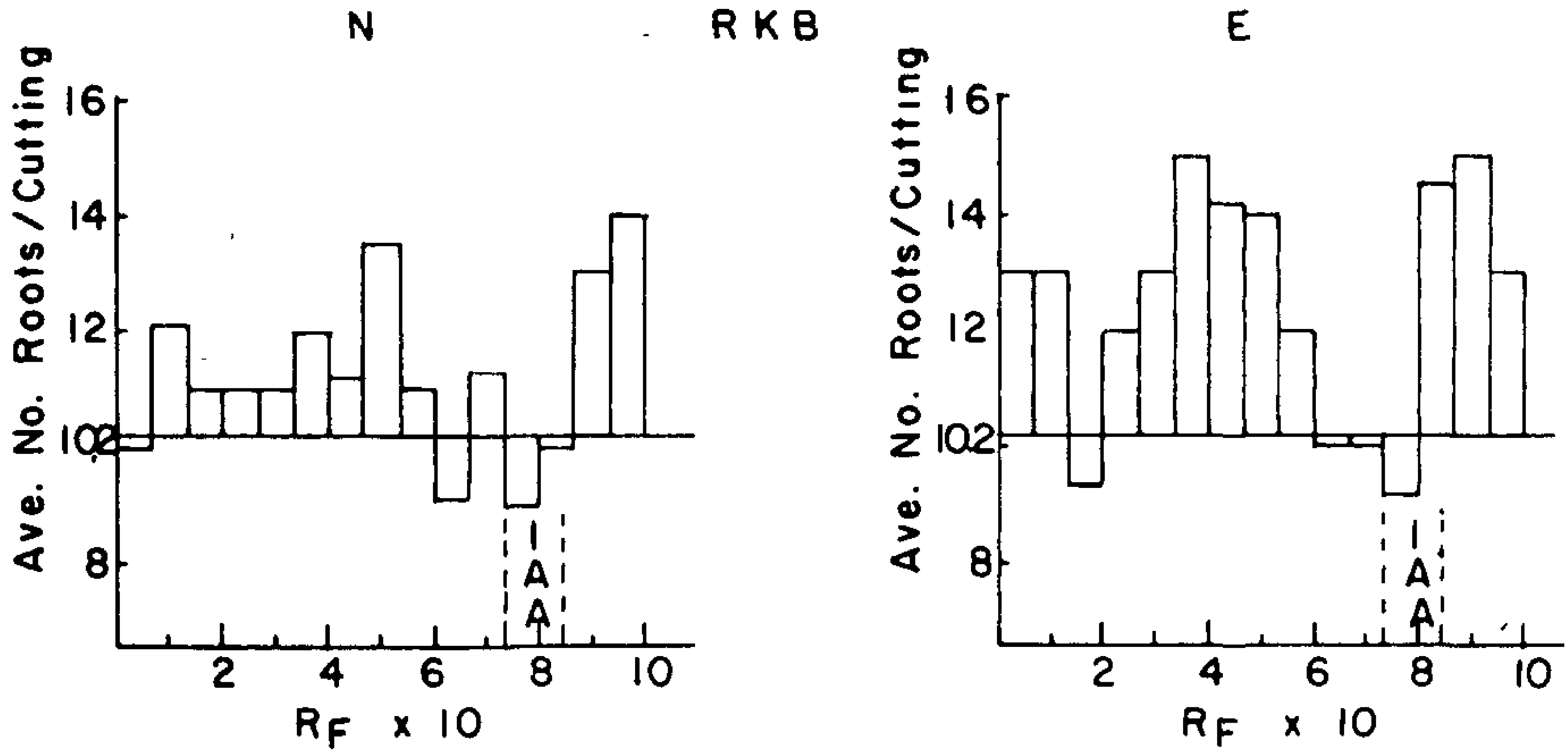

Figure 17

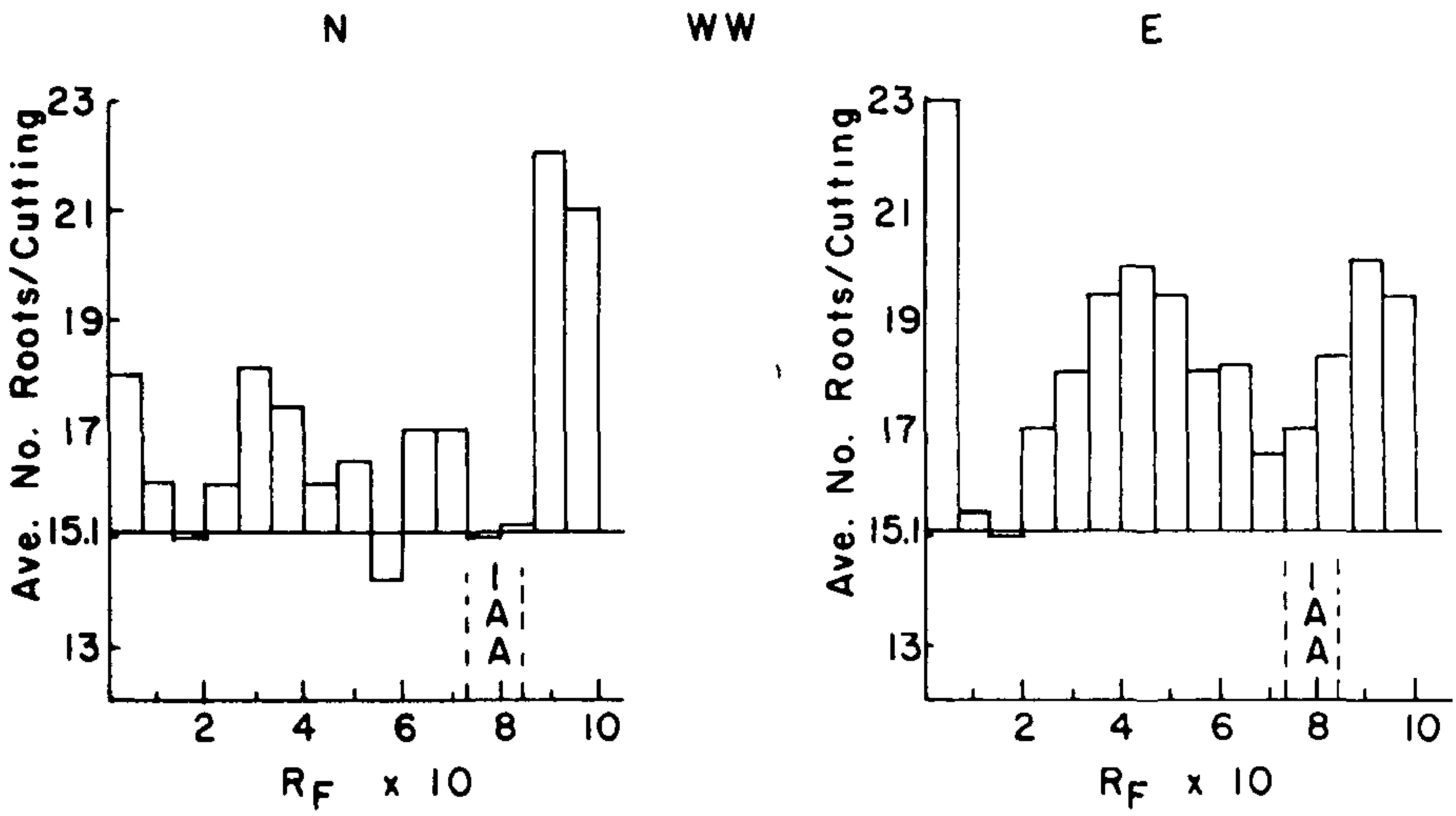

Figure 18

This supposition is supported by the fact that easy-to-root cuttings respond more to auxin application than do difficult-to-root cuttings. Mature and juvenile English ivy and easy-to-root CR and difficult-to-root WW *Hibiscus* are typical examples.

The results of the bioassay of the extractable rooting "cofactors" are expressed in the histograms in Figures 17-18. Higher levels of rooting cofactors with etiolation are apparent in the RKB and the WW *Hibiscus*, but the results with the CR and RW *Hibiscus* were not consistent. However, since these studies have been conducted, it has been found that cofactors 1, 2, and 3 are more soluble in 70% methanol than in absolute methanol. Thus, in using the absolute methanol we may have not been getting a complete extraction of the rooting cofactors, at least the first 3. This problem will be further investigated.

VI. Summary and Conclusions

Etiolation plays a definite role in enhancing root initiation in many plants. Using Red kidney bean and 3 varieties of Chinese *Hibiscus*, this physiological role was investigated by employing 4 different approaches, including differential rooting studies and anatomical, auxin, and rooting "cofactor" investigations. The etiolation treatment involved a localized blanching of the tissues from which root initiation was to occur. The basic conclusions derived from these studies were:

1. Root initiation studies significantly revealed a marked promotion in rooting incurred as a direct result of etiolation. Not only was there a higher numerical rooting per cutting, but the per cent of cuttings rooted was greater when the stems were etiolated prior to taking the cuttings.
2. The anatomical study revealed various anatomical modifications in cells and tissues of etiolated plant stems, e.g., decrease in starch content, mechanical strengthening tissues, cell wall thickness and cell wall deposits, and in total amount of vascular tissue; also an increase in parenchyma cells and a greater quantity of tissues in a less differentiated condition were present in the etiolated as opposed to the nonetiolated stems.
3. The investigation of the endogenous auxins showed a slightly higher auxin content in the etiolated tissues as opposed to the nonetiolated tissues.
4. An investigation of the extractable rooting "cofactors" indicated a somewhat higher rooting "cofactor" level in at least some etiolated as compared with nonetiolated plants. However, the relationship was not consistent and the postulation was made that some unknown substance(s) or auxin synergist(s) e.g., rooting "cofactors," accumulate in etiolated tissues, but which were not released in large enough quantities with the extraction solvents utilized in this study to be detected in the bioassays.

Also, the fact that there was a great response on the part of the etiolated cuttings to an exogenous auxin application indicates most strongly the presence of some other substance(s) which acts synergistically or as a cofactor in determining the overall rooting response.

It is evident from the preceding summary that the physiological role which etiolaton plays in the rooting process cannot be ascribed to any one factor. In the contrary, the marked increase in root initiation incurred from cuttings which are previously etiolated may be attributed to a complex of factors. These factors interact, some synergistically, in a final realization of the rooting response of a plant.

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PRESIDENT MAHLSTEDE: Thank you very much, Dale, for your very interesting paper. We will have a few minutes for questions.

MR. JAMES WELLS: How long were the *Hibiscus* and the beans etiolated?

MR. HERMAN: The *Hibiscus* were etiolated for five weeks and the beans, three weeks.

VOICE: Did you identify any of the compounds on the chromatograms?

MR. HERMAN: We have good evidence from R-f values and color reactions that the principal auxin was indoleacetic acid, but we have not crystallized it. We did not identify the other active areas as yet.

MR. PETER VERMEULEN: Will a short exposure to light eliminate the root promoting effects of etiolation?

DR. C. E. HESS: No, a short exposure will not eliminate the promotive effects of etiolation upon rooting. There are substantial changes in the structure and chemical make up of the stems during etiolation. It would take a period of several hours or more to remove the effects of etiolation. You may be thinking of Seymour Shapiro's paper about the growth of preformed root initials as are found in willow and poplar. If branches are placed in a moist, dark environment for approximately three days and then are exposed to a very short period of light, particularly red light, the outgrowth of the preformed roots is inhibited.

MR. AL LOWENFELS: How can etiolation be used practically?

MR. HERMAN: It is already used in layering.

THURSDAY AFTERNOON SESSION

December 5, 1963

FIRST SECTION

The first section of the afternoon session convened at 1:15 p.m., Arthur J. Lancaster, Jr., Coleman Nurseries, Portsmouth, Virginia, moderator.

MR. ART LANCASTER: The first paper this afternoon will be given by Dr. Charles E. Hess, Department of Horticulture, Purdue University.

WHY CERTAIN CUTTINGS ARE HARD TO ROOT

CHARLES E. HESS
Department of Horticulture
Purdue University
Lafayette, Indiana

I would like to begin by describing some of the factors which can affect the rooting of a cutting, then go into how some of these factors may work, and end up with a few techniques which are used to increase the rooting capacity of difficult-to-root cuttings.

JUVENILITY

Figure 1 summarizes some of the factors which affect rooting. Juvenility, in my opinion, has a profound effect upon the rooting ability of a cutting. Cuttings taken from young plants almost invariably root better than do cuttings taken from older plants. For example, 31%, 18% and 9% rooting was obtained with cuttings taken from 1, 2, and 3 year old *Pinus strobus* plants respectively. In each case the same type of cutting was taken, using one year old wood (18). Therefore, even though you may use 'young' wood, if it is taken from an old plant, it will still be difficult-to-root. There are exceptions, of course, but the generalization is particularly applicable for difficult-to-root plants.

Most, if not all, plants go through a period of juvenility between the time they are in the seedling stage and until they flower. In some plants, the juvenile phase is quite clear because the plants actually look different. One striking example is *Hedera helix,* the English Ivy (9). During the juvenile phase, the plant is a ground cover with lobed leaves, redish stems and aerial roots. Mature plants are woody shrubs with entire leaves, green stems, and no aerial roots. Other plants have less obvious indicators of juvenility such as the presence of thorns on apple seedlings and the presence of needle-like leaves on junipers in the juvenile phase and scale-leaves in the mature phase. The length of the juvenile period is quite variable be-

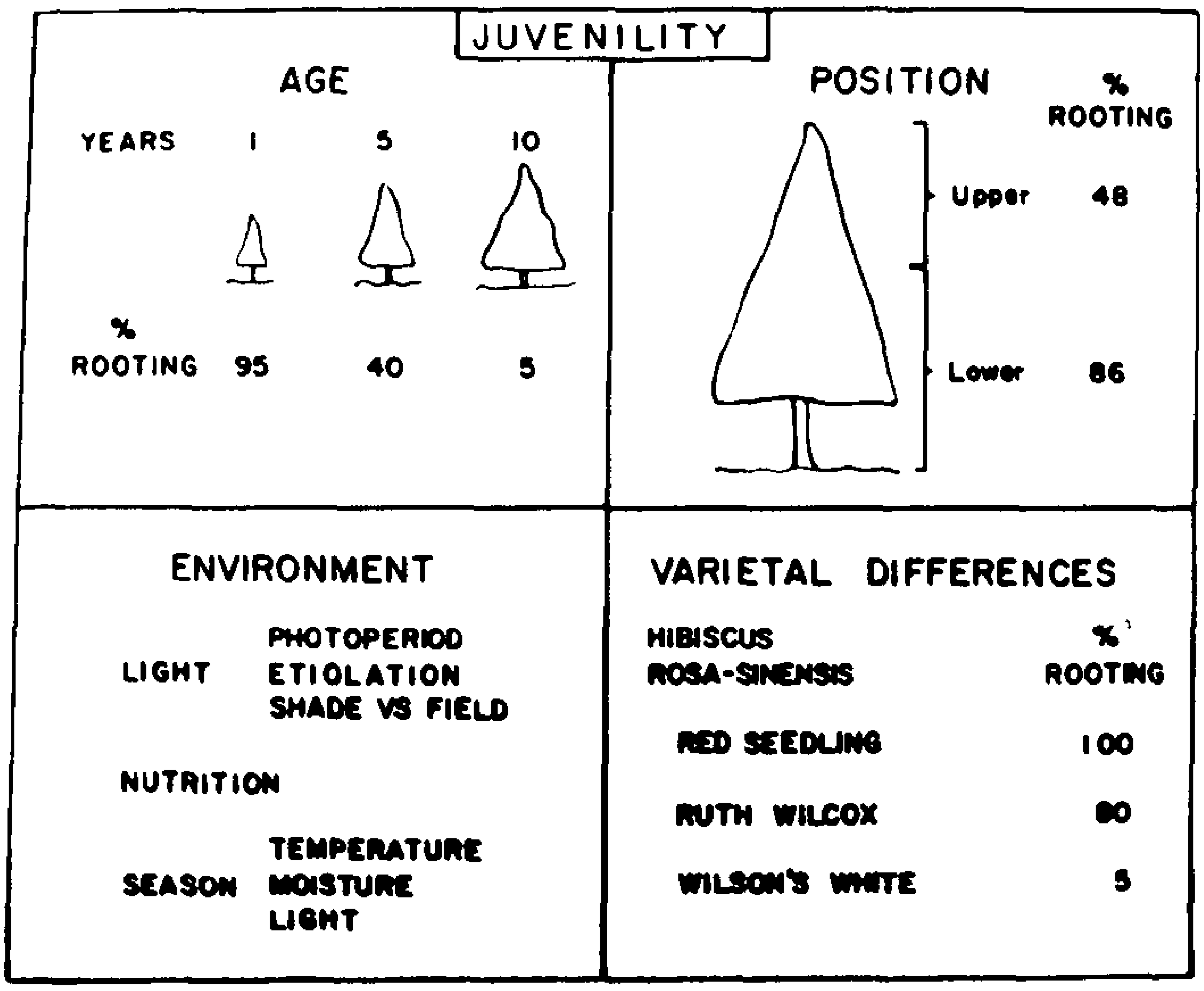

Figure 1 Factors affecting the rooting of cuttings.

tween species. It may be indefinite in the case of *Hedera* as long as the vines are allowed to grow along the ground (the mature form usually appears only after the plants have grown up a wall or a tree). In contrast, using the example of *Pinus strobus* given above, the juvenile period appears to be rather short as far as rooting ability is concerned. The plant may not have reached the seed producing stage and already be considered difficult or impossible to root. Therefore, there exists a transition between the highly juvenile, easy-to-root, seedling phase and the difficult-to-root mature phase.

An interesting feature of juvenility is that a plant does not become completely mature. The lower portion of the plant, close to the root system and including the root system, remains juvenile or at least has the ability to produce juvenile shoots. Thus, when an apple tree is severely pruned and shoots develop from the base of the plant, they are juvenile. They are called water sprouts, epicormics, or suckers and have characteristics of juvenility such as thorniness, rapid growth rate, and no fruiting spurs. Similarly, it is very common to find juvenile shoots of *Hedera* at the base of the mature, shrub form, *Hedera helix aborescens*.

Leaf retention late into the fall and winter is also an indication of juvenility. The triangle of leaves seen at the base of beech and oak trees indicates that part of the tree which is still juvenile.

The fact that the lower portion of a plant retains its juvenile condition is reflected in the rooting ability of cuttings taken from the upper and lower portions of a plant. As shown in Figure 1 cuttings taken from the upper portion of a cone bearing spruce plant rooted 48% while those taken from the lower portion, rooted 86% (5). Another example is the presence of root nodules (bubbles) on the stems of certain conifers such as *Juniperus chinensis* 'Hetz' and *Thuja occidentalis* 'woodward.' The nodules, which are preformed root initials and develop into roots very quickly in the proper environment, are found on the lower portion of the plants (24).

ENVIRONMENT

The environment also plays an important role in the ability of a cutting to root. As shown in Figure 1 some of environmental factors which have a major role in rooting are light, nutrition, and a complex of several elements of the environment expressed as seasonal variation.

LIGHT

Light is of major importance because it is the energy source used in the process of photosynthesis. The sugar which is produced by photosynthesis provides the energy needed for the thousands of reactions within the plant and also provides the raw material from which new substances are made.

In addition to being the plants' energy source, light affects plant growth and development in another way. The length of the day or the photoperiod can regulate the flowering of a plant. For example, a chrysanthemum is classified as a short day plant because under natural conditions it flowers in the fall when the days become short. Nitsch (11), Waxman (20), and Peringer (13) have demonstrated that long days on stock plants or on cuttings enhances the rooting response, either by faster rooting or by a larger, more branched root system. Plants such as *Weigela, Ilex, Buxus,* and *Cornus florida* are benefited by long days. However, the response is quite variable and it is not possible to generalize and say that long days should be used on all cuttings. For example, long days used on dormant evergreen cuttings may stimulate vegetative growth before rooting. Another complication is that in some cases the presence of flower buds decreases the rooting ability of a cutting (2, 12). Therefore, if a long photoperiod also promotes flower initiation, the stimulatory effect upon rooting may be lost or neutralized.

We have stated that light must be supplied to the stock plant because it provides the energy required for photosynthesis. In contrast, the actual process of initiation appears to be favored by darkness — that is darkness in the area where the root initials are being formed. As has been discussed this morning (8) and in previous Proceedings of the Society (17) etiolation (the development of plants or plant parts in the absence of light) has a great stimulatory effect upon root initiation. The process of etiolation is utilized each time a cutting is stuck into a medium, soil is placed around the base of a plant in layering, or when sphagnum moss is wrapped around a stem in an air layer. However, the beneficial effects of etiolation are greater when the stem section is truly etiolated (i.e. it has developed without having been exposed to any light) as compared to blanching (covering a stem after it has developed in light). The blanched stem may look similar to an etiolated stem, but the internal structures will be different. For example, there will be more fiber tissue present in the blanched stem.

A phenomenon, probably related to etiolation, is that some cuttings taken from shade grown plants root more easily than do cuttings taken from plants grown in sun (15). There is a smaller amount of lignification and fiber formation in shaded plants with the result that a greater number of cells are available to form root initials.

NUTRITION

The nutrition of a stock plant can affect the rooting ability of cuttings taken from it (6, 14). Of the major elements, nitrogen seems to have the greatest effect upon rooting. A high level of nitrogen is generally detrimental as compared to a medium or low level of nitrogen particularly when soft wood cuttings are taken (14). The reasons why a high level of nitrogen is detrimental may be associated with a stimulation of vigorous vegetative growth. The soft, succulent growth is believed to be low in sugars which are essential for rooting as has been mentioned above. In addition there is some evidence that other substances essential for rooting may be in short supply in rapidly growing shoots.

Two minor elements have been shown to have an effect upon rooting. One is zinc (16) and the other is boron (7, 22). Zinc is essential for the synthesis of tryptophane which is a precursor of indoleacetic acid. Boron does not appear to stimulate the actual process of root initiation, but does stimulate the growth of the roots once they have been initiated. Low concentrations are used. For example, Weiser used 50 and 100 ppm (50-100 mg/1) when treating deciduous azaleas and dwarf rhododendrons (23).

The addition of nutrients to cuttings is receiving increasing attention, particular in the application of nutrients through mist. At present there does not seem to be any beneficial effect upon the rate of root initiation. However, the establishment and growth of the cuttings after rooting was greatly enhanced with the addition of a complete fertilizer in the mist (19).

SEASONAL VARIATION

We all recognize the fact that for each plant there seems to be a time which is best for taking cuttings. The use of mist and softwood cuttings has increased the time when cuttings may be successfully rooted. However, timing is still very critical with plants which are difficut-to-root. For example, Waxman reported a very short period of time near the end of March when *Sciadopitys verticillata* could be rooted in commercial feasible percentages (21). The causes of seasonal variation are very difficult to explain because the variations are a result of complex interactions between such factors as temperature, moisture supply, and light — both intensity and day length. I will not say more about this area because Dr. Lanphear will present a paper on seasonal responses in evergreen cuttings later in the program (10).

VARIETAL DIFFERENCES

Perhaps one of the most intriguing problems in plant propagation is varietal differences in the rooting ability of cuttings. Why is it that closely related plants grown under identical conditions vary so much in their rooting response? Take, for example, three varieties of *Hibiscus rosa-sinensis* grown under the same conditions and using similar cuttings from plants of equal age. Cuttings from a red variety rooted 100%, 80% rooting was obtained with Ruth Wilcox, and 5% rooting with Wilson's White.

We feel that a part of the cause of the varietal differences can be attributed to differences in the ability of the cuttings to manufacture substances essential for rooting. Auxins, such as indoleacetic acid (IAA), do not seem to be limiting in the difficult-to-root cuttings. However, other substances which may act as cofactors with IAA are found in smaller amounts in the difficult-to-root cuttings (9). The chemical nature of the rooting cofactors has yet to be established, but present indications are that purines, phenolic compounds and terpenes are involved.

A frequently observed characteristic of difficult-to-root varieties is the presence of fibers, particularly outside of the phloem. Beakbane (1) has made a correlation between the continuity of the phloem fiber ring and rooting ability of apple cuttings. If the ring was only 41% complete, rooting was excellent, 64% continuity resulted in good rooting, 75% continuity — fair rooting, and 84% continuity — poor rooting.

There are two ways in which the problem of lignification can be overcome. One is by using very soft cuttings which have not developed secondary tissues. In fact, the reason the cuttings are "soft" is because lignification and fiber formation have not taken place. Etiolation provides a second way in which lignification can be prevented. Lignin is a complex substance made up of phenolic acids, and light is essential for one of the steps in phenolic acid synthesis. Etiolated tissues are very low in phenolic acids and little or no lignin is formed.

A very interesting side benefit from blocking lignin formation by etiolation may be the accumulation of precursors of phenolic compounds which in turn may be stimulators of root initiaton. Thus, etiolation may have a dual effect. One, it blocks lignification and fiber formation and therefore more cells are available for cell division, and two, it may cause the accumulation of a root promoting substance.

Figure 2 shows the technique used to etiolate a *Hibiscus* stem and Figure 3 shows the appearance of etiolated and non-etiolated *Hibiscus* stems. Notice that root initiation took place during the etiolation process.

I mentioned in the discussion of varietal differences that some cuttings may be difficult-to-root because they do not manufacture a sufficient quantity of the substances essential for rooting. A technique which can partially overcome this problem is to girdle a shoot, leave it on the stock plant for a period of time, and then make the cutting as shown in Figure 4. The longer the shoot is left in the girdled condition before the cutting is taken, the better will be the rooting response. Figure 5 shows a comparison of the rooting response of an easy (Red) and an intermediate in rooting ability (Ruth Wilcox) *Hibiscus* after being girdled for 0, 9, 18, and 27 days. Notice that the easy-to-root red variety exhibited the greater response to the girdling treatment. The reason is believed to be due to a higher production of root promoting substances in the red variety and therefore more were available for accumulation above the girdle.

I started out by saying that juvenility played a very important role in the ability of a cutting to root. I would like to finish by giving two examples of commercial practices which perpetuate the juvenile phase. The examples are shown diagrammatically in Figure 6. Hedges, as suggested by Garner (4)

Figure 2. Technique used to etiolate a *Hibiscus rosa-sinensis stem*. The virmiculite was added every other day as the shoot grew up through the cone.

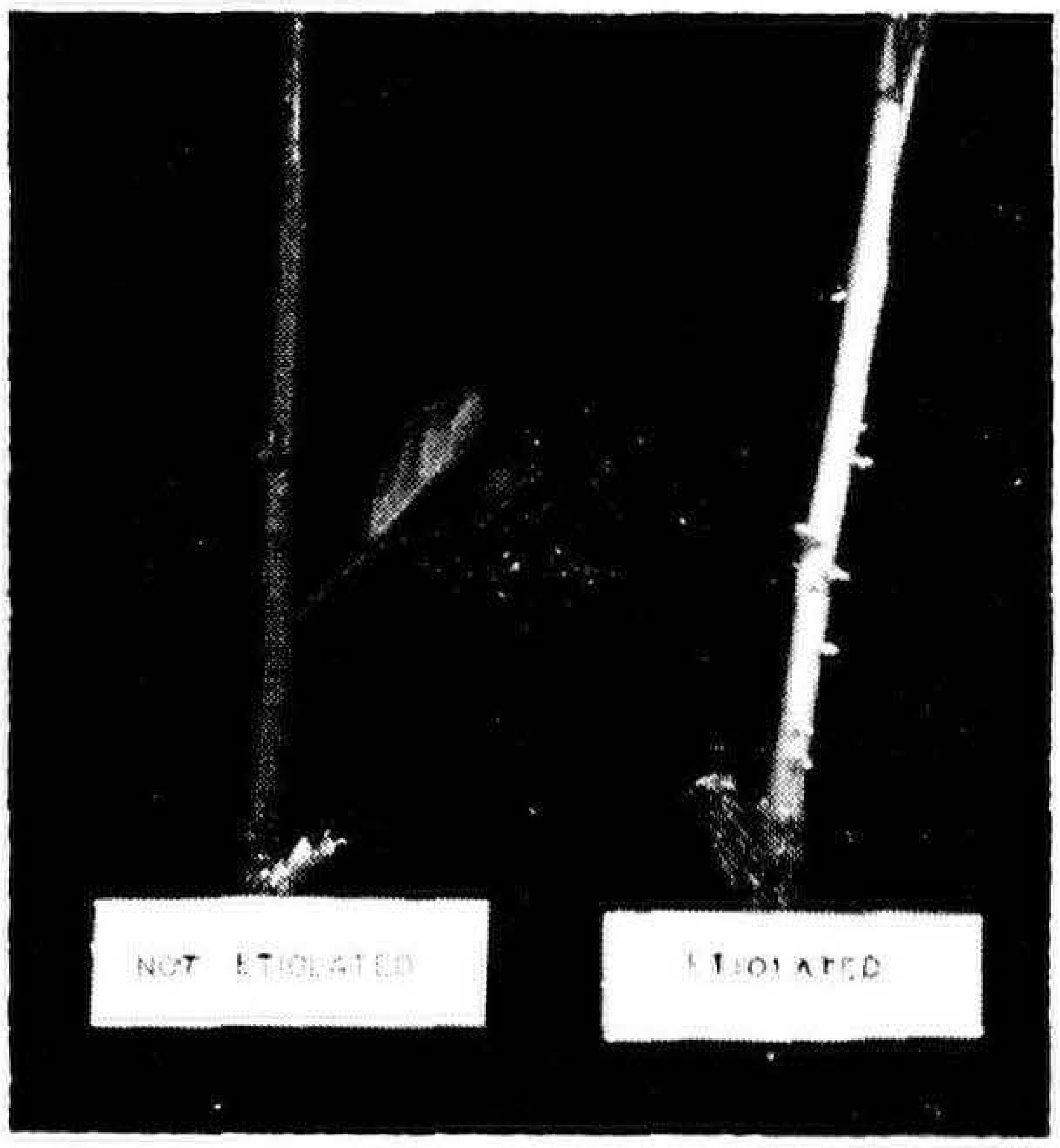

Figure 3. A comparison of an etiolated and non-etiolated stem of *Hibiscus rosa-sunensis*. Root initiation took place during etiolation.

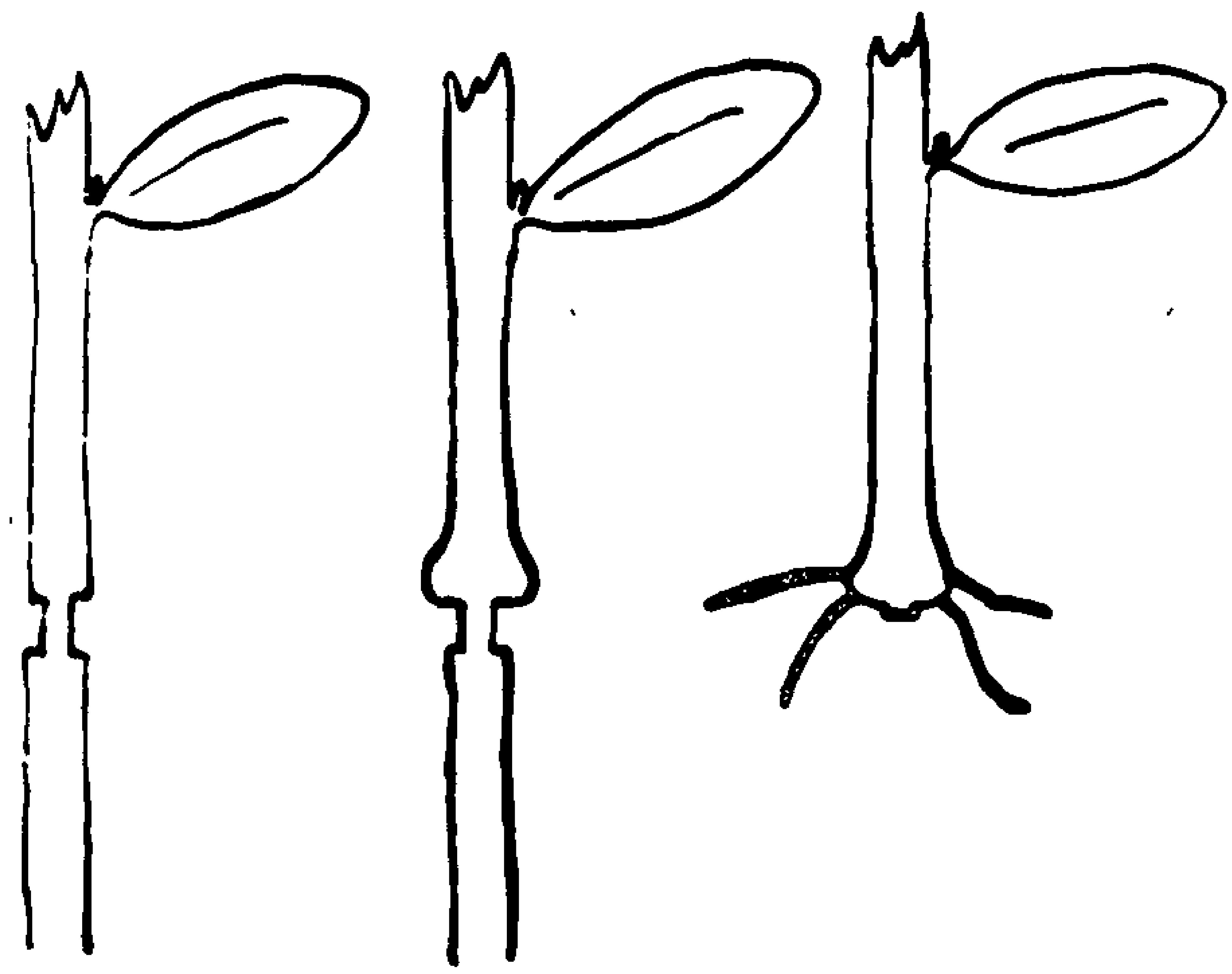

Figure 4 Girdling to promote the accumulation of root promoting substances before taking a cutting.

and stool beds perpertuate the juvenile state because the stock plants are continuously cut back. Thus, the new, vigorous shoots arise only from basal, juvenile portion of the plant.

Finally, the process of root initiation seems to cause a degree of rejuvenation, at least in respect to rooting ability. It is commonly reported that cuttings taken from cuttings root better than the original cutting taken from a mature stock plant. For example, Dr. Sylvester March made this statement in the 1962 Proceedings; "We have propagated Freeman (Magnolia) hy-

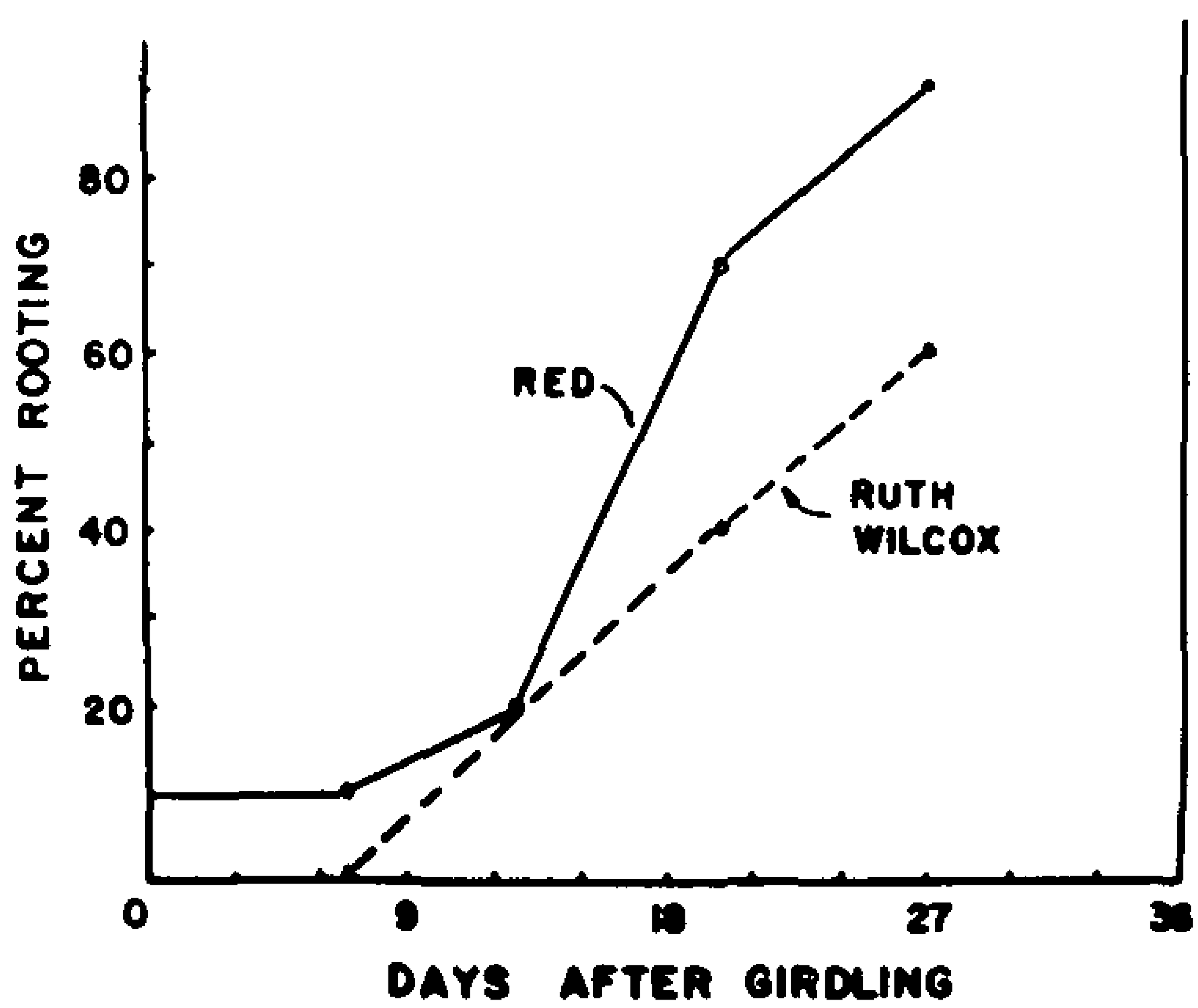

Figure 5 The effects of increasing numbers of days of girdling upon the percent rooting of two varieties of *Hibiscus rosa-sinensis*

PERPETUATING JUVENILITY

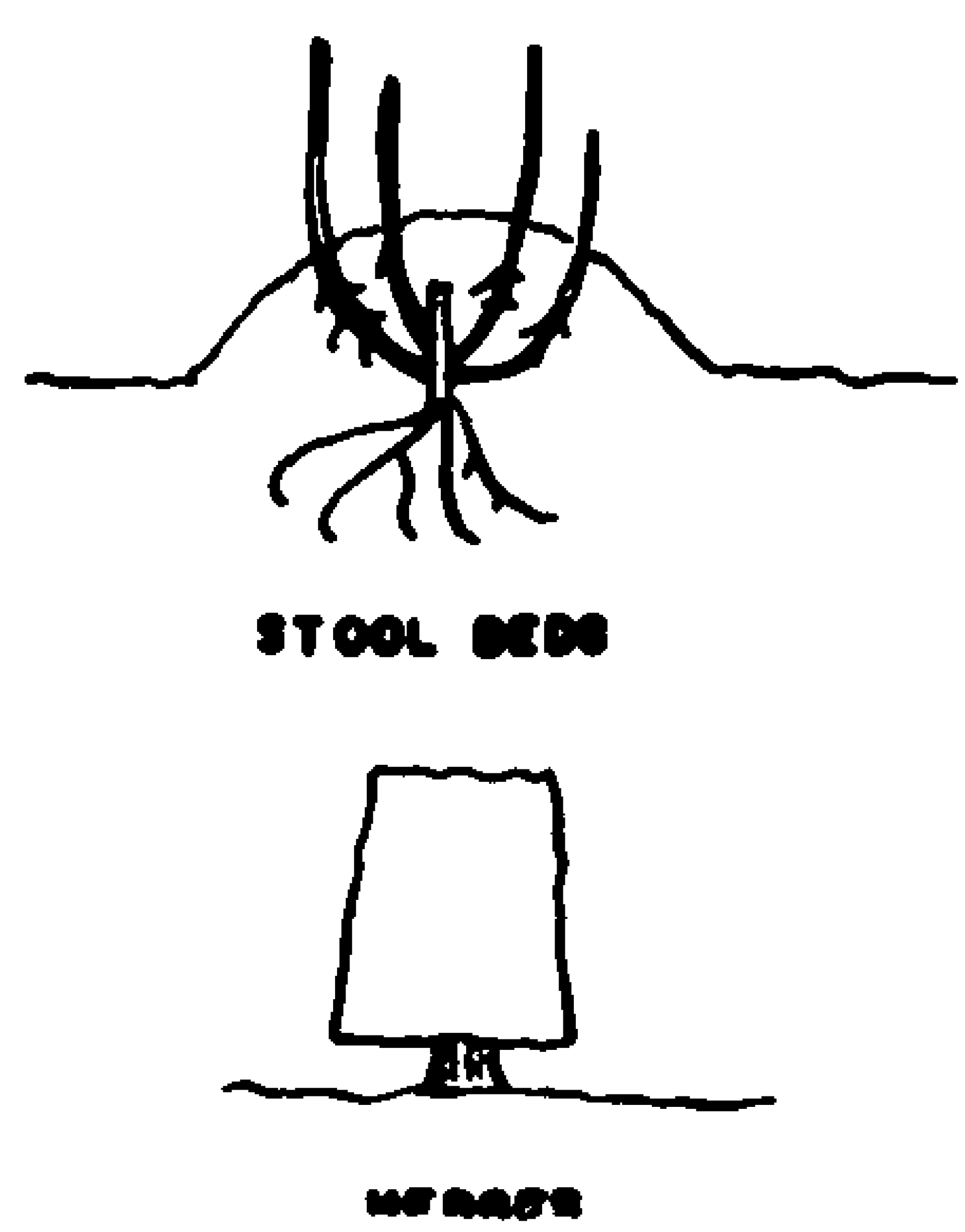

Figure 6. Commercial techniques used to perpetuate juvenility.

brids, using cuttings from young plants. We find this is the key to the whole problem. If a cutting is taken from the original tree, the results are very poor. It is a matter of getting some of the original cuttings to root and then to take your cuttings from the young juvenile plants."

The process of root initiation is very complex and can be influenced by many factors. However, we are gradually identifying the important factors affecting root initiation and are learning how they actually work to alter the rooting process. I hope that the information we have covered will provide a better understanding of why certain plants are hard to root and perhaps give you some ideas of what you can do to improve the rooting ability of difficult-to-root cuttings.

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MR. ART LANCASTER: Thank you very much, Charley. The next paper will be given by Dr. Richard Zimmerman, Texas Forest Service, College Station, Texas.

ROOTING COFACTORS IN SOME SOUTHERN PINES

RICHARD ZIMMERMAN
Texas Forest Service
College Station, Texas

INTRODUCTION

The Tree Improvement Program of the Texas Forest Service is concerned with the selection and breeding of superior strains of southern pines for paper pulp and lumber. One of the problems encountered in this program has been the vegetative propagation of selected trees. Since only mature trees are selected, rooting capacity is low (6, 7) and the selections have been propagated by grafting in the past. For our purposes, this has the disadvantages of (1) a different genetic constitution of the stock and scion, (2) possible incompatability between the stock and scion, and (3) higher cost.

Attempts at working out a satisfactory technique for propagating older pines from cuttings met with little success. Accordingly the decision was made to begin a basic investigation of rooting in pines. The purposes were, first, to study root initiation in pines and, second, to determine the relationshp between juvenility and root initiation. The first phase of the research has been to determine if the rooting cofactors that Hess (1) reported are present in pines.

MATERIALS AND METHODS

Pine needles are collected and dried by lyophilization or "freeze-drying." The dried tissue is ground up and a 100 milligram portion weighed out. This is extracted with absolute methanol for two hours at 0° C. The extracts are filtered, dried, and dissolved in a small amount of 95% ethanol. The concentrated extract is applied as a streak on a two inch wide strip of Whatman 3MM chromatographic paper. The chromatograms are developed by ascending chromatography with isopropanol-water (4:1 v/v) following a 15 hour equilibration period. Development of the chromatograms is stopped when the solvent

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To determine root initiating activity of the substances in the pine needle extract, we use the mung bean rooting bioassay developed by Hess (3) with some slight modifications. The mung bean seeds are sowed in water-saturated vermiculite and placed in a controlled environment chamber. The growing conditions in this chamber consist of a 16-hour photoperiod with a light intensity of 2000 foot-candles at plant level, a temperature of 77° F in the light and 73° F in the dark, and a relative humidity of approximately 40%. At the end of ten days, cuttings are made from the seedlings by making a cut 3 cm below the cotyledonary node. At this time the primary leaves are fully developed and the first trifoliate leaf is in the bud stage. Five of these cuttings are placed in a vial containing four milliliters of 5×10^{-6} M indoleacetic acid plus a section from the chromatogram. After 15 hours, the cuttings have taken up nearly all the solution and glass-distilled water is added to the vials. Glass-distilled water is added twice daily until the roots are counted. The roots are long enough to count after four or five days.

RESULTS AND DISCUSSION

The research was started with seedlings of loblolly pine and has been expanded to include older trees of this species and trees of other species as well. In needles of seven month old seedlings of loblolly pine, several substances are present which stimulate root initiation in the mung bean cuttings. The most active substances were found at R-f values of 0.45, 0.55 and 0.85. These correspond approximately to the values Hess has published for cofactors 2, 3, and 4 respectively (2, 3). In addition, a slightly active substance was found at R-f 0.1, corresponding to cofactor 1 (2, 3).

Preliminary results with slightly older loblolly pines indicated a significant reduction in the rooting cofactor content of the needles. Upon repeating this work and extending it to even older trees, we found no apparent reduction in rooting cofactor content occurred even in trees 22 years old. There were definite indications of wide variation from tree to tree however.

In one eight year old tree, active substances were found only at R-f values of 0.5-0.6 and 0.8-1.0, corresponding to cofactors 3 and 4. Another tree of the same age, from the same seed source, and growing under the same conditions gave very different results. Active substances at R-f values of 0.1, 0.65, and 0.9-1.0 correspond to cofactors 1, 3, and 4 respectively. In addition active substances occurred at R-f values of 0.3 and 0.45. The latter probably corresponds to cofactor 2. It appears that there may be more than four co-factors in some trees. As yet we have not compared the rooting ability of cuttings from these two trees.

We have also sampled needles from twelve year old loblolly pines from the same seed source and growing on the same site as the eight year old trees. These contain active substances at R-f values of 0.5, 0.65, and 0.9-1.0, which correspond to cofactors 2, 3, and 4. A slightly active substances has been found occasionally at an R-f of 0.75, between the normal positions of cofactors 3 and 4 on the chromatogram.

While the eight and twelve year old trees were old enough to flower, we could find no evidence that these individual trees had flowered. Samples were collected from branches with and without cones on 22 year old trees. The results were similar in both cases. Active substances were present at R-f values of 0.45, 0.55-0.75, and 0.9-1.0 and a substance with a slight amount of activity at R-f 0.1.

Extracts were made from needles of eleven month old seedlings and eight year old trees of slash pine. The seedlings contained active substances at R-f values of 0.4-0.6, 0 7, and 0.9-1.0 with a slightly active substance at 0.1-0.2. The older trees contained active substances at 0.5-0.65 and 0.9-1.0.

After we had determined that rooting cofactors were present in pine needles, the next problem became that of identifying the active substances. On this we have just begun.

Hess has reported that cofactor 4 can be separated from the others by partitioning the extract between water and chloroform (4). Cofactor 4 and the chlorophylls will be found in the chloroform layer while the other cofactors will be found in the water layer. Cofactor 4 can then be separated from the chlorophylls by running the chloroform fraction through a column of activated charcoal and celite (4). Hess has also reported that cofactor 4 consists of four separate compounds (5).

Working with extracts from loblolly pine seedlings, we have been able to separate cofactor 4 from the other active substances by the same technique. We have also been able to separate cofactor 4 from the chlorophylls in the same manner. By using different solvent systems for developing the paper chromatograms, we have found that there are several components to cofactor 4 extracted from loblolly pines also Our only attempt to separate the cofactors in the water layer so far have been unsuccessful.

We have observed an interesting phenomenon with the substances which have R-f values of approximately 0.45-0.5 and 0.6-0.65, that is cofactors 2 and 3. Often on the mung bean cuttings used to test the chromatogram sections carrying these substances, the roots which are initiated develop very little. In some cases the epidermis of the stem will not be broken; in others, the roots will be no more than 2-3 mm long. The base of the stem is usually dead At times, the number of roots initiated will be greatly reduced, even to the point where none are initiated. In the same amount of time, roots will be at least 8-15 mm long on cuttings used to test other sections of the same chromatogram and on the control cuttings. At first, the cause of this inhibition of root development appears to be too high a concentration of the active substance. Yet, when the crude extract is diluted so that inhibition of root development no longer occurs, stimulation of root initiation is greatly reduced or disappears. The same phenomenon has been found when mung bean cuttings are treated with such compounds as thiamin, ascorbic acid and arginine.

SUMMARY

From the results just presented, it is clear that needles of loblolly and slash pines contain substances which are very active in the mung bean rooting bioassay. Most of these substances appear to be very similar to, if not the same as, the rooting cofactors Hess has discovered in *Hedera* and other plants. Whether these substances will stimulate rooting in pine cuttings as well as they do in mung bean cuttings is not yet known. The quantities of these rooting cofactors appear to be as great in 22 year old flowering trees as in seedlings less than a year old.

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MR. ART LANCASTER: Thank you very much, Dr. Zimmerman. The next paper will be given by Peter Vermeulen, John Vermeulen and Son Nursery, Neshanic Station, New Jersey.

MIST PROPAGATION OF CUTTINGS INSERTED DIRECTLY INTO THE ROOTING-GROWING MEDIUM

J. PETER VERMEULEN
John Vermeulen & Son, Inc.
Neshanic Station, New Jersey

The subject of Mist Propagation of Cuttings Inserted Directly into the Rooting-Growing Medium is not a new one. I recall saying to this society last year that none of us have completely original thoughts. I am sure that there are many propagators who have at some time or other rooted cuttings inserted concentration of the active substance. Yet, when the crude extract is diluted so that inhibition of root development no longer occurs, stimulation of root initiation is greatly reduced or disappears. The same phenomenon has been found when mung bean cuttings are treated with such compounds as thiamin, ascorbic acid and arginine.

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Leslie Hancock has twice described before this society his Burlap Cloud Method of rooting soft wood cuttings in soil (1). Harvey Templeton has given us the details of the Phytotector Method for rooting cuttings (2). C. W. M. (Charlie) Hess, Sr., talked on the subject in 1955 (3), as did Jack D. Hill (4) and Kenneth W. Reisch (5) in 1957. In 1959 I very briefly described some little work we had done that year in rooting some woody ornamentals inserted directly into peat-moss pots (6).

Rooting Media:

Before going on I wish to comment briefly on an area that may cause some confusion. Most of us are to varying degrees presumptuous. I know I tend to be so. This can be difficult, dangerous or even disastrous at times. To preclude this possibility in our discussion of rooting-growing media I wish therefore to take a moment to discuss media.

Just what is a medium? What distinction exists between a rooting medium and a growing medium? A thorough discussion would fill a greater period than we are permitted at this time and the subject has been discussed and documented frequently before. You may wish to be reminded of three publications of recent import. These are the well known "U.C. System for Producing Healthy Container—Grown Plants" edited by Kenneth F. Baker (7), "Mist Propagation of Cuttings" by Patricia Rowe-Dutton (8) and the paper of Dr. Wendell H. Camp presented at our Sixth Annual meeting in Cleveland (9). There are of course numerous others of importance which your own particular research can seek out.

At this time it would appear to me that there need be very little difference between a rooting medium and a growing medium. A rooting medium must be one that holds the cuttings in position, must provide adequate drainage and in so doing and at the same time provide for a proper oxygen-water relation during the process of root initiation. A growing medium must have all of these attributes and at the same time be capable of accepting and retaining and in turn releasing a nutrient supply of proper balance for optimum plant growth. With the materials now available all of these requisites can be met. It then seems entirely feasible to use a rooting medum as a growing medium and vice versa by merely adding the nutrients once rooting has occurred. It has always been our thinking that soil per se should be incorporated in a good, well balanced growing medium. Our thinking has not been prompted by scientific research entirely but mostly by 'green-thumb' reasoning. Dr. Camp, in his discussion of micro-organisms in soils and their action on plants (9) tends to lend validity to our thinking.

Our present rooting-growing medium therefore does contain some soil but only a very small part. It is formulated as follows: 18 parts (53%) German peat-moss, 6 parts (17½%) #1 horticultural grade perlite, 6 parts (17½%) finely shredded stryofoam, 3 parts (9%) clean fine sharp deep pit sand and 1 part (3%) soil. I must add that our soil is a Birdsboro silt-loam and that which we add to the medium has been prepared with a liberal quantity of rotted cow-manure after which it is fumigated. All of the ingredients, including sufficient Dieldrin to satisfy USDA requirements for Japanese Beetle certification, are thoroughly mixed. Other formulas may and I am sure can be used. Nutrients are added as required after rooting has occurred and after the plants have been hardened-off.

Purpose:

Our primary consideration in this endeavor was to establish a plant in the container in which it was to be grown and ultimately sold or from which it would be transplanted for growing on. We had been discouraged many times in the past by failures of quantities of excellently rooted cuttings shortly after the transplanting operation. If we could eliminate transplanting we would not only gain more plants but we would also eliminate a major production cost. Another substantial gain would be the realization of increased growth by eliminating the 'set-back' usually concurrent with transplanting. We therefore looked for a technique and a container.

Containers Used:

Based on our past experiences we were already convinced of the many attributes of peat-moss pots for growing lining out stock and so naturally used them for the bulk of our experiments. We have also used some clay pots and plastic pots and find them acceptable but with the usual limitations, chiefly the labor of removal of the pot at shipping or planting time.

A most important consideration in the use of any container is drainage. To facilitate good drainage in the peat-moss pots we punch holes in the bottoms. This is easily and effectively accomplished by using a long skewer or pointed rod which is pushed through a whole row of pots at the time they are removed from the shipping carton. Good drainage is also essential in the flat or tray the pots are placed in as well as in the mist frame into which they are set.

Peat-moss pots we have used are the 2¼″ regular, 2¼″ Polyskin, 2½″ Xtradeep or rose pot and the 3″. The 2¼″ regular and 3″ pots were unfertilized. The others are from stock and we are told that they contain some nitrates "to replace those lost in the breakdown of the wood cellulose fiber in the pot wall." We recommend and try to use only unfertilized pots which are made up for us on special order. This year, for the first time in these experiments, we used Polyskin pots which are regular thin wall peat-moss pots covered on the outside with a "skin" of polyethylene film. Our purpose in using them was to attempt to contain the roots. In a past experience with *Acer palmatum* and *Pyracantha* we achieved very good rooting only to find that the roots persisted in growing away from the pot. At time of shipment this created quite a problem. Results have been excellent. Rooting percentages this year of *Acer palmatum Oshiobeni,* 'Bloodgood' and 'Burgundylace,' while not exceptional, are commercially acceptable at 81%, 83% and 87% respectively, with all roots in the pot and sure to go along with the plant at the time of sale or transplanting. The polyskin is easily removed at time of transplanting. Here again caution must be observed with regard to drainage. The pots are furnished by the manufacturer with holes prepunched in the polyskin. We find it necessary however to punch additional holes in the bottoms of the pots, right through the poly.

The pots are filled with the rooting-growing medium and firmed but not packed. Square pots or the newer Jiffy-strips lend themselves to quick filling since they can be placed in the flats and the medium poured over the entire flat. After firming, a straight-edge is used to level the medium even with the rim of the pots. The flats are then watered lightly and piled so as to be ready for the stickers. This operation is usually accomplished a day or so in advance but if room and time permit a week's supply can be made up at one time and covered with some polyethylene.

Selection, Preparation and Treatment of the Cuttings:

We recognize the importance of good judgment and practice in the maintenance of strong and healthy stock plants and in the selection and subsequent care of strong and healthy cuttings. Cuttings used in our experiments were not specially selected nor did they receive any care or treatment not otherwise given. When brought in from the nursery, cuttings are dipped in a solution of Malathion and Morton's Soil Drench in water and dripped dry. They are kept fluffed up, covered with polyethylene and cool. After making up, the cuttings are treated and inserted directly into the pots containing the rooting-growing medium. When a number of flats are completed they are thoroughly soaked with a solution containing Morton's Soil Drench and water. They are carried outside to the mist frames later in the day when the sun is not so high and hot.

The Mist Bed or Frame:

All of our work in these experiments has been with softwood cutting starting in June and continuing through the summer. We use outdoor mist frames without shade. The flats are set directly into the frames. Intermittent mist is supplied under pressure which we attempt to maintain at 125 lbs. We favor low capacity nozzles because of the drainage factor and have used successfully 1.5 gallon per hour oil burner nozzles both outdoors and in our greenhouses. These have a spray angle of 90 degrees and are hollow cone nozzles. They require an adapter and a nipple as well as tapping when installed. Material costs are $1.01 per nozzle not counting the pipe. This year we used some Flora-Mist Foggers with an .020″ orifice. They require no adapter, nipple or tapping and cost 36c. They do give 7 gallons per hour under our pressures however. A full summer's experience has shown them to be completely acceptable.

Mist is controlled by a 24 hour on-off time clock and a 30 minute repeating timer. The timer is adjusted manually according to the weather and the condition of the cuttings in any desired increments of 30 seconds.

Last summer and the one before we experienced low night temperatures in August at a time when we still had quantities of newly inserted cuttings in the frames. Medium temperatures fell below the optimum rooting level of 65 to 70 degrees. In a newer mist bed for Junipers we had installed heating cables and there we were delighted with exceptionally heavy and quick rooting in spite of the cool nights. Needless to say all of our mist beds next year will be so equipped. We find one 120′, 800 watt cable sufficient to heat 145 square feet of frame. Bear in mind that this is for Summer or early Fall operation in USDA Plant Hardiness Zone 6a. Cables are spaced 7″ from the walls and 14″ apart toward the center of the frame and are operated on 220 volts. Each section should be thermostatically controlled.

Our frames are dug out 12″ and may be considered an adaptation of the Boliver Pit Frame described by Steve O'Rourke in 1955 (10). They are lined with 6″ hollow cinder blocks. On the bottom is placed approximately 4″ of drainage material such as stone, gravel, cinders, broken pots, etc. On top of this, in the heated frames, should go 2″ of shredded styrofoam — this to prevent loss of heat to the ground. One inch of sand is placed on top of the styrofoam and the cable laid on it. Over the cable is spread evenly another 1″ of fine sand. Next comes a protective barrier of 1″ mesh braided or welded wire. In those sections which are to hold flats of cuttings, we then spread 2″ of fine sand. The flats are placed on top of this layer of sand. In those sections in which cuttings are to be inserted directly into the frame, we are more particular to use clean fine sharp deep pit sand and the depth is increased to 4″ or 5″.

We think that this frame, with a polyethylene tent cover can also be used to overwinter newly rooted plant material and at a low heating cost.

Plant Material Tested:

Following is a list of cuttings attempted this past summer. It is obvious from it that our work has been limited and that results have not all been those hoped for. They are sufficient, however, to encourage us to go forward with further experiments with additional material as well as to expand quantities on those with which we have had apparent success. Proof of the pudding was made clear to us this past year in our experience with *Prunus Kwanzan* and *Magnolia stellata* 'Royal Star.' With those inserted in the pots we achieved 98% success with *Prunus Kwanzan.* In sharp contrast however was our failure with those inserted in sand and later transplanted to peat-moss pots. Of 1936 cuttings inserted 1195 or 60% rooted and we lost 700 in the transplanting operation leaving us with a net of only 23%. With the 'Royal Star Magnolia,' whereas we had a 93% success with the cuttings inserted directly into the rooting-growing medium, we had only a 53% net with those stuck in sand and transplanted. Our male *Ginkgo* also did much better in the pots.

Item	Date	No Stuck	Rooted	%
Acer pal. 'Bloodgood'	6/21	940	786	83
Acer pal. 'Burgundylace'	6/24	504	439	87
Acer pal. dissectum	6/19	360	96	27 *
Acer pal. dis. atropurpureum	6/21	540	93	17 *
Acer pal. Oshio-beni	6/19	504	410	81
#*Azalea* Exbury & Knaphill Hybrids:				
Balzac	7/1	25	6	24
Basilisk	7/1	61	7	11
Berry Rose	7/1	36	32	89
Cecile	7/1	108	73	68
Harvey Moon	7/1	47	27	58
Hotspur	7/1	108	70	65
J. Jennings	7/1	76	48	63
Strawberry Ice	7/1	72	41	57
White Swan	7/1	108	90	83
Cornus florida plena	7/24	150	138	95
Cornus florida rubra	7/24	200	190	95
Franklinia alatamaha	8/15	1500	1300	86
Ginkgo biloba pyramidalis	7/3	50	42	84
Ginkgo biloba fastigiata	7/3	100	93	93
Ginkgo biloba, selection #9	7/3	50	47	94
Ginkgo biloba, selection #1	7/3	150	139	93
Ginkgo biloba, selection #7	7/3	150	145	96
Magnolia stel. 'Royal Star'	7/23	200	185	93
Prunus 'Kwanzan'	6/28	500	490	98
Rhus cotinus atropurpureum	6/25	280	260	93
Rhus cotinus 'Royal Purple'	6/25	880	820	94

All **Azalea** cuttings should have been taken 1 week earlier
* Cuttings were hard

Summary:

In view of the experience mentioned we feel that there are distinct advantages and possibilities in the propagation of cuttings inserted directly into a rooting-growing medium, so much so as to make it commercially practical. The medium must be chosen and formulated with great care. Utmost attention must be given to drainage throughout all operations. The advantages apply primarily to plant material difficult to transplant but almost equally as a substantial savings in the costs of labor in transplanting operations. Where operation of misting facilities is a high cost factor different criteria must be established. As we carry on our work at Neshanic Station we will be most willing and happy to exchange information with anyone who is interested in doing likewise.

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MR. ART LANCASTER: Thank you very much, Pete. The final paper for the first section of this afternoon's session is by J. Paul Wilms, Gwenn-Gary Nursery, Inc., Columbiana, Ohio.

PROBLEMS AND PROPAGATION PROCEDURES OF A SMALL TO MEDIUM SIZE OPERATION

J. PAUL WILMS

Gwenn-Gary Nursery, Inc.

Columbiana, Ohio

Back in 1937, when the J. P. Wilms Nursery began, budding of roses and fruit trees was the only propagation work done. At the end of the next three years, after the name had been changed to Gwenn-Gary Nursery, rooting of evergreen cuttings was begun. The nursery of 10 acres supplied most of the cutting wood which was set in either cold frames or in rented space in nearby greenhouses.

In using rented greenhouse space, several problems occurred. (1) The cuttings had to be made in advance in large quantities, and some drying out occurred before the cuttings could be set. (2) Alternating temperatures, such as when the cuttings were brought in from the cold, made up in a room at moderate temperature, and out in the cold again to be transported to the greenhouse before being set in a controlled temperature environment. (3) However, the most critical problem was the inability to oversee watering and care after the cuttings were we carry on our work at Neshanic Station we will be most willing and happy to exchange information with anyone who is interested in doing likewise.

1 Hancock, Leslie, 1953 "Shrubs from Softwood Cuttings". Proceeding PPS — 3 151-164 1955 "The Burlap Cloud Method of Rooting Softwood Cuttings". PPS — 5 56-58
2 Templeton, Harvey M, 1953 "The 'Phytotector' Method of Rooting Cuttings" PPS — 3 51-52
3 Hess, C W M, Sr, 1955. "Rooting Cuttings in Containers under Mist" PPS — 5.135
4 Hill, Jack D, 1957 "Propagating Plants Directly in Containers". PPS — 7:75-78
5 Reisch, Dr Keneth W, 1957 'Propagating Plants Directly in Containers by Means of Hardwood Cuttings" PPS — 7.78-79
6 Vermeulen, J Peter, 1959 "Propagation of Woody Ornamentals Under Mist in Peatmoss Pots" PPS — 9 207-210
7 Baker, Kenneth F, 1957 "The U C System for Producing Healthy Container-Grown Plants" Calif Agri Exp Sta, Berkeley 4, Calif
8 Rose-Dutton, Patricia, 1959 "Mist Propagation of Cuttings" Commonwealth Bureau of Horticulture & Plantation Crops, East Malling, Maidstone, Kent, England
9 Camp, Dr Wendell H, 1956 "Micro-Organisms in Soils and Their Action on Plants" PPS — 6 107-121
10 O'Rourke, F L (Steve), 1955 "The Bolivar Pit Method of Rooting Cuttings". PPS — 5 54-56

MR. ART LANCASTER: Thank you very much, Pete. The final paper for the first section of this afternoon's session is by J. Paul Wilms, Gwenn-Gary Nursery, Inc., Columbiana, Ohio.

PROBLEMS AND PROPAGATION PROCEDURES OF A SMALL TO MEDIUM SIZE OPERATION

J. PAUL WILMS
Gwenn-Gary Nursery, Inc.
Columbiana, Ohio

Back in 1937, when the J. P. Wilms Nursery began, budding of roses and fruit trees was the only propagation work done. At the end of the next three years, after the name had been changed to Gwenn-Gary Nursery, rooting of evergreen cuttings was begun. The nursery of 10 acres supplied most of the cutting wood which was set in either cold frames or in rented space in nearby greenhouses.

In using rented greenhouse space, several problems occurred. (1) The cuttings had to be made in advance in large quantities, and some drying out occurred before the cuttings could be set. (2) Alternating temperatures, such as when the cuttings were brought in from the cold, made up in a room at moderate temperature, and out in the cold again to be transported to the greenhouse before being set in a controlled temperature environment. (3) However, the most critical problem was the inability to oversee watering and care after the cuttings were set. At best, using rented space was inconvenient, but much better than nothing at all.

Lining out stock was purchased to compensate for losses and to obtain items that were "unrootable" or required special techniques and operations, such as grafting or growing seedlings. The preceding operation was continued for about 10 years and the nursery acreage was increased to 25.

In 1950, an extensive building program was inaugurated. The principal building was for storage, office facilities, potting and garage areas, but also included two attached, adjoining greenhouses. It was a four-level, two-story building designed by Mr. David Metzger of Terrace Gardens, Inc. of Youngstown, Ohio, with revisions made by Dr. L. C. Chadwick of Ohio State University and some of his students.

An oil-fired boiler supplies hot water heat for the building, and underbench heating in the greenhouses.

The two greenhouses (14½ feet by 52 feet) each hold three benches. The outside and end benches measure 30 inches wide and 6 inches deep; the center one, 57″ by 6″ and are constructed of redwood. Four two-inch pipes extend under the outside benches, and six under the center bench. Two pipes also run along the outside walls of the two houses to provide ample heat.

In the fall of 1950 cuttings of *Taxus, Thuja, Juniperus,* and *Ilex* varieties, in respective order, were made, prepared and set in the houses. Washed sand was the media used, Hormo-Root "B" and "C" were the growth regulators tried, and hand watering methods were employed.

In the next three or four years the immediate problem was the every-day care required to maintain a good crop. One man with the right touch was the key to successful rooting of cuttings. (Rooting percentages in these first years were similar to those of the usual beginner's luck.) Another problem was created when the building and the greenhouses were built. The building shaded the southern portion of the greenhouses about 5 feet. Overwatering and subsequent losses occurred until the "touch" was acquired to prevent overwatering. The third problem to arise at this time was the uneven heating which occurred in the houses. The above-bench locating of the thermostat was the cause, and also the reason for detrimental, early bud breakage, as bench temperature was often less than that of the house temperature. To alleviate these problems, the thermostat was placed beneath the benches and the benches skirted with muslin to retain the heat under the benches. Increased rooting percentages and lower heating costs were the result. Also, at this time, I became a charter member of the Plant Propagators' Society.

Each fall the greenhouses were thoroughly cleaned out and new sand was brought in to replace that from the previous year. The benches were repainted with "Cuprinol" or copper napthanate solution every two years. We tried silica sand for a media, but rooting percentages did not improve enough to merit the extra cost and, was dropped after two years of use.

In a statement made by Mr. Case Hoogendoorn at one of these meeting, he said that the selection of cuttings taken from the base, or near the base of *Juniper excelsa stricta* had bubbles on them and rooted very readily. This information was incorporated into our program at home, and although it was necessary to stand on your head to get the cuttings, the percentage of rooting increased about six-fold — from 15% to 90%.

The rooted cuttings of all varieties we grew were transplanted into the open field in rows 18 inches apart and 5 inches in a row. All varieties came through wth the exception of *Taxus* species. Through inquiry and information obtained from this organization, we discovered the need of *Taxus* to receive some protection in the first few years after rooting. Thus, we constructed a bed area where all our *Taxus* have been grown for the first two years after rooting. These beds are covered with shades, allowing 50 percent light to pass through.

After these first two years, the *Taxus* are transplanted into the field in rows 4 feet apart and 8 to 12 inches in the row for two more years.

The yews are then transplanted again into field rows 4 feet apart and 26 inches apart in the row, and from here are balled and burlapped. The other varieties go directly to the field from the greenhouse for two years in the liner area, and then into the field row of 4 feet and 26 inches in the row.

In 1958, three nights of constant watch over a balky oil furnace, with 85,000 cuttings in the greenhouses and the temperature near zero, was sufficient reason for us to purchase an auxiliary furnace to avoid a possible recurrence of this emergency.

During the years of 1958 and 1959, while my son, Gary, was attending Michigan State University, Steve O'Rourke guided him in several experiments. One of these was the rooting response of cuttings in various types of media. A mixture of styrofoam and peat moss repeatedly showed good results with a mature root system that did not break easily when handled.

In 1960, one greenhouse was used to experiment with different media to see if it would improve our rooting, and produce a more easily handled root system than was produced in sand. The expense of styrofoam, and the cost to break it up, resulted in our substituting perlite for the styrofoam in our mixture. One bench in the greenhouse was filled with a mixture of sand, perlite and peat moss in equal portions by volume; another bench with peat moss and perlite in the same proportions; and the other bench filled with sand.

The cuttings rooted in the peat moss-perlite mixture were the best developed, and easiest to handle, that we had ever worked with. We are still using this mixture today, but with a greater percentage of perlite (roughly 60%) than we started with.

A new idea was developed in this year, too, to improve the water drainage and heat penetration into the media. The center boards in the benches were removed and replaced with ¼-inch wire mesh and covered with a thin layer of peat moss to prevent the loss of the media through the screen.

Also, the greenhouses, with the exception of the vents, were lined on the inside with plastic to cut off drafts which had developed with age in the house. (Separation of glass and ribbing, and little pieces of broken glass and at joints of overlapping glass. Other advantages soon were apparent with the installation of the plastic. It was easier to maintain humidity, and the water drawn from the media condensed when it touched the plastic and dropped back to the media. Less watering was thus needed. The area between the glass and the plastic provided 2 inches of air space insulation, and the heating costs were reduced somewhat.

The water-retentive qualities of the peat-perlite mixture made it necessary to adjust the "touch" in watering to prevent excessive moisture detrimental to obtaining healthy-rooted cuttings. One problem of this media that we have had was redampening this media when it dries out. Water applied to the dry mixture would saturate a layer on the top, but flow through the lower portions more or less in channels, and drain out, leaving only a small portion of the media with moisture.

With background information received at several Plant Propagators' Society meetings, I began grafting scions of upright Junipers on unrooted "bubble," cuttings of *Juniper excelsa stricta* in the fall of 1960. There were 25 to 30 grafts in each of four different varieties. Twenty out of 27 *Juniper scopulorum 'Blue Haven,'* 27 out of 29 *Juniper keteleeri,* 23 out of 27 *Juniper 'Hill's Pyramidal,'* and 20 out of 25 *Juniper virginiana cupressifolia* were successful.

With this encouragement, 1500 grafts were made in 1961. Half of these were grafted on *Juniper chinensis hetzi* "bubble" cuttings, and the remainder on *Juniper excelsa stricta.* The same relative percentage of take occurred with those grafted on *Juniper excelsa stricta* as in the year before, but only 20 to 25% were successful on *Juniper chinensis hetzi.*

In 1962 (last year) 3500 grafts were made on *Juniper excelsa stricta* "bubble" unrooted cuttings. Initial progress was good, with substantial callous formation and union beginning to take place. However, while on vacation last winter, it is my opinion that excessive watering caused the rotting of a majority of these grafts and the mortality rate was quite high this past spring.

In this year, also, we added further insurance to growing a successful crop of cuttings by purchasing a tractor-driven power generator which will supply enough power to maintain the building, greenhouses, and near by house in case of extended power failure.

In this subject I have covered some of the procedures, techniques, and problems encountered in the small to medium-sized operation that we have at Gwenn-Gary Nursery, Inc. However, the most important thing of all to give particular attention to is the care of cuttings after they are set in the bench. A good illustration of what I mean is clearly pointed out with the loss of our grafts last winter. The "after-care," as I call it, requires a man with what can best be described as a "touch," seasoned with experience, guided with the help which comes from above, and with perseverance to toil day after weary day to meet the challenge of Mother Nature, and the constantly changing picture in the greenhouse with success. This requires work, sacrifice, and persistence to make good, but the reward is great in seeing a crop of well-rooted cuttings being planted out in the ground, or sold to a happy, satisfied customer.

MR. ART LANCASTER: Thank you very much, Paul. We will now entertain questions for the four papers you have just heard.

MR. LESLIE HANCOCK: Has any work been done with the application of nutrients during the rooting of cuttings?

DR. HESS: Dr. Harold Tukey from Cornell reported on experiments with mist fertilization last year, and I'll turn this question over to him.

DR. HAROLD TUKEY, JR.: Our experience with feeding nutrients, primarily nitrogen and phosphorous, through a mist system, is that it does not speed up the rooting process, but the plants grown from the rooted cuttings are vastly superior.

MR. JACK HILL: I would appreciate some more detailed information about *Ginkgo biloba* cuttings.

MR. PETE VERMEULEN: The cuttings were taken from the tops of large male trees. The cuttings were 6-8 inches long, they were taken in July, just after the wood had matured. The cuttings were treated with number three Hormodin or with the Germain formulation. We used intermittant mist with a medium of sand, peat, and perlite, 1/3 of each.

MR. JACK HILL: How soft are the cuttings?

MR. PETE VERMEULEN: It's rather hard to describe, but the cuttings will crack if you bend them.

MR. ARIE RADDER: What time do you take the blue spruce cuttings?

MR. PAUL WILMS: We took the cuttings after the first of August. We used Koster cuttings, placed them in peat and perlite, in a greenhouse with intermittant mist. The cuttings were pretty hard, but we had about 65% rooting.

MR. RADDER: Did you use current seasons wood and did you wound the cuttings?

MR. WILMS: Yes, we used current seasons wood. We did not wound the cuttings.

MR. RADDER: What hormone powder did you use?

MR. WILMS: We did not use any.

VOICE: Why are you using cutting-grafts?

MR. WILMS: We have been using potted grafts for years and with good success. But there is one problem. The roots in the pot follow the pot and form a knot. And even on larger Junipers, when you dig them up, you still find the knot with a few large roots going out. We have trouble in transplanting. With the cutting-grafts, we never put them in a pot. They go right from the rooting medium out to the field just like a cutting.

VOICE: You tried both *Juniper stricta* and *Juniper Hetz.* Didn't you find that *Hetz* gave the better root system?

MR. WILMS: This we will have to find out. We haven't had them long enough.

MR. HARRY HOPPERTON: The understock will also regulate the height of the plant later on.

MR. WILMS: Yes, when upright junipers are grafted on *Hetzi,* the plants will not grow as fast, but they make nicer, fuller plants with less trimming.

MR. HOPPERTON: In addition, the final height of the plant is reduced.

THURSDAY AFTERNOON SESSION

SECOND SECTION

The second section of the Thursday afternoon session was moderated by Mr. Charles Tosovsky, Home Nursery and Greenhouse, Edwardsville, Illinois.

MR. CHARLES TOSOVSKY: The first paper in the second section will be presented by Dr. Leon Snyder, Department of Horticulture, University of Minnesota, St. Paul, Minnesota.

PLANNING A PLANT INVENTORY FOR THE TWENTY FIRST CENTURY

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St. Paul 1, *Minnesota*

In planning a plant inventory for the future one must understand the manner in which new cultivars are developed. Each plant in nature belongs to a particular genus and species. i. e. *Pinus sylvestris* (Scotch Pine), *Pseudotsuga menziesii* (Douglas Fir) and *Acer platanoides* (Norway Maple). A species may be defined as a group of numerous individual plants, usually within definable geographical limits, all with so many common characteristics transmitted by seeds without loss from from generation to generation, that the plants are considered closely related and of a common descent. A botanical variety is a group of individual plants. usually within a geographical area, that differ from the type species in some important characteristic. Both the species and the botanical variety breed reasonably true from seeds. Individuals within a species are known to differ in such characteristics as form, color of foliage, color of fruit, etc. Some of these individuals may be selected and grown as cultivated varieties.

To distinguish between the botanical variety and the cultivated variety, a new name 'cultivar' has been proposed and is rapidly gaining acceptance. A cultivar may be a selected *clone* that must be propagated by vegetative means or it may be a *line* or a *line-hybrid.* Every plant of a clone has evolved from one parent plant by vegetative increase. A line is seed propagated but maintained by rogueing the seedlings to a uniform standard. A line-hybrid is also seed propagated but maintained by reconstituting a first generation hybrid by crossing two selected clones or inbred lines.

Nurserymen and landscape architects have used seed propagated species and botanical varieties rather extensively in the past and still use them to a considerable extent. Most of our street trees in the midwest are still seedling American Elm

(*Ulmus americana*), Green Ash (*Fraxinus pennsylvanica*), or Sugar Maple (*Acer saccharum*). Only recently have nurserymen turned to the vegetative propagation of selected cultivars of some of our important street and commercial trees.

Cultivars are by no means new to the nursey industry. We have been growing selected varieties of fruits, lilacs, mock-oranges, peonies, iris, etc. for centuries. As early as 1771, the Prince Nursery of Flushing, Long Island listed 42 cultivars of the pear.

It is of interest to note the manner in which new cultivars have been introduced to the nursery industry and to the gardening public. By far the greatest number of cultivars among our woody ornamentals has been the result of the selection of superior clones from natural or cultivated stands of species or botanical varieties by observant plantsmen. Examples of this sort are: *Prunus virginiana* 'Shubert' (Shubert Chokecherry), *Malus ioensis* 'Plena' (Bechtel Crabapple) and *Acer platanoides* 'Crimson King' (Crimson King Maple).

An ever increasing number of cultivars are the result of plant breeding efforts. Selected parents are crossed and superior individuals are selected from the resulting seedling populations. Some of these plants may have two or more species in their gentic makeup. Occasionally crosses may be made between species in two related genera. Sometimes a species name is applied to the individuals resulting from an interspecific cross, i.e *Spiraea* x *bumalda* (*S. japonica* x *albiflora*) and *Philadelphus* x *lemoinei* (*P. microphyllus* x *coronarius*). 'Anthony Waterer', 'Crispa' and 'Froebelii' are cultivars of the hybrid species, *Spiraea* x *bumalda*. 'Avalanche', 'Innocence', and 'Manteau d'Hermine' are cultivars of the hybrid species, *Philadelphus* x *lemoinei*. When several species are used in the development of a cultivar or when the male parent is unknown, the cultivar name may follow the generic name, i.e. *Malus* 'Flame' and *Rosa* 'Chrysler Imperial' x *Sorbaronia alpina* is an intergeneric hybrid resulting from a cross between (*Aronia arbutifolia* x *Sorbus aria*).

The development of new cultivars in woody ornamentals is in its infancy. Breeding efforts at our educational and research institutions have been confined largely to edible plants: fruits, vegetables, and cereal crops. Only recently have plant breeders at these institutions been encouraged to turn their efforts toward the improvement of ornamental plants and even now these efforts are inadequately financed to accomplish very much.

True, much has been accomplished by hobbyists, commercial plant breeders and government research workers in the improvement of our annual flowers and certain specialty groups of perennials such as iris, peonies, garden roses, daylilies, chrysanthemums, etc. The popularity of these plants and the relatively short period of time needed for these plants to come into bloom have made the improvement of these plants a profitable venture.

As we look to the future, what improvements are needed in our inventory of woody plants and whose responsibility should it be to bring about these improvements. The rapid urbanization of our population, the endless freeways, and the emphasis on recreation with resulting parks and recreational areas are creating needs for types of plant materials that do not now exist. There is need for low compact shrubs for the modern home, groundcovers for difficult slopes, narrow upright trees for narrow boulevards and screens, low globe headed trees for use under wires and smaller ornamental trees for lawn and patio. Attention must be paid to disease and insect resistance.

To develop this inventory of plant materials will require the best efforts of everyone concerned. Nurserymen will need to keep an ever watchful eye for superior variations that occur in nature and in cultivated plantings. Plant breeders and geneticists at our research institutions will need the support of their administrations and funds at the local, state and federal level will need to be increased for this purpose. We can all help by informing our administrators of the need for this type of research.

There are encouraging signs that research efforts are being directed to this task. Arboretums and Botanical Gardens are adding geneticists and plant breeders to their staffs. An ever increasing number of Agricultural Experiment Stations are recognizing Ornamental Plant Breeding as an important area for research. Our New Crops Research Branch of the United States Department of Agriculture has recognized the importance of new ornamentals and a number of recent plant exploration trips have emphasized ornamentals.

Gardeners are becoming more plant conscious. They are becoming better informed through garden magazines, garden programs and through visits to arboretums, botanical gardens, and commercial nurseries. They are beginning to demand and will continue to demand plant materials suited to their needs.

The isolation of superior cultivars alone will not be enough. Practical means of propagating these cultivars and an educational program to acquaint the gardening public with their merits will be needed. We have too many superior cultivars today that are known only in arboretums and botanical gardens. Only if all of us, nurserymen, plant propagators, research workers, garden editors, horticultural extension specialists, and others engaged in educating the gardening public work together can we meet the challenge of better ornamentals for the future.

MR. CHARLES TOSOVSKY: Thank you very much, Dr. Snyder. Our next paper is by Dr. L. C. Chadwick of Ohio State University.

NEW FORMS OF DECIDUOUS AND EVERGREEN PLANTS

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In the very limited time allotted to this discussion I am taking the liberty of limiting it to "Some Recommended Uncommon Shrubs and Small Trees." On the mimeographed list that is being distributed, I have listed 75 different plants in this category. There are several others that could be added that are equally satisfactory for landscape purposes.

Before I show the slides and discuss some of these shrubs and small trees let me comment briefly on the "Quality" of plants. Quality is somewhat of an elusive term, but as it applies to ornamental plants for landscape purposes it should include the characteristics of 1) Hardiness, 2) Adaptability, 3) Durability, 4) Requiring little maintenance, and 4) Possess good habit of growth, outstanding foliage, attractive flowers and prominent fruits.

With these points in mind, I will turn to the slides and plant discussions. The following are comments about some of the plants illustrated and discussed.

LOW SHRUBS — 1½ - 4 feet

1. *Caragana frutex* 'tidy' — Tidy Peashrub
   Small, upright spreading shrub to 4 feet with fine textured foliage. Flowers bright yellow in May and June. A good small shrub for dry, sunny situations.
2. *Cotoneaster adpressa praecox* — Early Cotoneaster
   Low prostrate shrub to 2 feet with small, dark, glossy green leaves, small pink flowers, and bright red fruit which are larger than the species. A fine shrub for edging, foundation planting, and rockeries.
3. *Hypericum kalmianum* — Kalm St. Johnwort
   Small, upright shrub to 3½ feet with bluish green leaves, 1 to 2 inches long Leaves glaucous beneath. Flowers yellow in July and August. One of the hardiest of the Hypericums. Adaptable to sunny or semi-shaded situations.
4. *Physocarpus monogynus* — Mountain Hinebark
   Small shrub to 3 feet with spreading and somewhat arching branches, small leaves, and an abundance of small pinkish white flowers. A soil tolerant shrub which will do well in sunny or shady situations.
5. *Viburnum opulus* 'Compactum' —
   Compact European Cranberrybush
   A low, compact, rounded bush to 2 or 3 feet, with attractive white flowers and red fruits. A superior plant to the more common *Viburnum opulus* 'Nanum' which seldom flowers or fruits.

SMALL SHRUBS — 4 - 6 feet

6. *Clethra alnifolia* 'Rosea' — Pink Summersweet Clethra

Upright spreading shrub to 6 feet with glossy leaves and pinkish white, fragrant flowers borne in terminal racemes. Excellent shrub for moist, partially shaded situations.

7. *Cotoneaster multiflora calocarpa* —

An upright spreading shrub to 6 feet with arching branches, attractive foliage, handsome white flowers, and red fruits which are produced very freely. A good shrub for specimen and mass planting.

8. *Hydrangea quercifolia* — Oakleaf Hydrangea

An upright shrub to 5 feet with reddish tomentose spreading branches, large, dark green leaves which are whitish underneath, and with large panicles of white flowers. Reddish or purplish fall color. An excellent shrub for planting in partial shade where bold effects are desired.

9. *Syringa microphylla* 'Superba' — Superba Littleleaf Lilac

A small shrub of upright growth habit to 4 or 5 feet with small leaves and dainty pink flowers in late May. Use in sunny situations and in well drained soil. A good addition to the lilacs for small specimen and border planting.

10. *Viburnum dilatatum xanthocarpum* —

Yellowberry Linden Viburnum

A yellow fruited form of the popular Linden Viburnum. A plant that may reach 8 feet but usually much smaller. Upright, bushy in its growth habit, with attractive foliage turning bronzy red in autumn, white flowers in May and the yellow fruits in September remaining on the plant until early winter. Best used in sunny situations in fertile soil.

MEDIUM SHRUBS — 6 - 10 feet

11. *Euonymus sachalinensis* — Sakhalin Euonymus

Upright, spreading shrub to 10 feet with rather large obovate leaves to 3½ to 4½ inches, turning reddish purple in the fall. Fruit bright red, 5-angled and produced abundantly in drooping clusters. A good plant as a specimen or for border planting.

12. *Malus sargenti* 'Rosea' — Rosy Sargent Crabapple

Low, horizontatly spreading tree-like shrub to about 6 feet high and 18 to 20 feet spread. Excellent habit of growth, good foliage, and abundance of rosy pink flowers in May and followed by many dark red fruits that persist until winter. The best of the small crabapples and one of the best medium sized plants. Does well in average soil and in sun or partial shade. Excellent as a specimen or as a hedge plant.

13. *Philadelphus* 'Mrs. Thompson' —

Mrs. Thompson Mockorange

One of the smaller Philadelphus reaching a high of 6 to 8 feet. Much better habit of growth than most of the Mockoranges, with low branches and good foliage to the base of the plant. Flowers pure white in late May, single and fragrant. Use in well drained soil and sunny situations, as a specimen or border plant.

14. *Viburnum sargenti flavum* —
Yellow Fruit Sargent Viburnum

An upright spreading plant to 8 to 10 feet with somewhat corky branches and thick, waxy, bright green leaves. The leaves are lobed with the center lobe elongated and essentially entire. Flowers white in cymes, produced in late May to early June. Fruit yellow, differing in this respect only from the species. An excellent shrub to use in good soil and in sunny or in shaded situations.

15. *Viburnum tomentosum* 'Roseum' —
Pink Doublefile Viburnum

All plantsmen are familiar with the Doublefile Viburnum, Viburnum tomentosum, one of the real outstanding shrubs. The Pink Doublefile Viburnum is similar to the species in all respects except the flowers are rosy pink.

LARGE SHRUBS OR SMALL TREES — 10 - 25 feet

16. *Acer buergerianum* — Trident Maple

A small tree to 15 to 18 feet with rounded habit of growth Leaves 3-lobed with the center lobe somewhat elongated. Leaves dark green above glossy, and pale green beneath. Excellent foliage turning reddish orange in the fall. Hardy to 20° F. below zero in well drained soil. An excellent small specimen tree.

17. *Acer griseum* — Paperbark Maple

An excellent small tree to about 25 feet with rounded, compact top. The cinnamon brown, papery bark is the most attractive feature of this plant. The bark is particularly outstanding on the main trunk and large branches and adds a very pleasing note to the winter scene. The compound leaves are composed of 3-leaflets which are dull to semi-glossy green and coarsely toothed. The Paperbark Maple is a hardy small tree that should be used much more extensively as a speicmen plant.

18. *Crataegus ambigua* — Russian Hawthorn

A small tree to 12 to 16 feet with wide spreading branches with bark that is mottled brown and green. The leaves are deeply lobed, dark green and attractive, turning bronzy red in the autumn. The flowers are white followed in the autumn by attractive red fruits. Crataegus ambigua is one of the real good Hawthorns with good habit of growth, attractive bark, good foliage and interesting flowers and fruit. This plant is hardy to 20 and 25° F. below zero and will do well in average soil. Use as a specimen or border plant.

19. *Hamamelis mollis* — Chinese Witchhazel

A large shrub or small tree to 25 to 30 feet with densely hairy branches and large, rounded leaves, 4 to 6 inches long, densely hairy beneath, normally dark green but becoming a beautiful orange yellow in the fall. The flowers are golden yellow produced in late winter. The Chinese Witchhazel will do well in sun or shade. It is one of the most outstanding of the Witchhazels and should be used in our landscape plantings much more often than it has been in the past.

20. *Koelreuteria paniculata fastigiata* —
Upright Panicled Goldenraintree

This small tree is a narrow columnar variety of the common Panicled Goldenraintree. The foliage, flowers and fruits are typical of the species; the variety differing from the species only in habit of growth. An attractive, narrow columnar, yellow flowering small tree to 15 to 20 feet.

21. *Malus*, 'Snowdrift' — Snowdrift Crabapple

There are many excellent small to medium sized flowering crabapples but I will mention only two of the newer introductions. The Snowdrift Crabapple is quite upright in its habit of growth, probably becoming about 25 feet at maturity. It has an excellent habit of growth, attractive foliage and a mass of beautiful white flowers that show a little pink color in bud. The fruits are small, produced somewhat sparingly and are reddish yellow in color. This should be a type of crabapple that is adapted to street planting.

22. *Malus*, 'White Angel' — White Angel Crabapple

One of the most attractive crabapples is the newly introduced White Angel cultivar. The plant is a small tree, about 20 feet in height and approximately as broad as high with a rounded head. It produces a great abundance of white flowers and small red fruits that persist until nearly spring. One of the most beautiful of the small flowering trees.

23. *Pyrus salicifolia* — Willowleaf Pear

An upright small tree to 20 to 25 feet with somewhat pendulous branches and narrow, grayish green leaves. The young leaves are especially attractive with an abundance of white tomentum. The flowers are white, typical of most pears and the fruits are usually less than an inch in size. The Willowleaf Pear is hardy and does well in average soil. It may be somewhat straggly when young but eventually makes a small tree much superior to the Russian Olive where gray foliage is desired.

24. *Rhamnus frangula* 'truehedge' —
Truehedge Glossy Buckthorn

The Truehedge Glossy Buckthorn is a narrow upright cultivar of the species with similar bark, foliage, flower and fruit characteristics. It varies from the species in its habit of growth, becoming a narrow column to about 12 to 15 feet but can be easily restrained to lower heights. It may become a little leggy with the base sparsely branched and with little foliage. It does, however, make a good narrow plant for screen purposes.

25. *Symplocus paniculata* — Asiatic Sweetleaf

The Asiatic Sweetleaf is a large shrub or small tree to 30 feet or more but most often is within the 8 to 12 feet range. It is slow growing but makes an attractive rather stiff, wide spreading plant eventually. The leaves are 2 to 3 inches long, bright green in summer and reddish yellow or purple in the fall. The flowers are small, white and fragrant but not particularly outstanding. The most attractive characteristic of the plant is the abundance of small bright blue fruits produced in the fall. It is, perhaps, the most outstanding shrub or small tree that we have with blue fruit It is hardy, does well in sun or partial shade and is worthy of much more extensive use in the landscape, either as a specimen, as a border plant or for hedge purposes.

MR. CHARLES TOSOVSKY: Thank you very much, Chad. The final paper of this afternoon's session is by Roy Nordine, from the Morton Arboretum.

ORGANIZED AND UNIFORM TESTING AND EVALUATION OF NEW CULTIVARS

ROY M. NORDINE
The Morton Arboretum
Lisle, Illinois

My remarks and development of this topic will be limited to the geographical area of the Eastern region of our Society.

Instead of proposing a program with definite forms and plans to implement a testing program, I will review briefly the past, present and future of work with woody ornamentals.

A tremendous amount of effort by many agencies and individuals has been devoted to testing woody ornamentals. New programs and new areas for future development appear each year.

One of the leaders in the introduction and dissemination of new plants has been our Department of Agriculture. In 1898 a separate section was created in the Department for the introduction of plants new to this country. This section is now called, "New Crops Research Branch." Mr. C. O. Erlanson is the director. This agency has brought in more than 285,000 new plants to date. Most of these new introductions are agriculturally economic plants, grains, grasses, forage, fiber, oil, vegetable, and fruit characteristics. It varies from the species in its habit of growth, becoming a narrow column to about 12 to 15 feet but can be easily restrained to lower heights. It may become a little leggy with the base sparsely branched and with little foliage. It does, however, make a good narrow plant for screen purposes.

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In recent years the Department of Agriculture has cooperated in a plant exploration program with Longwood Gardens. This Society has enjoyed reports of these trips by John Creech to Japan, Walter H. Hodges to Australia and Fred G. Meyer to southern Europe.

The Plant Introduction Station makes every attempt to propagate these new introductions and make them available to interested and responsible agencies. Some of the seed that John Creech collected on a trip to Nepal in the fall of 1962 has appeared as plants on dissemination lists this fall. About two years after the station has sent out a plant, a questionnaire about the performance of this plant is distributed to all recipients. This information is then gathered and filed and should be available to all interested parties.

In 1961 the Society visited the Plant Introduction Garden at Glen Dale, Maryland. Other stations are located at Chico, California; Miami, Florida; Savannah, Georgia; Experiment, Georgia; Ames, Iowa; Geneva, New York and Pullman, Washington. A number of substations are scattered around the country, each containing a plant collection of material from the parent station at Glen Dale.

In 1945 the station at Ames, Iowa, initiated a project for testing woody ornamental and shelter plants in a 12-state area known as the North Central Region. This includes the area from Michigan to North Dakota and from Ohio to Kansas and Missouri. Performance records are maintained and reports are published after a plant has completed a five year record. Of a total of 153 trees and shrubs in regional trials, 55 plants have been reported on in the three reports published to date. Mr. Albert Dodge gave us a report of these trials at our annual meeting in 1962.

Every state has an agriculture experiment station, and many stations contain an area maintained by the State University Department of Horticuture. These areas vary in size and development from small collections of woody plants, used primarily for study purposes to large, well labeled collections. A few have arboretums. A few examples are as follows:

> Rutgers University maintains in the agriculture station an arboretum of 25 acres, containing plants in 400 genera and 2000 species and cultivars. These plants form a collection of 100 hedges, 50 small size trees and some taller shade trees, 65 Taxus selections, vines, Rhododendrons and Azaleas and an orchard and trials of American Holly. There are plans for a larger development of area and services.
>
> In 1948, Auburn University in Alabama began a collection of woody ornamentals in a new area that has grown to include 300 species and cultivars, and all labeled with a plastic, laminated label.

The Virginia Polytechnic Institute at Blacksburg has an arboretum of 60 acres containing 2,600 clones and about 500 labeled trees and shrubs.

On the grounds of the Ohio Agriculture Station at Wooster is the Secrest Arboretum of 75 acres. In 50 years this station has tested nearly 1300 species, varieties, hybrids and clones. This Arboretum also contains several collections under the management of the Ohio State University. Of special interest is a collection of 125 Taxus selections, that began in 1942, and a collection of 90 Flowering Crabapples.

On the campus of Michigan State University at East Lansing there is a collection of 3218 species and varieties of woody plants. In the year of 1959 there were added 273 new species and varieties in 64 genera.

The University of Wisconsin has a new research farm at Arlington, Wisconsin. In cooperation with their state nursery association they have on trial and test 91 various species and cultivars. This will be expanded.

The University of Minnesota has a new arboretum of 150 acres and recently acquired 97 additional acres. They have planted about 1400 species and cultivars from 147 genera of woody plants. In 1962 there were added 361 species and cultivars.

For thirty years the University of Kansas maintained at Manhattan and three substations a collection of 4000 trees in 180 species, plus 20 clonal varieties, 380 deciduous shrubs and 50 broadleaved evergreen shrubs. The shrub collection has been moved twice in five years for new buildings.

All of these institutions make frequent and annual reports on the performance of the plants under observation.

Additional reports can be cited of other plant collections at various state universities and to include the many that have plans for future projects. The substation at North Platte, Nebraska has started a collection of woody plants that will tolerate the arid condition of the western great plains. The University of Nebraska is discussing with their state highway department a project, "The Collection, Propagation, Culture and Evaluation of Plant Materials for Windbreaks, Snow Control, Noise Abatement, Safety and Landscaping on Highway Right-of-Ways."

And then there are the many arboretums of all sizes scattered in all regions of our country. The sum total of their woody plant collections would be enormous. Many of the arboretums that are not limited by planting space maintain an active interest in all new plants as they appear. New arboretums are being formed and others are expanding, both in acreage and number of collections. Most arboretums have some sort of publication in which their activities are reported and added to the literature. All arboretums are interested in disseminating plant material to interested parties.

A great deal of credit is due to the many nurserymen who have developed new clones through observation and selection. The most notable recent example is the improvement in shade trees. A few nurserymen have the opportunity to travel abroad and have introduced some excellent plant material. A growing number of nurseries maintain their own test and trial plots from which superior selections are frequently made.

We cannot fail to mention the many articles about noteworthy plants that appear in the American Nurseryman. The long series of papers by C. E. Lewis are very informative and the present series by Donald Wyman in sorting out the more worth while species in each genus is invaluable.

Nor can we omit the various organizations that are formed in the interest of one particular group of plants. There now are societies for Roses, Camellias, Rhododendrons, Boxwood, Holly and Magnolia. Each plant society has an active program for the promotion of its particular genus and annually contributes performance reports for the literature. The American Rose Society has a most elaborate and thoro program for screening, testing, announcing and publicizing their product. This is accomplished through a separate group known as the "All American Rose Selections Inc.". Many other valuable reports on the performance of plants have been contributed by the various state and local horticultural and garden club societies.

All of this effort is duplicated through similar agencies and groups in the country to the north, namely Canada.

The word "new" in the title as applied to woody ornamentals can have two meanings. It can mean a plant that is new to the literature or to commerce, as a hybrid, selection, clone, cultivar, etc., or it can be an old plant that becomes "new" when first tried in a new area. Plants that are brand new or only recently created by being hybrids or selections do not appear in any great quantity. During the twelve years from 1948 to 1960 when all nurserymen were requested to register any new plant with the American Association of Nurserymen's office in Washington, about 400 new plants were so recorded. This does not include Camellias. John Wister has recently listed about 90 new cultivars of lilacs that have appeared in the years 1953 to 1963. The first Plant Patent was issued on August 18, 1931 to a climbing rose called "The New Dawn," the number of patented plants to date is 2282. Excepting roses and camellias, only a small number of this large group of patented plants are woody ornamentals. Several of the earlier patents are no longer available.

In the North Central States trials conducted by the Plant Introduction Garden at Ames, Iowa, 153 different species and cultivars have been under test in their twelve state area. Of this number 37 were brand new plants within the past twenty years. While 116 forms were old in the literature but brand new to the areas where they were being tested. At the Wisconsin Research Farm at Arlington there are 91 various kinds of plants on trial. Twenty-three are new in their origin, less than twenty years old, while 68 lots are new to this area. In both test trials, plant and flower bud hardiness and tolerance to both soils and rainfall are the most important facts to determine.

A well conducted, conservative nursery in a neighboring state is very pleased to have discovered, in the near-by woodland, an ash with outstanding purple fall color. This tree is native to all parts of their state and the species is conspicuous each fall by its purple fall color. In the eyes of the nurserymen it is a new plant and will probably be marketed as such. Incidentally, the tree is White Ash, *Fraxinus americana*.

Who can say how many years are required to evaluate shade and street trees? Arnold Arboretum has reported on a few. Holden Arboretum has now begun a collection. The last Bulletin of the Morton Arboretum reported on 124 different lots that have been added to a plot begun in 1955. Of this number 29 are new plants during the past twenty years. All of these trees must go through their normal life span to be properly evaluated.

A program for evaluating woody ornamental plants could have tremendous value to the industry and the buying public. There are numerous problems involved in creating and establishing such a program, problems such as permanent organization, propagation, distribution, test areas, scoring methods and sheets, awards, publicizing results etc. This program should include the entire continent and is of such scope we cannot discuss all the implications in the few minutes allotted, or in a regional meeting of our society. At the business meeting of the society I will enter a motion for a committee to be selected to consider this topic and report back to the society at our next annual meeting.

PRESIDENT MAHLSTEDE: I would like to thank our afternoon speakers and moderators for the fine job that they have done. We will adjourn until 8:00 p.m. this evening when we will have the reports from the recorders of the round-table discussions.

(The session recessed at 5:15 p.m.)

THURSDAY EVENING SESSION

December 5, 1963

The Thursday evening session convened at 8:00 p.m. in the Crystal Room of the Sheraton-Jefferson Hotel. Summaries of the round-table discussions held Thursday morning were presented by the recorders. Tom Pinney, Jr., Evergreen Nurseries, was moderator.

MR. TOM PINNEY, JR.: I believe that this is the first time we have had a round-table discussion at a Plant Propagators' Society meeting. I know that some of you wanted to go to all three meetings. Since that was not possible, we have recorders who took notes during the meeting and now they will summarize the morning's discussions. The first report will be on storage and care of cuttings, grafts, and established nursery stock. Jack Hill will give the report.

STORAGE AND CARE OF CUTTINGS, GRAFTS, AND ESTABLISHED NURSERY STOCK

Moderator: DR. JOHN P. MAHLSTEDE
Recorder: JACK HILL

We had tremendous interest and everyone had something to contribute. We had a little difficulty keeping on the track since it seemed that we slipped out of storage and into the problem of overwintering.

One of the first subjects was the storage of hardwood cuttings. Most members reported that their hardwood cuttings were made in the October - November period and that they were stuck in April. However, a few members reported putting the cuttings out in the fall. They overwintered either covered or mounded with soil.

For storage, the medium should be moist, but not wet. The medium could be peat moss, fresh sawdust or sphagnum moss. The temperature which seemed to do the best was 34° F. In subsequent discussion it was worked out that 32° F. ± 1° F. was actually the optimum temperature.

The question of crown gall came up. It was concluded that the crown gall did not come from the medium in which the cuttings were stored, but came in with the cuttings. It was suggested that a dip to kill the bacteria could be used, but the best solution was to obtain clean stock. Somone then pointed out that really crown gall never hurt the plant — it was only the nursery inspector who was concerned.

A comment which was not directly related to the discussion, but nevertheless interesting, was that hardwood cuttings stuck on an oblique in the ground rather than straight up and down seemed to root better. Next, we moved on to the subject of softwood cuttings. Almost no one would admit that their work schedule was so poor that they had to store softwood cuttings. However, it was concluded that 32° F. seemed best.

The storage of rooted cuttings to free bench space has good possibilities. The cuttings were stored in common or controlled storage with temperature ranges of 34 - 35° F. and 28 - 32° F. Some stored their cuttings jelly roll fashion with the roots in sphagnum and polyethylene and the tops out. A storage period of 6 - 8 weeks worked out very well.

STORAGE OF POTTED MATERIAL

A number of people commented on what you might call the "edge effect" experienced in overwintering in the North. It consists of the deterioration of plants along the edges of the bed, especially on the south and the west, suggesting that it is due, not so much to the cold, but to the differential heat caused by the absorption of solar energy on the south-west side.

One suggestion which seemed to give good results was to stack the container on their sides and cover the whole pile with marsh hay. I wondered if this might lead to a problem of drying since the cans would be on their sides and it would be difficult for moisture from rain or snow to enter. A less successful attempt was the construction of a sawdust mound on the southwest side. After the first rain and freeze, the mound became a solid dam. The ground sloped in such a way that the whole area stood in water and everything was lost. The moral of that story is do not use a form of winter protection which will block natural drainage.

Next, we discussed storage of balled and burlapped material. Everyone in this room is aware of the reasons for the storage of balled and burlapped stock, the first of which would be the reduction of the acute labor problem in the spring of the year when everybody wants their stock at once. A second reason would be to reduce the amount of winter injury to the top of the plant. We have investigated this problem and have had rather indifferent results. Some years we have had good result and other years, under nearly the same conditions, we lost nearly everything in storage.

MR. TOM PINNEY, JR.: Thank you, Jack. We will have time for questions after we have heard from the other two recorders. Next, we have Dr. Fred Lanphear who will summarize the discussion on the round-table on sanitation and propagation.

SANITATION AND PROPAGATION — METHODS AND MATERIALS

Moderator: JAMES WELLS
Recorder: F. O. LANPHEAR

The round-table discussion on sanitation and propagation provided some useful and interesting information for the many that were present. As might be expected, the sanitation practices varied considerably among the propagators. One example that illustrates this was the difference in frequency of changing the rooting medium; varying from changing with every batch of cuttings to using the same medium for 20 years. In relation to the differences among propagators it was pointed out that those on the West Coast are known to be much more concerned with this problem and practice sanitation much more extensively than most propagators in the East.

The discussion centered around certain key points which I will now attempt to summarize. One of these was the use of various chemicals as disinfectants in the various propagation steps. There appeared to be considerable use of Morton Soil Drench and Pano Drench either as a drench for the rooting medium or for the cuttings themselves. Some applied these materials to the medium prior to inserting the cuttings, others applied them immediately after sticking the cuttings, and some continued to apply them on a weekly basis. Other chemicals that were mentioned for possible use as disinfectants were Chlorox and Purex. It was pointed out that for certain disease problems such as *Rhizoctonia* on Rhododendron cuttings, more specific chemicals such as oxyquinoline sulfate, sold as "Sonox," might be used.

Another topic that received considerable attention was the use of various fungicides on the cuttings prior to sticking. Rather than drenching the cuttings with the materials mentioned previously, some used Captan or Fermate with apparent success. The Captan was either mixed with the talc containing IBA or applied as a solution. The availability of certain commercial products, such as Hormo-Root, containing both the root promoting substances and fungicides was noted.

An interesting problem that was raised in relation to the use of these chemicals is "what effect does continual application of these materials to the rooting or growing medium have on plants or to the people applying them?" It was pointed out that many of these materials particularly mercury compounds, with repeated usage might attain toxic levels to plants or even humans. Roses were mentioned as being particularly sensitive to mercury. Another after-effect of chemicals was noted from spraying stock-plants of camellias with "Cygon" for scale control. Cuttings taken from the sprayed stock plants did not root as readily.

The use of chemicals was not, however, considered the only approach to sanitation. As was suggested, the use of chemicals do not substitute for good management. Practices that were considered useful by some were (1) removal of dead leaves and debris that accumulate during the rooting process, (2) general clean-up of the entire propagating house annually, and (3) mixing media on a clean concrete surface.

The importance of the environment on the diseases and their control was illustrated with the problem of basal rotting of *Taxus*. If the medium temperature was maintained between 60 to 70° F., very little basal rot was observed; however, increasing the temperature to 80 and 90° F. resulted in a much greater incidence of the basal rot. It was also noted that adequate light and proper manipulation of other environmental factors might be of definite value in preventing many disease problems.

And finally, a question of commercial importance, "to what extent do all the sanitation measures improve your chances of success in the propagation phase?" In one case, drenching junipers with Morton Soil Drench was estimated to decrease basal rotting 25 to 40%. Many believed that definite improvement would be obtained with good sanitary procedures. The statement that seems to summarize the opinion of most on this question was that the cost of precautionary sanitary measures was small in comparison to the cost of losses that could be incurred from a serious disease problem.

MR. TOM PINNEY, JR.: Thank you, Fred. Now for the final report, Wayne Lovelace will summarize the discussion on cost control in propagation

COST CONTROL IN PROPAGATION — LOWERING COSTS

Moderator: GEORGE ROSE
Recorder: WAYNE LOVELACE

Our discussion group opened by asking, "What is meant by cost control in propagation?"

Does this mean to produce smaller cuttings, grafts, or seedlings, or to crowd more cuttings into a given area, or to produce cheaper, easier to grow varieties. It could mean to use cheaper, less experienced help, or to use cheaper, more easily worked understock regardless of the quality of the resulting plants, or to increase the volume of propagation to cut the cost of the individual item and then hope that the material produced can be sold.

We concluded that cutting the cost of propagation is only a very small part of the answer to production cost control.

The following points were presented to be of prime consideration along with actual propagation costs.

1. Change in consumer demand.
2. Change in marketing procedures and outlets.

These enter into cost control much more than trying to produce a plant cheaper than your competitor.

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The following discussion proceeded concerning the change in consumer demand.

We must determine what the man on the street wants and what he will want in the next five years. We must examine ourselves and see if we have changed with our consumers. In these rapidly changing times we can no longer grow just what dad grew, or what is easy, or what we like.

There are, however, a few constants in our favor, as Martin Van Hof indicated. Our customers will always demand quality in our product. Charles Tosovsky suggested that the trend appears to be toward the small sized plant unit. He feels that a large volume of plant sales will be to the working class consumer who, now more than ever, has leisure time to spend gardening. They want a lower cost item and are willing to wait for it to grow.

Don Hartman agreed and indicated that as an industry we will have to produce on a volume basis to remain competitive. He further pointed out that this will mean a more concentrated production as a means of cost cutting.

Hank Skinner commented that the change in consumer demand has to be created by those of us selling the product. Sam Lambo agreed that we must educate the public as to what they want. He currently determines his customer demands by traveling, keeping abreast of new plant materials, working closely with landscape architects and observing current trends such as the Japanese influence. Dave Dugan commented that we should observe today's teenagers — their likes and dislikes. A short time in the future they will be our consumer.

Our second main point discussed was the change in marketing procedures and outlets.

Tom Pinney, Jr. stated that analyzing our markets largely comes down to educating ourselves through our various associations and all means available to make good decisions. He further stated that we must understand the market and just where we are going. We should then get an edge on the market. By this he meant to have various channels into different markets along the production route in case the original market no longer looks good.

Moderator Rose asked, "How can we look to a future market?"

Hank Skinner stated that prior to producing a plant much time and effort must be spent on studying previous market acceptance. His marketing procedures include previous stock records, customer acceptance on a small scale and examining whether he can produce the item cheaper than he can buy it.

Ed Davis commented that the key to profits is production control. They look to past records of plants produced and sold, along with customer trends and plant shortages combined with what other producers are doing.

The question was asked, "How many present are producing items that do not pay?" There was virtually a 100% show of hands.

The following reasons were given for producing these items.

1. There is a small customer demand.
2. They are easy to grow.
3. The grower just liked the item.

Don Hartman commented that by keeping general areas of cost accounting they have been able to eliminate some of these items.

Hans Hess stated that nurserymen will have to pool resources in given areas to promote and develop their markets and get our share of the American dollar. His remarks were echoed by Case Hoogendoorn.

Moderator Rose in closing stated that 8% of the nation's farmers produce 85% of the total farm product. The remaining 90 - 95% produce but 15% of the total production. If the current trend continues 2,000 farmers who have not kept abreast of various cost cutting procedures and current markets will go out of business in the next 10 years.

This points to the necessity of gauging our markets as a propagation and production cost.

MR. TOM PINNEY, JR.: I certainly want to thank Wayne, Fred, and Jack for the fine job they have done in summarizing the morning's round-table discussions. Are there any questions?

MR. AART VUYK: Do you notice a difference in rooting between cuttings taken from the field with normal fertilization and those grown in containers with a high level of fertilization?

MR. JACK HILL: Although we have not done a detailed, statistical study, we find that cuttings taken from plants grown in containers invariably root better than similar cuttings taken from field grown plants.

MR. AART VUYK: In regard to storing rooted cuttings, we have had good success by placing the cuttings in a heated cold frame. It has just top heat, not bottom heat. The temperature is kept at about 40° F.

MR. AL LOWENFELS: Is there any benefit from dipping hardwood cuttings in a root promoting substance before or after storage?

MR. JOHN ROLLER: You do get a stimulation, but on easy-to-root plants, you sometimes run into a problem. The roots start to come out in storage and dry out during planting or are broken off. So you have to be careful about the type of cutting you treat.

MR. JAMES WELLS: In Holland, very good results were obtained with hardwood cuttings of *Laburnum Vossi* which had been treated with a Captan-hormone dip before being stuck in the field in the fall.

MR. ARIE RADDER: Is there anyone who has any information about storage of B. and B. stock?

MR. JACK HILL: I can comment on the experience of another nursery which has had excellent results. It does not seem to matter when the plants are brought in — whether it is in fall or just before freeze up. The plants are placed in a barn and are arranged so the foliage does not touch. The balls are packed in moist shingletoe, with care that the shingletoe does not get into the foliage. During warm periods in the winter the doors are opened and the area is aired out. We have tried similar techniques and had not been successful. To emphasize the example I have given, the customers specifically ask for stored stock.

MR. TOM PINNEY, JR.: Jack, do you feel that differences in relatively humidity could explain the differencs in results?

JACK HILL: I am certain that relative humidity is important, but I feel our humidity was as high as in the successful example I described.

The session adjourned at approximately 10:15 p.m.

FRIDAY MORNING SESSION

December 6, 1963

The session convened at 9:20 a.m. in the Crystal Room, Sheraton-Jefferson Hotel. Professor J. C. McDaniel, moderator.

SPEAKER-EXHIBITOR SYMPOSIUM

MODERATOR MCDANIEL: The first speaker this morning, Dr. Jake Tinga, Virginia Polytechnic Institute, Blacksburg, Virginia is unable to be with us. Mr. John McGuire will read the paper.

HOW TO MAKE TWO DOLLAR PLANTS IN FOUR MONTHS WITH LARGE CUTTINGS

J. H. TINGA AND CHARLES HAYES, JR.
Virginia Polytechnic Institute
Blacksburg, Virginia

During the summer of 1961 and 1962 pilot experiments in the use of large cuttings were made in the mountains of Virginia. As a result of these experiments a larger project consisting of 1,000 three gallon cans were established near Norfolk, Virginia. This was to test the theory that large saleable plants could be produced in one season. If the unrooted cutting was stuck in the media in July, and if the plant could be moved to the landscape site in October, then no moving or handling would be necessary, thus decreasing labor costs.

The experiment was all under one mist system which was controlled by the balanced arm and screen wire mechanism. The mist was *on* when the screen wire weight was dry. It did not usually operate at night or in cloudy weather.

The first variable was the rooting media. There was not a significant difference between rooting results of the four following mixtures: (1) half bank sand and half German peat, (2) half bank sand and half Canadian peat (this peat was much more fine and dusty than the former), (3) half coarse Perlite and half German peat, (4) half coarse perlite and half Canadian peat.

The next variable was the plant species. Three cuttings of 24 to 36 inch length were cut from the mother plant, knife wounded by a tangent cut 3 inches long, dipped in Hormodin 1 powder and stuck into the media of one can. In other words there were three large cuttings placed in a 3 gallon can so as to appear similar to a mature plant. The problem was to establish a good root system. The plants were stuck during the month of July. Two months later, the quantity of mist was tapered off slowly for 30 days. Four months after sticking the cuttings, they were examined with the following results.

(1) *Ilex crenata rotundifolia*

200 containers: In 94 percent of the cans, media was well covered with roots filling the 3 gallon can except for the top 2 inches. New growth had begun. Six percent of the cans had smaller root balls of 4 to 6 inch diameters.

(2) *Ligustrum lucidum*

200 containers: In 92 percent of the cans, the root ball extended from side to side of the can. In six percent of the cans the root ball was from 4 to 6 inch diameter. In 2 percent of the cans, the root ball was 2 to 4 inch diameter, apparently a position effect caused by not enough mist. The Lucidum were well berried. In one quarter of the lot the berries were removed. This did not affect the rooting results.

(3) *Ilex cornuta burfordi*

200 cans: In the first group of 160 cans the root ball size was 4 to 6 inches in 82 percent, 2 to 4 inches in 13 percent and 0 to 2 inches in 5 percent. These were heavily berried branches when they were stuck. There was quite a variation in berry drop in the group. Some dropped 75% of the fruit and some

Figure 1. Four month old Burford Holly with plenty of red berries.

dropped only 25%. But all cans had fruit on in October. A factor in increasing the sales appeal was the presence of red berries in October.

The last group of 40 cans was from a mother block that had been exposed to salt spray mist. A big storm blew salt spray 5 miles inland from the ocean. Although the branches looked acceptable at the time large cuttings were made, only 3 percent of them made acceptable root growth. This highlights that the prior condition of the foliage is very important in the subsequent rooting.

(4) *Pyracantha coccinea graberi*

200 cans: In the first group of 160 three-gallon cans, the root system was "heavy" on 36 inch cuttings in 42 percent of the cases. As you know, the Pyracantha does not make much of a root ball. In 26 percent of the cans, there was "medium" root system, in 13 percent there was a "light" root system. (Six major roots of 6 inches long was a light root system). In 19% there was little or no rooting response. The previous year there had been 87% heavy rooting from a different mother block. We examined the mother block of these cuttings and found that there was a large variation in the vigor of the individual mother plants. This probably was reflected in the rooting response of these 36 inch cuttings.

(5) The final group of large cuttings to be reported on was: *Juniperus chinensis pfitzeriana*, 24″; *Mahonia aquifolium*, 24″; *Abies Cunninghamia lanceolota*, 18″; *Azalea ledifolia alba*, 15″; and *Forsythia varigata*, 24″.

Some cuttings in each group rooted and produced a top growth that was outstanding in each case, showing that it was possible and practical, but the group did not root uniformly well. The reason for this will be investigated next year.

Three plant species that failed were *Raphiolepsis, Pittosporum* and *Juniperus horizontalis*.

Summary:

(1) Large cuttings rooted well for several species. The vigor of the wood was much more important than the age of the wood. Some 3 year old *Pyracantha* and Holly wood rooted easily.

(2) There was no difference in the media of the three gallon containers, but there was a difference in weight of the finished plant. Peat and sand weighed 30.5 pounds. Peat and Perlite weighed 19.1 pounds.

(3) It will take a large mother block of well grown plants to supply the "truck load of brush" that went into this experiment. We are drawing the preliminary conclusion that it is easier to grow quality plant tissue on a vigorous mother plant than on a newly rooted cutting. It is possible to grow a large root system on these plants in one season.

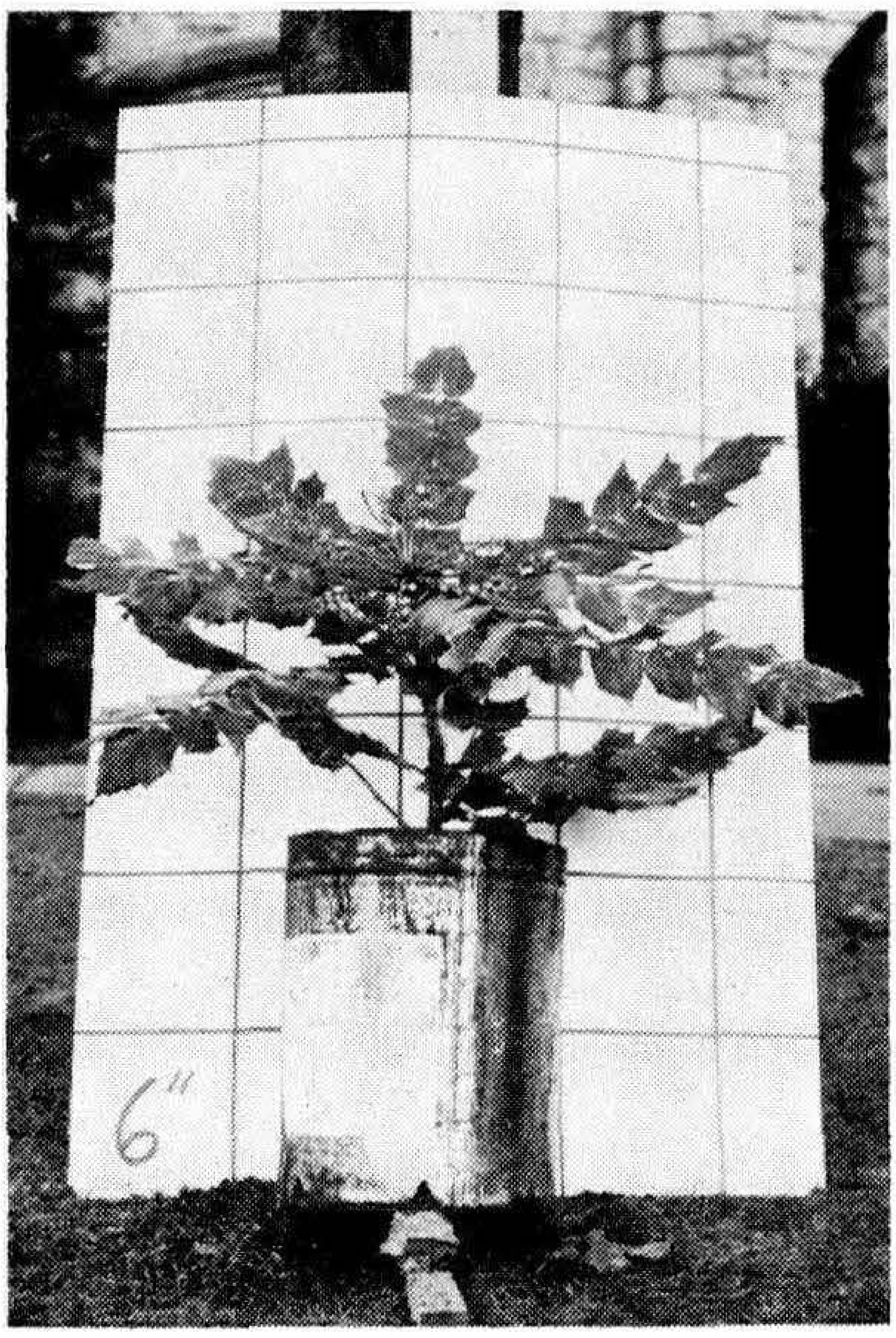

Figure 2. Four month old *Mahonia* with large flower cluster (single cutting — roots filled the can.).

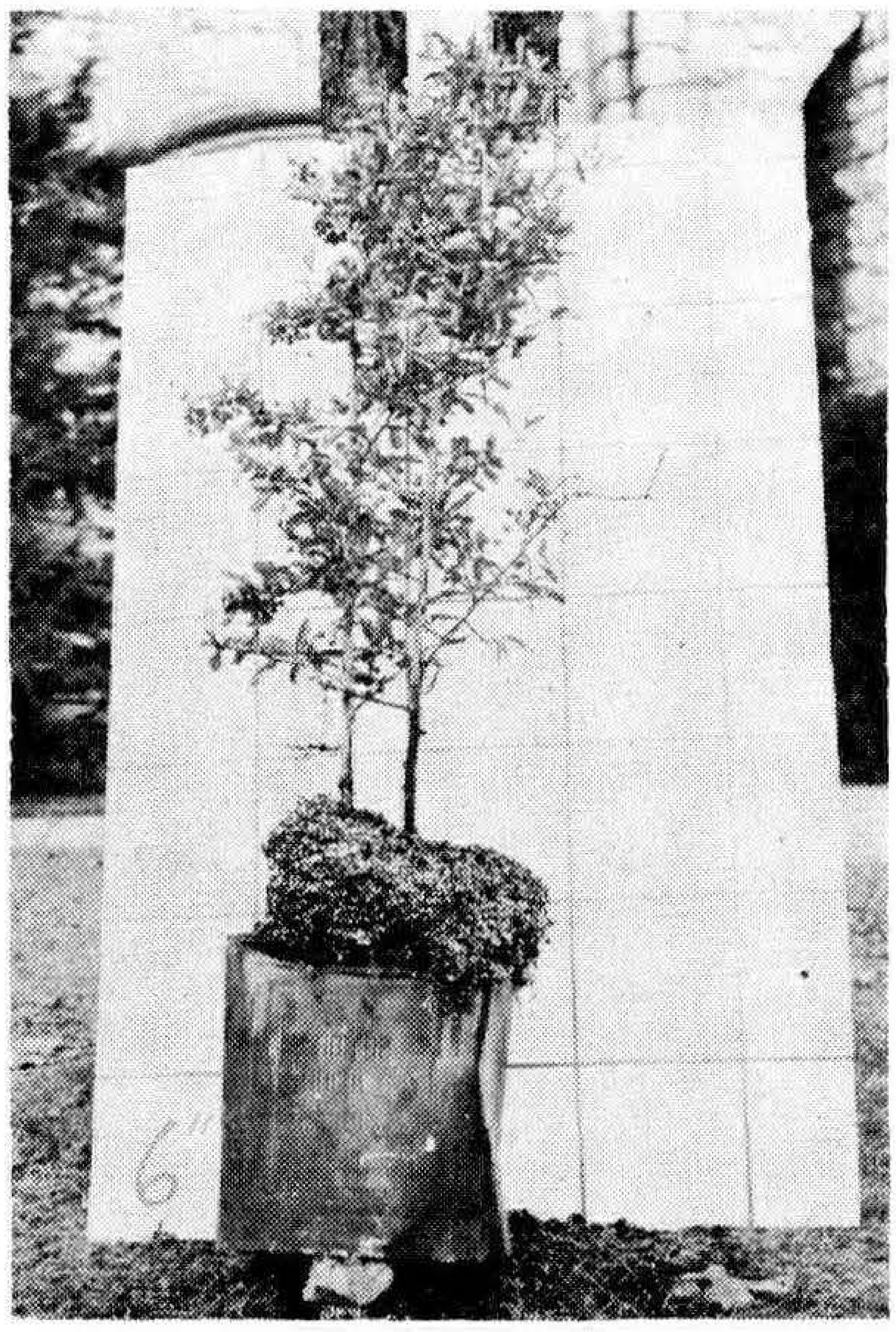

Figure 3. Four month old *Pyracantha* with fruit and good root ball on inverted can.

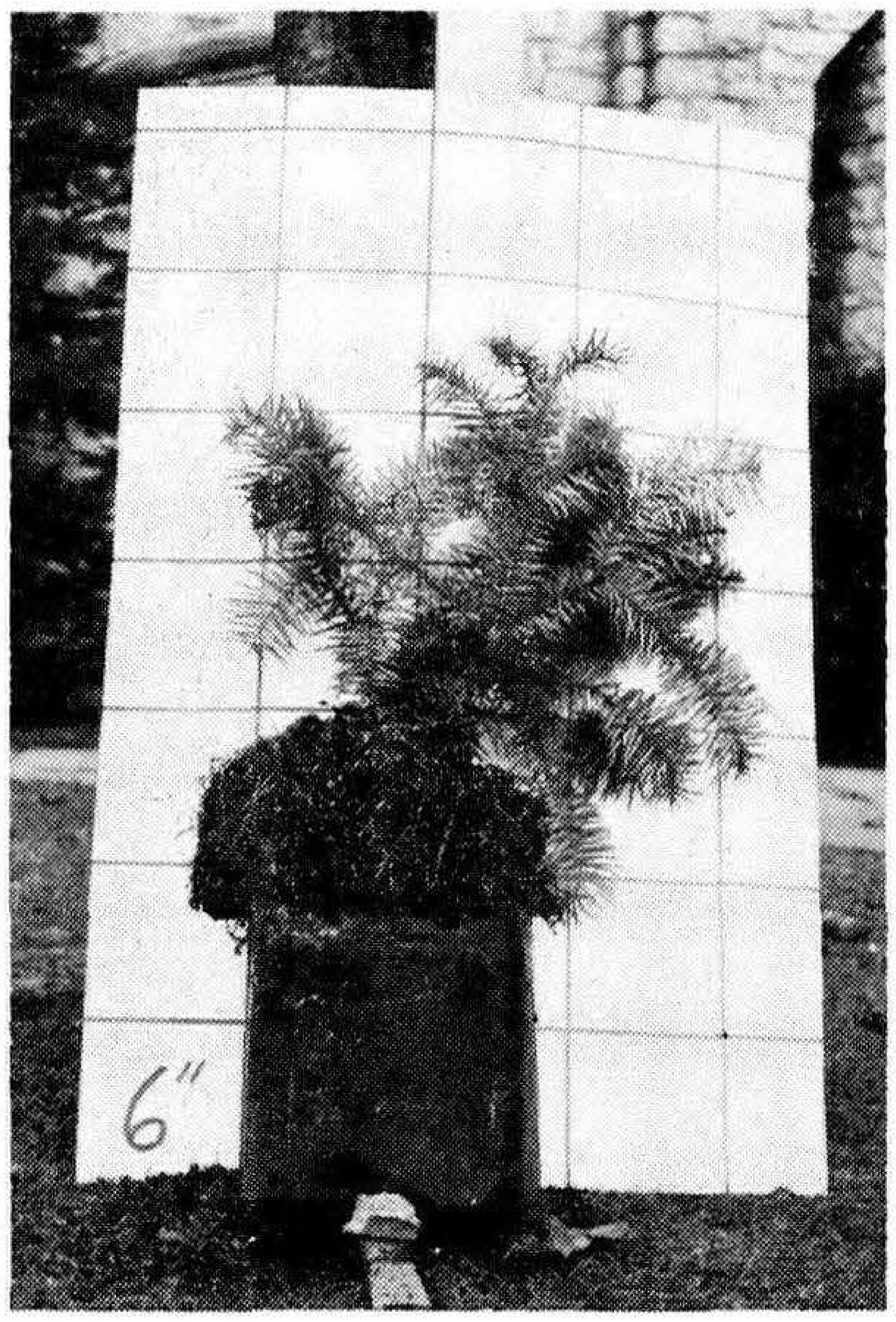

Figure 4. Four month old *Abies Cunninghamia*, Chinese Fir (single cutting).

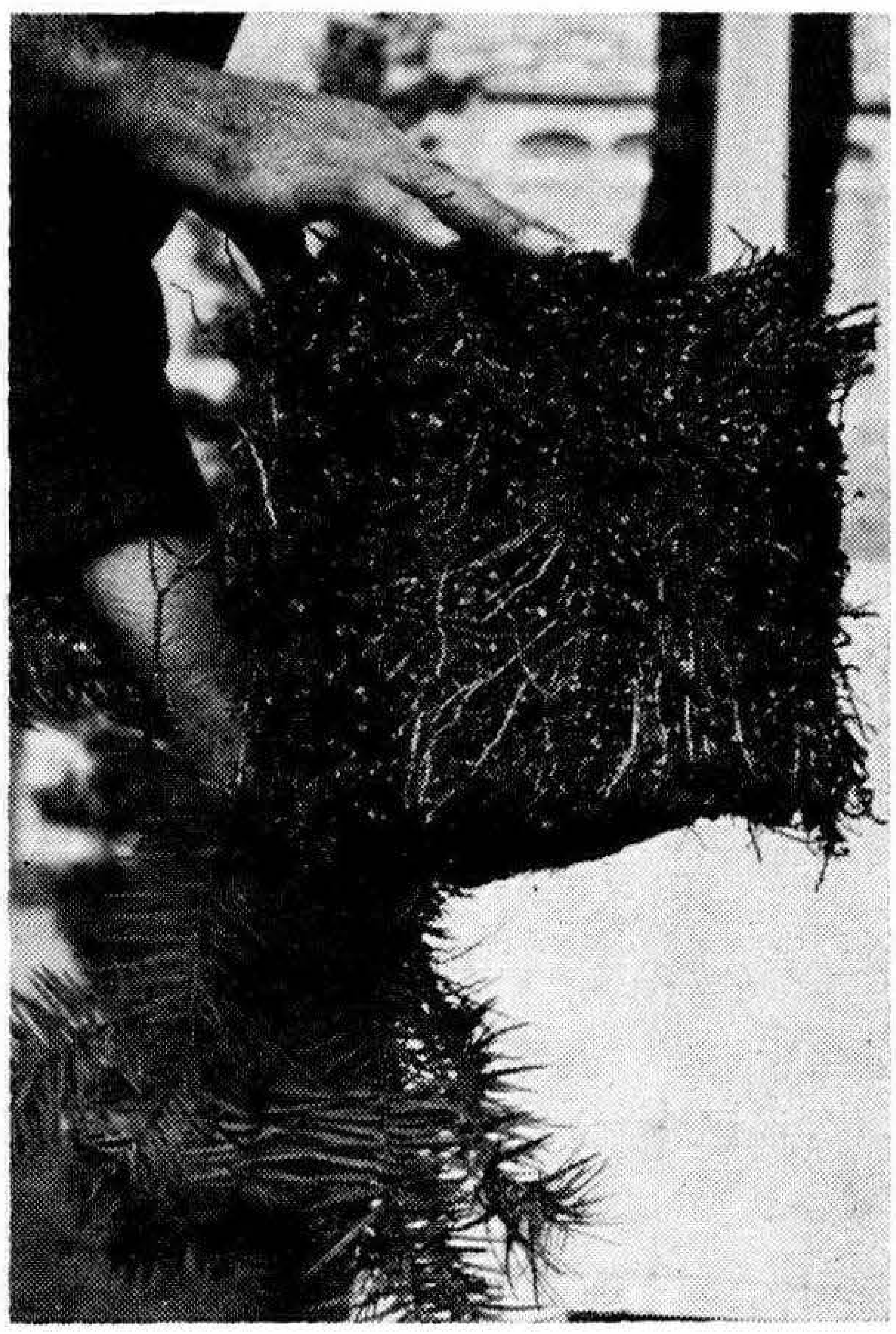

Figure 5. Four month old *Abies Cunninghamia* showing root system on the bottom of the can.

(4) This project is aimed at net profit for the grower. The total labor bill for the entire experimental set up including building 200 feet of mist line was 181 man hours With no handling and no transplanting ,this method of growing landscape sized plants in one season has good possibilities.

MODERATOR MCDANIEL: Thank you very much, Mr. McGuire. Our next speaker is Mr. Paul Bosley, Sr., Bosley Nurseries, Inc., Mentor, Ohio.

WHY BUDDING IS SUPERIOR TO GRAFTING AND POINTS ON WHICH SO MANY FAIL

PAUL R. BOSLEY, SR.
Bosley Nurseries, Inc.
Mentor, Ohio

Budding is usually done in the open field and requires no expensive physical lay-out, such as greenhouses, heating plants and grafting cases.

Budding requires a minimum amount of handling and labor.

Budding takes advantage of the natural cycle of rest and growth that takes place in a plant during a year.

Budding produces the maximum size plant in the minimum amount of time. And a true union of tissues takes place during the first growing season.

I have found much to my amazement that different practices are employed in different parts of the country, as for example along the Eastern Seaboard and up around Long Island most nurserymen practice grafting and they don't have the technique or the help to establish a budding practice. In Lake County everybody practices the budding methods and budding help is generally available.

There was a time when young boys 10 and 12 years old were winders behind budders and before they had finished high school they were doig the budding and some of these same people today do budding on the side, or do contract budding. When contract budders are employed you usually can get a guarantee of a 90% "take" on the buds or the budder will come back and re-do his job. Under a set-up like this budding certainly has every advantage.

Most growers who have been grafting are not prepared to think in terms of budding and do not anticipate the entire program and in a change-over very often are discouraged with their results the first few years.

In most cases one should select a vigorous species rootstock or understock as closely related to the item that is to be budded as is possible.

Many plants have a so-called crown which is the dividing line between root tissue and top growth and as rule, there are

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In most cases one should select a vigorous species rootstock or understock as closely related to the item that is to be budded as is possible.

Many plants have a so-called crown which is the dividing line between root tissue and top growth and as rule, there are very few adventitious eyes below this natural crown. Such plants when used as an understock should be planted two to three inches above the normal ground level and then the soil should be banked up around the plant, so that it has the feeling that it is properly planted.

Budding usually takes place in the summer when the understock is growing vigorously and at that time the soil is brought down to ground level, but the person that is unhilling the plants should not be more than 5 or 10 minutes ahead of the man that is going to do the budding, otherwise the bark is likely to what we term "tighten down" and be much more difficult to handle. Budding is also usually timed according to the condition of the budwood. It should be quite firm and mature and yet not too mature but that the woody part underneath each eye can be removed cleanly, with a glossy cambium and certainly not with a hard stringy effect. There are some budders who can cut an exceptionally thin bud where the ratio of healing tissue is very great and that there is little of woody tissue left. However, 9 budders out of 10, and certainly the beginner should practice cutting a more generous size bud and removing the woody part beneath the eye. Some plants have a characteristic of holding a little woody sliver underneath the eye and this must be removed without scratching the cambium tissue. This is very important.

A budder usually holds his knife very firmly and with an extended forefinger as a guide along the understock does the various cutting and opening operations. The cross cut is usually made first, both in a slanting and in a downward direction and then the uppercut is made with a definite firm stroke until the cross-cut is reached and then at this point there is a critical motion to be observed. With the forefinger as a guide against the understock the hand is usually rotated ever so slightly to the side and the knife is used to open the bark. While this is taking place the other hand slides the bud down into position. Just ahead of cutting the bud, the budder usually cuts the leaf petiole rather close to the bud and with the back of his knife presses downward and against this leaf petiole to help shove the bud into a snug position underneath the bark of the understock.

Just at this point many budders lose their bud stands. It is absolutely necessary that, as the bark of the understock is opened that the knife *does not* touch or scrape the wood of the understock; if it touches even in the slightest degree then the bud that is inserted and left over that portion is sure to die, and if a budder realizes through feel or sensing, that he has scraped the bark, then usually he opens a channel further down and shoves the eye way beyond this point and can save the bud that he has inserted. I repeat again, that an understock that is scraped results very definitely in a dead eye or bud.

The operation by the budder must be done with hands that are immaculately clean and the budder should usually be preceded by what is known as a "cleaner." The cleaner should not only have leveled down the hill of dirt but should have thoroughly wiped the understock because a particle of dirt minute enough to hurt one's eye will result in a dead bud if it rattles down behind it. The bark of the understock should almost be polished before the budder starts.

Budding is usually done on the side of the understock that faces the prevailing spring winds. When the growing buds are soft and tender, a lashing spring wind can result in the almost complete destruction of a budded field on certain varieties, particularly if they are budded on the wrong side of the stock. Budding from the direction from which the wind comes allows the remaining understock to be a shoulder against which they can have some leverage against the wind.

Practically all budding is now done with some sort of a rubber budding or tying strip and here again is a place where you can gain some percentages. A number of years ago we experimented with winding the cuts solidly with a rubber budding strip and then we got to thinking how hot rubber boots were to wear in the middle of the summer and we experimented with making a wind of the band so that only about 50% of the whole of the area was covered and we found that by keeping definite records on budding that was done on the same variety and the same day that we increased our stands at least 10% by this open winding method.

Once a bud is properly set and has been tied in properly with a rubber budding strip it will have developed a suction so tight in 10 or 15 minutes that it is very difficult to remove should one wish to make some sort of a change.

Results are usually definitely established in the first 8 days, however, the budding strips are always left on for 21 days as a standard time to insure proper healing. Care should be used in cutting the rubber budding strips because in the event that you have to re-do any of your budding it can be accomplished on the opposite side of the understock and rebudding can be done immediately. In the case of some plants you could make three or four attempts to re-bud in a season and still get results.

At this point I would like to discuss a very great pitfall where even the professional budders sometimes fail and that is, the wet season where the rains are copious and the plants don't seem to stop growing. Under those conditions the sap is what we call watery and the tendency is to what we refer to as "drown out the buds." Sometimes the understock will seem to literally "pop" open and just be full of a copious amount of sap, and this is truly a dangerous condition.

The procedure at this point is to do budding in the normal way, but then immediately after the buds have been set, to reduce the top of the understock approximately 50% and this will take care of this situation very definitely.

Some nurserymen practice the winter hilling of budded plants or bringing soil up over the new buds but this isn't always considered desirable or necessary.

And now we come to the crucial point for maximum success and that is the time when the understock has to be headed back or cut off in the spring. In the latitude of Lake County which is generally in the Cleveland area, this time is very definitely the 15th of March. For those living farther South, say in the St Louis area, the time would be around the first of March. At this time the deep frost is always out of the ground and there is a slow stirring in nature. This is the time when the understock needs to be cut back to within approximately a quarter of an inch of the upper-cut where the bud has been placed and after this is done a slow healing takes place on the understock. Then when the tremendous surge of sap comes and the pressure to grow develops, the one bud will take over the whole life of the plant in place of the upper part of the understock that was there previously. When I was a very young and green nurseryman I had some roses that I cut back, some on the proper date, some a week later and some as much as four weeks later. And the results were dramatically like stair steps so that on the cutting that had been done a month too late, the results were so poor that the plants were never harvested.

During the flush of the spring season the growth can be fantastically vigorous, and in the case of some varieties of plants it might be advisable to stake and tie them to take care of possible wind damage. I have noted measured growth of between two and three inches in one 24 hour period.

Lilacs when budded on privet, and this point I will gladly discuss with you, will make heavy and bushy and budded two to three and three to four foot plants in two growing seasons. Dogwoods will make three to four and four to five foot heavily headed plants in two growing seasons. I cite these two plants as examples of what the results are from budding because these are two plants that are very often grafted or grown "own root" in the East or other parts of the country. Some varieties of plants are sometimes budded in order to take advantage of that surge of spring growth and develop a nice straight stem and sometimes the stem is again re-budded in order to develop a head, as for example in the tree rose or tree euonymus.

It is a well known fact that when grafting is done, there is never a true layer of connecting tissue built between the understock and the scion until the second and third year. As a result grafted plants get off to a very slow start on this basis alone. Sometimes however, due to the physical structure of certain plants it is impractical to bud them, as for example the blue spruce would be very difficult to bud, but wherever it is possible, budding has a distinct advantage over grafting.

MODERATOR MCDANIEL: Thank you very much, Mr. Bosley. Our next speaker will be Roy Nordine from the Morton Arboretum, Lisle, Illinois.

A FEW DWARF SHRUBS

Roy M. Nordine
The Morton Arboretum
Lisle, Illinois

Acer Campestre nanum Lodd., also called *A. campestre globosum de Vos* and *A. campestre compactum* Schw.

A very dense, globular, slow growing form of the Common European Hedge Maple. Scions were obtained from Arnold Arboretum in 1950 and grafted onto *Acer campestre* during the winter and grown in a grafting case. These plants are now 3 feet high and wide. The plants on the slide were grafted in the winter of 1954 and now measure 2½ feet high and 2 feet wide.

Acer Ginnala Durand Dwarf

In 1954 a large witches broom was found on an old *Acer Ginnala* in Durand Eastman Park, Rochester, New York. In 1956 we made a few grafts on *Acer Ginnala* and grew them in a grafting case. What you see is now a plant 3 feet high and 5 feet wide. Growth when small is short and slow but increases with age. This year's growth was 9-12 inches. Anyone can speculate about the ultimate size of this round shrub-like plant. The same brilliant fall colors of orange, scarlet and purple appear in this cultivar.

Berberis thunbergii aureo-marginata, Schneider

Similar in growth habits to the type except somewhat slower, the slide shows a plant grown from a summer cutting in 1957. Six years later our plant is 3 feet high and 4 feet wide. Distinguished by three colors of foliage, green, yellow and pink, these colors become brighter during the fall. A close-up slide of the foliage will also reveal pink stems.

Berberis thunbergii Crimson Pygmy

First named and described as *B. thunbergii atropurpurea nana* G. van Eck. It has also been listed and sold as "Little Favorite." This plant rose to popularity very quickly after its introduction in the early 1950's. Plants retain their uniform compactness of growth, excellent red color that becomes more intense in the fall. The twelve year old plants in our slide are now 2 feet high and 5 feet wide.

Euonymus europaea nana (Loud) Beissner, Dwarf European Spindle-Tree

Our slide shows a plant grown as a summer cutting in 1955. Plants grow quickly, they are now 2½ feet high and 2 feet wide. Branches are upright, growth is dense, indicating possibilities for a good hedge or accent plant. More tender than the type species, damage occurs only during winters with below our normal temperatures. Flowers and fruit have never been noted on our plants.

Forsythia intermedia Mertensiana, Mertens & Nuss.

A new Forsythia that originated in Switzerland about 1950.

Our plants from a hardwood cutting in 1960 show a dwarf and spreading habit. The plant you see is 2 feet high and 4 feet wide. The ultimate height is unknown but it has good form when young for a dwarf plant. It blooms with light yellow flowers.

Forsythia virdissima Bronxensis Everett

This plant originated at the New York Botanical Garden in 1939. The ten year old plants on the screen show a dwarf, flat topped plant 18 inches high and two feet wide. It also has the distinction of a dwarf Forsythia that blooms satisfactorily. We have found it to be more flower bud hardy than many of the other Forsythias. There are reports that this cultivar does not root along the stems, as the other dwarf Forsythias do, therefore, it should retain its form and shape and remain within the planting area.

Genista tinctoria L., Dyers Greenweed

A plant native to much of Europe and Western Asia, and naturalized in parts of our eastern states, we have a clone that came to us from a nearby garden. Neat and attractive low rounded shrubs, 2 feet high and 3 - 4 feet wide, and annually covered with a mass of yellow flowers in early June. It has proved hardy except in our most severe winters. Genistas are adaptable to poor soil or sand, gravel and drier sites. This shrub is easily produced from summer cuttings.

Ligustrum obtusifolium Regelianum (Koehne) Rehd., Regel Privet

Plants purchased in 1955 are now 4½ feet high and 6 feet wide. Attention is directed to this plant because some growers are producing it from seed with the unfortunate result of losing the true form and shape. Always wider than high and distinct with horizontal slender branches. Annual clusters of small, persistent blue berries, and a shrub tolerant of shade and soils. The true shrub is now somewhat difficult to find.

Loncera tatarica nana (Alphand) Rehd.

A dwarf form of Tatarian Honeysuckle. The slide shows a plant started by a hardwood cutting in the spring of 1958. Seven years later it is now 5 feet high and 4 feet wide. The annual growth is 9-12 inches. It blooms well in the spring with small pink flowers, and bears the usual heavy crop of fruit Height at maturity would be about half that of the type species.

Lonicera xylosteum nana, Dwarf European Fly Honeysuckle

This plant went unnoticed in our collection until planted into a well drained, sloping area filled with humus. Five year old plants from hardwood cuttings have rapidly become 3 feet high and 6 feet wide. Rather flat-topped and densely branched from the ground, with soft grey-green leaves that remain on the plant until late fall. Our plants have not bloomed, but the flowers should be pale yellow, followed by dark red berries.

Potentilla fruticosa L., Cinquefoil

Although this species has long been known and cultivated, it is only in recent years that it has received the popularity it deserves. The species occurs throughout the Northern Hemisphere and is very variable. Many varieties and cultivars are known. A few are shown, namely: Katherine Dykes and Gold Drop and a slide of the collection showing the color range from white through all shades of yellow. Full sun is required, but they tolerate a wide range of soils and dry conditions and most of them bloom from June to October.

Ribes alpinum pumilum (Lindl.) Rehd., Dwarf Alpine Currant

Smaller in every part from the type species, and also different in growth habit. Branches remain stiff and the bush rounded and mound-like, and never opening up as do old Alpine Currants. The early spring blooms become small, bright red fruit that is quickly gathered by the robins. The plants you see were grown by summer cuttings in 1943. Plants are now 3 feet high and 4 feet wide. This cultivar has been tested and is immune to the White Pine Blister Rust.

Rosa multiflora nana

There is no authority for this name nor does it appear in the literature. I found a hedge of material by this name at Breeze Hill, the home of J. Horace McFarland, Harrisburg, Pennsylvania, in the fall of 1955. The original plants came from the now defunct Gardens Nursery, Osage, Iowa. Seedlings vary in growth, some grow rapidly and need to be rogued out. What you see are 8 year old plants in bloom and fruit on October 15, 3½ feet high and 3 feet wide. It may have potential as an ornamental, informal hedge, understock or shelter plant.

Viburnum opulus compactum, Compact European Cranberry-Bush

Here we have a plant that has all the superior qualities necessary to make an excellent dwarf shrub. Propagation is very easy from summer cuttings. Growth is rapid, and flowering and bright red fruit occur at an early age. A fine rounded shrub that will become 5 feet high and never leggy. The plants in the slide are 3 feet high and 3½ feet wide from 1954 summer cuttings.

MODERATOR MCDANIEL: Thank you, Roy, for a very interesting and informative talk. Our next subject will be cutting propagation of *Eucommia* by Dr. Jack Gartner. Dr. Marvin Carbonneau will read the paper.

PROPAGATION OF EUCOMMIA ULMOIDES

J. B. GARTNER
University of Illinois
Urbana, Illinois

Eucommia ulmoides is a tree obtaining a final height of about 60 feet with wide spreading branches and it has been suggested as replacement of the elm. It is a very nice tree with very glossy green leaves and serrated, and shaped much like those of the elm. It is more attractive than the elm and is apparently very disease resistant. This tree is a native of central China and was introduced into the United States by the U.S.D.A. several years ago. It is dioecious (having male and female flowers on different trees) which makes it a very clean tree without any fruit. The fruit is similar to the elm being a compressed winged nutlet with the flowers being very inconspicuous. A mature tree approximately fifty years old exists on the University of Illinois campus and has brought much interest since the loss of elms. Very few nurserymen carry this tree, possibly because of its difficulty to root. There are a few mature specimens throughout the country, but these are from the original introduction from the U.S.D.A.

In the summer of 1956, Dr. J. R. Kamp and H. F. Wilkins made studies on the proper time of propagation and found that the *Eucommia ulmoides* rooted only after the new growth first reached maturity in late May or early June and propagation was impossible the other seasons of the year.

In their trials, they used Hormodin Nos. 1, 2 and 3 along with Chloromone and a new rooting compound, Geigy 416. Cuttings were taken on June 13 and placed under intermittent mist propagation in the greenhouse with five replications. The rooting media used was a coarse river sand. Records were taken on September 29. Half the cuttings were wounded and the other half unwounded and the records indicate that there was very little difference between wounded and unwounded cuttings and without rooting aids only three to four percent rooted. The only rooting compound that gave any increase over the control was Chloromone where 57 percent rooting was obtained.

In 1963, it was decided to repeat this work using various medias and only Hormodin No. 3 and Chloromone were used as rooting aids and the following medias were used: Sand, 50% sand and 50% peat by volume, 50% perlite and 50% peat by volume, peat, vermiculite, 50% calcined clay and 50% peat by volume. Calcined clay was the coarse grade being one-fourth inch in size which is a new material produced by Wyandotte Chemical Company and basically is an expanded clay. Again. cuttings were taken on May 29th when the new growth reached maturity and records were taken on September 18th. As recorded by Kamp and Wilkins, rooting was less than 5% with no treatment or when Hormodin No. 3 was used, except in the plots containing the coarse calcined clay and peat mixture where 50%

rooting was obtained. Fifty percent rooting was obtained in all other medias where Chloromone was used except in straight peat, rooting was reduced considerably even when Chloromone was used as a rooting aid. Where coarse calcined clay was used, rooting was increased when treated with Hormodin No. 3, but not significantly greater than where Chloromone was used. In addition to percent rooted, cuttings in calcined clay and peat had a heavier root system, being much thicker and coarser than in other medias. The cuttings retained their foliage longer and were much greener in this media. The leaves of the cuttings in the other medias had a tendency to turn chlorotic and drop off. The possible factors to attribute the superiority of the calcined clay and peat mixture is that this mixture had better drainage and aeration than the other medias used in these experiments. As indicated by Kamp and Wilkins, rooting percentages were decreased significantly on cuttings taken at later dates after the wood matured.

MODERATOR MCDANIEL: Thank you very much, Mr. Carbonneau. Next, we have a very interesting paper by Mr. Al Fordham, Arnold Arboretum, Jamaica Plain, Massachusetts.

AN UNUSUAL WITCHES'-BROOM ON PINUS STROBUS

ALFRED J. FORDHAM
Arnold Arboretum
Jamica Plain, Massachusetts

This series of slides depicts a witches' - broom development on *Pinus strobus,* located in the Berkshire Hills of western Massachusetts. It is of unusual interest for although witches'-brooms seldom produce flowers or fruits, this one bears cones containing viable seeds which have given rise to numerous dwarf plants. What appears to be two trees is actually one that divides into two parts four feet above ground and the broom comprises the entire crown of one leader. It is about ten feet tall by ten feet wide and is borne on a tree approximately eighty feet high.

A second view shows the site and gives some idea of its immediate surroundings. In the foreground, with the broom-bearing tree situated at its edge, is a fifty yard wide clearance cut through the woods to accommodate high-tension electric lines. As a result of this unnatural opening in the woods, seeds shed from the broom had a better chance of developing into plants than would be the case in natural woodland where any abnormal or slow-growing subject would be at a serious competitive disadvantage.

Herbarium specimens collected bore only female conelets and this appears to be the sex of the entire formation. Its growth is clean and apparently free from the usual witches'-broom rooting was obtained. Fifty percent rooting was obtained in all other medias where Chloromone was used except in straight peat, rooting was reduced considerably even when Chloromone was used as a rooting aid. Where coarse calcined clay was used, rooting was increased when treated with Hormodin No. 3, but not significantly greater than where Chloromone was used. In addition to percent rooted, cuttings in calcined clay and peat had a heavier root system, being much thicker and coarser than in other medias. The cuttings retained their foliage longer and were much greener in this media. The leaves of the cuttings in the other medias had a tendency to turn chlorotic and drop off. The possible factors to attribute the superiority of the calcined clay and peat mixture is that this mixture had better drainage and aeration than the other medias used in these experiments. As indicated by Kamp and Wilkins, rooting percentages were decreased significantly on cuttings taken at later dates after the wood matured.

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Herbarium specimens collected bore only female conelets and this appears to be the sex of the entire formation. Its growth is clean and apparently free from the usual witches'-broom causitive agents thereby making it reasonable to suppose it originated as a bud sport.

Twig and cone specimens from the broom, compared with those of normal white pine, show its small cone and growth characteristics.

Cones from the broom compared with normal white pine cones show the diversity of subnormal sizes that have occurred. The upper row taken from a normal tree measured from four and three-quarters to five and one-half inches in length, while those produced on the witches'-broom varied from one and three-quarters to three and five-eighths inches with most being less than two and one-half inches long. Normal white pine cones have five clearly defined sets of spirally arranged cone-scales fixed to a central axis. Though not as clearly defined in some cases, this same cone-scale arrangement persisted in the witches'-broom cones. However, the number of scales present varied enormously. Scales on twenty-five witches'-broom cones were counted and the number ranged from a low of twenty to a high of fifty while scales of the normal cones ran between sixty-eight and eighty. There was no relationship between cone length and scale number as the shortest cone, one and three-quarter inches, had twenty-five scales, whereas the longest cone, three and five-eighths inches, had only twenty-one scales. However, seed size varied with the small cones having proportionately small seeds.

Through the years over two-hundred and fifty dwarf pines such as this one have arisen in the vicinity of the broom-bearing pine, some as far distant as one-quarter of a mile.

This professional plant collector, who wishes to remain anonymous, discovered the witches'-broom and the abnormal seedlings in October of 1962. He holds its location in great secrecy and showed it to me only after exacting a promise that I would never reveal its whereabouts to anyone. Last autumn he collected about one-hundred dwarf seedlings from the area and carried them to a nearby farm where he started a small nursery.

Two closer views show the assortment of dwarf forms which are present. Some bear leaves about normal in size while others have leaves less than one inch long. A number have started to assume shapes similar to that of *Pinus strobus umbraculifera.*

The method of maintaining the line clearance in past years was to have a crew pass through and cut out unwanted growth. Fortunately, the pine seedlings were left undisturbed because of their small size. This year, however, the power company decided to treat the clearance with an application of brush-killer.

In early September the discoverer, on realizing that any remaining plants were in jeopardy, searched the area carefully and gathered about one hundred and fifty more dwarf seedlings. They were carried to a location near a brook where water could be provided during the drought which prevailed at that time. Again the wide range of variation can be seen in these plants which are distinctly abnormal.

This series of slides has illustrated one method by which dwarf conifers originate spontaneously.

MODERATOR MCDANIEL: Thank you very much, Al. We will now take time to have questions on the papers you have just heard.

MR. VINCENT BAILEY: I would like to ask Mr. Bosley if he has used any other ties in addition to rubber strips in his budding operation?

MR. BOSLEY: The answer is no.

MR. CASE HOOGENDOORN: You say you must remove the wood from the bud. How do you bud cherries, and mountain ash? When you take the wood out you also take the heart out of the eye.

MR. BOSLEY: I said nine out of ten budders should take the wood out. It takes a good budder to use a wood bud. We have budded cherries and we have taken the wood out and have had no trouble.

MR. HOOGENDOORN: Yes, but when you take the wood out you also take the heart out. What is going to sustain it?

MR. BOSLEY: Are you referring to that little point that goes into the eye?

MR. HOOGENDOORN: Yes.

MR. BOSLEY: Removing it does not seem to have caused any problems in our area. Our biggest problem is to get good enough budders who can cut thin enough buds so the ratio of healing tissue is great enough to cause healing to take place.

VOICE: I might say that in Michigan all cherries are budded with the wood in. When we tried to bud with the wood out we have had failure. We usually can not bud until about August 25th when the buds are mature.

MODERATOR MCDANIEL: We have had somewhat similar experience with cherry and pear at the University of Illinois. We use the buds with the wood.

MR. BOSLEY: I want to mention that our experience with cherry had been with the flowering cherry and not that which is grown for fruit.

MODERATOR MCDANIEL: We will now return to the presentation of papers.

SECURING SEED PRODUCTION IN MAGNOLIA ACUMINATA AND M. CORDATA

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The cucumber tree, *Magnolia acuminata* L., ranges from the north shore of Lake Erie in Ontario to Louisiana and Georgia, attaining 90 feet in the Great Smoky Mountains. It is the largest growing deciduous magnolia in America, probably second to *M. grandiflora* as a timber source, and one of the hardiest magnolias in the world, succeeding in northern Europe up to southern Norway. It has sometimes been used as an understock for grafting other magnolias, but in recent decades has lost favor particularly to *M. Kobus,* whose seeds seem more readily available from trees in cultivation. With the rise of mist propagation in recent years, relatively few of the deciduous Asian Magnolias now are grafted. *M. acuminata* understocks may still offer the most feasible means of multiplying select clones of the closely related but smaller *M. cordata,* sometimes regarded as merely a variety of *acuminata.* (The Chinese *M. liliflora* is more distantly related, and through it, *M. Soulangiana.*)

Cultivars of *M. acuminata,* itself, have seldom been propagated. A variegated leaf form has been grafted occasionally, but as with so many variegated forms in broad leaf woody plants, the normal green leaf tends to take over. Varieties described by botanists include one, var. *ludoviciana* Sargent, from West Feliciana Parish, Louisiana with broader leaves and larger flowers (3½ - 4″ long, compared to the usual 2½ - 3″ petals.) Ashe described a more pubescent variety from Alabama. Forms with all yellow petals (forma *aurea* Hardin) have been described, and one or more of them now have been grafted a little. In the usual *M. acuminata,* however, the green to greenish yellow flowers that appear after the leaves are not nearly as showy as those of the earlier flowering Asian kinds, nor do they have the fragrance of the later, white-flowered Sweet Bays (*M. virginana L.* and *M. australis* Ashe) and Southern magnolia (*M. grandiflora L.*) It is as a hardy, relatively pest-free, large growing shade tree with gray branches that *M. acuminata* now has its principal landscape use.

It would rate higher as a tree with decorative fruits in late summer, if the August - September maturing dark red gynoecia (or cones) were more consistently or abundantly retained. I believe we now have the knowledge and materials to make this improvement, and also to obtain worthwhile seed crops from cucumber trees.

In cultivation, at least in a wide area of the Midwest, in Tennessee, Alabama and southwest Virginia and probably elsewhere if *M. acuminata* is planted as a single specimen, the trees usually have appeared to be highly sterile. They flower abundantly, but by mid-August, year after year, all or nearly all their gynoecia (cones) have failed to develop any seeds, and have dropped off without becoming showy. Occasionally we do see a tree with some gynoecia in which one seed or more have developed. It was surprising to me, therefore, after watching this sequence on several trees in and near Champaign-Urbana for ten years, to see an exceptional one, two or three years ago with a heavy crop of seeds for its size, these developing throughout the flowering branches of the tree. After 90 days of stratification, the seeds produced thrifty seedlings. Why should the American native cucumber tree, growing thriftily in good soil, and flowering abundantly after the spring frost season, produce so few seeds on trees in Central Illinois, Indiana and eastern Iowa, where other native American species like *M. tripetala, M. virginiana* and *M. grandiflora* (when it was to free flowering stage) had good seed crops, and where even the exotic hybrid *M. Soulangiana* (presumably partially sterile because of its unbalanced chromosomes) had fair seed crops in most years? What was the particular weakness of *M. acuminata,* or its weak link in regard to setting seed and how had this one particularly fruitful tree overcome it?

I applied a little detective work which is not yet completed, but I think I now have the answer, or a major part of it. It appears that *M. acuminata* trees in general (and this apparently applies to the related *M. cordata*) are incompatible with their own pollen, but will set seeds when properly pollinated with pollen from a different clone of the same species. The one very fruitful tree in Urbana is exceptional, though probably not unique, in being a clone of *M. acuminata* that is fertile when self-pollinated.

The self-fertile condition is usual with most other species of Magnolia grown in Illinois, including *M. tripetala, M. virginiana, M. australis, M. grandiflora, M. salicifolia, M. Kobus* (including its varieties *stellata* and *Loebneri*) and several of the hybrids of the *M. Soulangiana* group. It may not be true with the clones we have of *M. denudata* and *M. liliflora,* which produce very few seeds at Urbana.

American Magnolias in general cannot set seeds on their earliest flowers of the season. Without exception their flowers, so far as I have observed, are protogynous. Their pistils are receptive when the flowers first open, or shortly before that stage, but do not remain receptive for the day or so longer that it takes a flower to begin to shed its own pollen. But later flowers on the same trees, of such species and varieties as are not self-incompatible, can generally receive from their own earlier-opening flowers, pollen carried either by certain beetles, bees and other insects, or even by gravity from flowers higher on the tree.

I bagged a few dozen unopened flower buds on three *M. acuminata* trees in Champaign and Urbana for pollination experiments last spring, and wasted most of them, as it turned out, in attempts to cross with *M. grandiflora* pollen from farther south. (That is a perhaps impossible cross, as two subgenera are represented.) Where the bags were left over the uncrossed flowers through their flowering period, too, no seeds were set. But two of three intraspecific cross-combinations involving these three clones of *M. acuminata* were highly successful. Pollen from tree "K," the self-fertile one, was placed on pistils of one flower of tree "B," the largest in Urbana. That flower developed a gynoecium with 87 good seeds, and those were the only seeds seen on the whole tree this year. Pollen from tree "M," the largest of its species in Champaign, resulted in three nearly as well filled gynoecia from controlled crosses on tree "K". Two that were saved from the squirrels had a total of 137 seeds. On a few flowers of tree "M" where pollen of "K" was applied, nothing developed, and no fruits developed on the rest of that tree, in this or other recent years. My timing may have been off, when pollinating that tree, and I plan to test it more extensively another year.

While conducting a pecan grafting demonstration last spring on the farm of Mr. Roy Vick, near Thebes in Alexander County, Illinois, I noted that his woods contained several small flowering trees of *M. acuminata* which are native in a few counties at the southern end of our state. Mr. Vick was later able to collect for me a quantity of ripe fruits, from which seeds are being germinated. Vick's fruits were smaller than the average gynoecia developed on tree "K" in Urbana, but do indicate that the species is reasonably fertile where a few seedling trees are near enough together that cross-pollination by insects can be effected. Dr. J. Nelson Spaeth, head of our Forestry Department, who formerly was at Cornell, tells me that seedling trees in the Cornell forest planting of *M. acuminata* near Ithaca, N.Y. also were regularly productive of seeds. I have recently heard of another lone *M. acuminata* that is self-fruitful in a Northeastern state.

M. acuminata, though it tends to have large buds and thick pith, can be readily budded by the chip bud method in August, at Urbana, if the buds are wrapped completely over with polythylene plastic. They can be handled thereafter like any dormant bud. I have budded a large seedling in its first year of growth, and also have top worked by this method onto branches of tree "M", which must be at least seventy years old.

While ordinarily we would bud only onto young understocks, it appears that buds of such a self-fertile clone as tree "K" might be worth inserting to produce pollen-source branches high in any seedling *M. acuminata* on which it is desired to increase the production of seeds or ornamental fruits. This particular one, tree "K", might be worth extensive bud propagation in nurseries as it has a good sized flower for the species, with better than usual color; it is known to be fruitful, and its fruits are decorative. At maturity, under Urbana conditions, the fruits are taken off and the seeds consumed mainly by gray squirrels, which seem to find them both delicious and nutritious.

Coming after hazelnuts and before most of the walnuts, acorns and hickory nuts, an abundance of *Magnolia acuminata* seeds might fill a niche in the food economy of squirrels in suitable woods and many towns where such rodents are encouraged.

Some of my slides show *M. acuminata* trees around Champaign County, Illinois at different times of the year, and indicate variations in growth habit of various clones. Seed harvest by use of a truck-mounted power ladder is shown.

The last few slides show a tree of the rare yellow flowered *M. cordata,* that may be the oldest grafted magnolia, and the largest of its species, now in cultivation in America. It was grafted on *M. acuminata* some 120 years ago, and the graft line is still visible. Donald J. Hillenmeyer showed me this tall tree, which was originally planted at a farm residence outside Lexington, Kentucky. With the growth of the city, the area now is incorporated in Woodland Park. *M. cordata* is not native in the Lexington area. As well as Mr. Hillenmeyer can reconstruct this tree's history, it was probably included in a landscape plan drawn by the naturalist Rafinesque, who taught for several years at Transylvania College in Lexington. The actual propagator may have been a Frenchman who had a nursery at Lexington for several years around 1830-1840.

Michaux, who discovered it, had introduced *M. cordata* to France from the vicinity of Augusta, Georgia about 1880. The Lexington tree very likely is from one of the clones first taken to France and later brought back to America. The species was unknown in the wild for more than a century, until L. A. Berckmans rediscovered it in 1910-1913 at three Georgia and South Carolina locations near Augusta. Still later, some more wild trees were found also in eastern Alabama by W. W. Ashe and others.

Like most of the isolated *M. acuminata* trees, this *M. cordata* specimen failed to produce any seeds in 1963, but Don tells me it sometimes matures a few.

Magnolia cordata was crossed with *M. acuminata* in 1944 by Oliver M. Freeman, and his hybrid seedlings are being grown by the U.S. National Arboretum at Washington. Mr. Freeman, now at Tryon, North Carolina, tells me that he got a good yield of seeds from this cross, and a considerable variation among the hybrid progeny. Both *M. cordata* and *M. acuminata* are tetraploid species, and are much nearer to each other in kinship than to any of the other North American species, which are mainly diploid, except for the generally hexaploid *M. grandiflora.* Their nearest relative is the Chinese *M. liliflora,* also a tetraploid, which is widely cultivated in its variety *nigra.* Further hybridizations, with these and other Magnolias, are discussed in another paper in this volume.

RECENT HYBRIDIZATIONS WITH AMERICAN MAGNOLIAS

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Introduction

In the following paper, which is an updating of the talk I gave at the Cincinnati meeting of the International Plant Propagators' Society in 1962, I discuss my own crosses involving so far the two Sweet Bays, *M. virginiana* L. (synonym: *M. glauca*) and *M. australia* Ashe with other species; mention crosses which several other breeders have made with American Magnolia species; and outline some of the possibilities of further breeding to secure new hybrids worthy of propagation as evergreen or deciduous ornamentals. Though one prominent botanist told me that he thought any two magnolia species were fertile to each other's pollen, experience indicates the situation to be less simple. We may not in the foreseeable future cross between the two subgenera of Dandy's classification, but there are enough interspecific crosses and even intersectional and 3-sectional hybrids (within both subgenera) to indicate that much more may be done with breeding in this ancient genus. In the North American species of both subgenera, too, there remains much that can be done in selecting superior cultivars. Summer chip-budding, with a plastic wrap, appears to be an economical propagation method for all such cultivars as do not grow readily from cuttings.

Complexity of the Genus

The genus Magnolia has recently been given a systematic treatment by J. E. Dandy (1948, 1950) who differs somewhat with the classification given by Rehder (1927.) With three additions of tropical American species published since Dandy's work, we now count at least 89 species, subdivided by Dandy among two subgenera (Magnolia and Pleurochasma) and eleven sections. Their distribution is in Eastern Asia and the Americas, north of the Equator. In each of the subgenera (according to Dandy) there is a section with species from the more northern temperature parts of both North and eastern Asia.

In subgenus Magnolia there are some Asian evergreen Magnolias, but none is in the same botanical section as any of the American species, and none appears to be quite as hardy as our *M. grandiflora*. Of the total 27 recognized American species, seventeen are in the section Theorodon, which includes besides *M. grandiflora* some sixteen others, divided between the continental uplands and the high islands, southward to the slopes of Cerro Roraima in the Guiana highlands of Venezuela. That section, and the small section Magnoliastrum, limited by Dandy to the Sweet Bays, are strictly American. A more cosmospolitan section in subgenus Magnolia, however, is the deciduous Rytidiospermum, including five species from eastern U.S. and one from the mountains of southern Mexico allied to *M. tripetala* and *M. macrophylla,* plus three in Asia, the Japanese and Chinese *M. obovata, M. officinalis* and *M. rostrata.*

In subgenus Pleurochasma there are two important (in cultivation) but wholly Asian sections, and a third section, Tulipastrum, with a single Chinese species, *M. liliflora,* and two American ones, *M. acuminata* and its close relative, *M. cordata.*

Earlier Hybrids Mainly of Asian Species

Recognized hybrids of Magnolia date back in origin to at least 1808, when Mr. Thompson, a nurseryman at London, raised an intersectional hybrid between two North American species, *M. virginiana* (synonym *M. glauca*) and *M. tripetala,* this fragnant hybrid still in cultivation as *M. Thompsoniana.* It was introduced about 1820. From France in 1826, Chevalier Soulange-Bodin introduced *M. Soulangiana,* another intersectional hybrid but from the second subgenus, having the Chinese *M. denudata* and *M. liliflora* as parents. Soulangiana varieties, the original and others, have become the most widely grown deciduous Magnolia cultivars in both America and Europe. In this century, its two parents have entered into further breeding in England and the United States. In 1907, Mr. Peter C. M. Veitch obtained a cross of *M. denudata* X *M. Campbellii* from which three seedlings were germinated, and one of these which first flowered in 1917 was introduced as *M. Veitchii* (an intrasectional hybrid in the section Yulania of subgenus Pleurochasma.) Mr. D. Todd Gresham of Santa Cruz, California in very recent years has produced some outstanding hybrids in combining *M. Veitchii* with *M. liliflora* (intersectional), and is continuing cross breeding in this promising line, to combine the beauty of *M. Campbellii* with the hardiness and smaller plant of *M. liliflora.*

Other introduced hybrids in the subgenus Pleurochasma vary from probably intraspecific for *M. Loebnerii* (*M. Kobus* var. *stellata* X *M. Kobus* var. *Kobus* according to Professor Benjamin Blackburn), through the intrasectional *M. Proctoriana* (*M. salicifolia* X *M. Kobus* var. *stellata*) and *M. highdownensis* (*M. sinensis* X *M. Wilsonii*) to perhaps 3-sectional in the sterile Magnolia 'George Henry Kern', if we consider the latter to be *stellata* X *Soulangiana.* In subgenus Magnolia, the hybrid *M. Watonsii* is said by Dandy to be an intersectional hybrid (*M. obovata* X *M. Sieboldii.*)

Recent Hybrids from American Species

Interest in hybridizing American Magnolia species revived in 1930, when Oliver M. Freeman, then of the U.S. National Arboretum at Washington, made the first recorded crosses of *M. virginiana* X *M. grandiflora.* From his numerous seedlings, the 'Freeman' cultivar was selected and named by the Arboretum in 1961. See Freeman (1937) and Kosar (1962.) Meanwhile, at least three others, including myself, had repeated Freeman's intersectional hybridization, and I had used pollen of the

'Freeman' clone to make back crosses on *M. virginiana* in 1961, with interesting results to be discussed below.

In 1960 and later, I have also intentionally repeated and confirmed the accidental 1808 cross of Thompson, and have several hybrids of the combination *M. virginiana* X *M. tripetala*, two clones of which were uninjured when exposed as top grafts to -14° temperatures in the 1962-63 winter at Urbana, Illinois. (The original *M. Thompsoniana* from England is reputedly less hardy than either parent.) I am increasing one hardy and vigorous clone of my *M. virginiana* X *M. tripetala* cross by cuttings, and if its flowers prove equal to those of the original *M. Thompsoniana* it will be introduced as a hardier cultivar.

While still at the U.S. National Arboretum, where Mr. William F. Kosar now is in charge of Magnolia work, O. M. Freeman in 1944 had crossed *M. acuminata* X *M. cordata* (sometimes regarded as *M. acuminata* var. *cordata*.) Clones of this intrasectional hybrid are being evaluated, according to Mr. Kosar (1962.)

At the Royal Botanical Gardens, Kew, England, what was probably the first intercontinental (though intrasectional) hybrid was produced, I am told, by crossing between *M. tripetala* and *M. obovata*. This hybrid seemed in England to offer no advantage over its Japanese parent, and was not introduced. It might merit repetition in America, where I have observed that the more decorative *M. obovata* is less hardy than *M. tripetala*, which is being grown as far north as St. Paul, Minnesota. The second, and more exciting intercontinental hybrid (also intrasectional) was mentioned at our 1962 Cincinnati meeting by its breeder, Doris M. Stone of the Brooklyn Botanic Garden staff (1962 Proceedings, p. 114.) She has secured some quite promising crosses using *M. acuminata* as the female parent. One of her *M. acuminata* X *M. liliflora* hybrid seedlings, nine feet tall in 1962, had flowers described as a sort of "dusty pink" color, and was quite hardy in a cold part of Westchester County, 50 miles north of Brooklyn. We may look for some introductions of hybrids from Mrs. Stone's work before many years.

Reasons for Some Newer Crosses and Back-Crosses Involving Magnolia grandiflora

Magnolia grandiflora is the principal "evergreen magnolia" planted in warm temperate areas around the world, and is justly regarded as one of the most beautiful in tree form and foliage among the world's ornamental trees, whether evergreen or deciduous. Sometimes regarded less strictly as a "flowering tree" than some of the deciduous Magnolias, it is probably more often included in modern American plantings for its foliage and form than for its fragrant large white flowers. Yet there are some clones in the southeastern states and up to southern Illinois in which the usual six weeks flowering season of the species may be stretched from mid-May to October or even November. Experience of growers scattered from Connecticut to Kansas shows that it is not so strictly southern in its adaptation as the common name "Southern Magnolia" would denote. Yet it is admittedly more southern than the deciduous Sweet Bay Magnolia, *M. virginiana,* which has one natural outpost in an Essex County, Massachusetts swamp area north of Boston. And as it grows to 100 feet in its native habitat, *M. grandiflora,* in climates and soils best suited to its growth, can become an embarrassingly large tree for a small home property, if not pruned back, or selected and propagated as a smaller than average cultivar. To Freeman, therefore, and to some of us working with it more recently, it seemed desirable to try hybridizing *M. grandiflora* with the naturally smaller *M. virginiana,* in an attempt to secure trees that might have wider usefulness because of greater hardiness, smaller stature, and perhaps finer texture. There was also the lure of seeing what unexpected new recombinations might be obtained from a hybrid not known to occur in nature.

Others who are known to have made crosses with *M. grandiflora* and Sweet Bay Magnolias between 1930 and 1960 are Dr. Yoneo Sagawa, a cytologist at the University of Florida, Gainesville, and Dr. Fred C. Galle of the Ida Cason Galloway Gardens at Pine Mountain, Georgia. Both probably had the Southern Sweet Bay, *M. australis* Ashe (or *M. virginiana* var. *australis* Sargent), the pubescent, taller, more nearly evergreen one which I think W. W. Ashe was correct in calling a separate species. It is the usual Sweet Bay in their areas, and probably the only one occurring naturally west of Georgia, in the range from Alabama and west Tennessee, through Mississippi, southern Arkansas and Louisiana to the edge of Texas. Dr. Sagawa used *M. grandiflora* as the female parent, and obtained hybrid seedlings but these failed to survive. Most of Dr. Galle's seedlings, which showed mainly *M. grandiflora* leaf characteristics, like Freeman's hybrids and my first crosses of similar parentage, accidentally were mixed with a lot of *M. grandiflora* in a landscape planting, but may be rediscovered when they reach flowering age. Dr. Galle also is culturing a few seedlings of *M. grandiflora* X *M. Thompsoniana,* which so far look like *M. grandiflora.* I have some seedlings also now from a 1962 cross of *M. australis* X *M. grandiflora* made on the one *M. australis* so far flowered in Urbana. As with my seedlings of the combinations previously mentioned, some are weak or have already died at early stages, but several are growing satisfactorily.

Variations Observed in Crosses and Back-Crosses

The cross of *M. virginiana* X *M. grandiflora,* like the early one of *M. denudata* X *M. liliflora* (and some more recent ones involving Asian Magnolias) unites species with different chromosome numbers. *M. grandiflora* has 114 chromosomes and is the only hexaploid among species native to the United States. *M. virginiana* is a diploid with 38 chromosomes. (Presumably *M. australis* also is diploid and *M. Thompsoniana* likewise.) In nearly all these first crosses of a diploid with the hexaploid *M.*

grandiflora, the latter has proved quite dominant for evergreen character (though the leaves may be relatively thinner) and in suppressing the expression of the glaucous underside leaf color common to the several American diploid Magnolia species parents. In the 'Freeman' hybrid, the flowers are of intermediate size between the two parents, but look more like a smaller *grandiflora* rather than a larger *virginiana.*

Mr. J. E. Dandy suggested that if *M. grandiflora* produces hybrids with another temperate-zone American species, the hybrids should be expected to show some degree of stipular scars on their petioles, which *M. grandiflora* does not, at least beyond the first few leaves above the colyledons in young seedlings. I find this to be true with some leaves on all the known *M. grandiflora* hybrids I have examined recently. By Dandy's criterion, and by other indications, an evergreen, generally *grandiflora*-like tree used as a pollen source in my 1961 crosses on *M. virginiana* and 1963 crosses on *M. australis,* may itself be of at least remotely hybrid origin. This is the somewhat mysterious specimen, probably more than 100 years old and of unknown original source, now owned by Mr. and Mrs. Charles E. Dickens in Franklin County, Tennessee. Its broad, glossy, flexible leaves and its large, highly red-pigmented seed cones at maturity are its chief readily visible distinctions from the ordinary *M. grandiflora* seedling. But as a pollen parent in my crosses with *M. virginiana* it gave rather similar seedlings to those obtained with the hybrid "Freeman" pollen, and a root-tip cytological examination of one of its open-pollinated seedlings (made by Dr. Frank S. Santamour, Jr. of the Northeastern Forest Experiment Station early in 1962) indicate it to be a 76-chromosome tetraploid. (Another open-pollinated seedling from the Dickens tree, examined by Dr. Hale M. Smith at the Botany Department, University of Illinois in 1963 appeared to be approximately hexaploid.)

The 'Freeman' and other such first crosses of *M. virginiana* X *M. grandiflora* should have received 57 chromosomes from *M. grandiflora* and only 19 from the diploid parent, so it is not surprising that the hexaploid parent should show so high a degree of dominance.

But cross such a hybrid back to *M. virginiana* and the resulting back-cross hybrids should be approximately triploids, in the neighborhood of 57 chromosomes, and with nearly equal numbers of chromosomes (give or take a few) coming from each of the original parental species. The back-cross seedlings I obtained with 'Freeman' pollen, and also the hybrids between *M. virginiana* and pollen of the Dickens tree are altogether more "hybrid" in appearance than are the first crosses, being more nearly intermediate in appearance between *M. grandiflora* and *M. virginiana.* Nearly all these 'Freeman' back-cross and Dickens hybrids show to a considerable degree the glaucous leaf undersides derived from *M. virginiana,* and their leaves are thinner and apparently will be narrower and shorter on mature plants than are those of 'Freeman.' The range of leaf variation is somewhat greater in the Dickens hybrids than in those from 'Freeman' pollen so far obtained.

Vigor of growth, as mentioned previously, shows considerable variation within nearly all my hybrid seedling populations, and I expect that it may be possible to get some rather shrubby evergreens at maturity, in addition to tall tree forms. All my 'Freeman' back-cross seedlings and all hybrids (and open-pollinated seedlings) from the Dickens tree so far seen appear to be evergreen, the climate permitting. They are gradually being tested for hardiness.

I should mention that Don Shadow at Winchester, Tennessee has started grafting clonal material of the Dickens tree, and it should be on the market as a cultivar some few years hence. Several nurserymen in that area have been growing open-pollinated seedlings of it, which in general reproduce its leaf type. Though they apparently show somewhat too much variation to properly qualify as a seed-reproduced cultivar, it is without doubt an elite seed source. In 1962, Mrs. Jewel Templeton used the Dickens tree as a seed parent and with *M. australis* pollen I furnished to her, had seeds develop which have apparently given apomictic reproduction of the seed parent. This subject of apomixis in Magnolias will be mentioned further below, and seems to need more investigation as a possible method of commercial propagation in certain cases. It remains to be seen whether the Dickens seedlings which now appear to entirely resemble the seed parent will actually be like it in spectacular fruit display when they mature.

Possibilities for Further Inter-Sectional Hybrids

In the subgenus Magnolia, the fertile hybrids already obtained suggest further possibilities for recombinations. At least one inter-sectional hybrid now is known, involving respectively the sections (1) Theorodon X Magnoliastrum, (2) Theorodon X (Magnoliastrum X Rytidiospermum), (3) Magnoliastrum X Rytidiospermum and (4) Rytidiospermum X Oyama. The sections Rytidiospermum and Oyama each have an intrasectional hybrid species. In Magnoliastrum, several trees have been seen which perhaps combine *M. virginiana* and *M. australis*, while *M. grandiflora* (section Theorodon) is so variable as to suggest probable descent from at least two other species (extant or extinct) within its section.

I am attempting hybridization of *M. virginiana* X *M. macrophylla*, and harvested two cones from this cross in 1963. If successful, this cross should give a reduced leaf size compared to *M. macrophylla*, while giving larger flowers than *M. virginiana*.

Section Oyama, with the species *M. Sieboldii, M. globosa, M. sinensis, M. Wilsonii* and the hybrid *M. highdownensis* (*M. snensis* X *M. Wilsonii*) is entirely Asian, but it has hybridized once with a species in the partly American section Rytidiospermum to give the beautiful *M. Watsonii* (*M. obovata* X *M. Sieboldii.*) Since *M. tripetala* is hardier than anything in section Oyama, either it or one of its hybrids should be tried in further crosses with the Oyama magnolias, to make their beauty available for more parts of America.

In the subgenus Pleurochasma, I understand that Mrs. Stone's recent hybrid of *M. acuminata* X *M. liliflora* has already been crossed with some pollen from one of D. Todd Gresham's hybrids, *M. liliflora* X (*M. denudata* X *M. Campbellii*), which should give quite interesting four-species, two section, two-continental hybrids. Further combinations of *M. acuminata* or its hybrids with anything in this large subgenus should be rewarding in introducing greater hardiness, as *M. acuminata* may probably be the hardiest of all Magnolia species. Some of the more fertile Soulangiana derivatives, such as 'Grace McDade' and 'Rustica' might well be tried, for breeding with the *acuminata* derivatives.

Apparent Barriers to Some Magnolia Hybridizations

There will no doubt be further combinations and recombinations of Magnolia species by controlled or chance crosses. I am now attempting with some success to line up a few pollen sources south of the U.S. for some of the relatives of *M. grandiflora*, to use on it and on *M. virginiana, M. australis* and their hybrids. None of these so-called tropical American Magnolias appears yet to be in cultivation in the continental U.S., even in southern Florida, according to recent correspondence I have had with E. A. Menninger, "The Flowering Tree Man" at Stuart, and Dr. John Popenoe of the Fairchild Tropical Garden at Miami. Menninger suggests that some of these may not actually be tropical in their adaptation, since they occur at elevations up to 8000 feet for the Costa Rican *M. poasana* and 7000 feet for two in Venezuela.) Dr. A. J. Sharp of the University of Tennessee thinks that at least the two he has examined in Mexican highlands may actually fall within the limits of the wide variation shown by *M. grandiflora* within the U.S. The Mexican *M. Schiedeana* is a hexaploid like *M. grandiflora.* But Janaki-Ammal (1952) found one of the two Dominican Republic species, *M. Hamori,* to be a diploid.

It has been shown that hybridization can occur between Magnolias with widely different chromosome numbers, and that some of the hybrids at least are fertile enough for further crossing. Hybrids are also known which cross the lines between two and even three of the botanical sections of the genus, and between Asian and American species within a section. No one, so far, has successfully crossed between the two subgenera, represented in both continents.

Mrs. Stone in 1962 has mentioned the occurrence of apomixis as an obstruction in the path of hybridization, particularly with *M. virginiana* as the seed parent. Though this is by no means universal in that species, as evidenced by Freeman's hybrids and those I have obtained with several different seed trees of *M. vrginiana* in Illinois, I too have encountered at least one tree where in 1960-61 several cross-pollinations resulted only in seedlings that looked like duplicates of it. With this particular shrubby and narrow-leafed clone growing in Champaign, Illinois, I obtained a few true hybrids with a long-flowering *M. grandiflora* selection in 1962, though the majority of its seedlings from my presumably well-controlled crosses continue to turn out non-hybrid. Wide crosses (pollen other than *M. grandiflora*) appear to give apomictic seedlings from the Dickens Magnolia tree in Tennessee.

In addition to crossing failures attributable to too little relationship between parents, some crosses, in the section Tulipastrum at least, may fail because there is too close a similarity. This section, including *M. acuminata* and *M. cordata* of North America and *M. liliflora* of China, seems to parallel the related genus *Liriodendron* in having many trees highly sterile to their own pollen. This sterility may extend to a considerable degree to crosses between trees having similar sterility factors, as reported for *Liriodendron* by Carpenter and Guard (1950) and Boyce and Kaeiser (1961.) Most of the other species of American Magnolias that I have studied show indications of being compatible with their own pollen. In another paper I discuss an exceptionally self-fertile *M. acuminata tree.*

Dichogamy seems to be universal in Magnolia flowers. In all but one reported species it takes the form of protogyny, where the pistils are receptive a little before and after a flower first opens, but became unreceptive before the same flower sheds its pollen a day or so later. The expection is reported by Johnstone in England for the Chinese evergreen species *M. delavayi* where the flowers are protandrous, shedding pollen before their own pistils become receptive. In no case should dichogamy, as such, be a barrier to cross-pollination, if proper pollen (or even "improper" but compatible pollen) is applied to the pistils during their receptive period. Since most magnolia trees have at least a several-day spread in time of flower opening, most should be fruitful within the clone, if suitable insects are present to carry pollen from an older to a newer blossom. A few of the hybrids seem strictly sterile, as 'George Henry Kern' and *M. Soulangiana* 'Verbanica'. Perhaps dichogamy has accounted for many failures of attempted magnolia crossing, where breeders applied the pollen too late. With the American species, at least, the late bud stage seems to me to be the most favorable pollination time.

Weather conditions can be a barrier to successful crossing (or selfing) of Magnolias in parts of the U.S. for species that usually flower there, for two or more reasons. In the lower Southeastern States there seems to be rarely any seed production on early flowering Asian species and their hybrids. Mr. D. Todd Gresham at Santa Cruz, California tells me that *M. grandiflora* (usually quite fruitful in the Southeast) seldom holds fruits after flowering along the fog belt of the California coast. Weather, or perhaps self-sterility, may account for the infrequent production of seed on a *M. denudata* specimen at Urbana, Illinois.

Besides actual freeze injury to the flower parts, weather too cool, or too hot, at flowering time may possibly interfere with pollen germination or fertilization. Unfavorable weather could result in spoilage of pollen, or interfere with its natural distribution by insects, though we do not need or want insects in our parent flowers for controlled crosses. Dr. Charles E. Heiser, Jr. of Indiana University has studied the relationship of insects to natural fertilization in American Magnolias.

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MODERATOR MCDANIEL: Our next paper will be given by Jim Wells, James Wells Nursery, Inc., Red Bank, New Jersey.

THE USE OF CAPTAN IN THE ROOTING OF RHODODENDRONS

JAMES S. WELLS

James Wells Nursery, Inc.

Red Bank, New Jersey

I would like to take one of the three minutes allotted to me, if I may, to mention briefly an aspect of our work which I think has not always been recognized, and that is the "quality" of the rooting obtained from any given treatment. I believe that sometimes we are inclined to be mesmerized by percentages, and it is very easy to present a misleading picture from figures which do not reflect the quality of the rooting obtained. We all know how much the successful re-establishment and ultimate survival of a young plant depends upon the quality of the root system produced in the propagation bench. Where material is propagated in fall or winter, the percentage of survival the following spring, no matter how carefully the storage conditions may be controlled, is in direct ratio to the number and the quality of roots on the cutting when they are first moved. I must own that I was quite disturbed to hear at last year's meeting, a numholds fruits after flowering along the fog belt of the California coast. Weather, or perhaps self-sterility, may account for the infrequent production of seed on a *M. denudata* specimen at Urbana, Illinois.

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The purpose of this preamble is to state that I believe the main value of the Captan treatment is in the improvement of the quality of the root system, although it does seem to have a definite effect upon the percentage of well rooted cuttings under certain circumstances.

I first learned of this treatment by scanning the reports of the Boskoop Trial Grounds which reached me in the spring of 1962, and we mixed up a few powders and tested them in the summer of last year. These initial tests indicated that the treatment was of real value. Let me quote one or two figures.

Rhododendron Luciferum — This is a variety which roots with reasonable ease but does not produce a very vigorous root system and the points of attachment to the cutting are often weak. One hundred cuttings were inserted on the 4th of August, 1962, and treated with 1% IBA. On November 29, they were lifted and compared to a similar quantity which we treated with 1% IBA containing ½ Captan. Results were as follows:

1% IBA — No Captan	1% IBA with Captan
55%	100%
41 Cuttings heavily rooted	92 Cuttings heavily rooted
14 Cuttings light rooted	8 Cuttings light rooted
45 Cuttings dead	

Comments on lifting — outstandingly good, well attached heavy balls. This clearly best.

These results could be duplicated on a number of other varieties, but there was one other aspect of the treatment which became apparent from this initial test. The inclusion of Captan in the rooting powder does appear to have a modest inhibiting effect upon the development of new top growth on the cuttings. This is quite important for batches of cuttings taken both early and late. It does not entirely eliminate the top growth, but it greatly reduces it and as a result the cuttings tend to keep in a much better condition.

Following these initial tests we commenced changing all our treatments to include the 50% Captan and a batch of cuttings was made on October 1st, 1962, of the variety Nova Zembla. Two hundred fifty cuttings were inserted treated with 2% IBA and Captan and two hundred fifty were treated with straight 2% IBA. Both were lifted on December 20. Results were as follows:

2% IBA
172 Cuttings heavily rooted
37 Cuttings medium rooted
11 Cuttings light rooted
19 Cuttings very light rooted
11 Cuttings callused

2% IBA with Captan
249 Cuttings heavily rooted
1 Cuttings light rooted

I would like to quote my comments on both of these as they were lifted:

Straight IBA Treatment — clearly inferior to IBA plus Captan. Note difference in figures. These differences appear to represent the value of Captan under seemingly ideal and identical conditions. We appear to have "hit it right" on this whole block as to timing, condition of cuttings, treatments. etc. Root balls on this treatment were not so even, nor so well attached as the IBA plus Captan treatment.

2% *IBA Plus Captan* — Results outstandingly good, even, heavy rooting with well attached balls. Cuttings have that certain clean look of well being as compared to cuttings adjacent which looked dull. Results could not have been better both in quality and quantity of roots; appearance of cuttings, leaves, etc. Captan has increased the rooted cuttings by 40, or about 15% in a given time.

If we assess the *quality* of rooting by assigning a numerical value to each type of root system, a further vital difference between these two treatments becomes apparent. To do this we gave the following values to rooted cuttings:

Heavily rooted	Root ball fitting into a 3" pot	5 points
Medium rooted	About equal to a golf ball	4 points
Light rooted	About equal to a 25c piece — 10 to 15 roots emerging	3 points
Very light rooted	5 to 10 roots emerging—no root ball	2 points
Callused but no roots		1 point
Dead		0 point

Now if we apply these point values to the treatment with straight 2% IBA, they achieve a total value of 1,090 points, while the 2% IBA with Captan would receive a value of 1,248 points. We see, therefore, that the addition of Captan to the hormone powder has done two things. First it has increased the number of cuttings sufficiently well rooted to be transplanted to the propagation bench by 40, an increase of about 15%. But second, and in my opinion, perhaps, a more important point is that it has improved the overall size and quality of the root systems by 15%. These two results combined are, I suggest, significant.

I must apologize to our scientific members for using such teleological expressions as "clean" and "bright" but these are the only words which can convey the difference which exists between cuttings treated with and without Captan, and in the interests of accurate communication, I think they have to be used. All our treatments are now made up by using double the required strength of hormones mixed in talc and reducing this powder to the required level by adding an equal quantity by volume of 10% Captan.

MODERATOR MCDANIEL: Thank you very much, Jim. Our next speaker will be Mr. Al Lowenfels, Willow Lake Farm, White Plains, New York.

LILACS, SECOND YEAR FROM CUTTINGS

ALBERT LOWENFELS
White Plains, New York

Because of the presence of so many learned and noted botanists, this talk should have said *"Syringa."* But just being a plain propagator I use the common name. My inspiration for raising lilacs from cuttings came from reading a pamphlet by Kirkpatrick issued at least 20 years ago by Boyce Thompson, Yonkers, N.Y. Aside from that I find very little in the literature on propagating lilacs from cuttings. Bailey, in his classical nursery manual, gave various methods of propagation and said "Green cuttings handled in frames in the spring and summer are used," and he also mentions that mature wood would grow. Well, I'm not able to root summer cuttings or mature wood. Mahlstede and Haber give one line on lilacs, showing spring and summer as the best time for green lilacs. Hartman and Kester give almost a page to lilacs including green cuttings taken early in spring, but remark, "due to the fact that cuttings must be taken at a definite time in the spring at the peak of the nurseryman's busy season, some commercial propagators practice grafting."

Well — I do not see where propagators are any busier in early May than any other time — and I do not think grafting is as good as own rooted plants. Putting liliac on lilac should be against the law. Putting them on privet means a battle with privet suckers, in a fair number of instances. Some growers, such as Heard of Des Moines, put lilac on Ash — but having rooted lilac cuttings for some years, I think this is the best method. Kirkpatrick told me that the best time to take the cuttings is when the terminal bud is unfolding, when the joint with the main stem is somewhat sticky — and that this joint should be included. My experiments show that this is correct. I have been unable to root lilac cuttings without this joint.

Last year I took my first cuttings on April 28th. I made 960 cuttings of about 25 varieties of hybrids and my list (which I will be glad to show anyone) shows 38 different plantings. This year I stuck the cuttings in perlite which was on top of peat moss. My last cuttings were made on June 12th. I used Hormodin #3 and had Captan on some — I didn't find this made much difference. I got 579 rooted cuttings. I think I would have had more except that on one very hot May day, my mist required strength of hormones mixed in talc and reducing this powder to the required level by adding an equal quantity by volume of 10% Captan.

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During the past year, Roger Coggeshall had an article in the trade paper in which he showed good results with cuttings taken later. But my experience is that the earlier cuttings are much better than the later, harder ones. Also that the thin spindly cuttings root with more ease than the heavy sturdier ones. I used to put rooted cuttings into plant bands, but thanks to a talk with Jack Hill at one of the meetings, I now put them right out in the open. (I use a shader.) You can see they have made new growth which is most important to get sizeable plants sooner and to help winter the plants over. I show you a cutting made last May, and one the previous May, which is the lilac the 2nd year from a cutting. Note the sturdy root system.

A publication called *Lilacs for America* should help anyone interested in lilacs. The first edition was in 1941 and it was revised and republished in 1953. The work was done by a committee headed by Dr. Wister — and the book shows a lot of it. A list of the 100 best lilacs according to those who should know — classified by color and whether single or double. A long list of all the lilacs that have been named, a list of nurseries who carry lilacs, public gardens where lilacs can be seen, etc. The book costs just $1.00 and I have a copy here which I'll gladly show anyone. While we have peony, holly, rose and many other societies devoted to single species, I do not think there is any U.S. Lilac Society. There should be — for everyone loves a fine spray of lilacs — and I find that the plants sell better than any other deciduous shrub.

MODERATOR MCDANIEL: Thank you, Al. Next we shall hear from Steve O'Rourke who will tell us about Arcillite as a soil amendment.

ARCILLITE AS A SOIL AMENDMENT IN POTTING MIXTURES

C. E. WILDON AND F. L. S. O'ROURKE
Department of Horticulture
Michigan State University
East Lansing, Michigan

Practical plantsmen have always used certain soil amendments to "lighten" soil for pot and container growing. Organic matter such as peat moss, leaf mold and compost and inorganic materials like sand, cinders, perlite and vermiculite are frequently used. One of the more recent materials to be employed is arcillite, a montmorillonite clay which has been calcined at high system was turned off through an error. I used an electronic leaf, English device, which I showed at a previous meeting and which I find most satisfactory, for all my propagation. My cuttings are in a greenhouse with bottom electric cable heat at around 65 to 70 degrees. I believe that green lilac wood can be rooted without a greenhouse, but that full sunlight, mist, and bottom heat are essential.

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One of the earlier uses of arcillite was its incorporation in the soil of golf greens. It has proven quite resistant to breakdown by freezing and thawing and as reported by Montgomery (1) greatly stimulates the uniform growth of grass apparently by allowing air to penetrate to the root zone.

Arcillite is a satisfactory medium for the cutting bench, either used alone or mixed with peat. It requires more frequent watering than other media due to its higher degree of porosity, but is ideal under mist systems. It has also been used mixed with fine peat as a medium for germinating many kinds of seeds.

In preliminary trials at Michigan State University arcillite was used alone, and in various concentrations with soil and with peat moss ranging from 10 percent to 50 percent. With the standard system of greenhouse watering, pure arcillite dried out more quickly than the mixtures and plant growth was usually somewhat less. The "half and half" (50 percent) was quite satisfactory but no more so than "two to one," or 2 parts soil to 1 part of arcillite. This latter concentration was therefore used in all further tests.

In 1962, Wildon and O'Rourke (2) reported on the result of trials with arcillite and several other soil amendments on the growth and bloom of Pink Peace roses. The plants grown in soil or peat mixtures containing arcillite were superior to those grown in mixtures of several other commonly used soil amendments. Continued trials with a large number of both greenhouse and woody plants have consistently shown greater growth, superior bloom and general all around vigor when the potting soil contained a third part of arcillite. The rapid increase in growth is particularly marked with newly potted plants from the seed flat or the cutting bench. This head start is usually maintained throughout the life of the plant so that the plants in the arcillite mixture attain a saleability status in advance of those growing in the standard potting soil. While the results vary with different species and seasons, it appears that those plants which have a high oxygen requirement and thus, require greater aeration in the root zone, respond to the arcillite mixes to a higher degree than those which tolerate more compact soils.

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2 Wildon, C E and F L S O'Rourke 1962 Growth of 'Pink Peace' rose in potting mixtures containing arcillite Mich Agr Expt Sta. Quart Bul. 44: 497-499.

MODERATOR MCDANIEL: Thank you very much, Steve. Dr. Donald Schoeneweiss from the Illinois Natural History Survey, Urbana, Illinois will tell us about grafting to overcome chlorosis in pin oaks.

GRAFTING TO OVERCOME CHLOROSIS IN PIN OAKS

DONALD SCHOENEWEISS
Illinois Natural History Survey
Urbana, Illinois

Iron-deficiency chlorosis has long been a major problem in the cultivation of many species of trees and shrubs. Among those spècies commonly affected by chlorosis, pin oak (*Quercus palustris*) frequently exhibits the most severe symptoms. The development of yellowing or chlorosis due to iron deficiency has been attributed to many factors, including insufficient soil-iron content, despite the fact that other species such as red oak may grow vigorously and without developing any symptoms of iron deficiency when planted adjacent to chlorotic pin oaks. Results of extensive soil testing indicate that chlorosis among pin oaks, at least in Illinois nursery fields, is most often associated with high pH or alkaline conditions.

The recommended control measures for iron-deficiency chlorosis involve the application of iron-containing compounds such as ferrous sulfate, ferrous citrate, or iron chelates. These compounds are soluble in water and may be applied as a foliar spray, which gives only temporary results; as a trunk injection through holes bored in the plant, which seldom lasts more than 3 years; or as a soil application, which gives more lasting results. Although soil treatment with iron compounds is usually recommended for treatment of chlorotic nursery trees, in many cases little or no alleviation of symptoms occurs. This is true particularly where the nursery soil is an alkaline clay, as is often the case in Illinois. Even the incorporation of sulfur compounds for the purpose of lowering the soil pH, thereby releasing chemically bound iron, has often failed to overcome iron-deficiency chlorosis in pin oaks.

The material presented in this paper is part of a research project designed to investigate the various factors involved in iron-deficiency chlorosis and to approach the problem of control not only from the standpoint of chemical treatment but by changing, if possible, either the availability of soil iron or the ability of the plant to obtain iron from the soil under adverse conditions. Since many species, among them red oak, are able to obtian iron sufficient to support good growth under conditions, such as high soil pH, where pin oaks become chlorotic, the role of specific rootstocks was considered worthy of investigation.

In determining the role of the root system in chlorosis susceptibility, successful grafts of susceptible stems on resistant root stock would provide excellent research tools. Although very little information is reported in the literature on interspecific grafting of oaks, such grafts have been made successfully in the past, indicating at least some capatibility between oak species.

Red oaks to be used as rootstocks were propagated from seed in the greenhouse. Young seedlings were transferred to 6" pots containing a potting mix composed of ⅔ soil and ⅓ peat moss. These plants were maintained for 1 year with daily watering and monthly fertilization. During the month of February, 1962, 10 grafts were made at the Natural History Survey greenhouse with scion wood from potted 1-year-old pin oaks. At the same time, 40 seedling red oaks were transferred to the Hinsdale Nurseries greenhouse at Hinsdale, Illinois, where dormant 1-year-old scion wood from field-grown pin oaks was grafted onto the red oak rootstocks. All red oak seedlings had broken dormancy at the time of grafting and were in an active stage of growth. Pin oak scions at the Survey greenhouse were breaking dormancy at the time of grafting and scions at Hinsdale broke shortly after grafts were made. All 10 grafts at the Survey were succesful, while 30 of the 40 grafts made at Hinsdale succeeded. All plants were side grafted, tied with rubber budding strips, and wrapped with floral tape. Tape was removed 8 weeks after grafting, and budding strips were removed 1 - 2 months later or as soon as they became too tight. The stem portions of the red oak rootstocks were removed at the graft as soon as the pin oak scions began putting on vigorous growth.

As part of the overall research project on chlorosis in the several years preceding the present work, a hydroponic nutrient culture apparatus was employed with satisfactory results. Vigorous growth of oaks and other tree species was obtained when the trees were planted in crocks containing sterile sand or perlite and sub-irrigated with nutrient solution. Maximum growth was realized when plants were irrigated with a modified Shive's nutrient solution. This type of culture offers a distinct advantage in nutritional studies in that the concentration of individual nutrients such as nitrogen, phosphorus, potassium, iron, manganese, etc. can be varied without altering the concentration of the other nutrients. In this way mineral deficiencies in plants can be produced under controlled conditons.

To evaluate the relative ability of red oak and pin oak rootstocks to obtain iron under controlled conditions, one red oak seedling, one pin oak seedling, and one grafted pin oak on red oak were planted in sterile, chemically inert perlite in each of 18 one-gallon nutrient culture crocks. All crocks were sub-irrigated daily with a modified Shive's nutrient solution. Since a direct correlation between pH and chlorosis was found in field-grown pin oaks, one half of the nutrient solutions were adjusted to pH 5.0 and the other half to pH 7.0 (pH 7.0 was the highest that could be employed in these studies since nutrients precipitated at higher pH). The source of iron was also varied: ferrous sulfate ($FeSO_4$) and a chelated iron, Sequestrene 330 Fe, were each added to 3 crocks at each pH level. No iron source was added to the remaining 3 crocks at either pH level. Sub-irrigation with the adjusted nutrient solutions was begun on February 25, 1963, and final readings on chlorosis were made three months later.

At the time the test was concluded, marked differences in the development of chlorosis due to the various treatments was apparent. Chlorosis was severe on pin oak seedlings in iron-deficient solution and in solutions with $FeSO_4$ as the iron source, particularly at pH 7.0. Slight chlorosis was apparent on pin oaks with Sequestrene 300 Fe as the iron source at pH 7.0. Red oak seedlings developed a moderate chlorosis in iron-deficient solutions and exhibited slight chlorosis at pH 7.0 wtih $FeSO_4$ as the iron source. Grafted pin oaks on red oaks remained dark green in all solutions.

From the results of these tests it may be concluded that under the conditions of the experiment, either the availability or the uptake of iron was directly affected by pH; the chelated iron, Sequestrene 330 Fe, served as a better iron source than did $FeSO_4$; red oak rootstocks were apparently able to obtain a sufficient amount of iron in all solutions to support good growth of the pin oak scions. Had the experiment had been continud indefinitely, chlorosis would undoubtedly have appeared on the grafted oaks as well as the pin oak and red oak seedlings in the iron-deficient solutions. The results, however, were considered to be significant at the time the experiment was concluded.

Although the grafted oaks employed in the tests described in this paper were produced for use as a research tool rather than as a practical control measure for chlorosis in the field, the results obtained were promising and indicate that the use of grafted oaks in the field to overcome chlorosis problems should at least be investigated. All successful grafts of pin oak scions on red oak rootstock appear to be growing vigorously two years after grafts were made and are being maintained for future field planting. Additional grafts have been made with seedling pin oaks as rootstocks and red oaks as scion wood. To date most of these grafts appear to be successful. Future work already under way will include additional nutrient culture tests with grafts of pin oak on red oak rootstock and red oak on pin oak rootstock to confirm the results reported here and to determine the levels of available iron required to support active growth of red, pin, and grafted oaks. The possibility of incompatibility showing up in time among these grafts has not been overlooked. In the meantime, grafted oaks are providing an excellent research tool for investigation of some of the factors involved in the development of pin oak chlorosis.

MODERATOR MCDANIEL: Thank you, Dr. Schoeneweiss. We next have a very interesting paper by Prof. J C. Moore, Auburn University, Auburn, Alabama.

PROPAGATION OF CHESTNUTS AND CAMELLIA BY NURSE SEED GRAFTS

J. C. MOORE
Auburn University
Auburn, Alabama

Introduction

A few years back while working with chestnut propagation at Auburn University, cuttings made from young seedling plants rooted readily while cuttings from old trees were very difficult to root.

This led to the belief that there were substances in the germinating seed that caused the young or juvenile wood to root readily.

Seed cotyledons enclosed in the old seed coat were removed from several young seedlings, and a simple hardwood scion from bearing trees, trimmed to a point at the base, was inserted into each of the removed cotyledons. These grafts with the cotyledons attached were placed in a medium of sand to see if the scion would absorb enough of the substances from the cotyledons to induce rooting. Checks were used without cotyledons attached.

Within a few weeks some of the scions began to grow vigorously while others put out weak growth and died in a short time. When the grafts were examined, it was found that those making good growth had formed a union with the cotyledon petioles and had formed a good root system. None of the checks rooted.

This process of grafting has now been evolved where a very high percentage of the scion will unite with the cotyledon petioles and produce good root systems.

Procedure

The young chestnut seedling is connected to the cotyledons by prominent petioles. In performing the graft, the cotyledon petioles are cut near the cotyledons, and a knife point is inserted between the cut petioles into the cotyledons making an opening for the scion. The scion, trimmed at the base similar to a cleft graft, is then inserted into the opening. Care is taken to bring the exposed cambium of the scion in contact with the cut surfaces of the petioles.

After the grafts are made. they are lined out with the cotyledons about one and one-half inches below the surface of the medium and handled as cuttings.

For best results with chestnuts, the scions are collected during the dormant season and the grafts are made in early spring. At present, the procedure has not been developed for semi-hardwood scions. Under mist the cotyledons rot and prevent a union; when a jar is turned over the scions, the leaves darken and drop off.

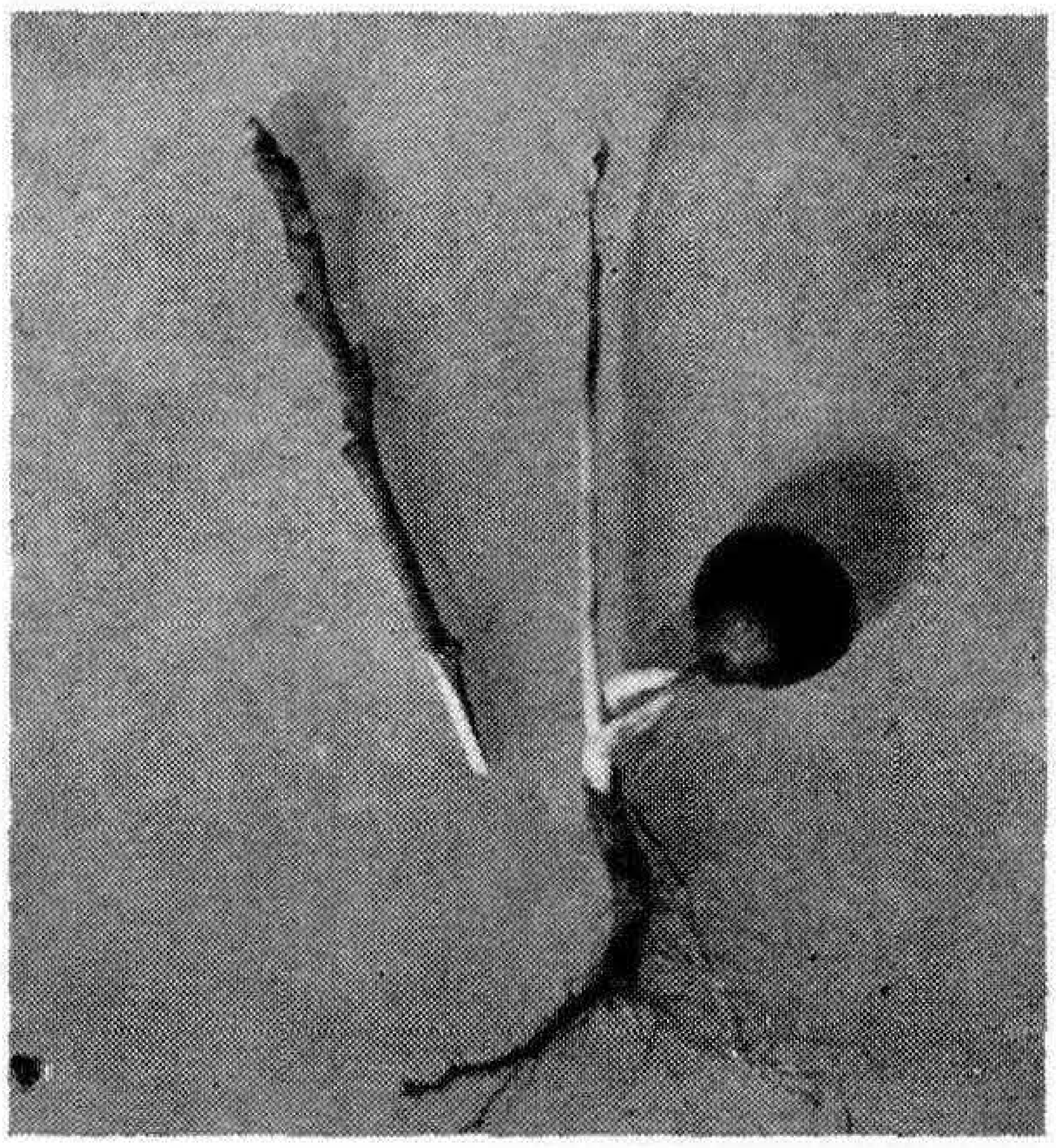

Figure 1. A chestnut seedling and scion.

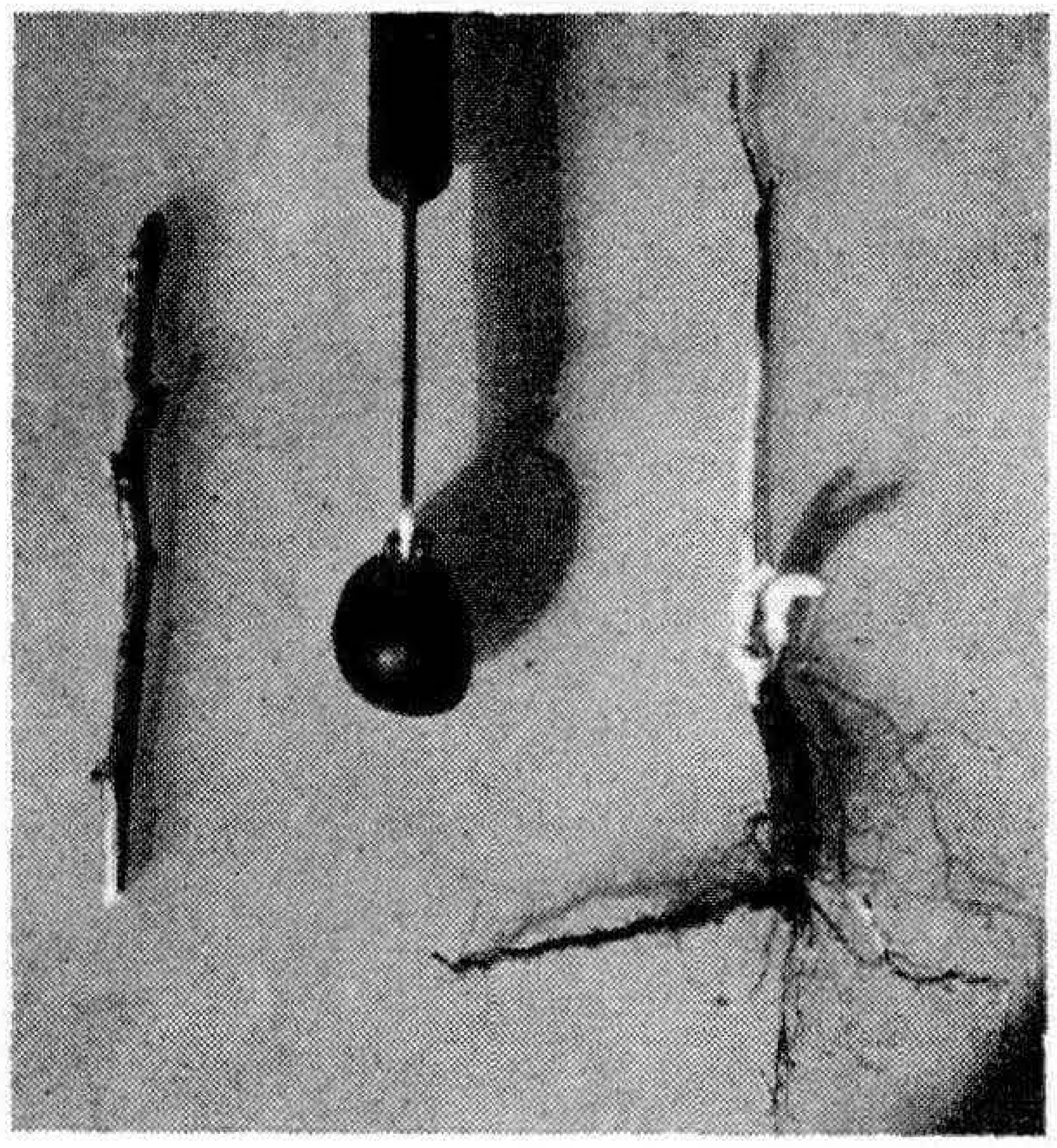

Figure 2. The seedling cut off from the cotyledons. The knife is used to spread the cotyledons and the scion will be inserted.

Figure 3. A rooted chestnut "nurse-seed" graft.

Mist Propagation of Chestnut Cuttings

Chestnut cuttings taken on June 15 and treated with Rainbow Hormone #2 powder have rooted very satisfactorily when placed under intermittent mist, using 16 seconds in a 2-minute cycle. The date for taking cuttings was determined by taking cuttings at 10-day intervals beginning April 28 and ending July 28. The following table gives the results in 1962.

While chestnuts have rooted readily under mist, forcing the buds into growth has been a problem. By June 15 the buds are in a resting stage and will not grow under normal conditions until the rest period is broken.

Table 1 Effect of Date on Rooting of Chestnut Cuttings under Mist During 1962 Growing Season

Date cuttings taken	Number of cuttings out of 12 that rooted
April 28	0
May 8	2
May 18	3
May 28	5
June 8	10
June 18	10
June 28	2
July 8	0
July 18	0
July 28	0

The rest period breaks normally after the cuttings have been carried through the winter. This has been true of those surviving from cold storage at 35° F., as well as those carried in flats under normal greenhouse temperatures. Cold is not necessary to break this rest period.

Many cuttings die during the long carry-over period. Those that have survived have made good growth.

Nurse Seed Grafting Camellias

Nurse seed grafting of camellias was just as successful as nurse seed grafting of chestnut. Both dormant and active scions were used in grafting camellias. Active scions of camellias were covered with a jar to prevent transpiration during high temperatures of summer.

There are two advantages in using the nurse seed graft for camellias: (1) The scion will root much faster and growth the first years is greatly increased, and many camellia varieties are difficult to root. Seed grafting gives excellent results with such varieties. The camellia seed is smaller in size than that of the chestnut seed, but the procedure is the same as for chestnuts. Both Camellia Sasanqua and Camellia Japonica seed have been used in this work.

This is a progress report and answers are not available on all points. However, this work opens up an interesting field in plant propagation.

MODERATOR MCDANIEL: Thank you, Prof. Moore, for a very stimulating paper. Our final paper this morning is by Dr. Fred Lanphear, Department of Horticulture, Purdue University.

THE SEASONAL RESPONSE IN ROOTING OF EVERGREEN CUTTINGS

F. O. LANPHEAR
Purdue University
Lafayette, Indiana

It is common knowledge among propagators that cuttings from most species root better at certain times of the year than at others. With narrow-leaved evergreens, we usually think of fall and winter as being optimum. The effectiveness of root-promoting substances such as indolebutyric acid (IBA) also depends on the season the cuttings are taken. However, very little is known about the controlling mechanism in this seasonal rooting response. Our first consideration might be the environmental differences that exist between seasons. One environmental factor that is particularly interesting in conjunction with this seasonal rooting response is photoperiod or the daylength. There have been numerous reports on the effect of photoperiod on rooting, mostly demonstrating the promotion of rooting by extending the photoperiod (3, 4). However, this is not always true. In some earlier work (2) we found that long photoperiods actually reduced the rooting of cuttings of Japanese yew and certain junipers taken in February. We therefore became interested in determining the role of photoperiod in controlling the seasonal rooting response, and in determining to what extent this response could be modified, either by manipulating the photoperiod or by treating with IBA. In addition, since this environmental control must eventually exert its influence on some

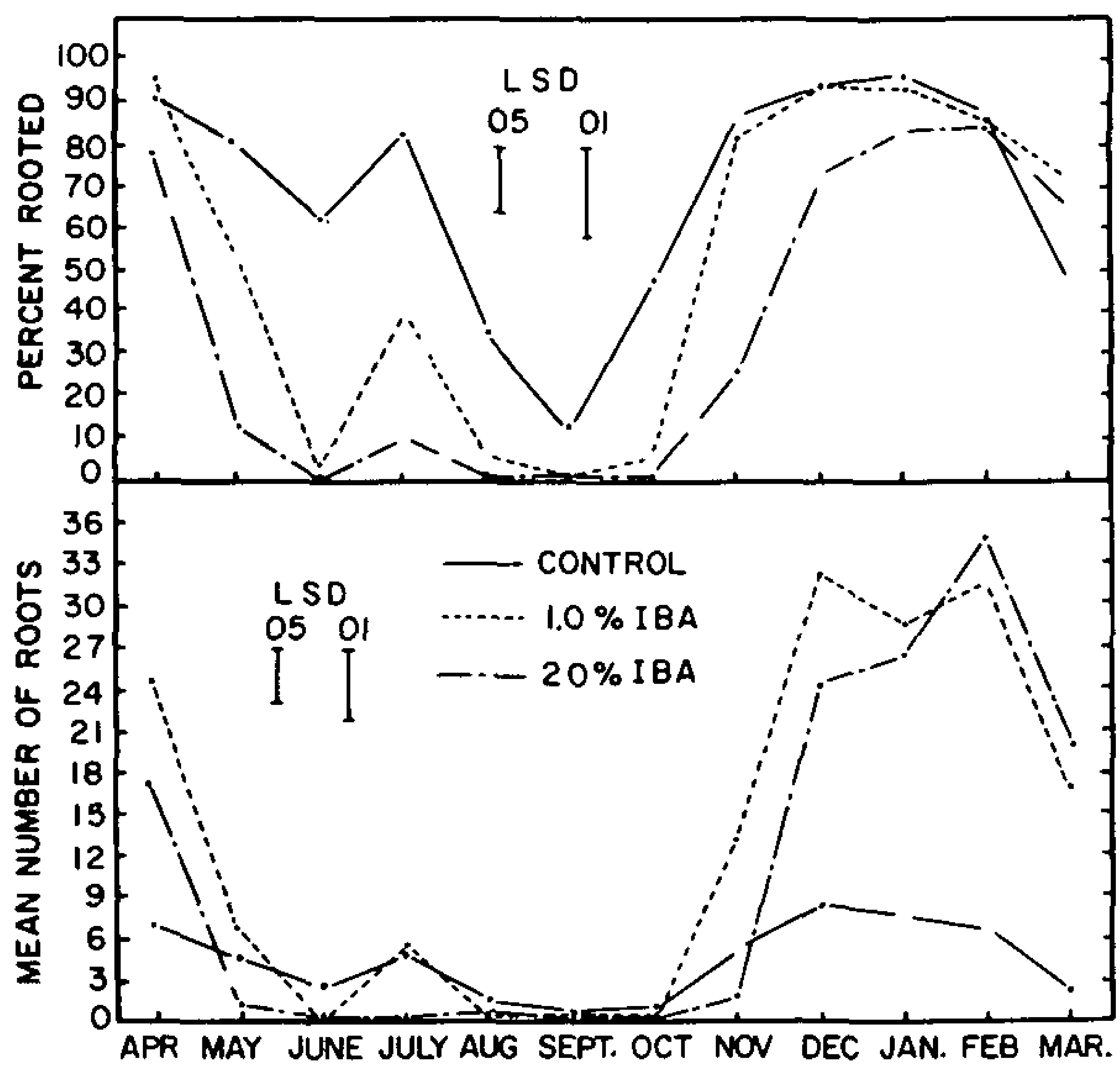

Fig 1. The effect of IBA on rooting of Andorra juniper cuttings taken at monthly intervals

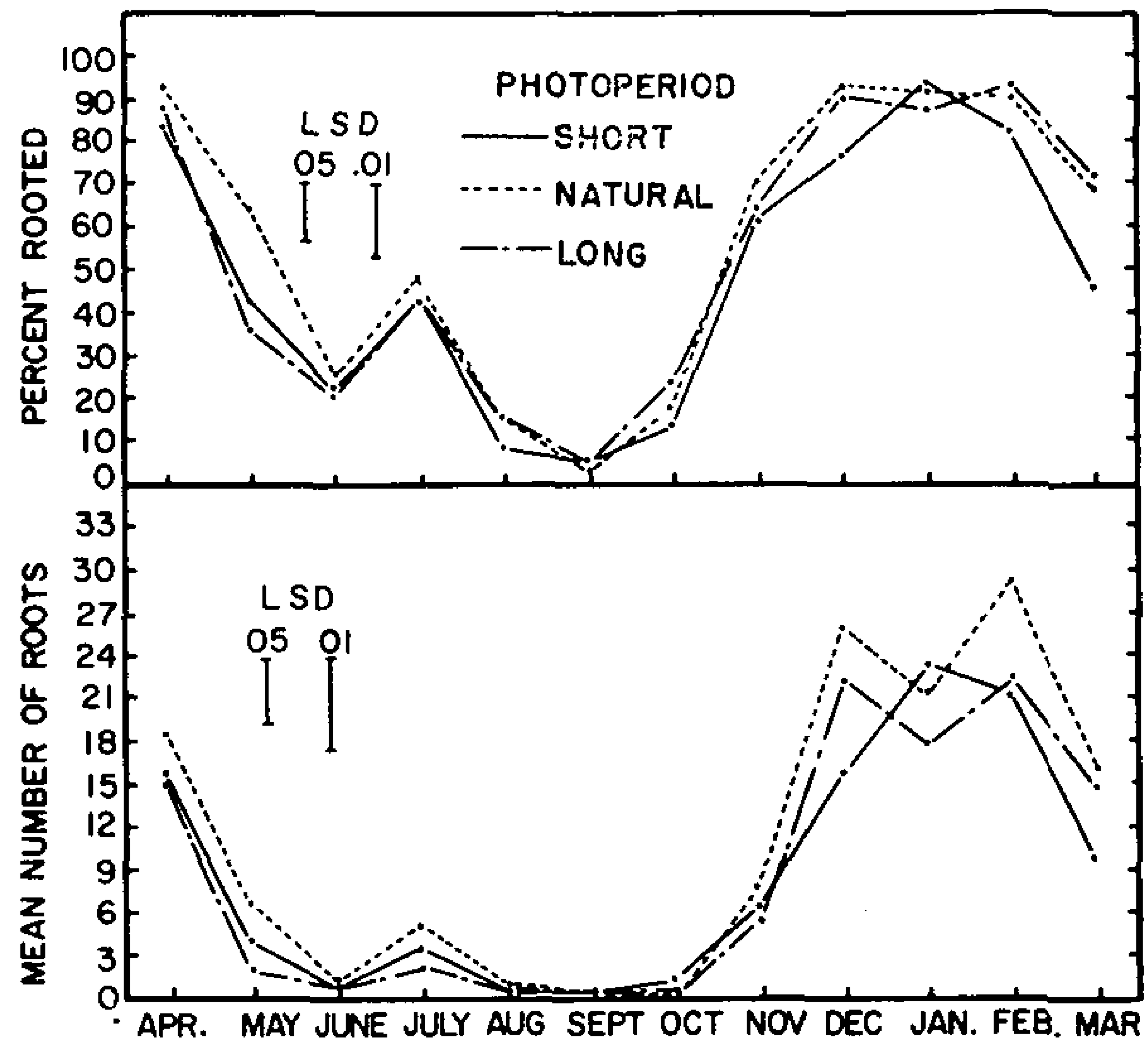

Fig 2. The effect of photoperiod on the rooting of Andorra juniper cuttings taken at monthly intervals

internal mechanism, we hoped to determine the role of rooting cofactors in this seasonal response.

The evergreens we included in this study were — Dwarf Japanese yew (*Taxus cuspidata* 'Nana') and Andorra juniper (*Juniperus horizontalis* 'Plumosa'). Terminal cuttings were taken each month for one year. The cuttings were divided into 3 groups — 1 group received the natural photoperiod which varied with the season of the year, another group received a short photoperiod of 8 hours of daylight and the last group received a long photoperiod accomplished by 8 hours of natural light plus a 3 hour light interruption during the middle of the night. Within each photoperiod the cuttings were subjected to various IBA treatments — 1 group was not treated, another group received a 1.0% concentrated solution dip treatment, and the last group received a 2.0% treatment. The cuttings remained in the rooting medium for 3 months and were then measured for the percentage rooted and the number of roots initiated.

The effects of IBA on the per cent rooting and the number of roots initiated with Andorra juniper cuttings are shown in Fig. 1. If we first consider the non-treated cuttings we see a very definite seasonal response in the per cent rooting, with the optimum rooting occurring with cuttings taken in late fall to early spring. The IBA did not alter this seasonal pattern except to accentuate it. When the rooting potential was low IBA actually decreased the percentage rooted. This may be due to the high concentrations used and might not have been true for other concentrations. It does raise the question whether IBA should be used at the same concentration in all seasons or even at all in some seasons. The number of roots initiated also showed a definite seasonal trend with IBA stimulating initiation but only during late fall to early spring.

The effects of photoperiod on the rooting of Andorra juniper are shown in Fig. 2. In general there was very little difference between photoperiod treatments, either on the percentage rooted or the number of roots initiated. Again, the seasonal response is quite evident and it might be interesting to note at this time that in general, rooting was highest during the seasons when the junipers were dormant. The exception to this is the peak in July which might be related to the summer dormant period that many evergreens exhibit. However, this was not determined.

The effects of IBA on the rooting of Dwarf Japanese yew cuttings are shown in Fig. 3. There was a significant seasonal variation in rooting with both the per cent rooting and the number of roots initiated. Without IBA, the per cent rooting was low from April to August and then increased in September followed by a second increase and optimum rooting in November and December. Cuttings taken after December showed a definite downward trend in rooting. However, IBA applied during these winter and early spring months counteracted this trend and kept rooting at a high level until March. Another interesting effect of IBA was the inhibition of bud activity about this same time. IBA was rather ineffective at other times of the year in increasing either the percent rooted or the number of roots initiated.

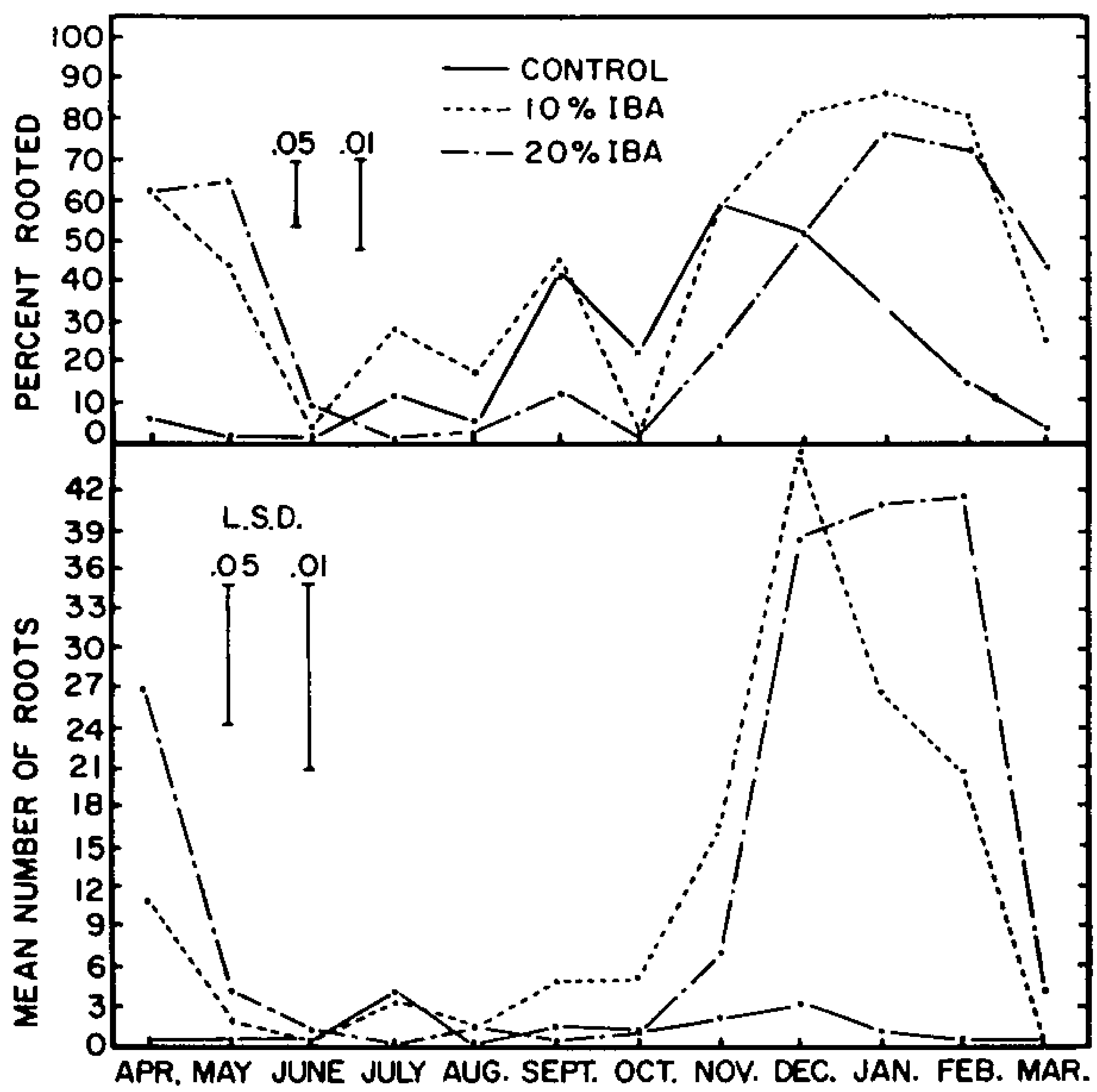

Fig. 3. The effect of IBA on rooting of Dwarf Japanese yew cuttings taken at monthly intervals.

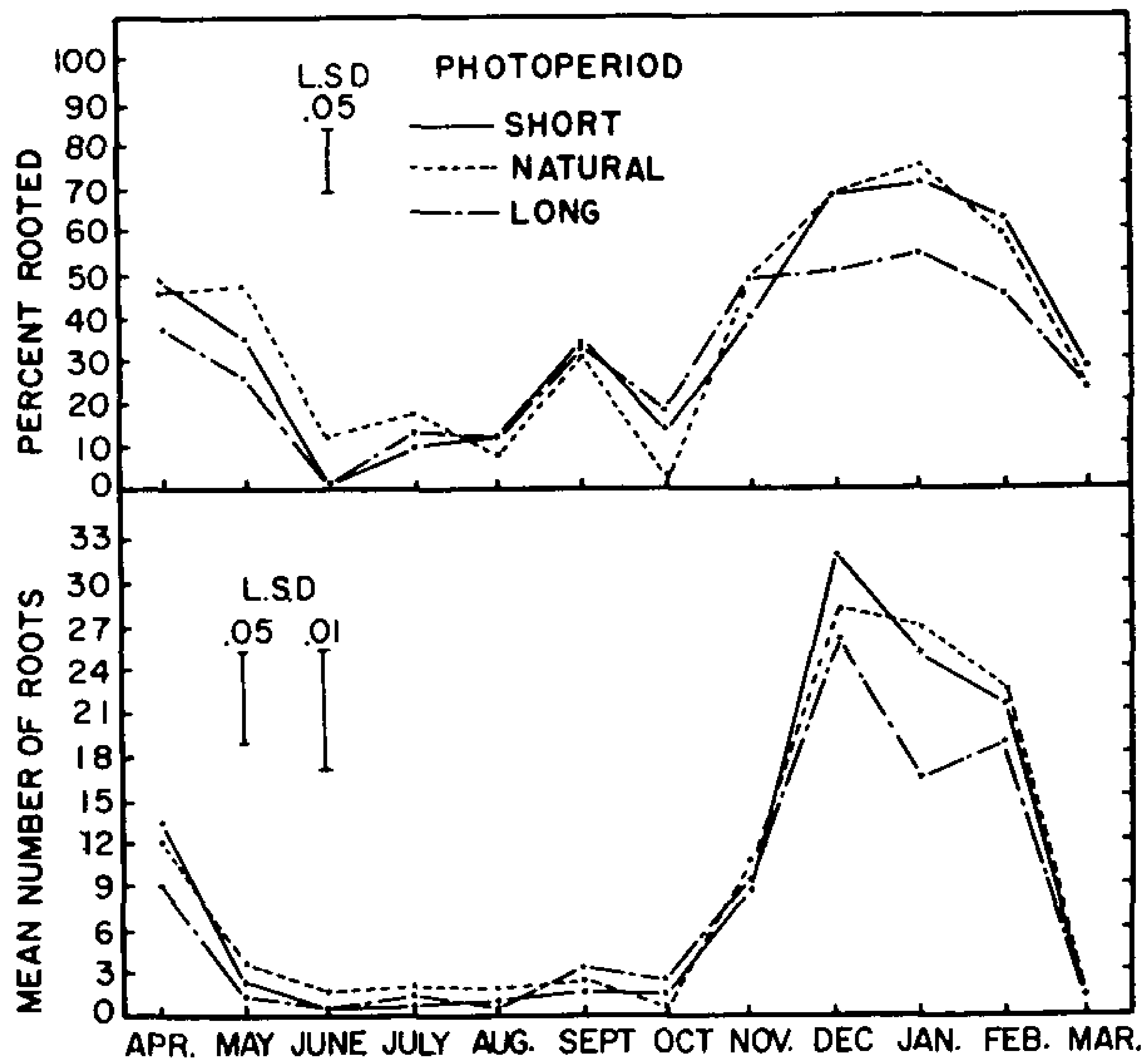

Fig. 4 The effect of photoperiod on the rooting of Dwarf Japanese yew cuttings taken at monthly intervals.

The effects of photoperiod on this seasonal trend in rooting of Japanese yew are shown in Fig. 4. Again the seasonal pattern is quite apparent, especially on root-initiation. The only time that photoperiod had any significant effect was during the winter months when the long photoperiod reduced the rooting of the yew cuttings. This inhibition of rooting due to the long photoperiod was noticed when the cuttings were taken in December through February, but at no other time. Not only did the long photoperiod inhibit rooting but it also was observed to stimulate bud activity, as might be expected. However, the photoperiod effect on rooting only existed if the cuttings had not been treated with IBA, as shown in Fig. 5. This interaction between photoperiod and IBA on rooting and bud activity suggests

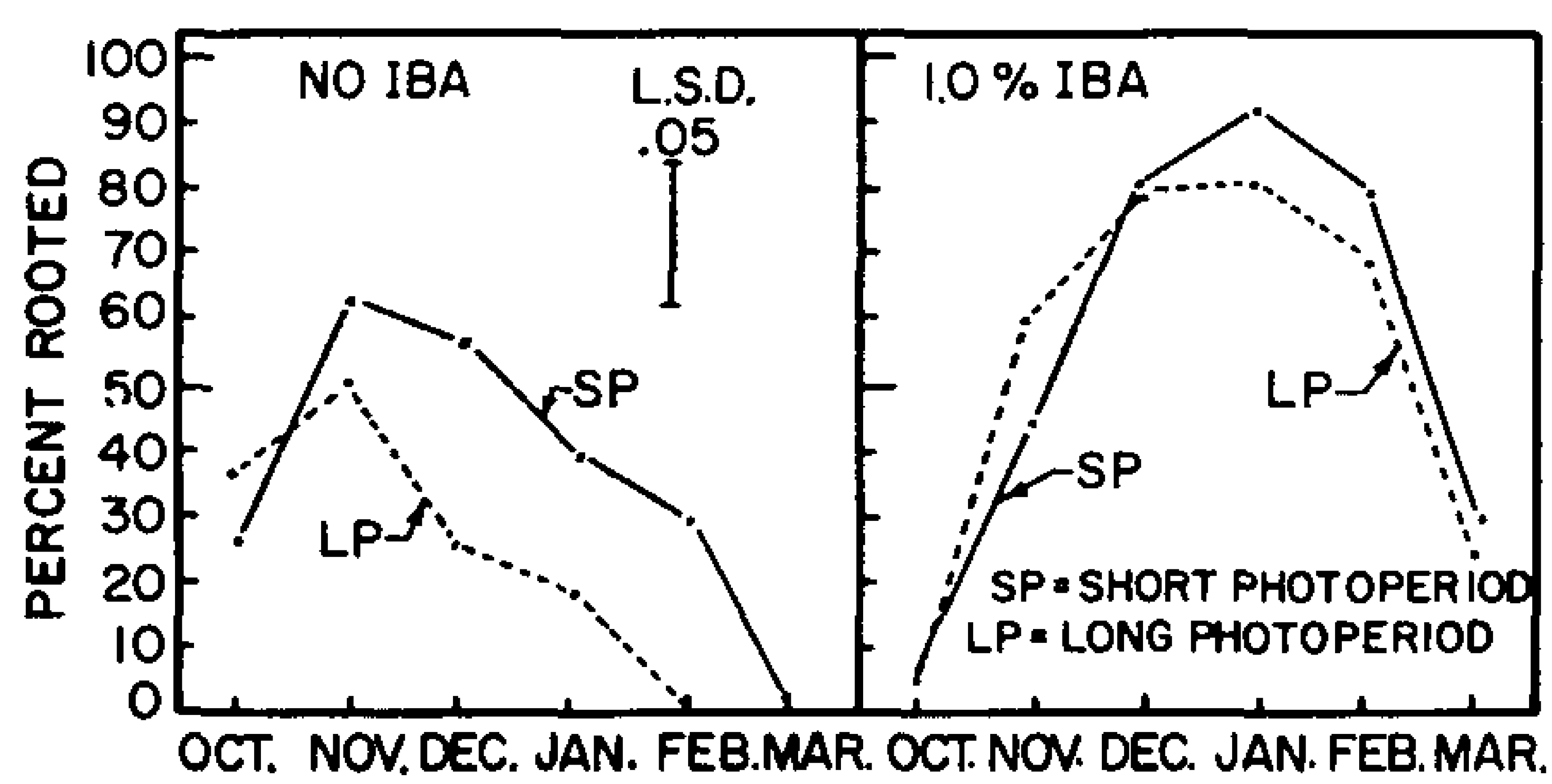

Fig. 5. The interaction of photoperiod on IBA on the percentage rooted of Dwarf Japanese yew cuttings taken monthly from October to March.

some interesting possibilities for the cause of the seasonal response. It appears that factors which stimulated growth of these evergreens, such as the long photoperiod, inhibited rooting, whereas factors that inhibited growth, such as IBA, stimulated rooting. This also coincided with the seasonal rooting pattern, since rooting was highest during the dormant period and lowest during the actively growing period.

We now come to the question of what are the internal processes causing this seasonal rooting response. We investigated the role of rooting cofactors using the test developed by Hess (1). If the rooting cofactors were responsible for this seasonal rooting response we would expect to find a reduction in the concentration of one or more of the cofactors in those seasons when rooting was low. We found that this was not the case in our studies with Andorra juniper. Although we were able to distinguish 4 active cofactor areas similar to those reported by Hess (1) we did not observe any changes in their concentration that correlated with the seasonal rooting response. However, the presence of the rooting cofactors in the foliage may reveal the rooting potential of a particular species, but does not necessarily assure their availability at the site of root initiation. What we are suggesting is that the critical factor in the seasonal response may be whether these cofactors are translocated to the site of root initiation, which perhaps may be dependent on whether the cutting is in an actively growing phase or a dormant stage. It is also possible that the seasonal response is due to changes in carbohydrate reserves or other substances essential for rooting. The question of what controls the seasonal rooting response still remains unanswered.

In summary, the root forming capacity of cuttings of Andorra juniper and Dwarf Japanese yew was highest during the period from late fall to late winter. IBA stimulated rooting but only when the root forming capacity was high. Photoperiod had very little effect on the rooting of Andorra juniper but with Japanese yew a long photoperiod during the late winter months decreased rooting if the cuttings had not been treated with IBA. It appears that the seasonal rooting response and the effects of IBA and photoperiod were directly or indirectly related to the growth phase. Conditions which tended to stimulate active growth inhibited rooting whereas inhibition of growth was associated with an increase in rooting.

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FRIDAY AFTERNOON SESSION

December 6, 1963

The Friday afternoon session was spent in a tour of the Monsanto Company research laboratories where new agricultural chemicals are screened and developed, and of the Climatron in the Missouri Botanical Gardens.

FRIDAY EVENING SESSION

December 6, 1963

PLANT PROPAGATORS' QUESTION BOX

Mr. Ralph Shugert, Neosho Nurseries, Neosho, Missouri served as moderator. The meeting convened at 8:00 p.m. in the Crystal Room, Sheraton-Jefferson Hotel. [*Editor's Note*: The questions and answers are included in this year's Proceedings for the first time.]

MODERATOR SHUGERT: Is it possible to root pines from cuttings?

MR. JOHN MCGUIRE: We have had some success rooting the candles. We had about 60% root this past spring.

DR. RICHARD ZIMMERMAN: In the Department of Forestry in Georgia there has been some success in rooting the needle bundles of slash and loblolly pine. However, there is a problem in that the needle bundles will root, but the dormant bud does not grow. They are now trying various treatments to get the bud to grow before the needle bundle cuttings are taken.

PROF. STEVE O'ROURKE: I would like to mention some Japanese work in which the terminals of the pines were cut to induce the needle bundle buds to grow. That paper is included in a review article I prepared for the 1961 Proceedings.

[*Editor's Note*: The article Prof. O'Rourke referred to is: Ishikawa, H. and M. Kusaka, 1959. Vegetative propagation of Japanese black pine (*Pinus thunbergii*) using leaf bundles. Jour. Bul. For. Expt. Sta., Meguro, Tokyo, No. 116:59-64.]

MODERATOR SHUGERT: What is the best procedure for rooting London plane trees by hardwood cuttings?

VOICE: We always use heel cuttings which have a small amount of 2 year old wood. The cuttings are made in the fall, dipped in hormodin, heeled in for the spring, and then stuck. We generally have 70% success.

MODERATOR SHUGERT: Can someone tell us conditions needed for growing beech in central Illinois?

DR. L. C. CHADWICK: I would like to mention that there have been several reports of damage to beech from over-fertilizing in the fall. As a consequence most tree men now use one half rate when it comes to fertilizing large trees of American beech. The tree requires a well drained, open soil.

MODERATE SHUGERT: How do you propagate *Cryptomeria?*

MR. CASE HOOGENDOORN: We can only root the understock, *C. japonica.* We take the cuttings before frost in October, dip them in #3 Hormodin and stick them in sand and they root very well. *C. Lobbi compacta* callus but do not root under our conditions.

MODERATOR SHUGERT: Has anyone had success in rooting mountain laurel cuttings?

MR. WIL CURTIS: We have a man in our area (Oregon) who takes the cuttings in March, puts them in sand and peat, no hormone powder, but with bottom heat and gets a pretty fair percentage of rooting. In fact, excellent rooting of the white forms and about 50% of the pink forms.

MR. ARIE RADDER: We took cuttings in February, wounded them on both sides, and used a strong hormone powder. We had about 50% rooting.

MODERATOR SHUGERT: Has anyone had success rooting *Taxus* under mist?

MR. HANS HESS: I don't believe that anybody has had much success rooting *Taxus* under the mist during the summer. They will root very well, but they become very chlorotic, are set back, and take a long time to recover. You can do a pretty good job of rooting *Taxus* under mist if you take the cuttings during February or the beginning of March, treat them with a hormone, and put them in flats of sand. During the first part of April, as the weather begins to warm up, put the cuttings under intermittent mist. Use as little water as possible. They will root in a period of 6 - 8 weeks without the chlorotic condition.

MODERATOR SHUGERT: I did not understand, when visiting the Forrest Keeling Nursery, if the seed was sown on top of the ground or was it drilled?

MR. HUGH STEAVENSON: The seed is on top of the soil or pressed slightly into the soil by the roller. On top of the seed we put a layer of sawdust. The thickness of the sawdust layer is determined by the size of the seed. As the seed germinates, we can rake some of the sawdust off. However, the seed will go through a much thicker layer of sawdust than through soil.

MODERATOR SHUGERT: Do you have any trouble with wind blowing the sawdust away?

MR. STEAVENSON: Yes, we do. It is a constant problem, requiring raking back. We also use erosion mats and they help a lot.

MODERATOR SHUGERT: Does *Prunus cistena* root better in the greenhouse or in outside mist beds?

MR. VINCENT BAILEY: We have best results in the greenhouse. Perhaps if we used the same care with our mist beds as we use inside, the results would be the same. We take cuttings when the plants are actively growing and remove the soft tip. We use about a 10 inch cutting.

MODERATOR SHUGERT: Has anyone rooted *Prunus Besseyi* or *P. tomentosa* from either hard or soft wood cuttings? The reason for the question is that seed has been hard to obtain for these two plants.

DR. CHADWICK: I have rooted *Prunus tomentosa*, taken from softwood cuttings in early July with about 75% success.

VOICE: We have rooted *Prunus Besseyi* from hardwood cuttings with about 50% success.

MODERATOR SHUGERT: How do you root *Sciadopitys* cuttings?

MR. GERRY VERKADE: Using Sid Waxman's techniques which are in our Proceedings, we were able to root 50% this past year. Timing is a very critical problem.

VOICE: We graft them on *Sciadopitys* roots.

MR. HOOGENDOORN: Where do you get the roots from?

MR. MARTIN VAN HOF: Perhaps from large *Sciadopitys* trees.

MODERATOR SHUGERT: What is a good understock for pear?

MR. CURTIS: A number of years ago we used the Anders quince entirely for a root stock for pear. After the war the Providence stock was available and the majority of the better nurserymen are using Providence. We get a better union and a more satisfactory tree. As for Bartlett, very few of us graft on either Anders or Providence because we feel it makes a very poor union. So we always use an interstock of Old Home. Old Home makes the most satisfactory interpiece and is less susceptible to "decline."

MODERATOR SHUGERT: Has anyone had any experience using the "Gro-Lux" lamp as compared with regular fluorescent lamps?

DR. KEN REISCH: We have tried "Gro-Lux" lamps on African violets and found little difference from the regular fluorescent lamps.

DR. HAROLD TUKEY, JR.: We have tried the "Gro-Lux" lamps on bedding plants and in growth chambers. They give exactly the same results as a combination of cool white fluorescent and incandescent lamps. In some cases the latter combination was superior.

VOICE: Is the Youngstown *Andorra* that Mr. Wilms showed yesterday the same as the compact *Andorra*?

MR. HANS HESS: The *Andorra compacta* which Mr. Owens sells is a different selection from the Youngstown compact *Andorra*. There a number a selections on the market.

MODERATOR SHUGERT: How is a zinc deficiency corrected?

DR. TUKEY: A zinc sulphate spray is the best way to get zinc into a plant.

MR. HANS HESS: What is the minimum temperature necessary in combination with lights to break dormancy?

VOICE: About 70° is the minimum.

MR. RICHARD VANDERBILT: In the case of *Rhododendron* we give the house an exposure of 20 days temperature under 40° F. We then warm it up to 65° F. and with lights to lengthen the day, the whole house breaks into growth at one time rather than over a period of a month.

VOICE: This probably varies considerably with the plant. For roses we use 80° F.

VOICE: I would like to comment about the use of zinc. We use zinc sulphate and lime, 8 pounds zinc and 8 pounds lime to a hundred gallons of water, to control bacterial spot on peach. Now, if the growers leave out the lime, I have seen peach orchards completely defoliated in the summer. I'm not sure if low quantities of zinc sulphate would do the same, but I thought I should mention it.

MR. BAILEY: Has anyone had experience using dormant apple buds held in storage for budding in July?

MR. HENRY SKINNER: Yes, we have used them on dwarfs. We take the buds during the winter and hold them in storage and use them in July or a little earlier.

MR. ROBERT SIMPSON: We have done this on ornamental crabs on plants which did not take the previous fall. We usually do this in May but I don't see why it could not be done in July.

MODERATE SHUGERT: Prof. O'Rourke, what is the difference between the calcined clays on the market?

PROF. O'ROURKE: The companies claim that the difference is in the temperature at which the clay is treated. The higher the temperature, the harder the material, and the more resistant it is to breakdown.

The session adjourned at approximately 10:00 p.m.

SATURDAY MORNING SESSION

December 7, 1963

FIRST SECTION

The first section of the morning session convened at 9:30 a.m. Mr. Ed Davis, Ozark Nursery Co., Tahlequah, Oklahoma, was moderator.

MODERATOR DAVIS: Our first paper this morning will be given by Dr. William E. Snyder of Rutgers University.

THE ROLE OF RESEARCH IN PLANT PROPAGATION

WILLIAM E. SNYDER
Department of Horticulture & Forestry
Rutgers University
New Brunswick, New Jersey

The definition of the word "research," according to Webster's unabridged dictionary is:

"Studious inquiry or examination, specifically and usually, critical and exhaustive investigation or experimentation having its aim the discovery of new facts and their correct interpretation; the revision of accepted conclusions, theories or laws in the light of newly discovered facts; or the practical application of such new or revised conclusions."

In the area of the arts and the humanities, research is most frequently accomplished by diligent investigation, comparison, criticism and interpretation of the writings, the paintings, the sculpture, the musical scores or other products of an individual or groups of individuals whose accomplishments may be related. By contrast, in the area of the sciences, research is most frequently accomplished by experimentation. Since the propagation of plants is primarily a science, we shall be concerned with the experimental approach.

Classically, two levels of research are recognized:

1. Basic Research
2. Applied Research

Basic or theoretical research is the first portion of the definition: "that discovery of new facts and their correct interpretation or the revision of accepted conclusions and theories based on newly discovered facts." In the past most basic research, of importance to plant propagation, has been the result of studies of the botanist or plant physiologist rather than the horticulturist. In more recent years, the horticulturist has accepted a greater role in basic research. This is probably the result of three major factors:

1. the employment of technically trained scientists in horticulture,

2. the greater emphasis of training in botany, chemistry, physics and statistics by the graduate student in horticulture, and
3. an increasing appreciation by administrative leaders that basic research is the major foundation for a strong program of applied research.

The second aspect of research, applied research, is included in the last portion of the definition: "practical application of new or revised conclusions." I like to think of applied research in two phases. The first, by the horticulturalist, to demonstrate the practical application of the new information to plants of economic importance and the second, by the commercial grower, to demonstrate that the new application is both economically feasible and physically practical at his level of operation.

At the time basic research is being conducted there may be little or even no thought of the practical implications or applications of the results.

To illustrate the relationship between basic research and its practical applications, let us devote some time to one illustration

Almost one hundred years ago, Charles Darwin recorded in his book "The Power of Movement in Plants" extremely valuable experiments and reflections upon the movement of plants in response to light, that is, the bending of the growing tip toward a unilateral source of light. Darwin demonstrated that light falling only on one side of the growing tip of a plant causes some influence to be transmitted downward, thereby resulting in the bending of the stem toward the source of light. Subsequently other investigators showed that if the tip was removed, little or no growth occurred, but growth continues if the severed tip is replaced. The insertion of a gelatinous plate between the tip and the stem did not change the growth response, however the insertion of a Mica plate prevented growth of the stem. The next significant contribution was that if an excised tip was replaced on one side of the cut stem, growth is accellerated only on the side beneath the tip. It was further shown that if the sap from these stem tips is put into a block of agar, the growth is similar to growth resulting when the cut tip is replaced. By using the agar block technique, it was soon demonstrated that some substances promoted growth while other substances inhibited growth. In 1928, Dr. Fritz Went demonstrated that the agar block technique could be used as a quantitative measure for the material produced by the stem tip. This technique is now known as the Avena Curvature Test. Several years later it was shown that the substance was indoleacetic acid.

At this point, some of you may be wondering how these results of basic research concerned with the growth movements of plants are related to plant propagation. As early as 1882, Sachs, a German plant physiologist, suggested that there was a "root-forming substance." In 1915, Loeb reported that the presence of vigorous leaves on a horizontally placed *Bryophyllum* stem not only increased the bending of the stem but also increased the production of roots. Several years later Van Der Lek reported that the presence of leaves and buds stimulated the rooting of stem cuttings. He also suggested that hormones were probably involved.

In the 1930's, it was found that crude extracts from pollen, bacterial preparations and urine, when smeared on intact plants. stimulated the production of roots along the stem. In 1934 it was discovered that these extracts contained indole acetic acid (hereafter designated IAA). Laibach and co-workers reported that IAA, produced in the organic chemical laboratory, markedly stimulated the production of roots when applied in a paste to the stems of intact *Coleus* plants. In 1935. Cooper and Zimmerman and Hitchcock, working independently, reported that IAA applied to stem cuttings resulted in significant increases in rooting.

It is now known that many compounds related to IAA are also affective in the stimulation of rooting of cuttings. Because they have been shown to be more effective than the naturally produced IAA, the two most widely used compounds are naphthalene acetic acid and indole butyric acid.

Thus years of basic research relative to the phenomenon of directional growth of plants resulted not only in the development of proof of the hormonal control of plant growth, but also to the many applications of the use of growth regulators in the production of agricultural crops.

Following the discovery of the effect of IAA on the rooting of cuttings in 1935, hundreds of papers have been published. Many of these were applied research, concerned with the application of this new information to a wide range of plants and plant parts, with the method of application, with the possible interrelationships with established practices and techniques and with the testing of related chemical substances. One bibliography includes 274 references to papers published between 1934 and 1946. The list of species and cultivars which have been tested for the effects of auxin-type growth regulators on the stimulation of rooting of cuttings is well over 1,000.

We in the Plant Propagators' Society are well aware that the knowledge of why and how roots are initiated is incomplete. We know that there are many species which remain difficult-to-root regardless of whether or not root-stimulating chemicals are used. We have been fortunate to follow the investigations of one of our members, Dr. Charles E. Hess, relative to the role of co-factors in the rooting of cuttings. These studies are basic and when identification of one or more of the co-factors has been made a series of research projects will be needed to determine how co-factors actually are involved in the stimulation of rooting and to apply these new findings to the rooting of difficult-to-root species.

Research in plant propagation has not been a series of outstanding discoveries and the application of new ideas, but rather has consisted of a gradual verification of techniques established many years ago, of occasional modification of these techniques and very occasionally of significant discoveries.

Many common methods of propagation are fundamentally the same as those practiced and described several centuries ago. Modern writings, however, have largely deleted irrelevant matter and superstitions stemming from the Middle Ages. Seventeenth Century propagators believed that yellow roses, rare at that time, resulted from budding on barberry understock. The understock may exert a significant effect on the scion, but today we know that yellow roses are the product of selective breeding of roses, rather than the use of a special understock.

Early propagators depended largely upon seeds and grafts: cuttings were employed primarily with those species which readily rooted from dormant cuttings. The importance of cuttings as a means of propagation of ornamental plants is of relatively recent advent. Improved techniques for control of the environment have contributed to the increased use of softwood stem cuttings. Consider the advancement in the control of atmospheric moisture between the bell jar and the intermittent mist. Humidistats, thermostats, electronic devices, solenoid valves, automatic ventilation, electric heating cables, washed air-cooling and timing mechanisms are just a few of the recent advancements in common usage to control the environment of the propagation structure. These are contributions of research of many individuals at many different research stations.

Research may reach a point where additional effort is relatively unproductive until a new technique or procedure is discovered. Polyploidy, a condition in which the organism contains more than the normal number of chromosomes, is frequently of considerable value in breeding programs. The discovery of the effect of colchicine on the induction of polyploidy resulted in a technique of major value to the plant breeder. Chromatographic techniques in chemistry have made possible the study of materials which are present in plant tissues in very small quantities. You will recall that this is the technique used in the studes of co-factors.

The two methods of propagation of ornamental plants which have received the major attention of the research men are the rooting of cuttings and germination of seeds, especially the problems of delayed germination. Budding and grafting have received the major attention for fruit crops. Studies emphasizing the propagation of fruit crops by cuttings and stock-scion relationships for ornamental crops are needed.

For softwood stem cuttings of deciduous plants and hardwood stem cuttings of evergreen plants, the major areas of investigation have been concerned with the effect of the environment — light, temperature, moisture, pH, media, etc. The roles of moisture, temperature and light in overcoming rest have been studied for many seeds. Studies of the effect of the environment on propagation should be continued and will undoubtedly prove productive, however what is really needed is a greater emphasis on studies of the chemical and physical processes which occur within the plant. Studies of this nature will, in my opinion, result in the most significant advancements in plant propagation. Detailed basic studies of the chemical stimulation of adventitious buds on leaf and root cuttings, on the chemical and physical causes of delayed germination of seeds and of the many problems of stock-scion relationships of ornamental plants should prove to be very valuable.

It is not to be expected that every new technique or procedure will be available for every commercial group. Even such an universally adapted technique as the use of intermittent mist has definite limitations and may not be advantageous in certain instances. Several years ago an interesting procedure involving the use of cutting-grafts was described. Adaption of this method of propagation should be determined by the crops being propagated, the success of the new method compared with the established procedure being used by the nursery, and the propagation schedule. The research man cannot determine whether a new procedure should be adapted; this is a responsibility of the commercial propagator.

On occasion the research man has been criticized because of the small number of plants used in a project. The scientists have devised techniques whereby accurate information may be obtained even with the use of relatively small numbers. For example, if a coin is tossed in the air, there is a 50-50 chance that it will show heads or tails. If the coin is tossed ten times, the probability of heads showing five times is slight, but possible. If, however, the coin is tossed one hundred times the probability of heads showing half of the time is greatly increased. Statisticians have developed systems by which significance, or validity, of experimental results can be tested. If the probability is 19 to 1, the results are acceptable and if the probability is 99 to 1, the results are considered to be highly significant.

Significant findings, however, may not prove to be practical. In other words, the differences may be valid but of such small magnitude that it would not be economically profitable to warrant changing. It is this practical testing, with large numbers of plants and under various propagation schedules, that the commercial propagator has and can continue to make valuable contributions. Again, what is practically adaptable for one situation or propagator may not be for another.

At most state agricultural experiment stations, research, including research in plant propagation, is supported largely by state funds. These funds may be augmented by allocation of Federal funds authorized by the Hatch Act or from special agencies such as the National Science Foundation and the Public Health Service. On occasion support may also come from private commercial sources or from commodity organizations, such as nurserymen's associations. There are undoubtedly instances in which an increased support for research in plant propagation would be helpful.

It must be remembered that many individuals who are currently conducting research in the area of plant propagation are also responsible for other areas of research with ornamental crops, with teaching, with advising undergraduate and graduate students and, in some instances, with administrative duties.

The results of basic research with plants are published in a number of scientific periodicals, such as the *American Journal of Botany, Plant Physiology, Botanical Gazette* and *Physiologia Plantarium.* The results of applied research are found in other periodicals, for example, *Proceedings of the American Society for Horticultural Science, Proceedings of the International Horticultural Congress,* and similar publications. These reports are prepared for the scientist and are of limited use to the commercial propagator. Results of research reach the commercial propagator through the activities of the extension specialist, reports at meetings of commodity groups, the trade publications, and certainly at meetings of this Society.

If there is any purpose for this discussion, it is two-fold: first, a compliment to this organization for the opportunity for teachers, researchers and commercial nurserymen to discuss formally and informally the problems of plant propagation and second, an earnest plea that each of you encourage and support both basic and applied research at instiutions throughout the country.

MODERATOR DAVIS: Thank you, Bill. Our second paper will be given by Dr. Ken Reisch, Ohio State University.

DISEASES INITIATED IN THE PROPAGATING PHASE WHICH LATER CAUSE PLANT LOSS

K. W. REISCH
Department of Horticulture
Ohio Agricultural Experiment Station
Wooster, Ohio

The incidence and spread of disease organisms in the propagating phase is probably far more critical and costly than most propagators realize. We know that disease or insect infected wood can readily be a source for infection and spread, but the contamination of previously "clean" stock is a problem with which all plantsmen should be concerned. Many growers on the West Coast have recognized the seriousness of some of these problems and have taken positive steps to correct them, through sanitation and disease control programs.

We are all familiar with fungus diseases such as those causing damping-off and we can readily diagnose the cause and take steps to prevent or correct it. If all diseases initiated in the propagating phase killed the plants at this time it would be fine, but the initiation of pathogens, which are evidenced later in the life of the plant, can prove to be very costly. The decline

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We have all heard and used the standard reasons given for plant decline and it is common to anticipate five to ten per cent or greater loss in each phase of production from propagation to sale, and the loss becomes more costly with time. We attribute much of this to soil, drainage, watering, fertility, high salts, weak stock, temperature and weather conditions, the workers, the time of year, or poor practices such as deep planting, improper cultivation, or possibly planting in the wrong phase of the moon. Many previously unexplained losses and poor quality stock have probably been due in part to pathogens which could readily have arisen in the propagating phase.

There is little research information on specific diseases arising in woody plants at the time of the propagation; however, there is evidence of this problem with certain florist's crops and we know it can be a problem on many softwood cuttings of ornamentals. Common causes of this trouble are soil borne diseases such as Rhizoctonia, Pythium, Phytophthora, Fusarium, and Verticillium, as well as parasitic nematodes. *Rhizoctonia solani* causes decay on stems and roots near the soil surface. It is spread by splashing water, dipping infected cuttings in water or auxin, soil in the watering hose, infected cuttings in the propagating bench, and infected flats, benches, medium, pots, tools, as well as hands and shoes of the workers. Spores are not usually produced in the propagating phase and spread is generally by mechanical transfer on tools, hands, etc. Also, conditions in the propagating bench, which may include good root aeration and drainage, will supress expression of the disease with symptoms appearing later in the field, container, or landscape plantings.

Pythium and Phytophthora, called water molds, are most damaging when soil is very wet. Mycelia penetrate root tips and these diseases may also be expressed, and can cause most damage, at a later stage in growth. The water molds may survive in dry soil for several months and then spread and develop when moisture is provided.

The greenhouse poinsettia is a good example of the subject of this presentation. Diseased plants are frequently sold and provide satisfaction to the consumer even though pathogens are present, which were introduced in the propagating phase.

The three fungi most commonly affecting this crop are *Rhizoctonia solani, Pythium species,* and *Thielaviopsis basicola.* Rhizoctonia is most severe at high soil temperature and low soil moisture. Pythium, in contrast, is most severe at low soil temperature and high moisture. Thielaviopsis is most severe at low soil temperature and damage usually occurs at the end of the growing season. Since the poinsettia is grown over a period of two to seven months, the disease organisms can become critical at almost any stage of growth; however, with proper manipulation of the environment, it is possible to produce plants, although diseased, which have adequate sales value. This situation is different with woody ornamentals which are expected to live, grow, and be of aesthetic and functional value for several years.

Fusarium wilt of carnations is another more specific fungus disease that causes abnormal growth of young shoots, and may gain entrance through wounds when the cuttings are made. As indicated earlier, many woody plant problems may also be due to pathogens which could easily be introduced in the propagation phase. Two specific types which have become serious in Ohio nurseries recently, were found on Rhododendrons. The evidence did not show up until plants died in beds or even in the field blocks. The United States Department of Agriculture, Ornamental Plant Research Laboratory in Delaware, Ohio, diagnosed the problem as (1) a root disease caused by *Phytophthora* species *cinnamoni* and (2) a stem canker, *Botryasphaeria ribis.* Some growers have indicated up to 75 per cent loss because of these problems. The root rot can readily be spread in infected mediums and the stem canker through any wound or on a cutting knife from cutting to cutting. Baker (1) indicated the same problem exists on Heather, on both cuttings and large plants and on avocado root stock and trees, as well as on some other economic crops.

As with most other plant problems, prevention is far more valuable and successful, and less costly than the control. Although there are chemicals such as Terraclor, Panodrench, Dexon and others which are affective against some of these soil borne diseases, their use should be considered as an addition to, and for maintaining sanitary conditions, rather than a replacement for preventive practices.

The proper approach is through sanitation and sterilization or pastuerization of medium, containers, benches, and all materials coming in contact with the plants. This can be accomplished by use of chemicals or steam and I refer you to the paper by W. W. Osborne (2) for a thorough coverage of this subject. This, unfortunately, is probably of least concern and one of the most violated practices in the nursery industry. The florist is concerned because he can see the results in a short time and is dependent on maximum production from high investment growing areas. With woody plants, however, the unseen long-term problems do not present immediate evidence of trouble and are therefore ignored.

Not only should propagating areas be sterilized and maintained free from reinfection, but this should also apply to bed areas, container plants, lath houses, and even field blocks when specific, difficult to control problems arise.

We are operating in the era of so-called soil-less mediums today, but even these must be checked for diseases. Weed seeds might be lacking, but actually are the least of the possible problems which could be present. This applies to peat moss, sand and other organic or non-organic additives which should also be sterilized.

The old adage "A stitch in time saves nine" certainly applies here since it is not possible to over emphasize the important place of diseases and other pathogens which originate early in the life of woody plants.

I have said nothing of nematodes, viruses, or other organisms which can be brought in on the propagating stock itself and introduced at this stage of production. For instance, virus in scion wood on grafted plants will reduce successful take. The practice of developing disease free stock plants is another extensive subject in this area and certainly of equal importance.

In summary, these problems are related to plant quality, production efficiency, cost saving, and indirectly to the building of an industry image. I believe we should strive to upgrade our industry in all phases of production and sale and certainly this aspect constitutes an extremely important phase.

I have possibly over-emphasized the problem, but I do not believe we can minimize any factor which may lead to tremendous losses and, more important, to a reduction in plant quality which we should constantly try to improve rather than maintain at a minimum level.

LITERATURE CITED

1 Baker, Kenneth F. 1957, The U. C System for producing healthy container-grown plants Calif. Agr. Exp Sta Manual 23 333 pp.

2 Osborne, W W. 1961 Soil Sterilization and Fumigation Eleventh Proc. Plant Prop Soc

MODERATOR DAVIS: Thank you very much, Ken. We will now have questions on the two papers you have just heard.

MR. MARTIN VAN HOF: Who do we go through or who do we approach if we want more help from research?

DR. SNYDER: I would suggest first contacting the people in the Horticulture Departments who are working on your problems, and then through channels to department heads, and deans. Also, contact your state representative.

MR. AL LOWENFELS: Dr. Reisch, do you recommend sterilizing peat moss and perlite?

DR. REISCH: Perlite should be free of pathogens because of the heat used in processing, but the peat moss may carry pathogens. It is recommended by Baker in California that it should be sterilized as a safety measure.

MR. HANS HESS: You may sterilize the greenhouse benches and paths, but what is going to prevent bringing disease organisms in on potted understock which has been held outside in frames?

DR. REISCH: Actually nothing. However, we are not trying to reach an absolutely sterile situation. What we should strive for is reducing disease organisms as much as possible

SATURDAY MORNING SESSION

SECOND SECTION

The second section of the Saturday morning session convened at 10:40 a.m., Mr. Joseph Houlihan, Houlihan Nursery, Creve Coeur, Missouri, moderator.

MODERATOR HOULIHAN: The first paper of this section will be by Prof. A. F. DeWerth, Texas A. & M. College, College Station, Texas.

THE USE OF A CONTROLLED ENVIRONMENT PLASTIC STRUCTURE FOR PROPAGATION BY CUTTINGS OR GRAFTS

A. F. DEWERTH
Texas A. & M. University
College Station, Texas

The techniques used for rooting leafy cuttings and grafts under mist are now well known and widely practiced by plant propagators. The mist sprays used maintain a film of water on the leaves which not only results in a high water vapor pressure surrounding the leaf but also lowers the temperature of the leaf and the surrounding atmosphere. All of these factors have a decided effect upon decreasing the rate of transpiration.

The use of the mist techniques in the research projects including plant propagation at the Texas Agricultural Experiment Station presented considerable difficulties due to the high soluble salt content in the available water supply. (This was largely due to sodium accumulation on the leaves.) This condition resulted in severe marginal burning of the leaves on most cuttings placed in this environment for periods exceeding 15 days.

Another well-known propagating technique for the propagation of cuttings and grafts is the use of a closed case covered with glass, plastic films, or other translucent materials. In a closed-case system of propagation, the rate of transpiration is reduced by humidification rather than mist. There is normally a distinct difference in the effect of humidification and mist on the rate of transpiration since the relative humidity around the leaf decreases or increases the water vapor pressure around the leaves. In this method the leaves are not usually covered with a film of water that reduces the leaf temperature and in turn decreases water vapor pressure within the leaves. Due to this condition, closed cases used for propagation are normally shaded to reduce temperatures. This reduction in light intensity often makes the rooting environment less desirable.

With the use of mist methods, an ideal environment for the rooting and growth of many types of cuttings and grafts can be maintained if an excellent water source is available, since transpiration is reduced to the lowest level and high light intensity can be maintained to promote a high rate of photosynthesis and a low rate of respiration. When the conventional closed-case propagation was used, unless the case was shaded and ventilated by laborious and time consuming methods, cuttings and grafts suffered due to reduced photosynthesis and increased respiration brought about by hading and high temperatures.

The disadvantages encountered with mist propagation when the water available had a higher than normal soluble salt content and the problems involved in trying to control ideal temperature and humidity relationships in closed-case management prompted the development of a closed-case propagation system with automatic or semi-automatic control of the environmental factors involved. This device has produced excellent results in the propagation of ornamental plants by cuttings and grafts, as well as by seeds.

The propagating case discussed here was constructed inside a greenhouse. (However, this is not an important consideration since it could be constructed and maintained just as efficiently under lath or field conditions where a suitable water supply with 50 pounds pressure and a source of electricity are available.) This closed-case system with automatic controls was constructed over a conventional concrete greenhouse bench 3 feet wide, 8 inches deep, and 33⅓ feet long. The construction of the case proper was kept as simple as possible. The supporting members were constructed of ⅝-inch standard steel conduit such as that used by electricians for electrical wiring. The material was formed with a pipe shaper into a form resembling an inverted "U" with a 2-inch flat area on the top when installed over the bench. The pipe supports were erected and held together and upright by the use of 5 wood strips, one inch thick and 2 inches wide, that extended the length of the case. One strip was bolted to the apex of the inverted "U" pipe forms when they were set in place on the bench. One strip was bolted to the base of the forms on each side and one strip was bolted to the forms at the tangent point on the sides of the inverted "U" forms. This frame made up the superstructure of the closed case.

The bottom of the V-bottom concrete propagating bench was filled with pea gravel to a depth of 2 inches. Thermostatically controlled soil heating cable was placed on the gravel and covered with ¼-inch mesh hardware cloth. One inch of the propagating medium was placed on top of the hardware cloth.

An automatic watering system based upon the sub-irrigating principle, composed of alternating one-foot lengths of porous clay tile with an inside diameter of ½ inch and an outside diameter of approximately one inch and one foot lengths of ½-inch diameter plastic tubing, was placed upon the medium. The watering system was installed in 2 continuous lines spaced 18 inches apart around the entire bench. One end of the system was connected to a small plastic water supply tank controlled by a small float valve. The other end was closed by inserting a

½-inch rubber cork into the end of the line. The water supply tank was connected to the water supply by ¼-inch plastic tubing and a valve.

The bench was filled with a standardized propagating medium composed of 50% horticultural grade perlite and 50% sphagnum peat moss with 7 pounds of dolomite and 10 pounds of gypsum thoroughly incorporated into each cubic yard of the mixture. (For acid loving plants, the dolomite could be omitted and in areas where sodium salts in the water are not a problem, the gypsum could be omitted.) The medium was well watered by hand to establish capillarity with the automatic watering system. (For grafts in pots or seeds planted in flats the bench could be filled about half full of perlite or fine gravel and the pots or flats placed on this medium and the watering system turned off.)

About three-fifths of the case (from the upper wood strip on one side to the lowest strip on the other side) was covered with weatherable mylar and stapled to the wood strips. The other side of the case was covered with polyethylene curtains, 9 feet 5 inches long, fastened to the upper wood strip. A wood strip was fastened to the bottom end of these polyethylene curtains permitting them to be rolled and unrolled like a window curtain. In this manner, one section of the case would be opened while the remainder of the case remained closed.

One end of the case was covered with a 50 mesh brass screen. A Defensor humidifier was installed in this end and was controlled by a humidistat and a solenoid valve. The humidistat was located in the middle of the case. The manufacture of this humidifier later was discontinued and the humidifier was replaced by 2 Monarch No. F 11OC fog nozzles installed ⅓ of the distance from each end of the case and connected to the same control system. A 10-inch exhaust fan similar to those used for greenhouse cooling was installed in the other end of the case. The area around the fan was enclosed with mylar. The fan was controlled by a thermostat located midway between the two ends of the case.

The watering system provides an excellent air-water relationship in the rooting medium by capillarity. When the thermostats on the soil cable are set at the desired temperatures they automatically control the temperature in the propagating medium. When the thermostat on the fan is set at the desired relative humidity a constant percentage of humidity will be provided automatically. The automatic control of temperature and relative humidity eliminates the need for the shading usually required with closed-case propagation.

Excellent results have been obtained with seed germination and the propagation of cuttings and grafts. Several types and kinds of plants, including several kinds of exotic plants that were difficult to root under mist, have been successfully propagated by this method. Bedding plants have been started from seed, both in flats and pots.

The growth chamber approach to this problem appears to give highly satisfactory results, since by regulating the controls the cuttings or seedlings can readily be hardened off for potting or transplanting before they are removed from the case. When peat pots are used the automatic watering system can be employed. This has worked especially well with the propagation and hardening off of bedding plants and small seedlings of woody plants.

It is hoped several additional uses will be found for this system in the future.

MODERATOR HOULIHAN: Thank you, Prof. DeWerth. The next paper will be given by Mr. Zophar Warner, Warner Nurseries, Willoughby, Ohio.

INEXPENSIVE PLASTIC STRUCTURES FOR WINTER PROTECTION OF PLANTS

ZOPHAR P. WARNER
Warner Nursery
Willoughby, Ohio

There is a great deal of information about plastic houses. The Cunningham house was described before this Society two years ago. This presentation can be found on page 142 of the 1961 Plant Propagators' Proceedings. Harvey Templeton has some pipe frame and woven wire structures. The Berryhill Nursery has been using quonset hut type plastic structures for several years. I am sure there are many other good ones in use, some with wood frames.

The most obvious requirement of an inexpensive plastic structure is that it cover the most area or furnish the most cubic feet of space at the least cost per square foot or cubic foot. On this level, it is an engineering problem in which local snow and wind loads must be taken into consideration. If this were the only problem this audience would be better served by having an architect or engineer furnish structural data that I am in no way qualified to present.

I would like to depart to a large extent from the structural aspects of "Inexpensive Plastic Structures For Winter Protection Of Plants." I think this can be done without departing from the spirit of the subject. Anyway, we can rewrite the title using exactly the same words to read "Inexpensive Winter Protection Of Plants in Plastic Structures." The structures in themselves may or may not be expensive since they are only one of several factors contributing to cost.

The first requirement of inexpensive winter storing is success!

When John Roller asked me to give this talk I was reluctant to make a presentation based on failure. After giving the matter some thought, I decided information based on known failure

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I would like to depart to a large extent from the structural aspects of "Inexpensive Plastic Structures For Winter Protection Of Plants." I think this can be done without departing from the spirit of the subject. Anyway, we can rewrite the title using exactly the same words to read "Inexpensive Winter Protection Of Plants in Plastic Structures." The structures in themselves may or may not be expensive since they are only one of several factors contributing to cost.

The first requirement of inexpensive winter storing is success!

When John Roller asked me to give this talk I was reluctant to make a presentation based on failure. After giving the matter some thought, I decided information based on known failure might be better than information based on accidental success. A few years ago we had substantial success in wintering plants under snow. This is the most economical protection known to man but unreliable or non-existant and is too costly to make with snow machines.

Last year we built these 10 foot wide huts of 6x6x6 reinforcing mesh with pipe ridge pole supports. We filled them through the side with a wide assortment of broadleafed material grown in containers. Four mil polyethylene was then stretched over the whole structure including the ends to make it as air tight as possible. Our figures showed that we had a very economical structure. However, when spring came our losses in all types of material was greater than the cost of construction. What happened? Stated simply the plants were killed by prolonged cold temperatures reaching 25° below zero. Specifically, they were killed by one or more of the following:

1. Soil temperatures too low for the roots to live.
2. Temperatures too low for the tops to live. Tolerance of temperature extremes by the tops of plants is almost always greater than the roots.
3. Desiccation caused by low humidity in turn caused by moisture condensing on the plastic and running down the sides.

If the winter had been normal, I am sure no losses would have occurred.

However, not everything we did turned out badly. Why we were successful under other conditions can best be shown in pictures of our use of polyethylene. It has occurred to me that anyone growing material likely to be winter damaged might do it more economically by keeping the whole operation under plastic structures covered in winter, uncovered in summer.

Since I can see no possibility of affording this economy, at least all at once, it is essential to divide structures for winter storage into two categories.

The first is constructed over the plants in the growing area.

The second is stationary and the plants are moved from the growing area and placed in the structures. Both have their uses but can be used to good advantage only if planning is done in advance.

The first type structure should be used to cover plants that are some time from maturity or sale and can be left through another growing season undisturbed.

The second is the place for permanent structures and should be used for small plants such as flatted material that is economical to move. Larger material should be placed in these permanent structures only if they have reached selling size and the winter storage is part of the selling operation. The cost of moving from the growing area to a plastic house for storage, back to the growing area, then back to storage the following autumn is prohibitive.

In fact, in most cases the permanent structure for wintering should be designed as a integral part of the shipping and selling facility where it can be used as a display for selling.

During the early 1950's while we were having mild winters, we worked out a system in which we wintered rooted cuttings consisting mainly of broad leaves and ericaceous plants in the greenhouse or cold frames. The next spring they were planted in peat beds for one or two years. From there they were sold, field planted or more recently placed in containers for growing on one or two years. In the beginning we found it unnecessary to use shades winter or summer. Polyethylene was unheard of. Since then, we have experienced a series of increasingly severe winters and we have made increasing use of Polyethylene.

The following pictures will show what we are now doing without making basic changes in our method or production.

The first pictures show poly covered frames. Last winter we suffered some loss of Ilex cuttings due to extreme cold. This year we have placed an inner lining of 2 mil poly over poultry netting. The netting is necessary because the poly alone would not support the condensation that drips down from the outer layer.

The azaleas beds are 80 inches, center to center. Two lines of one inch structural galvanized pipe unthreaded are supported every ten feet on concrete block. The joints are made by inserting the one inch pipe into a one foot section of 1¼ inch pipe. This 1¼ inch piece is kept from moving by a galvanized nail in the center. Forty eight inch snow fence is then rolled over the center of all the beds before the alternate paths are covered. Four mil poly is then placed over the whole area and weighted down with gravel. It is important to seal the ends and sides with the poly not only to keep it from blowing away but to prevent evaporation. Keeping the air space at a minimum maintains higher humidity since the ratio of cubic feet of air to the available moisture is better than it would be in a higher structure.

Furthermore, when condensation takes place the moisture drops back on the plants thus working in the same way as a sweat box.

A few years ago in Cleveland, I gave a talk before this society on the use of plastic in propagating houses. Before my turn on the agenda came, Mr. Gray had told about wrapping a bench full of cuttings in polyethylene and leaving them sealed until rooted. Mr. Wilson topped this by rooting juniper cuttings in a poly bag in the back of his car on the way home from Florida. I hestitate to make claims this optimistically but, these low, flat, air tight structures require less attention than large houses that can and should be inspected more often.

Unless watering is done and temperatures are above freezing it is imperative that any wintering structure be air tight. Holes or loose sides will cause more dehydration than no cover at all. These plants may be covered two years in this way The shades will be rolled up during the summer since they are generally detrimental in our area.

Where maintaining shade and humidity are not so necessary it is more economical to use 6x6x6 reinforcing mesh. We copied this from Berryhill Nursery. It has also been used by the Perkins DeWilde company and probably many others.

Shown here are container plants that have not reached saleable size and will remain in this area next summer. Next, this year's rootings of various kinds of euonymus have been bedded out. They were planted in September when time is more available and will be substantially better than they would have been if planted in the spring after growth had started. In both cases they have been covered with the mesh and poly.

Where additional temperature and humidity protection are required we are rolling 2 mil poly right over the plants before placing the mesh. We have never tried this before but it should work. If ventilating is necessary we can open the top layer without drying out the plants. When the beds are made or the containers placed on the ground, it is imperative that the edges be straight. The mesh is in 5 foot sections but the 100 lengths of poly cannot be kept tight if there is a bend.

Advance orders and the plants of a saleable size are brought to the shipping area and placed between two rows of baled straw, 20 feet apart. Pipe is placed across the bales to support shades. Here sections of shades are used so a little can be moved at a time as shipping progresses. This whole space is covered tightly with 24 foot 4 mil polyethylene.

Poly has been hung over the pipe every 60 feet or so to further retard movement of air This would be more important if you were working on a slope.

Results under this method of storage have been very good. The Bosley Nursery, Mentor, Ohio has been storing container material in a similar way with good results.

In addition to the humidity advantage, previously mentioned, soil temperatures do not drop as low due to the minimum radiation surface. Even if the soil freezes, it thaws out from the bottom. This is very important, particularly with container grown plants. This is the place for the permanent walk-in structure. We have not built any here because we expect to relocate the shipping area.

We have also had excellent results by laying down 5 gallon square cans, tops to tops, can to can. These were stacked 5 wide and three high and covered with 10 foot wide clear poly. These can be run in long rows and should run north and south so they will shade themselves.

Most of these pictures were taken November 16th of this year while we were still placing the framework. By now, December 7th, the polyethylene is nearly all in place.

I would like to make specific statements of fact that would furnish valid information for everyone present. This is not possible due to the wide range of interests of the members, differing climatic conditions and the wide variety of plants that need to be winter stored. The questions are the same in any case.

The answers reflect local requirements. A winter storage structure should accomplish the following:

1. Raise the soil and air temperature.
2. Maintain high humidity.
3. Prevent sudden fluctuations in temperature, probably by use of shade.
4. Enough light should be provided to prevent defoliation.
5. Should not encourage early growth.

If these items and a few others are dealt with properly, healthy live plants will result.

As mentioned in the beginning this is the first requirement for making storing inexpensive.

Efficient handling of the material, and speed in completing the storage operation in the limited time between dormancy and freeze-up are also important.

Only after the foregoing items are taken care of, can the actual cost of material used in the structure be considered. This in itself is complicated by whether depreciation or obsolescence occurs first.

A good way to reduce costs is to get more than one use from the material. We are using the old poly for weed control and packing. The snow fence can be used for conventional shade.

If we change our minds, we may bend the pipe into arches to make some of Harvey Templeton's 13 foot wide houses and the concrete blocks can be used for permanent frames. However, we have not yet decided to go into the paving business with the old reinforcing mesh! In closing, I would like to suggest that the need for additional information is endless. All the tolerances of all the varieties of plants should be known. A comprehensive review of the availability and use of new material needs to be made every few years.

Presently we are preparing for severe winters.

Will these preparations be detrimental in a mild winter?

MODERATOR HOULIHAN: Thank you very much, Zo, for a very informative paper. Our final speaker of the morning is Mr. Ray Halward, Royal Botanical Gardens, Hamilton, Ontario, Canada.

LEAF-BUD CUTTING TRIALS 1963

RAY E. HALWARD
Royal Botanical Gardens
Hamilton, Canada

It was pointed out in a brief summary in the March issue of the Plant Propagator under the heading "Field Trials for 1963," that some plants had been propagated successfully using the leaf-bud cutting technique. It was hoped that the field trials this year would add to the knowledge already available.

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Bottom, Pennsylvania. The other Robert L. Ticknor, Associate Professor of Horticulture, Oregon State University.

Paul Case reported the following: the cuttings were stuck in a greenhouse bed with a depth of 5 inches of sharp, washed sand. A heat cable maintained a temperature of 72° - 75° F. The cuttings were under a tent of plastic supported 10 inches above the sand by a wire frame. A 50 percent slat shade plus the usual whitewash shading covered the glass. The greenhouse temperature was generally under 75° with a night temperature 10° lower. The cuttings were watered heavily when stuck then checked every 7 - 10 days and watered at each inspection. The cuttings were dipped in 'Panodrench' prior to the 'Hormodin I Power.' The cuttings were again sprinkled with Panodrench after being stuck.

The following results were recorded:

Leaf-bud cuttings made 7/10/63 - 7/30/63

Date Stuck	Name of Plant	No	No Rooted	Remarks
July 10	*Magnolia stellata* 'Royal Star'	100	86	Date removed 8/30/63
	Prunus subhirtella pendula	100	0	
	Prunus persica (Amygdalus)	100	0	few callused
	Pieris axillaris	25	0	
	Oxydendrum arboreum	100	0	few callused
	Hydrangea petiolaris	25	0	
	Ginkgo biloba	100	0	few callused
	Syringa persica	100	0	few callused

All not rooted by 9/30/63 were discarded.

The experience gained this summer led Paul Case to draw a few conclusions:

(1) Leaf-bud cuttings were top heavy and time spent adjusting them was not justified according to the results obtained.

(2) The resulting plant from a leaf-bud cuttings is about one year behind a stem cutting.

The following is the report of Robert L. Ticknor — the cuttings were taken on June 28, 1963 and all were treated with Hormodin #3. Fifty cuttings of each species were inserted in perlite and in peat perlite.

Species	No rooted Perlite	Peat Perlite
Acer rubrum	3	6
Acer saccharum	18	2
Cercis silquastrum	0	0
Clerodendron trichotomum	18	11
Gleditsia triachanthus	4	0
Liquidambar stryraciflua	13	25
Platanus acerifolium	19	14
Quercus borealis	0	0
Quercus palustris	0	0

The plants were removed from the bench on September 23, 1963 with the following exceptions — 11 *Clerodendron* from peat perlite, 17 *Clerodendron* from perlite, and 15 *Platanus* which were removed on 7/31/63. Of the 15 *Platanus* cuttings removed on 7/31/63 only two appear alive at present.

It is questionable whether the maple cuttings will be alive in the spring but the sweet gum look like they will be alive. The *Clereodendrons* have shoots 4-8″ tall so will probably survive. All cuttings came from young four to five year old trees.

The leaf-bud trials at the Royal Botanical Gardens were carried out in a closed intermittent mist bed with cuttings stuck in boxes in a 3-sand 1-peat mixture. The results were very poor. 50 cuttings of each of the following were tried, half of them were treated with Seradix #1, and half no treatment.

Date Stuck	Name of Plant	No. rooted Seradix #1	No. rooted No treatment	Remarks
June 10	*Syringa 'Frank Patterson'*	2	3	
21	*Prunus avium*	0	0	Leaves dropped
July 4	*Liquidambar stryaciflua*	0	0	some callused
4	*Sorbus hybrida*	0	0	some callused
9	*Quercuh macrocarpa*	0	0	leaves rotted
9	*Quercus coccinea*	0	0	Some leaves stayed green until October some callused
9	*Quercus imbricaria*	0	0	
9	*Tilia cordata*	0	0	some callused
9	*Fagus sylvatica*	0	0	leaves rotted
17	*Magnolia acuminata*	0	0	leaves rotted
17	*Cercis canadensis alba*	0	0	

I am indeed indebted to Paul E. Case and Robert L. Ticknor for their time and effort contributed to the Field Trials 1963.

MODERATOR HOULIHAN: Thank you very much, Ray. Are there any questions?

VOICE: Mr. Warner, have you tried any white polyethylence for winter protection?

MR. WARNER: No, we have not. However, we are interested in any polyethylene which has a percentage of reflecting or shading material.

MR. JIM WELLS: Zo, when do you begin to remove the winter protection?

MR. WARNER: In the case of saleable material, when somebody comes to get it. For the other plants, in our particular part of the country, from the 1st of March to the end of April, depending upon the season.

MR. PAUL BOSLEYS As to uncovering, we usually wait until there is a general warming trend. We then open one side of the beds, the side away from the prevailing wind. This still gives quite a bit of protection. We are trying, this year, the white plastic made by the Dow Chemical Co. At present we do not know what the cost will be.

MR. ED DAVIS: We were curious about the amount of heat which would build up under a frame covered with white polyethylene. The temperature under the plastic was often 1 or 2 degrees cooler than in the shade on the north side of a building. We feel that this will help in decreasing the large amount of fluctuation of temperature you normally experience under clear polyethylene.

MR. WARNER: We are going to try spraying clear plastic with aluminum paint, putting it on heavier at the top of the quonset frame and tapering off at the side. In this way we will cut down on direct sunlight, but allow indirect light at the sides.

MR. GERRY VERKADE: Did the 5 gallon containers which were laid on their side receive any moisture?

MR. WARNER: No, but it is very important that a porous medium which holds a lot of moisture be used. After the plants are laid down, it is important to get the cover on right away, before any moisture is lost.

MR. LESLIE HANCOCK: Our experience with a plastic house was that there was little difference in the low temperatures. If it was 0° F. outside it would be 5 to 10° F. inside, but usually no warmer. But during the day, when the sun was out, the temperature shot way above the outside temperatures. We then covered the house with reed mats to get a better balance between light and temperature. The reed mats cut the light to about ⅓ full light and the temperatures were much more reasonable and we carried the crop through the winter.

SATURDAY AFTERNOON SESSION

December 7, 1963

The Saturday afternoon session convened at 1:15 p.m., Ralph Shugert, Neosho Nursery, Neosho, Missouri, moderator.

MODERATOR SHUGERT: Our first speaker this afternoon is Mr. Hans Hess, Hess Nureries, Wayne, New Jersey.

HOLLY PROPAGATION AND CULTURE

HANS HESS
Hess Nurseries
Wayne, New Jersey

Since all of our plants originally started from seed, this paper on Holly propagation will start with the miraculous and often exasperating little seed.

Berries are collected when ripe in November and December. They will vary in size and shape depending on the species, the largest being about ½ inch in diameter on *Ilex macrocarpa* and also *Ilex opaca* variety Emily, a selection of the late Wilfred Wheeler.

Inside the berry there are generally four individual nut like seeds, which if you carefully remove the pulp, appear as a single stone. The skin and pulp are removed from the seeds by fermenting in water with a small amount of sugar and rubbing over a screen or by using a commercial seed cleaner. The seeds of the various species vary in size in definite relation to the size of the berry. The imperfect seeds which are plentiful in some species are floated off and discarded. A bulletin which describes and illustrates the seeds of thirty some species was written some years ago by Dr. Harold Hume and published by the Holly Society of America.

The seed coat of all *Ilex* species is very hard and the embryo immature at the time the fruit ripens. Stratification is necessary to complete the development of the embryo; we have used both sand and peat moss with equal success. Most species germinate better than 60% the second spring. In the case of *Ilex opaca* only 10 to 20% germination takes place the second spring with 60 to 70 % occuring in the third spring.

We feel that since there is so little germination the second spring it is more practical to make your sowing during the fall, two years after harvest on *Ilex opaca.*

Seed should be gathered in or near your growing area or even at a more northerly location to insure hardiness of the seedlings. First year seedlings of all species should have protective lath shading the first growing season with the addition of salt hay or similar material the first winter. Birds are very fond of Holly seed and will destroy a bed of germinating seedlings unless a protective wire cover is provided until the plants have true leaves. Normal treatment with red lead or a similar product will not last through the stratification period. Seedlings of *Ilex opaca* are generally four to six inches tall the first year on a well prepared seed bed. The deciduous species such as *Ilex verticillata, Ilex serrata* and the evergreen types like *Ilex crenata* will develop a reasonably well branched root system as a young seedling. *Ilex opaca* on the other hand tends to tap root from the very beginning and seedling grown plants need several transplantings or root pruning to develop a good root system. Cuttings of *Ilex opaca* seem to make a well branched root syetem without as much transplanting. Fruiting of seedling grown *Ilex* species as with all seedling grown plants takes much longer than asexually produced plants. Most of the seedling Hollies cannot be expected to fruit in less than eight to ten years.

So much for Hollies from seed since to-day in large part asexual production of selected clones has replaced seedling production. Plants selected for their growth habit, superior foliage, fruit and its display are the ones currently in demand. The first method used to reproduce these selections was grafting and budding on two or three year seedlings and a few varieties are still grown by this method; however, with the development of automatic misting, virtually all asexual production of hollies is by cuttings. We have found that Hollies can be very easily and quickly rooted under mist in open beds, potted and carried in frost free storage frames for the winter. I must not forget to mention that we use a 20% dilution of Chloromone on these cuttings to speed up the rooting. Turning from propagation to culture of Hollies, let us begin with plant selection. Select only those which are hardy in your area, this pertains to all species which are native in the United States as well as those introductions from other countries. Next, when planting in your nursery or on your customers grounds, select a location with good moisture and drainage and also good air drainage to avoid frost damage to the flowers and foliage.

There is a great difference of opinion regarding the proper fertilizers for Hollies but generally speaking the standard organic fertilizer for broadleaves, plus some dolomitic limestone every three years will do a good job. Feeding of young plants should be made during the winter, so that food is available when growth starts and will not push the plants late in the season, causing kill back. Hollies in general do not have a large number of insect pests, but the well known leaf miner on evergreen species poses the biggest problem and it is actually more unsightly than harmful. The best known and generally used control is a combination spray such as DDT and malathion applied as growth begins in May and repeated again in about seven to ten days. The DDT providing a residual effect and the malathion to prevent a build up of spider mite. Systemics have been found very affective in the control of leaf miner, but because of the hazards it presents, it has not been widely accepted. In conclusion may I say that Hollies are a large group of plants, evergreen and deciduous, having red, black and even yellow fruits, some of them with smooth leaves, some with sharp spines. Their white flowers are generally inconspicuous. They are also dioecious, so be sure to select lots of females for fruit and a few boys to do their job and keep the girls happy.

Although they grow best in a rich well drained soil, they will thrive under a variety of conditions. If you select those hardy to your area, there is hardly a group of plants so well suited to such wide landscape use

MODERATOR SHUGERT: Thank you very much, Hans. The second speaker is Dr. Don F. Wetherell from the Department of Botany, University of Connecticut, Storrs, Connecticut.

GROWING WHOLE PLANTS FROM INDIVIDUAL CELLS

A Possble Propagation Technique for the Future.

D. F. WETHERELL
Department of Botany
University of Connecticut
Storrs, Connecticut

The age old practice of plant propagation has taught us that many of the organs of a mature plant can be separated from the rest of the plant and in a relatively short time will reconstruct the missing parts to reform an intact plant. This capacity for regeneration of parts must mean that at least some of the cells which compose these organs, carry all the information and metabolic tools necessary for the formation of an entire new plant, i.e., they must carry as much inherited information as the zygote which forms as the result of fertilization and which is the starting point for the embryonic plant contained in seeds. We call the possesson of all essential genetic information and metabolic machinery — totipotence. Biologists have long wondered whether such cells could be isolated from the protection of their tissues in the intact organ and still retain not only their ability to grow but also their totipotence. As long ago as the turn of the century intensive efforts were being made by Gottlieb Haberlandt, the famous German botanist and anatomist, to isolate single plant cells and make them grow under artificial conditions[1]. This ultimate refinement of plant propagation has been on the minds of botanists ever since but only very recently have we accumulated enough experience to permit us to test these ideas.

It was not until after the discovery of auxins in the 1930's and the subsequent recognition of their key role in growth and development, that we could carry out the first step, the culture of tissue masses on artificial culture media. Although auxin-dependent tissue cultures have now been common place for 20 years, the successful culture of single freely suspended cells (so called "cell culture") was not achieved until the mid 1950's. The sion may I say that Hollies are a large group of plants, evergreen and deciduous, having red, black and even yellow fruits, some of them with smooth leaves, some with sharp spines. Their white flowers are generally inconspicuous. They are also dioecious, so be sure to select lots of females for fruit and a few boys to do their job and keep the girls happy.

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It was not until after the discovery of auxins in the 1930's and the subsequent recognition of their key role in growth and development, that we could carry out the first step, the culture of tissue masses on artificial culture media. Although auxin-dependent tissue cultures have now been common place for 20 years, the successful culture of single freely suspended cells (so called "cell culture") was not achieved until the mid 1950's. The possibility of reconstructing intact plants from these cell cultures has only been demonstrated in the last few years. In this paper I will briefly outline the development of the knowledge of the hormones and their interplay in plant growth and then describe some of the recent researches in which the regeneration of shoots, roots or whole plants has been achieved starting from tissue-cultured cells.

When a wound occurs in plant tissue, masses of soft, so-called, parenchymatous tissue are quickly formed in the wounded area by the initiation of cell division and growth in cells which otherwise had ceased to grow and had settled down to a specialized existence as a part of a specialized tissue. If the wound is extensive then a large mass of wound tissue, or callus as it is often called, will form. This callus is at first characterized by thin walled rapidly growing cells, resembling in many ways the cells of the growing points of shoots or roots or of the cambium, but usually lacking the tissue organization exhibited in the normal growth centers. If the wound is not aggravated, there will occur in this callus, a return of certain cells to a degree of specialization which is familiar in maturing normal tissues. First one may observe a rather disorderly pattern of isolated elements of conductive tissue. Later orderly growth centers resembling root and shoot primordia may be formed, and under favorable conditions the regeneration of new shoots or roots may take place from the callus. Thus, it can be shown that the cells of the callus are totipotent.

There has been considerable speculation and a good deal of research over the nature of the stimulus which sets in motion the once quiet machinery of growth and cell division in wounded tissue. Attention has also often been focused on the conditions which bring about reorganization of the restraining forces which suppress the uncontrolled growth of the wound tissue and which direct its future development into normal tissue and organ patterns.

Soon after the discovery of the auxin hormone and the recognition of synthetic auxins, it was shown that the combined effects of wounding and auxin application resulted in a massive proliferation of wound tissue which assumed the appearance and proportion of a large shapeless tumor and as such dominated the nutritional supplies of the plant. These auxin-induced tumors strikingly resembled the pathological tumors of the crown gall disease and certain virus-caused diseases as well as the tumors which are known to form spontaneously on the stems of certain tobacco hybrids. The main difference being that the extent of growth of the artifically induced tumors was strictly dependent upon the supply of applied auxin while the other types required no auxin from outside sources. Much later it was shown that crown gall tumors were also dependent upon auxins but the cells of these tumors had somehow learned from the infecting bacterium to produce sufficient auxin to support the continued growth of the tumor. In short, it became clear that auxin possessed the capacity to induce and maintain cell division and growth at least in wounded tissue and that a poorly specialized, relatively unorganized callus tissue was the result of such growth.

To usher in the era of tissue culture it remained only for a curious mind to conceive and test the idea that it might be possible to supply the nutritional requirements of these tumors artificially. This was first reported in 1939 by P. R. White[2], the now acknowledged "father of tissue culture," when he surface sterilized bits of tumor tissue from hybrid tobacco plants and placed them on sterile culture media containing minerals, sugar, and some vitamins. The transplant grew rapidly in these test tubes and continued to grow vigorously even after many generations of transplanting to subcultures. It soon became common practice to place seedlings or plant parts on auxin rich media to induce callus formation and then to transfer bits of this callus to test tubes containing a culture medium similar to White's. Many such tissue cultures have been kept growing by repeated sub-culturing, for nearly 20 years and thus have established a kind of immortality for the original donor plant.

However, the shapeless mass of callus in its test tube certainly is not recognizable as any part of a normal plant. One wonders, does it still possess the minimum essential genetic and metabolic control to re-establish itself in the original form of its donor plant? Reflecting on the regeneration of tissues and organs observed in the wound tissue still attached to a plant, one would hopefully expect similar behavior of cultured callus. Right from the beginning with White's cultured tobacco tumor tissue it became clear that at least some cultural tissues were totipotent and by one means or another (frequently as a result of simply aging) they would regenerate normal tissues, roots and shoots. However, until very recently, such regeneration has been too sporadic, too difficult to control or predict, to evoke much interest as either a means of propagation or as a laboratory tool to permit the study of conditions controlling regeneration.

Outstanding contributions leading to our present state of knowledge and interest in tissue cultures have been made by Folke Skoog of the University of Wisconsin and F. C. Steward of Cornell University. Working with tissue cultures and cultured stem segments of tobacco, during the late 1940's and early 1950's Skoog and his associate discovered an entirely new class of plant hormones, the kinins[3]. Adenine and kinetin, both members of this class, were shown to work in conjunction with auxins to greatly stimulate cell division, and more important to facilitate the regeneration of new shoot buds in much the same way that auxins alone evoke root primordia.

From Steward's laboratories in 1958 came a striking example of the regenerative powers of single cells produced and grown by tissue culture techniques[4]. Working with the commercial carrot, Steward and co-workers have shown that once quiescent phloem storage tissue can be revitalized by certain constituents found in a liquid endosperm like coconut milk and that free cells sloughed from this proliferating phloem can readily be cultured and if given the proper conditions can reconstitute entire normal plants!

Our research at the University of Connecticut has added still another chapter to the continuing story of tissue cultures[5]. We have found in the wild carrot a most versatile and suitable test organism for the study of regeneration. Callus tissue cultures are obtained in the usual way by placing surface-sterilized seedlings or parts of mature organs on auxin-rich culture media in test tubes. The combined effects of wounding and high auxin level bring about extensive callus proliferation. We were pleased to find that this callus could be readily cultured on a simple medium all of the ingredients of which were known chemicals. The essential minerals, sucrose, an auxin and adenine or kinetin were all that was required. However, the uniqueness of this callus lies not in the ease of culture but in its amazing regenerative capacities. Individual cultured callus cells of this species were found to regenerate by recapitulating almost exactly the sequence of events which occurs in the growth and division of the zygote in the ovary of the fertilized flower, i.e., by first developing into a tiny embryo which in turn developed through the familiar stages of embryogenesis leading to a mature embryo. The cotyledonary node and the radicle are formed simultaneously and in their proper places on the globular embryo. The true shoot meristem is formed in the node and the radicle becomes a root meristem. This whole sequence of regeneration takes place in the simple culture medium described and more important, can be controlled by manipulating the concentrations of the two classes of hormones. A relatively high concentration of adenine and the auxin 2,4,D promotes a slow but uniformly unspecialized callus growth. If kinetin is used in place of adenine, growth is much more rapid but the uniformity of the callus is lost and some specialization takes place. Conductive tissue and pigmented cells appear scattered through the callus and a considerable portion of the callus enters the first stages of embryogenesis and progresses to the globular stage. Removing or lowering the concentration of the auxin initiates the rapid completion of embryo formation. The mature embryo so formed is apparently dormant for it develops no further until a small amount of coconut milk is added to the culture medium. (The use of coconut milk to stimulate the germination of excised seed embryos is a long established practice.)

Once embryo-genesis has been initiated in a segment of callus it proceeds until nearly all of the cells of the callus or the free cells derived from it become involved in embryo formation. Thus, from a small piece of callus only one eighth of an inch in dimension it is possible to obtain hundreds of uniform normal embryos. These may be germinated on appropriate media, transferred to soil and grown as normal carrot seedlings. Thus, through the careful use of auxins and kinins it has proved possible to both remove and reinstate the organizing forces which control normal growth and development. The carrot plant can be converted into a shapless mass of callus and stored in this condition, portions of the callus can be restored to the orderly form which we know as the wild carrot *Daucus Carota*.

The title of this paper and the purposes of this meeting obligates me to speculate upon the significance of these studies to the science of plant propagation. I do so fully aware that we are still a long way from understanding the process of regeneration even in the most favorable material, the wild carrot. We also do not yet know if the knowledge obtained from the study of these cultures can be applied sucsessfully to control regeneration in any other plant species. Therefore, at this time, we can only ask, if these techniques can be successfully applied to a broad spectrum of species, what advantages might be gained? If they cannot, and we are restricted to the study of a few favorable species, of what significance is this to plant propagators? First, let us answer the easier, less speculative question of the value of such studies to plant propagators. When we consider that in spite of centuries of wide-spread use of the propagation techniques and at least 50 years of scientific scrutiny of these techniques, we still know next to nothing about the physiology of regeneration of roots and shoots at the cellular level, we must welcome any favorable test organism which promises to shed light on these processes. It stands evident almost without saying, that the better our basic understanding of the details of root and shoot formation, the better will be our ability to control these processes to serve our needs. Unquestionably, wild carrot tissue cultures provide us with the best test organism yet discovered for studies of the complexities of regeneration.

Now to turn to the more speculative question of potential uses of tissue culture techniques in practical plant propagation. Four possibilities come to mind:

1. The use of tissue culture as a means of rapid propagation of new varieties. It should be possible, in a few months time, to produce thousands of uniform "true to type" plantlets from tissue cultured callus produced by auxin treatment of a single small piece of stem or root taken from a new variety.
2. Tissue culture techniques may enable us to propagate vegetatively, species which resist conventional techniques. Plants which are difficult to root in the cutting bench may respond more favorably to the more rigidly controlled environment possible with tissue cultures.
3. The production of new varieties through the use of mutation-inducing irradiation or mutagenic chemicals might become practical if tissue cultures were treated rather than intact plants. Attempts to induce new genetic forms by treating intact plants, seeds or even pollen grains with mutigens suffer greatly from the overgrowth of the mu-

tated cells in the highly competitive growing tissues or by the loss of new mutations because they are incompatible with the material tissue and therefore do not produce viable seed. In a system like the wild carrot tissue cultures, free-cell suspensions could be treated and all viable cells might be brought to the plantlet stage for further examination and testing of the induced changes.

4. Perhaps of more value to the breeder than to the propagator, would be the establishment of a tissue culture bank as an economical means of long term storage and maintenance of the germ plasm (the breeding stock) of the countless new varieties of plants. While no thorough genetic studies have yet been seen, we have good reason to believe that the plants which are regenerated from stored callus cultures are identical to the donor plant from which the original callus was obtained.

If any of these potential applications are worth achieving then plant propagators should keep one eye on developments in the field of tissue culture. The recent progress in this field, some of which have been described here, is certain to attract the attention of many new researchers. As a result, the rate of accumulation of new knowledge of the mechanism and control of regeneration should greatly increase. Thirty years ago, who among us would have believed that today commercial growers would be making routine use of chemical growth regulators or flash-lighting. It seems to me no more unlikely that the work we have described here will find its way into the practical procedures of the future.

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MODERATOR SHUGERT: Thank you very much, Dr. Wetherell, for a very stimulating talk. Our final speaker this afternoon is Dr. Don White from the Department of Horticulture, University of Minnesota.

EFFECT OF STOCK-SCION COMBINATIONS ON THE PERFORMANCE OF APPLES[1]

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This five year study was originally designed to observe the performance of four scion, five interstem, and ten rootstock varieties, in all possible combinations (Table 1). However, of all the factors that ultimately determine the usefulness of any graft combination, only survival, compatibility, and anchorage, will be covered here.

The plants were propagated at a commercial nursery in 1955 and 1956. Six-inch rootstock pieces were grafted to three-inch nurse root pieces of Western apple seedlings, using the whip and tongue technique. The grafts were callused and field grown for one season. In 1956, "two eye" stem pieces of the scion varieties were bench grafted to five-inch sections of the interstem varieties. The grafts were callused until bud break in the spring and then grafted, in the field, onto the rootstocks.

Survival

All failures in this study occurred during the first four years of growth. The specific combinations that failed completely were: Yellow Delicious/Clark Dwarf/Columbia; Yellow

Table 1 Selected Scion, Interstem, and Rootstock Varieties

Scions	Interstems	Rootstocks
Jonathan	Ottawa-524[1]	Columbia
Red Delicious[2]	Clark Dwarf[3]	Bedford
Yellow Delicious[4]	Malling IX[5]	Hopa
Winesap	Robin	Dolgo
	Malling VII[6]	Anoka
1 Hereafter 0-524		Beacon
2 " in tables	Red Del.	
3 " " "	Clark	Hawk. Grng.
4 " " "	Yel. Del.	
5 " " "	M IX	McIntosh
6 " " "	M VII	Yel. Del.
		Robusta #5

Delicious/M IX/Anoka; Winesap/Clark Dwarf/Hawkeye Greening; Winesap/Robin/Hopa; Red Delicious/MVII/Hawkeye Greening and Winesap/Robin/Hopa.

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Rootstocks:

The Dolgo and Bedford rootstocks resulted in the highest percent survival, with 90 and 92 percent respectively. Survival of the other rootstocks ranged from 71 to 82 per cent for all except Hawkeye Greening which was only 58 per cent.

Columbia performed well with the M VII and to a lesser degree with the Red Delicious scion variety. Survival was excellent with Clark Dwarf, Robin, and M VII/Bedford combinations and poor with the M IX/Bedford combination. Bedford also performed well with all but the Jonathan scion variety. Although, survival was high in the Jonathan/Clark Dwarf/Bedford combination. Survival was high with Jonathan/M IX/Hopa. Survival was poor with all other Hopa combinations. Dolgo with the Robin and M VII interstems and all scion varieties resulted in good survival percentages. This was especially evident with the Red Delicious and Yellow Delicious varieties. Anoka gave excellent performance only with the Jonathan scion variety and borderline performance with the M VII interstem. Beacon's performance was poor with all the interstems. However, the Winesap/Beacon combinations resulted in a high survival per cent regardless of the interstem used. McIntosh performed poorly with all interstems and scion varieties except the Red Delicious scion variety. Yellow Delicious, as a rootstock, resulted in satisfactory combinations only with the Yellow Delicious scion variety. All M VII/Robusta #5 combinations survived. Jonathan was the only scion variety that combined well with the Robusta #5 rootstock. The Robin/Robusta #5 combinations resulted in borderline performance when considering survival.

Figure 1. Rabbit damage on a Clark Dwarf interstem. Yellow Delicious/Clark Dwarf/Yellow Delicious tree damaged during the winter of 1959-1960. Rabbits showed a definite preference for the bark of the dwarfing interstems.

Interstems:

Before assessing the survival of the interstems, it should be realized that rabbits showed a definite preference for the dwarfing interstems. Also, the O-524 interstem has been eliminated from further consideration because of the prevalence of stem pitting found in the experimental material.

When interstem performance was considered, Clark Dwarf and M IX combinations resulted in the lowest survival rates. Clark Dwarf did give excellent survival with the Bedford rootstock and borderline performance with both Hopa and Dolgo rootstocks. Clark Dwarf, in combination with Jonathan, Red Delicious or Yellow Delicious scions resulted in approximately 75 percent survival, while only 53 per cent of the Winesap scion trees survived. Malling IX performed very well in combination with the Hopa rootstock. Borderline survival resulted from the Columbia and M IX/Dolgo combinations. This interstem resulted in 87 per cent survival with the Red Delicious scion and gave approximately 75 per cent survival with Jonathan and Winesap. Only 56 per cent of the Yellow Delicious scion combinations trees survived. M VII gave 100 percent survival in com-

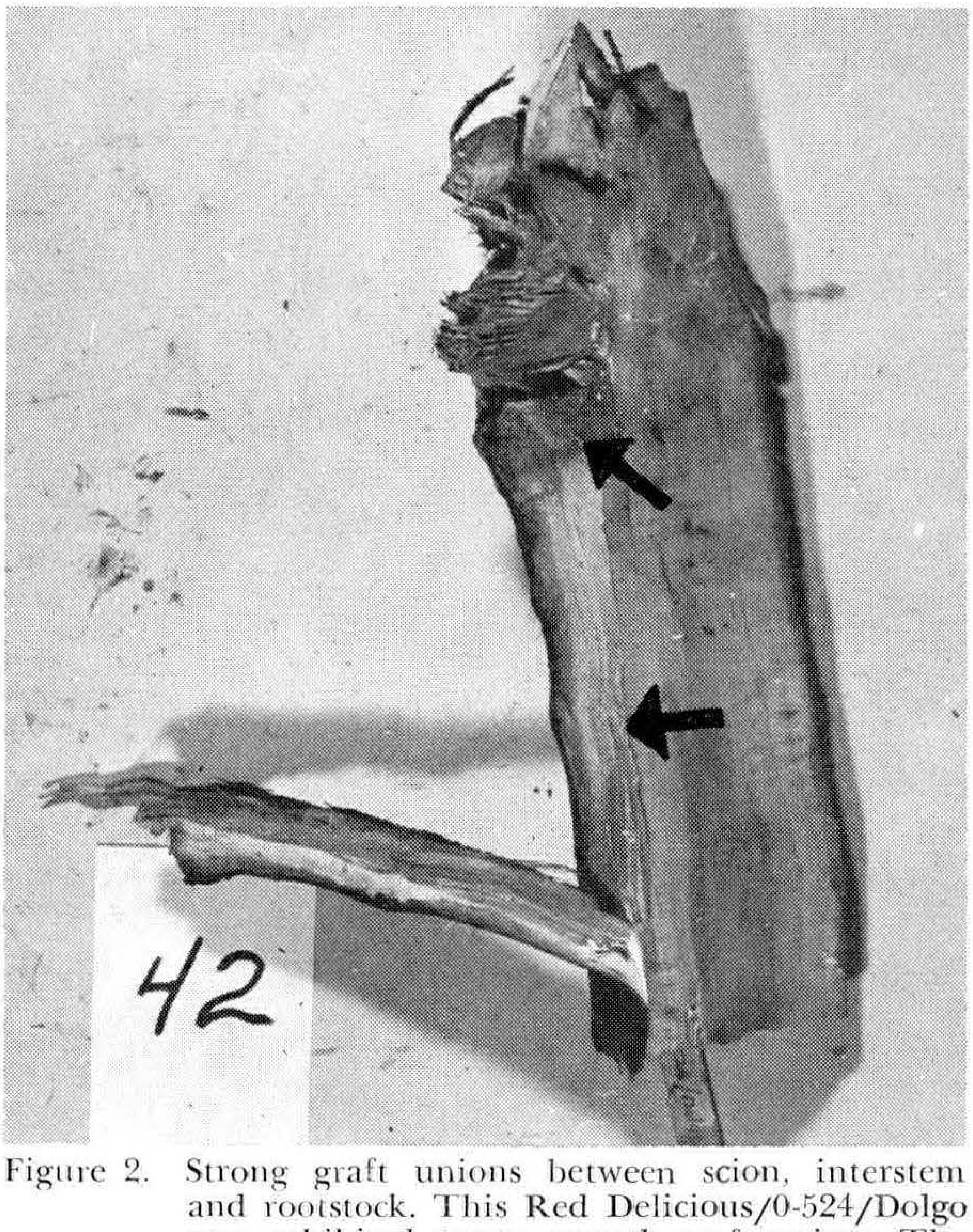

Figure 2. Strong graft unions between scion, interstem and rootstock. This Red Delicious/0-524/Dolgo tree exhibited strong smooth graft unions. The arrows indicate the location of the graft unions.

Figure 3. Profuse suckering of a Yellow Delicious/Clark Dwarf/Hopa combination. Note the broken interstem-rootstock union.

bination with both Bedford and Robusta #5 rootstocks. Approximately 84 per cent survival was realized with all scion varieties in combination with M VII.

The per cent failure of rootstocks, interstems and scions is presented in Table 2.

Compatibility

All Winesap/Robin/Hopa trees snapped at the scion/interstem union. Indications of incompatibility were also observed in the M IX/Beacon combination, in which six of the twelve plants failed during the first year in the field.

Vertical splitting of the interstem was observed in the Red Delicious/M IX/Anoka, Yellow Delicious/0-524/Hawkeye Greening, Red Delicious/Clark Dwarf/Anoka, Jonathan/0-524/Beacon, and Red Delicious/0-524/Anoka. No detrimental effects from the splitting were detected, since the wounds healed during the growing season.

Where possible, at least one tree in a combination was pulled with a TD-6 International Track-type tractor. Since this tractor could develop in excess of 20,000 pounds pull, breakage at a graft union does not necessarily imply the existence of incompatibility. However, breakage of this nature does signify a weakness in comparison to the other parts of the plant. Many combinations were pulled intact, although overgrowth of the interstems, another accepted symptom of incompatibility, was evident in some of the combinations. The combinations which displayed abnormalities at the time of uprooting are presented in Table 3.

Most trees that were broken in the pulling appeared sturdy and healthy. Combinations with the Jonathan scion variety contained more trees which were broken at the time of pulling than any of the other scions. Jonathan trees also had the highest rate of survival. The possibility exists that the more brittle nature of these graft unions will ultimately result in the loss of many apparently healthy trees.

Anchorage

Poor anchorage is accepted as a common failing of most dwarfing rootstocks in use today. Size and type of root system, the angle the roots take from the crown, and the mechanical strength of the roots are a few of the factors that enter into the anchorage problem. The interstem system allows the use of a good root type without the drawbacks of the dwarfing rootstock.

Anchorage and root development were ascertained visually each year as well as at the time the trees were uprooted mechanically. Any tree leaning off center was assumed to have poor anchorage, unless the cause could be ascribed to mechanical or rodent injury. Fifty-three of the 200 combinations displayed a tendency to lean (Table 4).

The Winesap scion produced the highest number of leaning trees, followed by Red Delicious and Yellow Delicious. All Jonathan scion trees were well anchored.

The dwarfing interstem combinations were expected to show the greatest tendency towards poor anchorage. However, the Yellow Delicious/MIX and Jonathan/MIX trees were particularly well anchored. Jonathan/M VII/Columbia gave sparse root development, while the Jonathan/0-524/Columbia possessed a strong but restricted root system. Brittle roots that snapped easily when pulled and which grew at a wide angle to the axis of the crown were found on Jonathan/M VII/Bedford and Jonathan/Robin/Robusta #5. These represent only three of the fifty Jonathan combinations, and, of these, two had M VII as the interstem.

Figure 4. Overgrowth of the scion and poor anchorage. Winesap/M VII/Beacon tree exhibiting overgrowth of the scion and poor anchorage.

Figure 5. Red Delicious/Robin/Robusta #5. An extensive system of llarge, fibrous roots was produced by this combination.

In considering the interstem, M VII was associated with the greatest number of poorly anchored trees. It should also be noted that fifty per cent of them had Winesap as the scion variety. Robin followed, with twelve faulty combinations which were divided quite evenly between Winesap and Red Delicious. Clark Dwarf was involved in ten poorly anchored combinations; six of which had Winesap as the scion. Malling IX followed, with nine poorly anchored combinations, seven with Winesap scions. It appeared that Winesap generally reacted with the interstems used here to produce poorly anchored trees.

A 10,000 pound draw meter was used to measure the pounds of pull required to uproot trees with the TD-6 tractor. The draw for trees requiring more than a 10,000 pound pull for uprooting was estimated by a very experienced tractor operator. The average amounts of pull required to uproot the trees is recorded in Table 5.

There were almost as many variations found in root development as there were graft combinations. Based on this method of evaluation, combinations with the Winesap scion variety were somewhat easier to uproot than the other scion varieties The two dwarfing interstocks, Clark Dwarf and Malling IX, gave the poorest anchorage of the interstems. Malling VII was intermediate in anchorage between the dwarfing stocks and the more vigorous 0-524 and Robin interstems. The differences in uprooting the rootstocks were relatively small. Columbia, Bedford, Anoka, Beacon, and Robusta #5 were easiest to uproot. Hopa, Hawkeye Greening, McIntosh and Yellow Delicious were intermediate. Dolgo required the greatest number of pounds pull for uprooting.

The findings of this study demonstrate that there are special combinations that perform most satisfactorily under a given

Table 2 Failure of rootstocks, interstems and scions in per cent

Component	Total
Rootstocks	
Columbia	23
Bedford	8
Hopa	18
Dolgo	10
Anoka	20
Beacon	29
Hawkeye Greening	42
McIntosh	28
Yellow Delicious	20
Robusta #5	26
Interstems	
0-524	15
Clark	31
M IX	27
Robin	23
M VII	16
Scions	
Jonathan	18
Red Delicious	18
Yellow Delicious	24
Winesap	30

Table 3. Combinations showing growth abnormalities at the time of pulling

Combination	Union where breakage occurred
Jonathan/Clark/Hopa	Interstem/rootstock
Jonathan/Robin/Robusta #5	Interstem/rootstock
Red Del./Clark/Hopa	Interstem/rootstock
Red Del./M VII/Columbia	Interstem/rootstock
Winesap/M VII/Bedford	Interstem/rootstock
Jonathan/Robin/Dolgo	Interstem/rootstock
Jonathan/M VII/Beacon	Scion/interstem
Jonathan/M VII/McIntosh	Scion/interstem
Jonathan/M VII/Robusta #5	Scion/interstem
Jonathan/0-524/Beacon	Interstem/rootstock
Jonathan/0-524/Yel. Del.	Interstem/rootstock
Jonathan/Robin/Robusta #5	Interstem/rootstock
Jonathan/Clark/Hopa	Interstem/rootstock
Jonathan/Clark/McIntosh	Interstem/rootstock
Jonathan/Clark/Anoka	Interstem/rootstock
Jonathan/M IX/Bedford	Interstem/rootstock
Red Del./Clark/Dolgo	Interstem/rootstock
Red Del./M VII/Columbia	Interstem/rootstock

Red Del./0-524/Anoka	Interstem/rootstock
Yel. Del./M VII/Bedford	Scion/interstem
Yel. Del./Clark/Hopa	Interstem/rootstock
Yel. Del./0-524/Hopa	Interstem/rootstock
Winesap/M VII/Bedford	Interstem/rootstock
Winesap/M IX/Hopa	Interstem/rootstock
Winesap/Clark/Beacon	Scion/interstem
Winesap/M IX/Beacon	Interstem/rootstock

Table 4. Combination observed to possess poor anchorage[1]

Rootstock	Interstem																			
	0-524 Scion				Clark Scion				M IX Scion				Robin Scion				M VII Scion			
	J	R	Y	W	J	R	Y	W	J	R	Y	W	J	R	Y	W	J	R	Y	W
Columbia		X		X				X		X									X	
Bedford				X				X						X	X	X			X	X
Hopa							X												X	X
Dolgo								X				X				X		X		X
Anoka				X		X		X		X		X		X		X		X	X	
Beacon		X						X				X						X		X
Hawk. Grng.												X				X				X
McIntosh			X			X						X		X		X				X
Yel. Del.								X				X		X				X		X
Robusta #5						X						X		X		X				X

[1]Many of these combinaitons showed the tendency to lean earlly in development However, a large percentage later developed strong root systems and became well anchored

Table 5. Average minimum pull required to uproot trees, based on component parts

Scions	Pounds pull	Rootstocks	Pounds pull	Inter-stems	Pounds pull
Jonathan	12,961	Columbia	11,000	0-524	12,250
Red Del.	12,158	Bedford	11,167	Clark	9,750
Yel. Del.	12,467	Hopa	12,444	M IX	9,846
Winesap	10,333	Dolgo	13,333	Robin	13,037
		Anoka	11,400	M VII	11,950
		Beacon	11,500		
		Hawk. Grng.	12,143		
		McIntosh	12,000		
		Yel. Del.	12,500		
		Robusta #5	11,875		

environment and that graft combinations should be selected carefully. Some of the superior combinations considering survival, compatibility, and anchorage are given in Table 6.

Table 6 Superior Scion/Interstem/Rootstock Combinations

COMBINATION	COMBINATION
Jonathan/M IX/	Yel. Del./Clark/Bedford
Jonathan/Clark/Dolgo	Yel. Del./M VII/Bedford
Jonathan/Clark/Bedford	Yel. Del./Clark/Dolgo
Jonathan/Clark/Hopa	Yel. Del./M IX/Hopa
Red Del./Clark/Hopa	Winesap/Clark/Bedford
Red Del./Robin/Bedford	Winesap/M IX/Dolgo
Red Del./Clark/Bedford	Winesap/M VII/Bedford
Red Del./M IX/Hopa	Winesap/M VII/Beacon
Red Del./M IX/Bedford	
Red Del./M VII/Bedford	

Acknowledgements

Interstate Nurseries, Hamburg, Iowa, for furnishing and caring for the material for this experiment.

Dr. J. P. Mahlstede, Head, Department of Horticulture, Iowa State University, Ames, Iowa.

MODERATOR SHUGERT: Thank you very much, Don. We now have some time for questions.

MR. JIM WELLS: I would like to ask Dr. Wetherell if he has tried his techniques on other plants in addition to wild carrot?

DR. WETHERELL: There are about 100 plants around the world, both woody and non-woody that have been cultured as tissue cultures. However, the induction of roots and shoots is rather sporadic and only recently have we learned how to do this for the carrot We are pursuing this, however, with plants such as blueberry, grape, forsythia, cucumber, and geranium. We would like to know what it takes for these plants to regenerate. It may be quite different from the wild carrot.

MR. MARTIN VAN HOF: I would like to ask Dr. White if he would graft a vigorous scion on a dwarf growing stock such as Malling IX.

DR. WHITE: Yes. In fact, we wanted to see if Malling IX as an interstock was as affective as a root stock. It turned out that as an interstock it was not as dwarfing and was intermediate in its dwarfing effect.

MR. ROBERT SIMPSON: Have *Zumi* seedlings ever been used as an understock?

DR. WHITE: I am not sure, but to my knowledge they have not.

MR. SIMPSON: We tried *Zumi* with ornamental crabs. The *Zumi* seedlings make an entirely different root system, a very vigorous root system, and what appears to be a superior system in comparison to *baccata.*

MR. AL LOWENFELS: Has Hans Hess had any success in rooting *Ilex verticillata?*

MR. HANS HESS: There are a number of selections that root well from soft wood cuttings. The Princeton variety roots well. The cuttings are made when they are soft and are treated with Hormodin #3 after the cuttings are wounded.

VOICE: I would like to ask Hans Hess if he uses any artifical treatment for *Ilex opaca* seed?

HANS HESS: We do not use any artifical treatment. At Boyce Thompson Institute they are able to excise the embryo and with special treatment obtain germination the first year. We have found from a commercial stand point that the best treatment is to store the seed for 2 years and then plant it. We store the seed in peat in a metal container with a polyethylene top. It is in an unheated stable so the seed is exposed to low temperatures in the winter and warm temperatures in the summer. However, extreme fluctuations in temperature are reduced by the building.

The source of the seed is very important. Southern seed will germinate the first year, but seed from the northern varieties, which are more hardy, require 2 years for germination.

The session adjourned for the business meeting at 3:00 p.m.

ROSA CANINA

J. L. PETTY
Rosecroft Nurseries
Langley, British Columbia, Canada

Rosa canina has been known and used as an understock for over three hundred years. This is true only in European countries, however, for on the North American continent there would appear to be only two growers using the stock to any extent. Both of these growers are to be found in Canada: Carl Pallek Sons, Vergil, Ontario, and Rosecroft Nurseries in Langley, British Columbia.

It is estimated that 95% of European growers use this stock extensively. However, in Britain and Holland, nurserymen seem to be equally split on the merits of *R. canina* and *R. multiflora* strains and much argument is heard on both sides. In Germany and Belgium, *R. canina* flourishes almost 100%. In British Columbia, the Rosecroft Nursery works on a fifty-fifty basis to meet trade requirements.

Rosa canina may be distinguished mainly by the dog-tooth thorns which are borne in profusion; it is from this characteristic that the species derives its name.

The growth is of medium vigour, whilst the structure is somewhat compact, with a tendency sometimes to spread. The leaves are generally small, 1 to 1½ inches long and ¾ inches wide, whilst the edges are heavily serrated. Colorwise, the variety is a much deeper pink than the native briar rose of the coastal region of British Columbia and this is still deeper than that of *Rosa multiflora*. As in most understocks, the blooms are borne on second year wood, and are 2″-3″ across.

Rosa canina's natural habitat is, of course, the Northern Hemisphere; Holland, with its suitable climatic and soil conditions, is the world's largest supplier to the trade. Selected strains have been available for many years, but at first they could not always be guaranteed to run true to type. Dutch growers, however, forged ahead of other European nurserymen in their research and now are able to supply selected strains of seedlings that do run true. Laggerman of Sappermeer, Holland, is one of the most outstanding producers. Canada probably imports most of its stock from Holland. Germany and Belgium also produce these lines but they do not ship out as much as do the Dutch. There output is mainly for home consumption.

Subject to normal conditions, *Rosa canina* will grow almost anywhere that understocks are generally used. It will withstand more severe climatic conditions than most, with the exception of *R. rugosa*. *R. canina* is also suitable to more variable soil conditions, showing marked resistance to drought and chlorosis in high alkaline soils. Once corrected, these factors are to the over-all advantage of the species. Since this understock is generally hardier, it imparts hardiness to the variety, and also increases the life span. When the writer revived Rosecroft Nurseries in the early post-war period, many of the customers were exhibiting from plants bought from my dad in the early 1920's. He was 100% for Canina.

The fact that Canina is onlv of medium growth vigour, the varieties which are worked to the stock are also inclined to be of medium vigour, therefore the growth is not so soft or succulent and this factor is a most important one where mildew occurs, and particularly where black spot is concerned.

At Rosecroft Nurseries we have grown Multiflora and Canina side by side and have had the opportunity to observe their many characteristics under various conditions. Many times we have noticed a variety on Canina (e.g. Show Girl) that is resistant to mildew, and found the same variety infected on Multiflora. The depth of colour and the substance of petal on Canina show marked improvement over Multiflora. The marked difference is so great in some cases that many distinguished Rosarians will misname the varieties on Canina.

Having stated that Canina is of medium growth vigour, the writer does not wish to mislead you into thinking that it is not possible to grow good vigourous plants. Manv of Rosecroft's customers have mixed beds of Canina and Multiflora, and are unable to distinguish the difference between understocks when considering only the size.

As far as expense is concerned, the slightly increased costs of Canina is due chiefly to the fact that seedlings are used. You will agree that growing seedlings will be more costly than the reproduction of Multiflora by cuttings. Due to the very short neck and budding area, the stock has to be very carefully planted; when opening for budding, this requires a little more patience. The short neck of Canina forces the budder to place his bud closer to the roots. making a very compact plant. This is very durable in severe climatic localities and the main root system is always in the most fertile section near the surface.

Rosa canina is as hard to propagate from seed as it is vegetatively. It is not economically feasible. on a commercial basis to reproduce by cuttings when a 50-60% stand is considered good. Rosecroft has tried every known means of vegetative reproduction, using all known hormones and using all feasible dates to take cuttings. The latest experiments, under *mist,* have not been any more encouraging. Furthermore, the stand of top grade plants is of lower percentage when working with Canina cuttings.

When attempting to reproduce from seed, which, of course, is of low viability, often not more than one third will germinate over a period of several years. Nature, making provision to reproduce the species should adverse conditions exist for a season or two, causes the nurseryman to make provision for this characteristic and ample seed must be sown to overcome this factor.

At the John Innes Institute in England, experiments were carried out with storing Canina seed. The following observations were made concerning proven storage methods:

1. Moist storage was preferable over dry.
2. Extreme change in temperature during storage
   — 2 months at 60-70° F. followed by
   — 2 months at 32-35° F. refrigerated controlled temperature.
3. Media used -- coarse vermiculite or perlite in clay pots, thus permitting good aeration and moisture retention.

The time for gathering hips is very important, for they must not be picked whilst they are green and have fresh sepals. In B.C., the best time is the first week of October approximately, when the hips are red, the sepals have fallen, and the flesh has not yet begun to soften. Occasionally a few hips will stay on the plant for over a year, and they will after-ripen naturally and, when sown without treatment, will germinate with as high a percentage as normally achieved in the aforementioned procedures. The seed should be cleaned immediately after they are harvested, and not left stored in the hips. If no refrigeration is available, a simple method is to plunge pots in wood ashes out-of-doors during the winter, making sure that they are protected from rodents.

Over the past several years, Rosecroft has been experimenting with various strains of Canina. Schmidt's Ideal has been found to be the best all-around strain. Certain favourable characteristics were noticed in other strains; however, it was felt that the best stand, when considering the over-all picture, was obtained with Schmidt's Ideal. Good vegetative reproduction was found in some cases in the various strains of Canina, but the qualities were not of a high enough percentage to warrant consideration.

The writer's personal views as to the future of Canina in Canada is not too encouraging. Over the years, Rosecroft has built a fairly elite market for Canina understock plants. However, the percentage increase in demand has not kept pace with the over-all demand. Also, keeping in mind we have no Plant Patent Law in Canada with the result that today's rose prices have not kept pace with reproduction costs. I would venture to say this would not be so in the U.S.A. for our biggest sales increases are to points in this area, in spite of all the red tape of import regulations.

I would like to take this opportunity to remind you, as propagators, that you should keep your interest in Plant Patents alive. Keep a close eye on its control of varieties outside of the U.S.A. borders. Too frequently, the latest introductions appear on the Canadian market at less than one-third the suggested retail price. U.S.A., second year introductions, have appeared on the Canadian market so reasonably priced that roses are treated as annuals in our Prairie Provinces.

MODERATOR HAUSCH: Our next speaker this evening on rose rootstocks will be Dr. Robert Ticknor. His topic will be, Nursery Performance of Selected Garden Rose Rootstocks.

DR. ROBERT TICKNOR: Thank you. After this strong case for *Rosa canina,* I am not so sure that in coming up here with *Rosa multiflora* that we have the right product. However, I think the difficulty in propagation of *R. canina* has been one of the main reasons that *Rosa multiflora* has been the leading rootstock in the U.S. From some of the reports I have heard from England they are using more *Rosa mulitflora* there also. Again, this is because of propagation problems and the fact that it produces slightly larger plants faster from the nursery view-point.

NURSERY PERFORMANCE OF SELECTED GARDEN ROSE ROOTSTOCKS

R. L. TICKNOR AND A. N. ROBERTS
Department of Horticulture
Oregon State University
Corvallis, Oregon

Studies of rootstocks for hybrid tea roses were started at Oregon State University in 1948 and are still being carried out. The present report deals with a trial started in December, 1960, and completed in November, 1962.

In Oregon, California, and the Southwest rose growing areas, cuttings are used for rootstocks, while in the Northeast, seedlings of *Rosa multiflora* are used. In the past, mixtures of different *R. multiflora* types were used as rootstocks for hybrid tea roses in Oregon. At present, most rose growers in Oregon, as well as in Texas, are using clonal lines of *R. multiflora,* while in Arizona and southern California the variety, Dr. Huey is used. Growers in all of these areas have made rootstock selections. In addition to grower-selected lines, Dr. G. J. Buck at Iowa State University, Ames, has a breeding program to develop better rose rootstocks.

Cuttings of two California, one Iowa, nine Oregon, and four Texas rootstocks were used in this trial, which was started in December, 1960. Nine-inch cuttings, which had been disbudded so that only the top two buds remained on each cutting, were inserted so only the top inch of the cutting was exposed. Rooting took place in hilled-up rows in the field during the winter and early months of spring.

Telone, at 28 gallons per acre, was used in September, 1960, to free the field of nematodes prior to hilling up the rows. Simazin, at one pound per acre, was applied to these rows in November, 1960, to prevent the development of winter annual weeds. Additional applications of Simazin, at two pounds per acre, were made in May, 1961, October, 1961, and April, 1962.

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Five hundred cuttings of each understock variety were randomized in blocks of twenty-five cuttings throughout the field. Each stock-scion combination was replicated four times. Five scion varieties were budded on the rootstocks in August, 1961: Etoile de Holland, red; Lowell Thomas, yellow; Picture, pink; President Hoover, bicolor; and White Prince, white. Border rows were also budded with the scion varieties.

The buds were covered with soil on September 30, 1961, for frost protection. The rootstock was cut off above the buds on March 8, 1962, and the soil was removed from around the buds on March 30, 1962. Pinching the scion shoot to induce branching, and removing rootstock suckers was done several times during the growing season. Digging and grading, to A.A.N. standards, was accomplished between October 30 and November 2.

Results and Discussion

Results of this experiment presented in Tables 1 and 2 show the cutting stand and the percentage of plants produced in the saleable #1 and #1½ grades. The majority of the rootstocks rooted well, with the exception of #1, #8, #5214, #5360, and Dr. Huey. *On a comparative basis, certain rootstock varieties*

Table 1 Number of cuttings rooted (out of 100 planted) and bud-take for sixteen understocks and for five scion varieties of roses Cuttings for each understock-scion combination stand evaluated August 28, 1961 Roses budded August, 1961; stand evaluated June 20, 1962

SCION VARIETY

Rootstock	Lowell Thomas		Pres Hoover		White Prince		Picture		Etoile de Holland	
	Cutting Stand	Bud Stand	Cutting Stand	Bud Stand	Cutting Stand	Bud Stand	Cutting Stand	Bud Stand	Cutting Stand	Bud Stand
Oregon										
1	79	36	86	66	74	24	86	53	85	27
6	94	53	82	61	95	28	93	41	86	38
8	93	41	90	44	87	33	80	29	81	30
Vandermoss	96	73	98	67	91	39	93	55	99	35
5214 P&D	83	45	61	33	72	33	80	55	75	39
5222 P&D	92	61	94	69	95	62	91	70	96	53
5234 P&D	94	69	93	63	95	58	94	67	92	58
5350 P&D	92	61	86	61	84	36	90	55	89	33
5360 P&D	84	48	65	41	72	25	75	42	78	46
Iowa										
D-1	84	66	89	58	94	60	90	64	94	45
Texas										
Ginn 58-L-2	98	61	91	73	100	48	93	47	91	39
Burr	97	54	99	67	81	32	100	46	94	41
Clark	98	39	96	63	98	21	94	39	96	34
Brooks-48	95	54	98	35	96	30	96	52	95	8
California										
Dr. Huey	78	38	86	55	78	35	78	35	87	17
Ragged Robin	99	47	94	37	100	41	98	40	92	34
Average	91	53	88	56	88	38	89	49	90	36

—Ginn, D-1, 5222, 5234, and Van—proved to be outstanding for bud stand with the five scion varieties used in this trial.

Significant differences in the production of #1 and #1½ plants, caused by both scion variety and by rootstock, were observed. Results with the variety 'Picture' were close to the mean of the experiment, while those with 'President Hoover' and 'Lowell Thomas'' were significantly better, and 'Etoile de Holland' and 'White Prince' were poorer. Four of the 16 rootstocks gave superior performance when all five scion varieties were considered, but a total of eight rootstocks were superior for a particular stock-scion combination.

Results obtained in this experiment were below usual commercial stands, but were not too different from those of many growers during these particular crop years. Late August budding, with temperatures up to 107° F., undoubtedly resulted in a lower bud-take.

Summary

Four superior rootstocks for nursery performance with the five scion varieties were determined. Four other rootstocks gave superior performance with one or more scion varieties.

Table 2 Production of No. 1 and No 1½ rose plants, expressed as mean percentage; based on 25 cuttings

SCION VARIETY

Rootstock	President Hoover	Lowell Thomas	White Prince	Picture	Etoile de Holland	Mean of All Varieties
Oregon						
1	52.9*	36.9	21.0	39.0	13.0	32.6
6	46.0	38.0	23.0	26.0	28.0	32.1
8	35.0	16.0	11.0	13.0	10.0	18.4
Vandermoss	52.0	56.0**	29.0	36.0	22.0	39.2
5214 P&D	22.0	31.0	23.0	35.0	13.0	24.8
5222 P&D	52.0	41.0	47.0**	50.0**	24.0	43.6*
5234 P&D	50.0	53.0**	48.0**	49.0**	25.0	45.0**
5350 P&D	51.0	48.0	31.0	46.0**	21.0	39.4
5360 P&D	26.0	34.0	16.0	28.0	29.0	26.6
Iowa						
D-1	50.0	57.0**	43.0**	42.0	30.0*	44.4*
Texas						
Ginn 58-L-2	62.0**	60.0**	38.0*	27.0	27.0	42.8*
Burr	56.0**	45.0	17.5	36.0	32.0**	37.5
Brooks - 48	27.0	44.0	25.0	28.0	5.0	27.4
California						
Huey	46.0	34.0	34.0	28.0	13.0	31.0
Ragged Robin	36.0	33.0	21.0	24.0	19.0	26.6
Variety Mean	44.7	41.2	28.2	33.2	21.3	
Gross Mean						33.7

Rootstock	8.10	10.69
Variety	5.37	7.52
L. S. D.	*p= 0.05	**p= 0.01

MODERATOR HAUSCH: Next on our rose program we will have Mr. Ralph S. Moore who is well known for his growing of miniature roses. His subject will be, Mist Propagation of Miniature Roses. Mr. Moore!

MIST PROPAGATION OF MINIATURE ROSES

RALPH S. MOORE
Sequoia Nursery
Visalia, California

I have been interested in mist propagation of cuttings for at least fifteen years. An article published in the American Nurseryman some eleven or twelve years ago reported experiments with misting over a two-year period and so I decided to experiment on my own. At about this time I found where a mist nozzle could be obtained which looked as if it would work, so I installed about a dozen mist heads.

As little information was available on the use of misting as an aid in rooting cuttings, I had to learn the hard way. For example, such items as amount of water, duration, drainage, rooting medium, hardening off cuttings after rooting, etc. had to be learned by the trial and error method.

I have observed a number of different misting nozzles but for my purpose still prefer the original Thompson #215 (made in Los Angeles by Thompson Sprinkler Co. and available through various dealers). It is relatively inexpensive and trouble-free.

These heads operate on low pressure (our's varies from 40-60 psi at the pump). Each head is adjustable — from full open to completely closed. This is important to us for several reasons. Individual heads may be turned on as the cutting bed is filled or one or more heads can be temporarily turned off to permit working in an area without interfering with misting the rest of the bed.

At time of hardening off, any individual area may be separately controlled by merely closing down the screw adjustment; all varieties do not take the same time to root, or a bed may not be all filled at the same time.

In addition to the above individual nozzle control, each line of seven to fifteen mist heads is separately controlled by an ordinary garden valve. In the past we have used globe valves and pipe unions but now have converted to the garden valve with a short section of rubber garden hose connecting to the mist line.

All of our propagation is outdoors (or in semi-outdoor houses) usually with no cover at all. Our winter temperature sometimes drops to as low as twenty-six degrees and we found that the loss of regular garden valves was nearly zero while we were losing nearly one-half of our globe valves. By using the short (18 inch) section of garden hose which is easily discon-

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At this point I should state that we are "primitive" — we do not use automatic or "interval" misting. In our area, with low humidity and high light intensity, we have not found constant misting to present any undue problems. However, we do intend to install time controls before another season to turn mist on in the morning and off in the evening.

As soon as freezing weather comes we discontinue use of misting until spring. All mist heads are removed from lines to prevent damage from freezing. They are cleaned and repaired during the winter and replaced on the lines early in the spring as needed.

Our first propagating structure using mist consisted of two beds, 3′ x 16′ built similarly to those we now use except that the bottoms were solid with 2″ wide spaces between 1 x 12 boards which were covered with screen. Rooting medium was sand. As an experiment we tried a 3′ section of a one-half peat moss and one-half perlite mixture, which proved so successful that we have continued to use this mix as our standard medium.

At present we have the following propagation space under mist:

3 houses — 4 beds 3′ x 24′
2 houses — 4 beds 3′ x 30′
1 house — 4 beds 3′ x 48′

This makes a total of 2,160 square feet. In addition we have an outside area under mist which holds approximately 200 flats (18 x 18″ square by 2½″ deep).

Our "houses" are really raised beds supported by a frame made of redwood 2 x 4 uprights on mud sills; bracing is 1 x 4. Beds (or benches) are of rough 1 x 4 redwood. These are made by nailing 1 x 4 sides of convenient length (8, 9, or 10′) on 34″ end pieces. One-fourth inch mesh galvanized hardware cloth, 36″ wide, is rolled out and stapled to make a bottom for each "box." This is then reenforced by nailing 1 x 4 x 36″ rough redwood pieces, spaced at 18″ centers, over wire mesh. Spaces between these 1 x 4 supports are filled in along the edges with 1 x 1″ pieces to give added support.

The finished wire-bottomed boxes (beds) are then turned bottom side down on the underframing. Thus, we have light, easily-built bench units which may be dismantled for moving, if necessary.

These benches are set up in house units with two benches down the middle and a path and bench on either side. A light framework is now added all around to support 3′ wide (high) screen glass (coated wire screen) which serves as a wind baffle. A light framework is included over the top which we sometimes cover with polyethylene during the winter. This affords protection for the workers and also helps to prevent overwatering during heavy rains.

Mist lines are set up on wood brackets about 18″ to 20″ above the beds. Mist heads are spaced about 40″ apart in the line. With our pressure this gives good coverage of the 3′ wide beds.

The rooting medium we like best is a mixture of approximately one-half Canadian peat moss and one-half perlite. This mixture is used the first time as it comes from the bag. Before a second use, the beds are treated with a Clorox solution. All of the remaining mix is then removed down to the layer of gravel (approximately ¾ to 1″ layer in bottom over the wire mesh). All the beds including theh gravel are treated with Vapam before refilling with fresh mixture.

Cuttings of miniature roses are made of both soft and hard (or semi-hard) wood depending upon variety and material available. Some varieties seem to do best using rather short cuttings (1 - 2″). Usually cuttings are made 2 - 4″ long. We find that if cuttings are made longer there is a tendency to stick them too deep into the medium.

Cuttings are dipped into a Clorox solution immediately after making, then drained and dipped into a solution of Orthocide just before sticking. Hormone treatment is regular Rootone powder. Too deep placement of cuttings seems to delay rooting and cuttings are more inclined to rot. We have found that cuttings root quickest and best in the top 1″ of medium, probably because they get more air.

Depending upon time of year and variety, cuttings root under mist 3 to 5 weeks — sometimes sooner. During the winter in the same beds, but without mist (using hard or dormant cuttings), rooting may take eight to nine weeks or more.

As soon as cuttings are sufficiently rooted the hardening off process begins. During hot, sunny weather and high temperature, close attention is essential. In cooler, fall weather or on cloudy or overcast days the minimum of attention is required. Water is turned on for a few minutes at a time at intervals. The entire hardening process usually takes about five days. After that, cuttings are on their own, needing only the minimum of care until potted.

MODERATOR HAUSCH: Thank you, Mr. Moore. I certainly enjoyed your talk and I think everybody else did too. Our next speaker will be Mr. E. P. Dering who will discuss storage and refrigeration of rose budwood. Mr. Dering!

STORAGE AND REFRIGERATION OF ROSE BUDWOOD

E. P. DERING
Peterson and Dering, Rose Growers
Scapoose, Oregon

My experience in freezing budwood, came as a result of a rather freakish circumstance. We had just built a warehouse and a refrigerator. We had some wrapped roses left over at the

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Our first method was to cut the buds in late fall, put them in a peach box with a layer of peat moss, another layer of buds, and another layer of peat moss, and then dip them in a pail of of water and freeze them solid at 25 degrees. However, they were hard to thaw out. So, finally, we decided to start wrapping them in newspaper and butcher paper, and from there we went to newspaper and polyethylene bags, which we use now. Now we keep these buds at 30° or 31° F.

We take these roses just before digging, in late October, and take off just the very hard wood along with the entire leaf. Then we wrap them in paper, dip them in a pail of water, let them drain a little, and then put them in the polyethylene bag and tie it tight. This method is now used exactly in rose garden areas all over the world. The European growers, however, have not gone ahead with it as much as American growers.

Of course, frozen buds are much harder to dethorn than fresh cut buds, I tried to trim mine one time without experimenting, and I dethorned about a half million buds. Needless to say, the frost got into where the thorn had broken off and we lost the entire lot.

MODERATOR HAUSCH: Thank you, Mr. Dering. Now we will hear from a rose grower from Wilsonville, Oregon, Mr. Fred Edmunds, who will discuss commercial production of roses in Oregon. Mr. Edmunds!

COMMERCIAL PRODUCTION OF ROSES IN OREGON

FRED EDMUNDS
River Ranch Nursery
Wilsonville, Oregon

Our aim in production of two-year field-grown roses is to provide a plant with a well-branched, heavy top, a shank of two inches or less, and a finely divided root system with many flexible roots. From the standpoint of trade acceptance as well as an item that can be handled with ease, we try to approach the ideal as nearly as possible by varying our cultural methods.

Our climate is best divided into the dry season and the wet season. From June 15 until October 1, less than 10% of our rain falls. The rest of the year is cool and moist with our coldest weather arriving about the middle of January. By employing the attributes of our climate to best advantage and devising proend of the season, and I decided to keep them in storage for another month or two. We looked at these buds throughout April and May, and they looked nice and plump. About the first of June, I took out these roses. The roots were just wrapped and the tops were frozen. The buds looked plump so I budded them. Everyone of them grew. Well, that gave me the idea that rose budding "eyes" could be kept in storage.

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We take these roses just before digging, in late October, and take off just the very hard wood along with the entire leaf. Then we wrap them in paper, dip them in a pail of water, let them drain a little, and then put them in the polyethylene bag and tie it tight. This method is now used exactly in rose garden areas all over the world. The European growers, however, have not gone ahead with it as much as American growers.

Of course, frozen buds are much harder to dethorn than fresh cut buds, I tried to trim mine one time without experimenting, and I dethorned about a half million buds. Needless to say, the frost got into where the thorn had broken off and we lost the entire lot.

MODERATOR HAUSCH: Thank you, Mr. Dering. Now we will hear from a rose grower from Wilsonville, Oregon, Mr. Fred Edmunds, who will discuss commercial production of roses in Oregon. Mr. Edmunds!

COMMERCIAL PRODUCTION OF ROSES IN OREGON

FRED EDMUNDS
River Ranch Nursery
Wilsonville, Oregon

Our aim in production of two-year field-grown roses is to provide a plant with a well-branched, heavy top, a shank of two inches or less, and a finely divided root system with many flexible roots. From the standpoint of trade acceptance as well as an item that can be handled with ease, we try to approach the ideal as nearly as possible by varying our cultural methods.

Our climate is best divided into the dry season and the wet season. From June 15 until October 1, less than 10% of our rain falls. The rest of the year is cool and moist with our coldest weather arriving about the middle of January. By employing the attributes of our climate to best advantage and devising protection from severe weather, we are able to produce one of the finest quality plants at the lowest possible cost per unit.

Our cuttings are shorter than usually planted, being only eight inches in length. We use the Clarke strain of *Rosa multiflora* for early budding, and the Burr strain of *R. multiflora* for mid-summer and late-summer budding. Both are upright and nearly thornless. *R. multiflora* is relatively free from pests and diseases and seems to thrive in our climate. We find also that it will produce the most ideal root system under proper cultivation procedures. The cuttings can be made any time between October 1 and February 15; planting begins in early December and should be finished before March 1. Planting earlier than December 1 results in premature rooting and sprouting which can result in winter injury when our temperature dips below 15 degrees F. Planting after March 1 results in a small, sub-standard plant.

Our soil is prepared in September from summer-fallowed sod. The ground is worked to good tilth to a depth of 10 inches and ridged up with hilling discs providing rows approximately 50 inches apart When the cuttings are planted they are stuck directly into the hills with only about an inch sticking up. Roughly we plan to have the bottom of the cutting above the bottom of the ditch between the hills over winter and, when the ground is leveled out in the spring, the cutting is actually in the ground only about half an inch. This procedure seems to take advantage of the warmer soil temperatures close to the surface in the spring and our cuttings root earlier and more evenly. The cuttings are hoed about May 1 after the hills have been worked down as far as possible with cultivators. Hoeing is usually simple because we apply three and a half pounds of Simazine per acre for weed control as soon as the soil preparation has been finished in the fall. The cuttings are watered immediately following hoeing, usually within three or four hours. By using irrigation even during cool, moist weather we insure that the cuttings have good soil contact even though disturbed by inept hoeing. A half inch of water is all that is usually necessary to insure perfect survival and a uniform stand. The hoeing in early May is usually down to the two-inch level because the cuttings are not well enough rooted at this time to allow lower hoeing. By June 15 the cuttings are rooted well enough to stand by themselves and we hoe them out to budding level, usually leaving only one-half to one inch of soil over the roots.

Cuttings can be irrigated just prior to budding the first week in July if the plants lack water. If plenty of moisture is available, additional moisture will cause the buds to sprout immediately or for the bark of the rapidly growing understock to close over the buds. Budding is usually completed by August 20. Budding after this date usually results in smaller plants and poorer stands. The resultant plant, too, is often more susceptible to mechanical damage the following spring, due to an imperfect bud union. The budded plants are covered up, usually following the first rain in September. The covering must be done to protect the buds over winter, particularly if any sprouting is in evidence. Waiting until the first rain germinates the perennial grasses will almost obliterate the weed problem. Weed seeds germinating after October 1 are usually heaved out and severely injured during our December and January freezes.

The brush is topped off the understock the third week in February. Normally, understock will start to sprout at this time and we try to catch them just as the buds are starting to elongate. Topping at this time seems to result in less "bleeding" and conserves the stored food materials in the root system. By waiting as long as possible, bud dormancy is insured for the longest possible time. The buds can be uncovered any time after April 5. The average date of our last killing frost is about this date. The hilled up earth is removed in part by small plows and the rest done carefully with a hoe. Delaying hoeing results in mechanical damage because the buds start to sprout through the warming soil by April 20, even if not uncovered.

Budded stock is fertilized at the end of the heavy winter rains, which is about the middle of April. In some years the fertilizer is applied before the buds are uncovered, but usually it goes on afterwards. We use a 10-20-10 with trace elements at the rate of 600 pounds per acre. The buds are pinched as soon as the initial shoot has elongated four or five inches and has at least two full sets of leaves. Early sprouting buds appear to have their leaves opposite, although this is not true. In pinching we remove the soft tip, leaving two full-sized leaves. The first pinch occurs ordinarily the first week in May. Recovery takes about two to three weeks and the second pinch comes around the first of June. The second pinch is a cut back to about three inches. The second pinch not only serves to enhance basal growth, but it reduces the size of the still tender bud to prevent damage from wind and cultivation. A further pinch is usually carried out about the middle of June when we top back the largest of the basal breaks to about 12 inches.

During our warm weather in summer the plants develop rapidly. Daytime temperatures average right around 80 degrees with our highest temperatures rarely reaching 100 degrees. The long sunny days in our latitude, plus our mild, humid nights are ideal for growth. Since we are essentially moisture-free during the first six weeks, we rarely need to worry about the encroachment of disease. As the difference between the day and night temperature increases along about the first of August, we run into nightly dews which provide optimum conditions for the spread of mildew. Disease protection is in the form of sulfur, flown on at the rate of 35 pounds an acre. From the 15th of June to the first of August it is applied once every two weeks. From then until September, once every week. If our native wild roses have shown signs of a heavy rust infestation during the spring, we add 8% Maneb to our sulphur dust to prevent further spread in our cultivated block.

Our heavy soils and mild temperatures reduce the need for summer irrigation. Ordinarily, only one heavy irrigation is applied, which is at the rate of four inches, around the first of August. In particularly hot, dry seasons we can irrigate as early as July 15, followed up by another the second week in August. Irrigating too early, when the maidens are in full bloom the first part of July, causes excessive breakage of the larger canes and forces sprouting of the budwood. Ideally, proper application of water will add a full set of basal canes with enough time left in the growing season to harden them off into good, sound wood. Lack of irrigation can sometimes result in excessively soft growth at digging time, which is forced by abnormally heavy rains in early September.

Digging begins the last week in October and can continue on as late as mid-February. Since our winter season is so wet we usually undercut our field about the middle of October to root prune and stop further growth. A lifter can then be run through on the digger even in extremely wet circumstances to enable the plants to be pulled easily. The early root pruning will result in formation of root initials all long the extremities of each root. These initials reduce the time necessary after planting for the roots to take hold and support the top. Unless it is raining, the plants are never allowed to stay in the field more than an hour and a half, and are washed before entering storage. The leaves must be picked from plants dug before November 15. In plants dug after that date the lower leaves usually absciss. Topping the plants in the field or removing the foliage, particularly with chemicals, will force the plant to break dormancy, thus reducing its hardiness and storage life. After digging, the plants are graded, top-tied, labeled and bundled into 10's. Once prepared, the plants can be stored in moist storage, bare root, at 34° to 36° F. for six months. The tenderest varieties are always held in storage; hardier varieties can be heeled-in in sawdust to the tops out-of-doors to take care of amounts of stock in excess of our storage capacity. In theory, *botrytis* storage rot can be controlled by holding the humidity below 85% — or over 98%. Since water is cheap and damp storage easier to work with, we prefer the latter. Constant misting in front of the refrigerator blower, or watering twice a day, will provide the necessary moisture. Stock with low vitality will not respond to any storage treatment without dying back.

In some ways our method of growing is a little more expensive per acre, but per unit of No. 1's it is less. Most of our cultural procedures are adapted to our highly variable climate according to the needs of the plants. We try to provide our trade with a high quality product properly dug and stored to be in the peak of condition at the time of delivery thus insuring excellent results the first year when planted. The uniformity allows standardization of our warehousing procedures and simplifies packing and shipping.

FRIDAY EVENING

October 4, 1963

Question and Answer Period — Dr. A. N. Roberts, Department of Horticulture, Oregon State University, Moderator.

MODERATOR ROBERTS: We are more than pleased to see such a fine turnout here this evening after such a busy day. I don't know how many of you enjoyed today's tours as much as I did, but I am sure you all did. Before we get started on the question and answer period I think, on the behalf of all of you, we should thank Bill Curtis and our two leaders of these tours, Bob Ticknor and Wayne Melott, and especially all the people who opened up their nurseries to us today and showed us such a fine time. Let's start out by giving them a big hand.

This is the first of these Plant Propagators' Society meetings I have attended. I have belonged to the Eastern organization since it started, but I have never been close enough to attend their meetings. I undertand from those who have attended over the years that one of the finest parts of the program is the question and answer periods where you have a chance to quiz one another and get some of your questions answered. And so with these few words we are going to launch off — so get your questions ready, for our panel is certainly ready to answer them. We will use slides of various places we visited today so as to refresh your memory and maybe spark questions concerning each particular operation. Some of our panel members have also brought slides of their own nurseries with them.

Do we have any questions on vegetative propagation of fruit trees from hardwood cuttings? I think that is one of the interesting things that you saw today.

VOICE: What were the procedures followed in the hardwood cutting propagation of pear and some of these other tree fruits?

DR. MEL WESTWOOD: Generally the procedure for pear is to take the cuttings around the first of November and treat them with indolebutyric acid, either as a soak or quick-dip, and then callus them at 65-70° F, and either plant them immediately or store them at 35° F. until spring, then plant them in the rooting beds. Lyle Brooks, in addition to this method, has for several years used a slightly different method for rooting cuttings of Old Home x Farmingdale seedlings by taking the cuttings in the wintertime, storing them loose and then, in the spring, making the cuttings, treating, and callusing at a lower temperature, around 50° F., then planting them as soon as they are callused. This method, although it is satisfactory for Old Home x Farmingdale cuttings, is not satisfactory for Old Home cuttings, so our procedure was changed from this as described for Old Home x Farmingdale cuttings to conform to that which Dr. Hartmann and others in California have previously described as being satisfactory for rooting Old Home cuttings: we found that we did get a very high percentage of rooting on these other types when using the fall-callusing method, rather than callusing the cuttings in the winter or spring.

DR. DALE KESTER: How old are the stool beds at the Carlton Nursery?

MR. WAYNE MELOTT: From three to ten years.

MODERATOR ROBERTS: Along that same line, our original stool beds at Oregon State, which we got from Dr. Tukey, were set out in 1943, I think. Some of those original beds are still producing. Their length of life seems to be quite long in our Oregon climate.

MR. BRUCE BRIGGS: Mr. Hausch, what objection do you have to using Simizine in your roses?

MR. HENRY HAUSCH: Well, we actually have no objection to it. We just haven't found why we should use it. In other words, we cultivate as late in the fall as we can to keep our weeds down, and we try to never let the weeds get ahead of us if possible, although we did have a little trouble this spring We mound up our cuttings. We have to knock this mound away when we hoe and the weeds are going to come along with it. We do the same thing with the buds after budding. We heal up to them in the spring of the year. We have to take the dirt away from them and the weeds come along too; so far we haven't had the necessity of using weed killers.

MR. ROBERT BODDY: I'd like to hear something about the can-cutting machine we saw at the Rhododendron Nursery.

MR. GORDON GLEASON: The can-cutting machine is a hand operated machine that we got at a second hand store for about five dollars. It originally wasn't intended for cutting cans. It's more of a crimping and beating machine, but I was successful in finding what they call a slitting shear, and then we just took the crank handle off it and found an electric motor and foot pedal to engage the cutters to streamline the operation and found it works quite satisfactorily.

MR. ALBERT LOWENFELS: I've heard somebody say, I think it was at Cornell, that flower buds inhibit rooting cuttings. I noticed buds on the rhododendrons cuttings at the Rhododendron Nursery. Has Mr. Gleason, or anyone else, worked on this subject? One more thought. A noted rhododendron propagator, Jim Wells, cuts the leaves so as to get more cuttings in the rooting bench and to reduce transpiration. I wonder why that was not done?

MR. GORDON GLEASON: Well, I have read Wells' book or parts of it. As I recall, he didn't distinguish any difference in cuttings with buds or without. I have really never made any experiments, but I've not noticed any difference in the ability of the cuttings to root or the quality of the resulting plants. One year when I transferred the cuttings from the cutting bench into the peat moss, I did remove the buds from half of one variety and left them on the other half, and I didn't notice any difference. As far as trimming the leaves, we do it only on the varieties where the leaves are very large so that the cuttings are not crowding each other. Otherwise we haven't seen any reason to cut the leaves, but perhaps there would be an advantage.

MRS. JEAN WHALLEY: I agree with Mr. Gleason, more or less. We do cut the leaves on our rhododendron cuttings, but it is just for lack of space. As far as the flower buds are concerned I can't notice any difference either in rooting. We usually remove our buds. For one thing the falling blooms in the greenhouse get sort of messy, and also I think it might help in the branching of the plant afterward, but I don't believe it makes any difference in the rooting.

MR. GLEASON: We do pick the buds off as they commence to open later in the season.

JEAN WHALLEY: We cut ours — we take off as many as possible when we put them in unless they're too tight.

MR. JOE KLUPENGER: I would like to say this to Mr. Lowenfels' questions. We always knock the buds out of the cuttings for the simple reason that after they start blooming and the flowers start opening up after a cutting is rooted in the bench, it is more or less a mess and does retard the growth — it holds growth back if you don't remove the buds. If you walk along and start pulling these cuttings out with buds on them which were in there about thirty days to six weeks and when almost every other cutting has roots ½ inch to ¾ inch long, I don't think buds have anything to do with inhibiting rooting. In pruning off the leaves we remove a portion of the leaves on large cuttings for the simple reason to eliminate their covering each other up in the cutting bench which sometimes causes problems; damping off may get started, foliage will drop, and a lot of cuttings will be lost. There has been a lot of discussion about whether you should or shouldn't remove the buds from such cuttings. We remove them, but I've seen a lot of cuttings where the buds were not removed. It seems to me the rooting is about th same whether you remove them or not.

MR. LOWENFELS: I was going to say one more word on this. I think if one looked up in an earlier Proceedings of the Eastern Region of the Plant Propagators' Society, you would find that Charles Hess worked on this at Cornell and he had one batch with flower buds and others without; he felt that the flower buds did inhibit rooting.

MODERATOR ROBERTS: I have been under that impression also. I think there is a general belief among many people that cuttings with flower buds are less easy to root than those with only vegetative buds.

MR. BILL CURTIS: I have always understood that flower buds on the cutting should be taken out but vegetative buds should be left in.

MR. KLUPENGER: We never remove the vegetative buds. We just remove the flower bud, for the reason that later flower will bloom in the process of growing and it become a problem; sometimes you'll disturb or destroy the roots by trying to break the flower truss out.

MR. RAY WALKER: Do these people practice wounding of cuttings in rhododendron propagation?

MR. JOE KLUPENGER: I would say that wounding the cutting is a general practice, and from what I have seen, other than what we do, different methods are used. A method is used of just splitting the bark through to the cambium, up ½ or ¾ inch above the base of the cutting. Some of them scab the bark off from ½ to 1½ inches up the cutting, so in practice there are different methods of wounding the cutting for additional callusing. As far as the percent of rooting obtained in one method in comparison with the other, I feel that there is a lot in the cutting itself, as to its ripeness, or maturity at the time the cutting is placed in the bench for rooting. This has more to do with rooting than the type of wound applied to the cutting.

MODERATOR ROBERTS: It is interesting to me to see amongst the nurseryman the trend toward what we might call a specialist propagator to take care of certain disease problems, particularly viruses, the true-to-name situation, etc. We have a number of these specialist-propagators or contract propagators — developing in this part of the country.

MR. RAY BURDEN: In the Whalley Nursery how do they take care of drainage under their propagating benches on the floor in their side houses?

MRS. JEAN WHALLEY: We have sand and heating coils under the cuttings and we use flats altogether. We have very good drainage in our flats. The flats are quite tight, but then we saw openings in them so we get very good drainage. We have no trouble with the drainage.

MR. ALBERT LOWENFELS: Regarding the problem of rooting red varieties of rhododendrons which is experienced in the East, has the Whalley Nursery found any difficulty of this kind here in Oregon?

MRS. JEAN WHALLEY: I have noticed in reading articles from Eastern growers that they do mention this, but with the exception of a few varieties that happen to be red, we haven't noticed any particular difference. We do find a lot of trouble in rooting Britannia. It is very difficult to root and Mars is rather difficult, but there are also some other rhododendrons that are not red that are also difficult and we don't use any different hormone for them than we use for all our rhododendrons. We use Hormodin No. 3 as a rule

MR. BILL CURTIS: Why does Mr. Klupenger put his Red Wing azaleas outside in the open under sprinklers?

MR. JOE KLUPENGER: Well, the short answer is that normally we always run out of space when we get to the middle of summer, so we pick the varieties that will take full sun and put them under sprinklers; we found that we have a few varieties such as Hexy, Red Wing, and some others that can survive normal summer conditions in our area under a regular sprinkling system in full sun. In fact we not only get a much better finished plant, but a better bud set

MODERATOR ROBERTS: I would like to ask a question, Joe, while you are on this point. For years you have been an advocate of "shading" with water, and now I see you have large expanse of saran cloth. What's your answer to that? Have you had a change of heart?

MR. JOE KLUPENGER: We use quite a broad spread of Saran cloth for azaleas. All our outdoor landscape nursery azaleas, of the hardier varieties, we finish practically all of them in the full sun. In the forcing azaleas, some of the varieties are a little more touchy on foliage, so we place these under poly-saran houses — a 42% shade for the summer months through the hot sun. Foliage on a lot of the *indicas* will not take full sun. Red Wing, Hexy, and some of the others used both for landscaping in this area and also for forcing have a firmer foliage, stronger growers, and by using "constant mist," like Dr. Roberts mentioned, all this material has been grown out in full sun in the past. Basically he was looking at rhododendrons and out-doors azaleas; we found that over the years under normal summers we can keep them coming right along in good shape by keeping constand mist over them. The hotter the weather the more water we keep on the plants. Years ago I was told that rhododendrons or azaleas should never be watered during hot weather until after the sun goes down. Well, if we wait until after the sun goes down I am afraid the foliage would be quite brown and we wouldn't have anything to water.

MODERATOR ROBERTS: For the membership or prospective membership — this critique sheet which has been passed out is for the Society's information on how to plan a program for you. This is your Society for exchange of ideas, etc., and if you have suggestions on improving the program write them down and see that one of the officers gets them back. These programs have improved tremendously over the years I've noticed. I am sure Dr. Hartmann over here can say the same for our Western Region, and we need more membership. Speaking for our home folks, we need membership here in the Northwest. The Californians have been carrying the load more or less on this, and I think it woud be nice if some of us here in the Northwest could get in and help plan these programs and bring the meeting back here to the Northwest again in the future.

Now this divulging of secrets, we kind of joke about this thing amongst the trade I am sure, but the purpose of this Plant Propagators' Society is an exchange of ideas. You give and you receive. I think that has been the philosophy over the 12-year period that it has been in existence, and I think it is really paying off. Propagation has advanced tremendously in the past 12 years by dissemination of information and it pleases me to see these people give us the information that they have. Any more questions?

MR. RAY BURDEN: A question to Ed Wood. How many species of ground covers are you propagating now?

MR. ED WOOD: We're trying many all the time even though they are not in production. I would guess around 300.

MR. DAVID A. LAWYER: I would like to ask Ed Wood if he thinks *Mahonia repens* has any value as a ground cover.

MR. ED WOOD: In very small areas perhaps; it is so slow-growing that I think there would be trouble making it commercial. I think *Mahonia jubila* is a far nicer, and faster growing plant for a ground cover.

MR. PERCY EVERETT: *Mahonia repens*, under California conditions, will fill in and cover the ground, if planted two feet apart, in a year's time.

MR. FRANK DOERFELER: Would Dr. Ticknor tell me why the field station at Aurora doesn't use fiber glass in the greenhouse tests.

DR. ROBERT TICKNOR: It is primarily a matter of cost. We have tried to put up houses for the least cost we could. We did not have a high budget so we tried to get as much area covered for the least amount of money as we could. Polyethylene so far is lowest on initial cost. Maybe on long range costs fiber glass would be less expensive but on initial cost you can build a polyethylene house for less.

MR. ALBERT LOWENFELS: I would like to ask is there any work done on propagating deciduous azaleas vegetatively rather than by seed? How do you increase the numbers of the fine azaleas you grow?

DR. ROBERT TICKNOR: Cuttings can be rooted, but the real question is will they be alive next spring. The biggest difficulty I know in deciduous azaleas is getting them to survive the first year. Dr. Blaney has done some work at Oregon State on this subject.

DR. L. T. BLANEY: Dr. E. J. Krause recorded some ten or twelve years ago in the horticultural magazines that he made cuttings from deciduous azaleas about the time the flowers were fading. Here in Oregon we have nice shoots at this time. They will root very readily. Then you pinch out the terminal bud after the plant is rooted. Cuttings may be made toward the end of May and grown in the greenhouse under constant illumination. By the following May we have plants we pinch, no branched plants, some a foot tall. A general observation I would make is that those deciduous azaleas which have *Rhododendron occidentali,* the native we have along the coast, heavily present in the parentage tend to respond to the constant illumination better than some of the other varieties.

I might add one other comment from work done at the Arnold Arboretum. They found that if they just root the cuttings in the flats and then don't transplant them until the following spring they'll come much better than if they try to transplant them as soon as rooted which, quite often, is the normal procedure.

MODERATOR ROBERTS: We have noticed that, too, in some of our class work. In the mist house we run deciduous materials through along with a lot of other things. A lot of these deciduous materials under our cold misting water will ripen off, form flower buds, turn their autumn colors, and drop their leaves. You may have fine root systems on the cuttings, but they're very difficult to get through the winter. In some of the work that we have done with cherries, we have found that if we can get the roots out rapidly, then either not transplant them, as Bob says, or transplant them as soon as the roots show and keep those leaves active for a few weeks before they drop off, that we can condition the cutting to get through the winter. If you drop the leaves too soon, if you leave them in there too long, you've got a devitalized piece of wood that just can't get through the winter.

MR. BILL ROBINSON: We have taken *Cornus florida* and these deciduous azaleas and made cuttings in flats in the greenhouse in June or July, and we leave them set. In the fall we move them out of the propagating house outdoors and then forget about them for about a couple of years; then in the spring we pot them up and they really take off. But if we transplant them too soon, we lose all of them.

MR. ELLERBROOK: About those azaleas; on the East Coast I have seen them put the cuttings in a pot when they are made and then they are not disturbed. They have been doing it very successfully that way.

MODERATOR ROBERT: There seems to be a consensus of opinion here that some materials, such as the deciduous azaleas, should not be moved after rooting. That's another argument in favor of rooting in flats and leaving them undisturbed.

SATURDAY MORNING

October 5, 1963

The meeting convened at 8:30 A.M. with Robert Snodgrass, Moderator, presiding.

MODERATOR SNODGRASS: We all have our secrets. We know how we grow plants. We know what works for us. You know, meetings like this one are real healthy for the industry. I think not long ago, less than ten years ago, such a thing as our session this morning would not have been possible. I know we used to snoop around a little and ask questions of the old timers, and the new timers who were growing things, and, boy, it was like prying secrets out of you know who — you just didn't learn anything because they figured — but actually education has proven otherwise — they figured, "Golly, I know this and I'm not going to tell anybody because I'm the only guy that can grow this." Well, with our organizations, such as the organizations of nurserymen which each of the states have and now with the Plant Propagators' Society, we've found that if we share our secrets it helps us, it helps the other fellow because the more we know, the better job we do, the more plants we can produce, the more efficient we become, and the more money we all make because there's room for all of us. I don't think anybody around here has a good looking, well-grown plant left at the end of the season. so it's a healthy thing — this Plant Propagators' Society is a very healthy thing. We'll swing around into some of the secrets probably as the program progresses. We do have a very fine panel lined up, and they are going to share some of their knowledge with us this morning. We'll start this morning with a talk by Ed Wood on low-voltage bottom heat.

LOW VOLTAGE BOTTOM HEAT

E. A. WOOD
Wood Floral
Portland, Oregon

The basic reason I investigated the use of low-voltage bottom heat was the cost. Since the advent of the better types of plastic-coated wire and the ability to run more lineal feet from one thermostat this is no longer so important.

In our latest installation we made and used this plastic-insulated cable under two inches of sand. Since we use perlite for our rooting media, we are having the best results by placing the cable in sand which gives better lateral distribution of heat. To protect the cable from being moved or broken we use saran screening on top of the sand and the perlite is then placed above that where it can be cleaned out easily without disturbing the cable.

I first heard about low voltage bottom heat in a short note stating that the Europeans were using it; I wondered why didn't we use it. At the time, I was installing 1000 sq. ft. of propagating area and, after pricing lead-covered heating cable, I thought the subject worth looking into. Cornell University a little later reported on some research on low-voltage heating cables. The work they did, which I read, did not include the use of a thermostat, which I felt I wanted. I had a local electrical firm wind a transformer to reduce a line voltage of 220v to 30v in the secondary. The reason I had one wound, rather than using a standard model was that I wanted to have two tap switches above and below the 30v setting. My reasoning was that on a hot day I could switch down and keep it from turning on and off so much and thereby protecting the thermostat. As it turned out, the heat was more even than I had anticipated, and I didn't need the extra voltage taps. It also seemed cheaper and more reasonable to purchase a contacter to carry the "on" and "off" lead than to purchase a thermostat that would have to take the full 220 line voltage. I guess I was right because in five years of operation I haven't had to touch it.

For our resistance cable we used #9 galvanized wire which we placed in the bed with lines three inches apart. Each two wires were in reality a loop down the bed 100 feet and then back. The two ends were bolted and soldered on ½ inch copper tubing which we used as a buss bar. The two copper tubes were connected to the different sides of the transformer by standard car-starter cables. By this placement of the wire, with one end of each loop connected to the different sides of the transformer, we achieved a good distribution of heat.

The galvanized wire had to be replaced after four years of constant use. This was fairly simple as we had just used fence staples to hold the wire to the bottom of the bed. Many standard 5 kilowatt transformers are on the market and can be purchased at relatively reasonable cost. The only trouble we encountered was the overheating and eventual burning out of the starter cables. We overcame this by using two parallel cables from each side of the transformer to the copper tubing. Our total outlay for a 500 sq. ft. installation was about $150.00. One of the main advantages of the low voltage installation that I can see is that there is no chance of a shock even when you put your hand directly across one of the loops. Whether this system would be worthwhile under today's prices of 110v heating cable would have to be determined by each individual.

MODERATOR SNODGRASS: We're always looking for new things whether it be in ornamentals, trees, or whatever in plant life, and one of the men in our area who is always looking for and is growing these new things is the next speaker. He is going to talk on new conifer selection. Harry Carlson!

NEW CONIFER SELECTIONS

HARRY CARLSON
Carlson Nursery
Troutdale, Oregon

Among the large number of varieties of conifers we grow at the nursery, we often find a new variation starting to grow. Some of these new plants are worthwhile growing, while others have to be discarded. We will keep some of them several years to watch their growth habits. I have some slides that will show some of these new varieties and their characteristics.

Juniperus horizontalis

This plant was selected from some seedlings of *J. horizontalis*. A good many had to be discarded. I kept three that were very compact and of a different shape. This plant is blue all summer, but when cold weather comes, it turns to lavender. It is a fast grower and resembles Bar Harbor, but the winter color is entirely different.

Juniperus horizontalis

This is another juniper from the same lot as the other one. This is very low-growing, compact, and takes less shearing to make a nice plant. It has finer foliage than the first one. It is also a slower growing plant and lower than Bar Harbor. It is very dense and compact. Four year old plants are not more than 4 inches in height. This plant does not change color.

Juniperus horizontalis

This is another of the juniper seedlings. The plant is different from the last one — a much faster grower, but still compact and dense in shape. It makes a nice plant. It is also a very low-growing plant and keeps its color, which is a deep green, all year.

Juniperus

This is another unnamed juniper that I found in a row of blue pfitzers, but it is different from any that I have ever seen before. It is a low grower and very compact. I have not sheared this one at all, as I wanted to see how it would grow. It is only about 10 inches high, but spreads out. The center is well-filled.

Juniperus scopulorum

This juniper was found in central Washington. It is a *scopulorum*, but differs from others by being quite full and of a good color. This plant has been in the field 4 years. It has a good root system and takes moving quite easily. This plant keeps its shape very well and has not been sheared.

Juniperus scopulorum

This juniper is a very slender plant, but is still compact and a good blue color. It does not need any shearing to keep it in shape. It has a good root system and is different from some of the other junipers.

Western Juniperus occidentalis

Most of the western junipers are not very good for ornamentals; this one has been in the nursery 5 years, is very slow growing, and is deep blue in color. As a rule the western juniper has a poor root system, but this one has a good system. I don't think this plant would take a very heavy wet soil.

Chamaecyparis (Cypress)

This is a cypress and is very dwarf. The color is a light green in summer but changes color in the fall to a reddish plum. I don't think it would take the weather east of the Cascade mountains as it is more tender than the junipers.

Mugho Pine

If a person wanted to select some real dwarf pine, the pumito strain would be very good to use. This plant has been in the field 4 years and several years in the seed bed before that. It has not been sheared at all, and it still keeps a round shape which is very dense and compact It would be very good where a slow-growing pine is wanted. There are also very good to use for bonsai plants.

Dwarf Pyramidalis

The plant is similar to the regular *pyramidalis* except it is a very slow growing plant — about half as fast as the big ones —much more compact and keeps its shape very well. It is as hardy as the regular *pyramidalis* but fuller in shape and a deeper color.

Dwarf Norway Spruce

This plant was one that was found among Norway spruce seedlings, but is slow growing and compact. This plant is 9 years old and has not been trimmed. It was narrower when smaller but is growing a little wider now.

I will show some additional slides that illustrate how some dwarf plants will tend to grow back to resemble the parent plant. A great many times one branch will start from a compact plant, and if this branch is cut off, no more will grow again. Sometimes one branch will come out a different color such as gold or variegated — one branch on an azure cypress is quite gold in color, which is a contrast from the blue or azure color. A branch may be variegated either white or gold, but if cuttings are taken and rooted, the green plant will grow faster and dominate the color in some cases. The plant will have just a few variegated branches.

There are just a few of the new plants at our nursery that we have started lately. There are always new things to discover as we keep in this business.

MODERATOR SNODGRASS: Thank you, Harry, and remember, keep all the questions that you have in mind. You may want to know about the availability of some of these things. I know the Carlson's are starting a lot of little plants that won't be ready for a few years. I knew lots of you people have the same ideas and are always looking for these new things.

Our next speaker is Mrs. Leona Drew, and she'll talk to us about cold-frame propagation. Mrs. Drew!

PROPAGATION BY HEATED FRAMES

LEONA DREW
Drew's Nursery
Beaverton, Oregon

Propagation by this method has been used for many years. The results, in most cases have been equal to the more modern way, in greenhouses, with mist systems, and other modern conveniences.

First, location; this can be either inside of a lath house, or out in the open, provided the frames are shaded. The shade can either be permanent or controlled manually.

The construction of these frames is not expensive; in fact, this is an ideal way for young people, who are starting out on a shoestring, to get started in plant propagation. The frames are generally built, in length, of multiples of three-foot sashes. A frame, six feet in width by fifteen feet in length, seems to be the most advantageous. Whenever two frames are constructed together, back to back, they should be twelve feet in width, with the center four inches higher than the outside edges. Instead of using glass sashes, we find it more economical and easier to lift, to use a cover constructed of two pieces of angle iron put back to back at the center, to be used as hinges. The frame of the cover is made of 2 x 2 lumber, with plastic near-glass tacked on. Space 2 x 2's every eighteen inches to keep cover rigid. Plan for counter-balance weights so each fifteen foot section can be lifted with one hand and will stay where put.

Whenever the water table is low, the frame can be set so the bottom is a few inches below ground level. If excess water is a problem in winter, then the bottom of the frame should be raised enough to miss the ground water during heavy thaws or rain storms. The outside of frame can be constructed of wood or concrete, keeping in mind that all joints should fit as tight as possible. The tighter the fit, the better the frame retains moisture. Assuming the outside height is sixteen inches and center height is twenty inches, then put in four inches of sand as a bottom layer, then lay the electric heating cables. Cover with about two inches of sand. Then either four-inch deep flats can be set on this sand, or the rooting medium may be put directly on top of the sand, about four inches deep. We find it much easier to use the flats, as they can be filled and the cuttings put in them in the potting shed. Then the flats are set in the frames.

In the rooting of conifers, the use of sharp sand or perlite, with about one-third peat moss mixed in, seems to work very same ideas and are always looking for these new things.

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In the rooting of conifers, the use of sharp sand or perlite, with about one-third peat moss mixed in, seems to work very well. Cuttings of most conifers root best if taken with a node, and are about 3½ to 5 inches long. These are dipped in any good rooting powder (indolebutyric acid formula) then put in the flats with a dibble in rows about 1½ inches apart. Water flats enough to firm cuttings. After this, water only with a fine spray once a day when the weather is warm. Keep sand moist but not too wet, as this will cause rot. Set the thermostat for 60° to 70° F. A great many conifers will root without any bottom heat, but it takes much longer.

Inside of the propagating frame all material coming in contact with cuttings, as rooting media, water, etc. should be very sanitary. Molds and fungi can spread very fast in warm, damp air.

The propagation of broadleaf evergreens is very interesting. There are many types and varieties, some of the most fascinating being the rhododendrons, camellias, azaleas and heathers. All of these do best on an acid medium, and a mixture of half peat moss and half perlite seems to work well for rooting. The larger-leafed varieties need more space in the flats and it is a good idea to cut the leaves back about half way and take off some of the bottom leaves. Some varieties root quickly but others will take from four to six months. After a period of trial a person can learn to root almost any plant. However, at this time it is not so much a question of how to root, but what to root, trying to guess what the style in plants will be in five years.

MODERATOR SNODGRASS: This year there's a new hormone on the market called Root Miracle. I purchased it to try to find out if this Root Miracle will help to root the Loderi series of rhododendrons. It's a liquid that you immerse the cutting in overnight — ten hours on the hardwood cuttings; next year we will know whether that works. We've had real good luck rooting Britannia.

MRS. DREW: I used Root Miracle last year on several different things. I had very bad luck on the rhododendrons I put in early; I find you do have to have very hard wood in order to have success, but when it does work you get wonderful roots — two or three times as many as you do with powder hormones, but never take real tender cuttings, like sometimes I do. I did find it worked absolutely wonderful with *grandiflora rosea* camellias. I've had lots of trouble with *grandiflora,* but almost everyone that I put in with Root Miracle really rooted well and had big roots. I feel that it is a question of when you take the cuttings and how long you leave them in the solution. I think, myself, that on their schedule they have indicated too long a treatment. I think you can burn the cuttings. Another thing you have to do with the Root Miracle is dry the cuttings off. Most of the time I leave them out over night. I make them in the afternoon, spread them out on the bench, let them dry overnight, put them in the solution in the morning. With the *grandi-*

flora camellias, I think I left them in four to five hours, and it did work.

MR. ED WOOD: One thing on this Root Miracle; basically, as I understand it, the active ingredient is indolebutyric acid. If you are used to using a dry powder, I think you are going to find, as Mrs. Drew says, that when you put a very succulent cutting to soak overnight in this solution you are going to get into trouble, no matter what it is.

MR. RAY BURDEN: Earle of Athlone is a comparatively difficult rhododendron to root; I have had good success in rooting it by using Hormodin No. 3 (indolebutyric acid) in pure sand, no peat moss. There may be a reason why that particular variety does not do well in peat moss.

MODERATOR SNODGRASS: Does anyone else have a real good tip? Bill Curtis.

MR. BILL CURTIS: You are all interested in saving money. I found that if you use for bottom heat the heating cable that the heating contractors use for wall heating or ceiling heating, that you cut your cost about in half; its real good cable; you just get the length that you need for your particular rooting bed. Go to one of your electric supply dealers. You can save yourself a lot of money.

MODERATOR SNODGRASS: We'll resume now with a talk by Bob Whalley. He's going to talk about custom propagation of rhododendrons. Mr. Whalley!

CUSTOM PROPAGATION OF RHODODENDRONS

BOB WHALLEY
J. B. Whalley Nursery
Troutdale, Oregon

Actually, as you may know, there is no difference in the propagation whether custom or otherwise, but we do quite a lot of custom rooting.

When the cuttings are ready for rooting, that is, if they are brittle enough to snap off rather than bend, our customers bring them to us, often in clean wet burlap bags or, better yet, in plastic sacks. This test does not always hold good, as a few types actually should be put in when they are soft or even sticky, but it is a general rule. We urge that they be brought to us as soon as possible after cutting, so they will be fresh for making up. We usually make our cuttings about 4½" or 5" long with a slanting cut on the end and a single, medium-deep wound. We pull off the bottom leaves and any flower buds, leaving the top 6 or 7 leaves, which we cut into half, so as to allow the air to circulate through the flat. We root our cuttings in flats and use a mixture of two-thirds sharp river sand, one-third peat moss, well *flora* camellias, I think I left them in four to five hours, and it did work.

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The cuttings are usually in the flats for about 5 months before we transplant them. We find they do better for us if they are very well-rooted before we transplant them. We transplant them into 2¾″ wooden bands and place them 30 in a flat. We use straight coarse peat moss and, after they are well established, feed them with a liquid fertilizer as needed before turning them over to our customers. During this time they are in a greenhouse but without bottom heat. We usually set the top heat for about 50° unless we are working there and want it higher for our own comfort. In custom propagating, the customers bring the cuttings to us and pick them up again when they are ready in the spring.

Our method of rooting might not work well under other conditions but it has proved to be the best we have been able to work out under our own conditions. We have been able to get as high as 90% or even higher, when the cuttings are from young, vigorous plants, and usually get about 75 or 80% to root in our overall crop. Of course, there are some varieties we find very difficult to root, if not impossible, but others make up for it in their ease of rooting.

This about covers what I have to say and I will now show a movie of our operation.

VOICE: How long does it take rhododendrons to root?

MR. BOB WHALLEY: Well, different varieties, of course, differ in this, but we find the dwarfs will root in three months. We usually leave our cuttings in so that they are well-rooted; we can get them to root in five months, and therefore we feel they have a good root system sufficient for transfer to a plant band.

We have found in some varieties that if you allow the medium to dry a little you are able to pull the roots more easily out of the medium and transplant into a band easier. We've been experimenting a little with our transplanting. Our medium is pure peat moss; we find there is quite a variation in the commercial brands of peat moss, and we have been using coarse to the extremely fine grades. We find that tending towards the coarse type of peat moss for transplanting is the best. You find also that some types of peat moss can be too absorbent and I think this will deter the root growth. Then, of course, you go to the other extreme; there are brands of peat moss that won't take the water, and there again you find that the root growth will not penetrate because it doesn't have sufficient moisture So it is just a matter of conditions and feeling out the peat moss to find out what is best for your particular greenhouse or for your operation, then using or sticking with that type of peat moss. We plant into plant bands (two and three-quarter inch bands). We are able to put thirty of these transplants to a flat. Now you probably say, well, why plant bands? Primarily we use bands because of the other phase of our business—shipping our finished product — so our operation is geared to bands primarily for shipping but so far none of our customers have objected to our using the bands. They actually pick them up at the time of year when they feel that the roots will fill the bands sufficiently that they can plant them out into their beds, so their timing is geared to when the plants are ready to go out by how soon the roots will fill the band. Of course, the weather here in Oregon limits how early we will be able to plant these out into a field. I imagine you would be able to plant them out a lot earlier in California than we are able to up here.

MODERATOR SNODGRASS: The next speaker is more competition, but, boy, he is healthy competition too. He grows some of the prettiest rhododendrons I have ever seen. He won't sell one until it is perfect. Bill Menke!

FIELD-GROWING RHODODENDRONS WITHOUT LATH

BILL MENKE
Menke Nursery
Portland, Oregon

Growing rhododendron liners in full sun was not a matter of choice. My lath house was never large enough, so from the start there was always stock spilling out into the sun. Then as time passed and I collected soil-borne insects and fugni, I had to fumigate. I just could not do a good job around posts, so now I have no shade on the place.

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We grow all our plants in flats, 20 to a flat, and keep them in the greenhouse or plastic house until all our field work is done, generally by the 15th of June. By the time we are ready to plant, the flats are a solid mass of roots and have to be cut into squares for planting.

We line the plants out in beds 7 ft. wide with 6 plants to the width of the bed, same spacing both ways; that gives them enough space for two season's growth. After planting, we spray with Simazine, at the rate of two pounds per acre, for control of weeds.

From then on they are watered and fertilized just like large nursery stock.

Our soil is a heavy clay, not too good for growing rhododendrons, but with lots of sawdust tilled in, it seems to be all right. By lots, I mean at least six to ten inches. Any kind of sawdust is all right — cedar, fir, hemlock, or even barkdust.

Fertilizing has to be watched very closely. Plants will starve without lots of plant food. Start with enough to make you lose some sleep, then do it again in about ten days. Then watch your weeds, if *they* are happy, the nursery plants will be too.

If the weather gets hot, which it seldom does here, we water the rhododendrons right in the middle of the day even when the soil is moist. We did have one or two days in the 90's this year.

MODERATOR SNODGRASS: The next subject is to be the seed production of Exbury type azaleas. Our speaker is a rhododendron grower, as you guessed. He has traveled in Europe and picked up a lot of new introductions. He is President of the American Rhododendron Society, very active in horticulture and has introduced a lot of new hybrids. John Henny!

EXBURY AZALEAS

JOHN HENNY
Henny & Wennekamp, Inc.
Brooks, Oregon

First of all it probably would be well to define just what is meant by the term, Exbury azalea. This is a strain of azaleas that was developed by the late Lionel de Rothschild at Exbury. It was developed by taking the best of the Knaphill varieties that Anthony Waterer had been working on and then crossing and selecting and recrossing and selecting until the strain developed into what is now called the Exbury strain of Knaphill azaleas. These are different from the *mollis* types in that they flower for the most part from two to three weeks later in the season. They have much larger flowers with rounded instead of pointed petals. The flowers tend to lay back flat instead of funnel-shaped and they are fleshy and of heavy substance. Also the foliage colors quite well on most of them in the fall.

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These azaleas, like most other deciduous ones, do not propagate readily from cuttings in commercial quantities. Grafted plants of deciduous azaleas are not very satisfactory in that they tend to sucker quite freely and if these suckers are not religously removed they will soon take over the graft.

For this reason we have been attempting, for the past 15 years, to grow these plants from seed and get them so that they can be sold to color without having seen them bloom. This we have been able to do with the yellows, orange, and orange-reds. The whites and pinks have, as yet, escaped us. However the white and pink crosses that we have made, and are still making, give us huge flowers of good substance, interesting colors and some of them fully double, but only 65 to 70 per cent in the color that we want.

It has also been our experience that all of the plants do not necessarily make good parents so that in crossing these plants, accurate records should be kept so that the good combinations can be remade and the inferior ones eliminated. We have seen some really poor forms that are being offered as Exbury azaleas.

We usually sow our seed between August 1 and 10. Germination is rapid from seed that was harvested during the previous January. However, sometimes the days get short and cloudy by the latter part of September and the seedlings just do not grow on to get large enough to pick off readily. If this happens a 150 to 200 watt light bulb left burning over the seedlings for three or four weeks usually will keep the seedlings growing. We plant the seeds in flats that have been filled to within an inch of the top with screened peat moss. The seeds are sown on top of the peat and are not covered with anything but a glass, which is left on tight until the seedlings start to root into the medium. The glass is then slowly raised every day or two until it is removed entirely. Morton Soil Drench C is used as per directions to eliminate damping off fungi.

The seedlings are usually ready to pick off by late October or early November and we do this at our leisure until the first of the year. We use a mixture of about ten percent sand, the balance peat moss, for the medium to pick them off into. The seedlings are planted 72 to a standard Oregon nursery flat, which is 15 x 20 inches. The flats are also dipped every year in a two percent copper-naphthenate solution. This not only makes the flats useable for many years but also stops any wood rotting fungi that will sometimes appear. The seedlings are then left in the flats until the following June or July by which time the greenhouses are empty of rhododendrons. They are then transferred into the benches and left there until the middle or latter part of September, at which time they are planted in beds in the open fields to be left there until they are budded.

We have found that by handling them in this manner we can save almost a year's time in growing the plants to flowering size. Also the seedlings can be picked off when we have more time than we would have in the late spring, which would be the time to pick off if the seed was sown in late December or early January.

MODERATOR SNODGRASS: Now who has the first question? Yes, Frank.

MR. FRANK DOERFLER: This is for Bill Menke. What type of sawdust do you use and are there any weed problems from the seeds of your sudan cover crops?

MR. BILL MENKE: On the first question, Frank, sawdust: we take any kind that we can get. Very often we get cedar. We get hemlock. We get fir. We prefer fir, and we'd rather have bark dust if it didn't cost so much. It doesn't seem to make a whole lot of difference. As to the Sudan grass seed, I don't think it reseeds because we kill it before it goes to seed, before it is completely mature There are a few seed pods, but I don't believe they were mature.

MR. ALBERT LOWENFELS: What medium is used in the flats for planting azaleas seeds?

MR. JOHN HENNY: When we plant the seed we screen horticultural peat moss and use the standard Oregon nursery flat. The seed is then sown right up on top of the peat, not covered — only with a glass — the glass is covered then only with paper. Then when the seed first starts to sprout, the paper is removed. This is done in the greenhouse. By the time the seedlings are beginning to touch the glass, then we slowly start to raise the glass daily, until we finally remove the glass entirely. There will be periods as we start to raise the glass when there will be rather heavy condensations of moisture; if this is the case and if I am in a hurry, I just turn the glass over and put the dry side down. If I have a little extra time I will wipe the moisture off. The mixture we use when we transplant from the seed flat into other flats is the same type of peat moss again only we do put in some sand to keep the mixture open so that the water will drain down rather than forming a flat coating on top which can get almost impervious to water.

In the spring when the plants start to bloom or start to grow — usually along in early April — we do start then, about every ten days, using about three tablespoons of liquid fish fertilizer per gallon of water and feeding the plants about every two weeks just to keep them coming along and getting nice and sturdy. A gallon of water probably would be adequate for about 30 to 35 flats; we then wash the fertilizer in with water.

MR. PERCY EVERETT: A question for Bill Menke. How soon after the sudan cover crop is tilled into the ground can you plant?

MR. BILL MENKE: Right away, as quick as we get the ground in shape.

MR. PERCY EVERETT: After the Exbury azaleas germinate how long do you attempt to keep them growing before they go dormant?

MR. JOHN HENNY: We don't make any particular effort at this. It seems that with these fall seedlings, if they go dormant, they don't show it because the foliage stays on usually for about a year or year and a half. They just don't drop these small leaves at all. We have transplanted them as much as 6 or 8 months later.

MR. PERCY EVERETT: Did you have any trouble with your seedlings going prematurely dormant?

MR. JOHN HENNY: No. Not in this area.

MR. ROBERT BODDY: Mr. Menke, what is the program for pinching or pruning the field-grown rhododendrons that are grown in the sun?

MR. BILL MENKE: Most of my plants are planted right out in the full sun. From the liners I don't do any pinching whatsoever the first year. I just let them go ahead and grow. They look lanky. We do our pinching after danger of frost the next spring. Sometimes we cut way down on them, that is, we cut down into the first year's growth. We generally get two growths on a liner in the summer time. We cut one completely off to get a branched plant. In case there is a late spring frost with a warm period before it, sometimes the plants start growth — start the dormant buds and then you're in trouble, because you lose the buds — so that's why we do our pruning, not pinching. we prune, in late May.

MR. ROBERT BODDY: What about your larger plants, your three and four year old plants? Do you use the same procedure?

MR. BILL MENKE: Generally there isn't any pruning necessary. If the plant is started out well-branched, near the ground, we just let them grow from then on. Some varieties, Cynthia for example, tends to grow rather lush and leggy so sometimes we cut the top growth off, but most of the others, once they are started right from the liner, we just let them grow.

MR. HALL: I would like to ask Mr. Henny another question about planting his azalea seed. Do you plant it on top of the peat moss? What age or stage of seedlings would you transplant first?

MR. JOHN HENNY: We plant directly on top of screened peat moss, planting about the first week in August. They're usually ready to pick off about the latter part of October. It will depend on the season. If we happen to have a lot of sun and bright weather with nights warm, they'll come along faster than that. Ordinarily, though, about the latter part of October, which would be 90 days.

MR. BRUCE BRIGGS: Mr. Whalley, in cutting back the leaves on rhododendron cuttings, does the angle of cut have any effect on fungus development?

MR. ROBERT WHALLEY: We haven't noticed any, Bruce, so I wouldn't be able to pursue that We haven't made any study of it.

MR. BRUCE BRIGGS: The reason I was asking is that some claim that if you cut the leaf on a slant the water drains off better. If you cut it flat, the water would lay on top of the leaf and you are more apt to have some rot start on top of the edge of the leaf.

MR. ROBERT WHALLEY: We haven't noticed anything in this regard. Many of our people do come through the greenhouses and want to know why the leaves were cut. There is a margin where the leaf is cut. But we have never had any rot problems.

MODERATOR SNODGRASS: I might just add one thing. On these smaller leaf cuttings, I don't believe we've cut the leaves. It is just the larger ones that are cut to provide air circulation.

MR. HALL: Mr. Whalley, what mix do you use for starting your rhododendron cuttings?

MR. BOB WHALLEY: Two parts of sand — sharp nursery sand — to one part of peat moss. We use a finer grind of peat moss in our rooting medium than we do for transplanting.

MR. BILL CURTIS: This is for Harry Carlson. Do you have any trouble in rooting *Juniperus siberica* or *jackii?* Is there anything in timing to help you root them?

MR. HARRY CARLSON: So far we haven't had any trouble at all.- They seem to root quite readily — as easy as *J. tamariscifolia* or the other junipers.

MR. BILL CURTIS: Do you put them in early or late?

MR. HARRY CARLSON: In October and the first part of November. As a rule we put them in then, and with not too much heat and they are rooted by February or first part of March. They root quite readily for us.

MODERATOR SNODGRASS: Incidentally, the only problem I have ever noticed with *Juniperus siberica* or *J. jackii* is that they are tough to transplant. They are real good to grow in containers. Personal observation. Is that true, or are you successful in digging them from the field and having them grow on?

MR. HARRY CARLSON: Well, so far, they grow pretty well for us in ball and burlap. They are doing all right.

MODERATOR SNODGRASS: Apparently Harry Carlson hasn't had my experience.

MR. O. M. HELTON: Is it general in Oregon and this area to root cuttings in flats rather than in open benches?

MR. ROBERT WHALLEY: We handle different types of plants. We find the handling is actually one of the primary reasons we prefer flats. Once we have used the flats in propagation, we never use them again. We reuse our flats in transplants, and then send the flats with plants out to the different cusomers. It's actually ease of handling for us. Because of our particular business we have many different varieties of plants that we handle at the same time and different locations in our houses — in other words, we might be feeding plants at different houses at the same time.

MR. O. M. HELTON: I was aware of that, but is this a general practice in propagation in this area — in flats rather than in open beds?

MR. ROBERT WHALLEY: Probably the primary reason we have gone to flats is that once you have filled the bench completely full of sand, put all your cuttings in, and then you have heating element trouble, then you're going to have a dig into your medium and disrupt the growth of the cuttings. So we would prefer to be able to pick up the flats and expose the elements. This fall I had a couple of cables that have given me trouble already and I would hate to have gone into those beds without the flats.

MRS. WHALLEY: I believe, though, that it is not a common practice in this area to use flats. I think it is much more common to plant directly into beds. I think we are one of the exceptions.

MODERATOR SNODGRASS: We plant in benches. We have hot water pipes so we don't have this heating cable problem. I think probably more of the growers in this area plant regularly in benches rather than in flats

MRS. LEONA DREW: I have rooting beds on the ground with just lift-up covers. I don't have much room. I use flats because some species root easily and I can take out the flats and put them in another cold frame that is heated with cables and start over again and put some more things in. Sometimes I do that about three times a year I get more material propagated that way.

MR. FRANK DOERFLER: What about the nodules or callus knobs that appear on the base of cuttings and what do you do with them — take them off or what?

MR. BILL CURTIS: *Juniperus tamariscifolia* can be very bad about this. If I am short of cuttings I will pull the callus knob off and put the cutting back and in 30 days time there will be a real heavy root system. Some things like the *Magnolia grandiflora* will also form a callus knob. I put them back and in about thirty days they'll root again too. The only thing is that if you use a hormone on any of these plants that have developed a knob, you had better put on a pair of gloves because there is some effect from the hormone that will cause a roughness to the knob which will cause discomfort to the fingers as you pull the knob off.

MODERATOR SNODGRASS: Bill, do you re-dip the cuttings in hormone after you've removed the knobs?

MR. BILL CURTIS: No, I don't.

MR. ALBERT LOWENFELS: What type of wound is generally used on your cuttings?

MR. ROBERT WHALLEY: We cut through the cambium area. It is an open-faced wound that is approximately an inch long and 1/4 inch wide.

MODERATOR SNODGRASS: I might add on that we have experimented with wounding and we also use this type of wound. We make a straight angle cut — and then it doesn't matter to us which side we wound whether we flip the cutting over and cut through the cambium with a slice, or take it on the same side as the angle cut. Others make almost a point, cutting both sides of the scion equally and bring them to a long point. Other people take the tip of their cutting knife, and after they make the normal cut on the scion — the angle cut — they flip it over, just take the tip and cut just a little slice down into — not a slice off the cutting, but a cut into the cutting — and they have had good luck. So it sort of boils down to whatever works best for you.

MR. FRANK KAMATA: Could we hear something about the use of a copper screen to induce root branching.

MR. PERCY EVERETT: The forestry people have put a copper screen under the seed bed, I'd say fifteen inches under the soil. When the seedling root gets down there the tip is killed. The results in a very nice branching of the root. I tried this scheme in raising some of our native oaks and pines, and I can vouch for the fact that this procedure does a very good job. Rather than getting an extremely coiled root system into cans by taking the seedling out of the flat, we grow them in seed beds and then transplant them directly to the field. That way we have gotten away from this terrific problem of coiled roots which you people with rhododendrons and azaleas don't worry about. Those of us who grow trees do have this problem. It's a very serious problem that the nursery industry needs to do something about because when you sell a person a tree with an extremely coiled root system you're doing him a disservice. This copper screen is used primarily on seedlings and it provides a much better root system rather than the long, wiry, winding root which in the past has been a problem to the eventual consumer and to the nurseryman.

MR. DAN SCHMIDT: Why use the copper screen when you can undercut to cause root branching?

MODERATOR SNODGRASS: We do undercutting to provide the feathering out of roots but this copper screen may do real well when the seedlings are grown on not quite so large a scale operation or when the seeedlings are grown in narrow seed beds.

MR. DAVID A. LAWYER: Has anyone used Clorox or Purex as a preventive of soil problems in the greenhouse.

MR. RALPH MOORE: In the propagation of miniature roses we have been using Clorox for the past year and a half or two years. We have used it in various concentrations — 2 to 8 teaspoons of the concentrate per gallon of water. It seems like the plants can stand quite a variation. We've had no difficulty. We have even dipped freshly-made cuttings right in these Clorox solutions, and still there hasn't been any difficulty. One of the main reasons we've done it is because on one or two varieties of roses we have had considerable incidence of crown gall and it occurred to us that this might be a preventive, and so far it has apparently worked very well.

SATURDAY AFTERNOON

October 5, 1963

This session convened at 1:30 P.M. with Wayne Melott, Moderator, presiding.

MODERATOR MELOTT: When I started in the nursery business about 30 years ago, we had one apple rootstock, French Crab; two cherries, Mahaleb and Mazzard. We had one plum root, Myro. We had one peach root, Lovell plus Muir and about everything else they could mix up into the bag, but that's all we had, just a few rootstocks. Now look what we have. You can't even count them. You haven't got enough fingers, toes, arms and legs all together to tell how many Merton-Mallings and East Mallings and Mazzard F-12-1's, Stockton Morellos and Mahalebs, Myros, and Myro 29's, and Marianna and just about everything. Give me the good old days! I am not going to say anything more about rootstocks because we have a real good program coming up. We have, first of all, a second generation nurseryman here in the Pacific Northwest, who is co-owner of the Pacific Coast Nursery Company, in business with his brother, John; they are located here in the Portland area and in Sunnyside in Washington. Martin's going to talk on seedling production. Martin Holmason!

SEEDLING PRODUCTION

MARTIN HOLMASON
Pacific Coast Nursery
Portland, Oregon

I don't believe that trying to cover the methods of seedling production in 20 minutes would be as hard as trying to tell you how to build an atomic bomb but I will have to try as I don't know how to build a bomb! There are many sides to the quesplants can stand quite a variation. We've had no difficulty. We have even dipped freshly-made cuttings right in these Clorox solutions, and still there hasn't been any difficulty. One of the main reasons we've done it is because on one or two varieties of roses we have had considerable incidence of crown gall and it occurred to us that this might be a preventive, and so far it has apparently worked very well.

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I don't believe that trying to cover the methods of seedling production in 20 minutes would be as hard as trying to tell you how to build an atomic bomb but I will have to try as I don't know how to build a bomb! There are many sides to the question of growing seedlings but I will cover the high points as I see them and if there are any questions you wish to ask, we'll have them at the end of my discussion.

We grow seedlings in two places, one growing ground is located in Sunnyside, Washington, and one is located here in Oregon on Sauvie Island.

I'll begin with our plant up in Washington where we grow all our apple and pear seedlings. Of course, some of the seed is imported, some from France, some from Austria or China or Japan while some is local seed. We import *Pyrus calleryana, P. ussuriensis* and French crabapple seed. Our domestic apple seed is locally grown and is mostly of the Winesap variety. Our Bartlett pear seed is from local canneries.

Some of the seed is planted in the fall and is planted dry. Seed planted in March and April has to be stratified from 6 to 8 weeks before planting. The seed is put to soak in water for about 10 days and then packed between layers of ice from 6 to 7 weeks until the ground and weather conditions are just right for planting. The seed is the planted with a four-row planter and within 3 to 4 days they have germinated and are ready to come through the ground. Of course, they must be raked and helped through the ground.

The reason for planting all our apple and pear seed in the Washington area is because we have flood irrigation up there and most of these seedlings have to be root-pruned to grow branched trees and the soil around the Oregon area does not grow good branched-rooted apple and pear seedlings.

After these seedlings have grown roots about 4 to 5 inches long, they are root-pruned and the water is turned on immediately after they are cut and then after about 2 weeks they begin to throw new roots which makes them branch.

All the seedlings in Washington are dug in the fall, beginning around November 1. They are all pitted in the ground from 4 to 6 weeks to sweat off the leaves. They are taken in from the pits and graded for shipping into 4 grades: 3/8″, 1/4″, and 3/16″ and 2/16″.

The seedlings we grow in Oregon are the Mazzard and Mahaleb cherry, Myrobalan and American plum, and the quince rooted cuttings.

Years ago, we used to stratify all this stone fruit seed in sand but now we have found that by planting the seed early enough in the fall (if the ground has enough moisture in it) we don't have to stratify. We plant this seed sometime during the month of October when they will get plenty of rain and, that way, they stratify themselves.

The seed is planted about two inches underground and then the rows are mounded two or three inches over the top. They are left until spring of the year and after they begin to sprout, the mound is raked off and the seed will come through the ground by themselves unless the soil is too heavy; then they have to be helped a second time.

These seedlings are left in the ground in the fall until practically all the leaves are gone, then dug. They are brought into the warehouse at the time of digging and sorted into the 4 grades as are the apple and pear. The 3/8" grade is tied in bundles of 50; the 1/4" and #1's in bundles of 100 and the #2's and #3's in bundles of 200.

The bundles are stacked in the warehouse and they are never sprinkled or watered from the time they are removed from the field until they are shipped. These bundles are stacked tightly in piles so they can't dry out, for once a seedling has dried out, it is very hard to revive and make grow; perhaps it would be impossible. If the seedlings are left alone and not watered, they will keep in the stack in our warehouse for 4 to 5 months without any trouble at all. We have kept seedlings this way in good condition until May or June following a December digging for many years now.

Our quince are planted as cuttings and after that, are treated just as any other seedling as to digging and grading and shipping.

When shipping any seedlings, we pack them in boxes in damp packing material and they have been held in cold storage by our customers as late as June and planted and still they have good results.

One thing we stress very thoroughly and try to tell our customers is that when they receive the seedlings, they must never be left to dry out. A lot of times the customer will take the seedlings from the packing, throw them on a loose pile, get busy with other things and the seedlings dry out, often to the point of dying. We know this to be the case because it has happened to us too. After the seedlings are trimmed they are either healed in outside in the ground or repacked in boxes until planting time.

In regard to the stone fruit seed especially, we have been trying for a good number of years to grow virus-free seedlings for our customers. It has taken a long time to get the right trees and get our orchards planted The orchards and the seedlings have been checked and rechecked usually twice a year and we believe that within two years, all our stone fruit seedlings will be virus-free.

Of course, we have a lot of seedlings now that are checked to the satisfaction of the Departments of Agriculture to be virus-indexed and free as is possible of disease but it will still be two years before they will issue a certificate saying they are 100% free. All our seed in both Oregon and Washington is grown in fumigated ground but our problem has been that the customers receive these clean seedlings, then plant them in infected ground and wonder why they have diseased trees.

The inspectors and the colleges and experiment stations have done a good deal of very fine work in this field and the work has finally paid off in clean, virus and disease-free seedlings.

I've tried to cover at least the high spots of this seedling propagation problem but there is a lot of ground to cover in a few minutes. It has taken us forty years to work some of these problems out so perhaps if there is some additional information you would like, we can take a few minutes for questions.

MODERATOR MELOTT: Are there any questions for Martin?

MR. C. J. ALLEY: Do you find certain lots of Mazzard cherry seeds from particular trees that are obstinate and will not split when you stratify them?

MR. MARTIN HOLMASON: That I couldn't exactly tell you. We have planted and kept seeds separate from seventy different trees, and planted each tree separately and haven't had any trouble with them. They all germinated about the same, providing they're good seed. Now we have had a lot of seed that would not crack, especially with old seed; it does not swell up enough and it will not crack the pit.

MR. C. J. ALLEY: Is there any treatment you can give this seed, the fresh seed, to make it crack?

MR. MARTIN HOLMASON: We used to stratify the seed in sand to make it crack years ago, but that is a lot of extra work, so we don't do it anymore. We just take the seed and plant it in dry in October. We get enough wet and cold weather to stratify the seed by spring, but if you were in a dry climate you could not do it.

MR. DALE KESTER: Did I understand you to say that you use a damping-off preventive spray on cherry seedlings?

MR. MARTIN HOLMASON: Yes, it is a Captan formulation.

MR. JACK DOTY: What time of the year do you root prune?

MR. MARTIN HOLMASON: About in July, after planting in March or April.

MR. DAVID A. LAWYER: I would like to ask if you hand-plant or machine-plant the seeds when you plant them. How do you keep from breaking off the root radicle when they start to sprout?

MR. MARTIN HOLMASON: We always plant the seeds in the fall. We plant them dry so there are no root radicles to break off. When we used to store them in sand for stratification, then we had to plant them by hand. Now we machine-plant; we do not plant by hand anymore and we never let any of the seeds sprout before we plant them.

MR. FROST: Do you have any problems with rodents — mice or field mice?

MR. MARTIN HOLMASON: We used to have a lot, but since we started fumigating they're pretty well out of the ground.

DR. C. J. ALLEY: Do you have some superior selections of Mahaleb seed trees?

MR. MARTIN HOLMASON: They are all superior that will be coming on now. We have planted about 500 pounds of superior selections. They're fully 100% supposed to be virus-free and they've been all started from layers, not grafted or budded, and they're all superior seeds.

DR. C. J. ALLEY: What I am getting at is in regard to some of the selection work that has been done by the Agricultural Experiment Stations where they have been selecting clones of Mahaleb cherry, say for either large leaf or upright growth. Do you have some better selections of these?

MR. MARTIN HOLMASON: We get all our seed trees from the Prosser Experiment Station in Washington; they are still working on large-leaf and small-leaf Mahalebs. They have come out with a Turkish clone now that is a large-leaf and a very good grower; we think that within the next four or five years that it is going to be the seedling used for Mahaleb altogether.

DR. C. J. ALLEY: Yes, but has work continued, say with these particular liners now, as to the type of top tree they would give; in other words, would there be better production of fruit or would it be a more vigorous type of growth?

MR. MARTIN HOLMASON: Well, we have budded-in — up there in Washington — on both varieties of Mahaleb this last summer, so we can tell you more about that in a year or two from now.

DR. C. J. ALLEY: Do these selections of Turkish-type seed source trees produce better than the ordinary type of Mahalebs?

MR. MARTIN HOLMASON: They produce as well but they are much slower ripening so we don't know how it's going to work out. It takes about three or four weeks longer than the ordinary Mahaleb cherry.

MODERATOR MELOTT: The next speaker is Kent Brooks from Carlton Nursery Company who has been a long time friend and business associate, together with his brother, Lyle, and myself in the Carlton Nursery Company. He has charge of propagation and production and is going to talk on double-budding of pear trees. Mr. Kent Brooks!

DOUBLE-BUDDING OF PEAR TREES

KENT BROOKS
Carlton Nursery Company
Forest Grove, Oregon

Most of you know, of course, there are varieties of pears that are not compatible with quince rootstocks, especially the Bartlett variety. While we have received reports of a Swiss and French selection of Bartlett as being compatible, there has

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Most of you know, of course, there are varieties of pears that are not compatible with quince rootstocks, especially the Bartlett variety. While we have received reports of a Swiss and French selection of Bartlett as being compatible, there has not been enough work done regarding these selections to propagate them commercially with the confidence that they would continue to grow favorably.

This situation caused us to consider various ways of getting a combination of a compatible variety between the rootstock and pear variety. Knowing that both Buerre Hardy and Old Home were compatible, we made up some grafts consisting of Bartlett grafted on B. Hardy or Old Homes using grafting tape to hold the grafts together. We then put these in moderately warm storage for approximately thirty days to start the callusing action at the graft union. After this thirty-day period, we either put them in cold storage or graft them in the field onto quince rootstocks. We were not entirely sure what growth we would get from this double graft, but it turned out to be very good. We couldn't see any difference between the grafts put in cold storage and those grafted immediately in the field, except the ones put in the field earlier seemed to have a head start over those put in cold storage for a couple of weeks. We questioned if it was necessary to make these grafts up and callus them in storage for the thirty days, so we made up several hundred, grafting them in the field right away. The results from these grafts were equally as good as the others.

After analyzing these various tests, we now make up our grafts with the thought of grafting them in the field as soon as possible. If weather conditions do not permit this, we put them in cold storage, holding them dormant until we can use them.

The budding, or double-budding, as we prefer to call it, is a relatively simple method of using a thin piece of a compatible variety between the Bartlett and the quince understock. We like Old Home for this as it seems to be more vigorous and we like the vigor in this particular place.

The first thing we do in double-budding, is make a regular "T" cut in our rootstock about one and a half inches long; then taking a stick of Old Home and starting at the small or tip-end, we shave off a piece of the bark about one-inch long, which we do not use. This leaves an exposed area of wood; we then go back and make another cut, starting about half an inch beyond the previous cut, cutting this like we normally would a regular bud. Making sure there is an area of bark on the nose of this, we take a sliver of wood about an inch and a half long, this we slip under the bark, pushing it to the bottom of the "T" cut. We then take a regular bud of the Bartlett or whatever variety we are using, cutting it long enough so that it will cover the exposed area of the Old Home put in previously. We use a solid wrap to cover this bud, leaving the eye exposed. We like to leave this wrap on from five to six weeks so the callus can form properly.

A couple of important points I might add, are the vigor of the rootstock, which should be in good, growing condition and the maturity of the budwood, the more mature the better under these conditions; we usually get a 95% take, or better, in our double-buds.

MODERATOR MELOTT: Are there any questions for Kent?

MR. DAVID A. LAWYER: Is Flemish Beauty pear satisfactory as a stock between Bartlett and quince?

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THE HISTORICAL BACKGROUND, THE DEVELOPMENT, AND THE PROPAGATION OF CLONAL APPLE ROOTSTOCKS IN AMERICA

H. B. TUKEY, *Professor Emeritus*
Michigan State University
East Lansing, Michigan

I have chosen to speak in general terms. You are fortunate in having horticultural experts in your midst, as well as able nurserymen and orchardists, who can give you detailed information on specific points for this region far better than I can do. But, perhaps looking in from the outside, I can point out the general features of clonal apple rootstocks and where they seem to me to fit.

Let us, then, consider three topics:

1. Why are we interested in clonal apple rootstocks?
2. What clonal apple rootstocks command our major interest and what do we know about these rootstocks?
3. How do we propagate clonal apple rootstocks?

Why Are We Interested In Clonal Apple Roostocks?

The tremendous interest in dwarfing rootstocks comes about because (a) we are historically due for the next step in the refinement of growing fruit, which is to adopt predictable clonal rootstocks to combine with our predictable scion varieties; and (b) we sense the solution to many of the modern problems of the fruit industry by the use of specific rootstocks, such as the East Malling and the Malling-Merton apple rootstocks.

The Historical Background

Centuries ago — in fact, only decades ago in some regions — fruit trees were propagated from seed. No two trees were alike. But we no longer raise our fruit orchards from seed. We have standardized on certain clonal scion varieties as the these conditions; we usually get a 95% take, or better, in our double-buds.

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The Historical Background

Centuries ago — in fact, only decades ago in some regions — fruit trees were propagated from seed. No two trees were alike. But we no longer raise our fruit orchards from seed. We have standardized on certain clonal scion varieties as the foundation of our industry, which are budded and grafted for uniformity of product. But the rootstocks upon which our scion varieties are propagated are seedling in nature and similarly present considerable variation.

The next step in development is, of course, to standardize the rootstock as well as the scion variety. Whether we use dwarfing rootstocks or not is beside the point — the important consideration is that we are ripe for uniform, reliable, clonal rootstocks upon which to bud and graft our selected, desired scion varieties. There are some in this room who will recall this sequence of events in the walnut industry. First, orchards consisted of seedling walnuts. Then came selected varieties, or clones, of walnut. We can observe the same sequence in the avocado industry. The next step will be clonal rootstocks.

In fact, propagation on special rootstocks has entered areas other than fruit production. Grafted tomato plants, cucumbers, melons, and other crops are becoming more and more common in vegetable production — watermelon on certain gourds, sugar melons on pumpkin, cucumber on gourds, and so on. It is all a part of the effort to control our situation. Tomatoes are grafted at the rate of 100 plants per hour, with 100 percent survival.

Man's Objective Is To Control His Environment.

Man must have seemed a very puny creature when he appeared among the great forces of nature. But he possessed the ability to adjust — either to adapt to his environment, or to change his environment. Little by little, he learned through the centuries to control fire, to provide shelter for himself, to clothe himself, to domesticate both plants and animals, and to provide a more reliable food supply.

The story of the development of power — water, coal, petroleum, electricity, atomic energy — together with refinements of agriculture, including plant breeding, insect and disease control, fertilizers and nutrition, cold storage, and transportation are the great stories of modern man. It is so commonplace that we fail to recognize the amazing achievements.

And, every time you look at this progress, you will find that it is an attempt to replace uncertainty with certainty, to provide warmth, to provide shelter against both cold and heat, to provide a constant food supply — cold storage, canning and freezing, and rapid transportation to bring food from all parts of the world. It is all, as I have said, a part of man's desire to adapt to his environment or control his environment.

Similarly, in fruit growing we have moved along these same lines and in the same direction. The trend is now towards specialization, refinement, automation, and the abundant use of cheap energy. We speak of biological engineering or horticultural engineering. Crops will be grown where they can be grown best, by men who can grow them best, and are transported widely. To be sure, there will always be a limited place for choice produce grown near to market for special purposes, but this will become the exception, and not the rule. Stoop labor is a thing of the past. Mechanical operations will rule — even the harvest. There are those who predict that the dairy cow will be as uncommon on farms within the next fifty years as the draft horse has become. This is the sort of overall thinking we must indulge in. It is into this kind of a world that fruit growing and dwarfing rootstocks must fit.

The Need To Solve Some Immediate Problems In The Fruit Industry.

Our sudden awareness of clonal rootstocks, especially dwarfing rootstocks, is due also to the fact that they suggest the solution to some of the pressing modern problems of the fruit industry. We demand still further control of our destiny in the fruit industry. We refuse to be subject to the whims of biennial bearing, drouth, pests, market gluts, labor shortages, and all the rest. We seek a regular, predictable, uniform supply of fruit of quality which can be economically grown, brought into early bearing, rotated to suit our needs, economically and easily sprayed, harvested, handled, and tailored to a consumer and a market demand which we intelligently command. In short, we demand compact trees and controlled production, and clonal rootstocks seem to suggest helpful possibilities.

Many of the solutions which we should like to attain, of course, may be realized in other ways than by the use of clonal rootstocks. Thus we can bring trees into early fruiting by the selection of early-fruiting varieties such as Gallia, Cortland, and the spur-type trees. Or, we can aid by low-heading, good cultural practices, little pruning, bending, root pruning, scoring and the like. Much of this we know. Or we can combine these factors with the rootstock opportunity. Much of this lies with the choice and the capacity of the individual.

But it is to the rootstock that many are turning for the greatest help in solving these immediate problems.

What Clonal Apple Rootstocks Command Our Major Interest And What Do We Know About These Rootstocks?

What do we know about the Malling and Malling-Merton rootstocks? Where did they come from? How should we use them? At the risk of repetition, let me trace briefly the story of dwarfing rootstocks.

In the first place many of them are very old. Some people think of them as something quite new, but they really are not. In fact, Alexander the Great, three centuries before Christ, sent back dwarfing apple rootstocks to Greece from his conquests of Asia. The name "Paradise" which has been given to one group of dwarfing rootstocks is suggestive of Persia and the Garden of Eden.

These dwarfing rootstocks down through the centuries increased in form and variety, and were broadly divided into the (a) "Paradise" rootstocks which were characteristically hairy-rooted, and usually severely dwarfing, and (b) "Doucin" rootstocks which were characteristically straight-rooted and usually semi-dwarfing.

Further, centers of the nursery industry, or of fruit production, tended to pick up or select certain rootstocks which were preferred locally, and known by local names of descriptive terms, such as "French Paradise," "English Paradise," "Hollyleaf," "Jaune de Metz," "Holstein Doucin," "Ketziner's Ideal," and so on. As transportation and communication increased, notably prior to the nineteenth century, these rootstocks became spread around and mixed. Much dissatisfaction arose because of the misnaming, lack of uniformity, and unpredictability of performance, just as scion varieties of fruits were widely mixed, and confused a half century ago.

From time to time, horticulturists attempted to clear up and standardize these rootstocks, but with not very great success. But about 1912, or 1913, another attempt was made at the East Malling Research Station, Kent, in England. The leader was Wellington, who was Director of the Station, and who brought together clonal apple rootstocks from many sources in England and from the Continent. The First World War then intervened, Wellington answered the call of his country, and the work was left in the hands of his assistant, Ronald Hatton.

Through careful study, Hatton, later Director Hatton, and, still later, Sir Ronald Hatton — still living — rogued out and standardized sixteen lines of apple rootstocks from among the many rootstocks he had secured. These he numbered with Roman numerals and introduced to the world as "true-to-name." They were called the East Malling apple rootstocks, as "East Malling I," "East Malling II," and so on, later abbreviated to "EM I," "EM II," and so on. The sixteen individual rootstocks can be found fully described and pictured in the literature, and will not be detailed here.

Some of the rootstocks were found to be very dwarfing. Some were less dwarfing, some were not dwarfing at all. In short, here were sixteen standardized scion varieties, representing considerable range in dwarfing and in general performance in both nursery and orchard.

At about this same time, fruit growers of Australia, and New Zealand were being plagued with woolly aphis on the roots of apple trees. The East Malling rootstocks were not immune; in fact, many of them were quite susceptable to attack. The Northern Spy apple was relatively resistant but it made poor rootstock material for other reasons.

To meet this situation an attempt was made in England, as a British Commonwealth service, to breed apple rootstocks which were resistant to woolly aphis. Crosses were made between the East Malling rootstocks and the Northern Spy apple. The work was done jointly by the East Malling Research Station and the John Innes Research Station at Merton, England. From this came eleven numbered apple rootstocks, fairly resistant to woolly aphis ,and which have been called "Malling-Merton" from their origin. These were numbered in Arabic, beginning with 101 through 111, and designated "Malling-Merton 101," Malling-Merton 102," and so on, abbreviated to "MM 101," "MM 102," and so on. In trials these were found, like their predecessors (the EM rootstocks) to represent various degrees of dwarfing and specific characteristics of nursery and orchard performance.

The list of standardized East Malling materials has subsequently been raised to twenty-six, and there are additional interesting clonal materials from other sources as A2 from Alnarp, Sweden, and Robusta 5 from Canada. As time goes on, we may expect additional rootstock materials from other parts of the world. It is thoroughly likely that there will be clonal rootstock materials developed here in the Pacific Northwest. I would urge you to make the effort. You could quickly assume a commanding lead.

And, so we do know considerable about these clonal apple rootstocks, although we have a great deal more to learn. But we have enough information about them to operate upon — perhaps not with final perfection, but at least with a fair degree of security. There will always be improvements. If one waits until all the answers are in, he will not live to attempt much in life. There is always the calculated risk in everything one undertakes.

Not only do we know that some of these rootstocks are very old, but we know that they have been widely used in Europe for a considerable time with a reasonably good record of performance.We know that in some areas of Europe essentially all fruit trees are grown on clonal rootstocks. We know also that some of these rootstocks are undesirable so that some have been discarded for the time being. Thus we confine our efforts to EM I, II, IV, VII, IX, XIII, XVI, XXV, and 26, and to MM 104, 106, 109, and 111. To this may be added A2 and Robusta 5.

Our first concern, perhaps, is in the degree of dwarfing or size control that each rootstock offers. This we understand in general terms, and we may divide them into the following five classes:

Class A—Very dwarf—EM IX
Class B—Dwarf—EM 26
Class C—Semi-dwarf or medium dwarf—EM VII, MM 106
Class D—Medium vigor—EM IV, MM 111
Class E—Vigorous—EM I, II, XIII, MM 104, A2
Class F—Very vigorous—EM XVI, XXV, MM 109

For simplicity, the general size relationship is EM IX, EM 26, EM VII, MM 106, EM IV, MM 111, EM II, EM I, EM XIII, MM 104, A2, EM XVI, MM 109, EM XXV.

But, it is not alone the degree of dwarfing which attracts us. Each rootstock is different from the others in many specific characters, just as the Delicious apple is different from the

Rome, the Jonathan, or the Winesap. This is a very great asset to our industry. It means that we have the opportunity to choose rootstocks for qualities beyond dwarfing.

Thus, the Malling-Merton rootstocks are resistant to woolly aphis, as already mentioned. EM I seems susceptible to collar rot, although I have never been satisfied that collar rot was not secondary, following winter injury at the crown. The matter of maturity at the crown is something we have not fully recognized. There is a disposition at the moment to set the union of dwarfed trees several inches above the ground so as to avoid scion rooting. I am suspicious that in some season we may see severe damage from an early fall freeze. One must choose between the chances of scion rooting and this kind of injury. Certainly, I have seen, vigorous trees destroyed by cold injury at an immature union. I have seen, for example, double-worked trees destroyed by complete killing at the unions just above and below the intermediate stem-piece. Every other part of tree — scion, rootstock, and intermediate stem-piece — was uninjured.

To continue. some rootstocks, as EM I. will accept cool, moist, relatively heavy soil, are susceptible to drouth, and are good for weak-growing varieties. EM II is better on light soils. EM XIII and XVI will also tolerate wet, heavy soils. EM 26, which is intermediate in size between EM IX and VII, is better anchored than EM IX; EM VII seems to have a wide adaptation; MM 104 is slightly larger than EM II, prefers light, well-drained soil, and is resistant to collar rot; MM 106 is not unlike EM VII but has better anchorage, suckers less, and is adapted to heavy soils; MM 109 is as large or larger than EM XVI but is suited to dry soils; MM 111 is about the size of EM II and will stand drouthy conditions.

Some rootstocks bring trees into bearing considerably earlier than others, as EM IX, whereas others are later, as EM XIII. Although the most dwarfing rootstocks are associated with early fruiting, and the most vigorous rootstocks with late fruiting, this is not a reliable rule. The EM IV, which produces a semi-dwarf tree will induce fruiting earlier than other trees the same sze on EM II.

The top-root ratio varies with the rootstocks. EM IV induces a vigorous early-fruiting top which inclines towards leaning and blowing over without support. Allowing for this, EM IV is an excellent rootstock and one that might do well in the Pacific Northwest. Some rootstocks require support, as EM IX, whereas other do not, as EM XVI.

Further, the scion variety has a direct relation to the success of a rootstock. Generally speaking, the more vigorous scion varieties are best on the more dwarfing rootstocks, and vice-versa. Thus, when Gallia is placed on EM IX, it is so weak and so early-fruiting that it virtually gets down on it's knees. On the other hand, Northern Spy, which is a vigorous, notoriously late bearer is excellent on EM IX. Each stock-scion combination must be evaluated as a different individual. We cannot speak about the rootstock without knowing the scion variety.

Still further, the performance of each scion variety varies with the length of the growing season and the general climate and cultural conditions provided. Combinations with EM IX (very dwarf), for example, may be insufficiently vigorous for northern regions, as British Columbia, but will be well adapted to the states of Washington and Oregon. Conversely, EM II may be too vigorous for Washington and Oregon and yet just right for British Columbia.

When I was in Angers, France, a few years ago, I was impressed by the La Page system of growing trees on trellises, in which the trees are set as yearling slips at a 45-degree angle. Branches are developed outward and upward at a 90-degree angle with the main stem. Enough shoot growth is made in one season ,using the EM IX rootstock, to fill the trellis with fruiting wood. But when I tried this at East Lansing, Michigan, with our short season, it took three years to attain the same growth.

Some rootstocks, as the EM IX, induce blossoming a week to 10 days early in spring, with accompanying earlier fall harvest.This may be an advantage or a liability, depending on circumstances. Low-growing trees may lose an entire fruit crop from spring frost, while taller trees may safely carry fruit in their tops. Wind damage may be severe in more widely spaced trees, but almost absent in a close planting of dwarfed trees.

The efficiency of the scion variety is altered by the rootstock on which it is growing. Dr. Al Roberts at Oregon State University has shown you the concept of tree-unit efficiency. Some stock-scion combinations produce more wood in proportion to fruit than do others, while some produce more fruit in proportion to wood. Golden Delicious and Rome have generally high tree-unit efficiency, but Golden Delicious has proved especially efficient on EM I and EM VI at Corvallis. Not one rootstock can be used universally — each has its favorite consorting variety for efficiency of production and performance. Trees on seedling roots are generally less efficient.

As a general rule, trees on the dwarfing rootstocks cannot be left to shift for themselves. They represent a refinement in horticulture, and they succeeded best in the hands of men who have the knack of growing good trees.

These, then are some of the problems we face. And the answers will come largely from the cut-and-try method which is often so disappointing, but also often so surprisingly satisfying. We are in an era of grower experimentation, and progress will depend upon meetings like this of the Plant Propagators' Society and meetings like those of the Northwest Dwarf Tree Association, where experiences of practical men are dove-tailed with the results of the scientist.

At all events, I am sure that the final results will show a degree of specificity that many of us may have failed to recognize. I feel sure that our answers will not be in broad, easy, generalities, but in the more narrow, more difficult, specifics of detail involving various combnations of rootstock, scion, and environment

How Do We Propagate Clonal Apple Rootstocks?

Now, how do we propagate the clonal apple rootstocks of our selection and for which we have demand? Each clone, just like each scion variety of fruit, has certain special characteristics which can be taken advantage of or which must be catered to. However, all of the common methods of propagation find a place, as propagation by hardwood cuttings, root cuttings, softwood cuttings, leaf-bud cuttings, mound layering, trench layering, nurse-root grafting, and double-working.

We should remember that the clonal rootstocks which we are discussing are characterized by their ability to regenerate roots. In fact, this ease of rooting carries over into the orchard, so that the stand of trees in a new orchard planting is proportionally much higher than with seedling roots. This is another good feature of clonal rootstocks. And so, we are beginning with material that is especially suited to propagation. The Malling-Merton rootstocks behave especially well in the nursery and are well liked by nurserymen.

Propagation By Hardwood Cuttings.

Hardwood cuttings are made from mature, dormant shoots. Of the three forms of cuttings (hardwood, root, and softwood), hardwood cuttings are the most readily procured and most easily handled. The land area occupied is less than for layering, and the attention required is less than for layering or for either softwood or root cuttings. Unfortunately, convenience and economy are offset by the fact that only a few of the desired rootstocks will produce roots readily from hardwood cuttings. However, these that will propagate by this method produce excellent rooted material very economically.

Next to the inherent nature of the plant material itself, the most important factors are friable soil, adequate moisture, and equable climate, and a relatively long growing season. In the United States, these conditions are generally better provided in the South and in the Pacific Northwest than in the North and Northeast.

Dormant, moderately vigorous shoots of the current season's growth (one-year-old wood) supply the material for hardwood cuttings. It is best to establish a row of a plantation especially for a supply of wood. In regions where winter cold is not severe, another source of material is the tops of budded, lining-out stock. The best tops are those which have made a vigorous growth in the nursery row and which have sent out vigorous lateral shoots. These laterals may be torn from the main stem and used as cuttings, and the main stem discarded. The tops should be cut at least 6 inches above the bud, and should be collected as late in the season as possible, yet before severe freezing weather has set in.

Perhaps the best source of wood is from stoolbeds which have been established for layering. When the bed has been harvested for rooted shoots in the fall of the year there will always be some shoots which are either sparsely rooted or not rooted at all. The bases of these shoots have probably been covered somewhat with soil so that the formation of root primordia has been induced. Cuttings of this type will root almost 100 percent. In fact, it is in this way that the hardwood cutting method is most useful for some of the Malling apple rootstocks; namely, as a supplement to layering.

Wood should be collected as late in the fall as possible, but before a severe freeze has occurred. Quince cuttings made from wood collected in November rooted 82.94 percent in one season, compared with only 2.74 percent for quince wood collected in March of the following year.

Cuttings should be stored for several weeks at temperatures of 60 to 70 degrees F., where they will form callus tissue over the base, and then be transferred to cool temperatures (32-35 degrees F.) to hold for spring planting. Many cuttings will initiate roots by spring. In fact, if the storage period is thought of as a period of root formation and if favorable conditions are provided, a good percentage of well-started cuttings will be secured by planting time. Even the apple, EM II, which does not root readily from hardwood cuttings, has given 100 percent rooting of basal cuttings when packed in damp sawdust at 38 to 40 degrees F. for three months.

In the spring, as early as possible, the cuttings are planted 2 or 3 inches apart in rows 18 inches apart, and placed so that the top will be about 2 inches above the soil level. Time of planting is important In mild sections, as in England or on the Pacific Coast of America, fall planting or mid-winter planting is ideal, the planting being done shortly after the cuttings are made.

If planting is done by hand, a good practice is to make a trench with one vertical side, against which the cuttings are placed. A little sharp sand or peat moss may then be thrown against the base of the cuttings and the soil drawn up over them. Excellent results have been secured by the use of peat moss in this way on soil which might otherwise have been too heavy for hardwood cuttings.

Propagation By Root Cuttings.

Propagation by root cuttings consists in planting small pieces of dormant roots upright in the soil; they then develop adventitious shoots from the upper end and roots from the lower end. This method is particularly useful where there is a shortage of plant material. Handling is not unlike that for hardwood cuttings, and the percentage of usable rooted shoots is high.

Roots should be selected which are about the size of a lead pencil — $\frac{1}{4}$ to $\frac{3}{8}$ inch in diameter — and cut into pieces 3 inches in length. Sections as short as 1 inch may be used, and even material slightly under $\frac{1}{4}$ inch diameter is useful.

The cuttings are bundled and buried until planting time in damp sand or peat moss in a nursery cellar or some similar location at a temperture of 36 to 38 degrees F., where they will not freeze. In the spring they are planted as early as possible, as with the hardwood cuttings, planting the root pieces firmly 2 to 3 inches apart in rows 18 inches apart. The procedure is essentially the same as with hardwood cuttings excepting that the root pieces are smaller and more delicate, and require a more intensive operation. Small beds or cold frames are good. Supplemental irrigation is useful. A 2 inch top dressing of peat moss, sand, sawdust, or light soil which does not bake and crust-over is almost a requirement so as to permit easy emergence of shoots, especially on heavy soils.

As an emergency measure, root cuttings have been made the last of February in the greenhouse, kept cool (60 degrees F.) for a week or 10 days, and then pushed at 70 degrees F. Nearly 100 percent rooting has been secured in this manner with root cuttings of apple EM I, II, IV, V, and IX. Other types could probably be rooted similarly.

The rooted plants were transplanted to the field in mid-May, and were large enough to be budded in August.

Propagation By Softwood Cuttings.

Softwood cuttings are made from immature or growing shoots with leaves attached. They are more difficult to handle than either hardwood cuttings or root cuttings. The introduction of intermittent mist propagation has greatly increased the usefulness of the method. Plants that are difficult to propagate by other means will usually respond to this method.

Wood is selected from vigorously growing plants, as from lining-out stock or stoolbeds. The wood must be just mature enough and stiff enough so it offers resistance to the thumb at the tip when the shoot is held in the fist and the tip bent by pressure from the thumb. This condition is usually reached in late June and early July.

All of the Malling rootstocks can be propagated in this way, although the same types which propagate most easily by mound-layering and from hardwood cuttings, also propagate most easily from softwood cuttings. Since nutrients are leached from the leaves by misting, small amount of nutrients can be supplied in the mist. Olives are propagated commercially very successfully under glass in California and in Italy by this method, and the apple rootstock A2 has been propagated similarly in Sweden. If plants are propagated in March in the greenhouse from potted mother plants brought inside in January and forced, the rooted plants may be transplanted to the field and budded the same season.

Propagation By Layering.

Layering consists of establishing a plantation of the desired rootstocks, and inducing new shoots to develop and root each season while still attached to the mother plant. The rooted shoots are cut from the mother plant each fall, and a new crop induced to arise each successive year.

There are two principal variations of layering used for the commercial production of clonal apple rootstocks, namely (a) mound layering, or stooling and (b) trench layering, or etiolation.

In *mound layering,* the mother plant is maintained as a closely cropped crown from which new shoots arise each year, as with gooseberry and currant bushes. The operation consists in cutting back a well-established and permanent "mother plant," or stool, during the dormant season to about soil level, so that in spring a number of shoots arise from the crown of the mother plant. By mounding with soil, these shoots are induced to form roots along 2 to 4 inches of their growth at the base. They are removed at the completion of the growing season and the entire process is repeated the next year. This method is especially well suited to the less vigorous clonal apple rootstocks, such as EM IX, and to those having a large number of growing points, as EM III, IV, V, VI, and VIII. It has also been used successfully for EM I, II, VII, X, XII, XIII, XVI, and MM 101, 104, 106, 109, and 111. There is no reason to believe that others of these types will not behave similarly.

A level site, in a sheltered location, well-drained, should be selected for the stoolblock. A friable loam soil of good fertility, which will not dry out, is important. The incorporation of peat moss into the stoolblock will improve the physical condition of the soil and assist in the mounding operation.

Well-rooted, No. 1 grade, lining-out stock is best for planting. The plants may be set upright 12 inches apart in rows 7 to 8 feet apart. It is a good plan to set the original plants in a shallow trench 2 inches below the ground level so as to help keep the crown low in the soil.

During the first growing season, the block should be cultivated and cared for so as to encourage vigorous growth and ensure a well-established mother plantation from which, in subsequent years, a good yield of rooted shoots may be cut.

Early the next spring, before growth has begun, the soil should be pulled away from the plants and the tops cut back to about an inch above the crown. Cutting at this height helps, again, to maintain the plants low in the soil so the mounding operation is more easily accomplished.

From the exposed crowns new shoots develop. When they have reached a height of 4 to 6 inches, soil is mounded up to and between them to half their height. When the shoots have reached 8 inches, more soil is again added, and the process repeated during the season once or twice more until the shoots are covered to a depth of 8 to 10 inches, or more.

Stoolblocks may be maintained in a profitable condition for a number of years. Thirty or forty years is not uncommon. They do require, however, the liberal use of fertilizer and of materials which will keep the soil friable and in good physical condition.

Diseases and insects are troublesome but controllable. Leafhoppers and aphids can get out of hand if not sprayed. Woolly aphid has been found on EM I, IV, VII, and I but less on EM II, XII, XIII. and XVI. This pest can be controlled with chlordane and aldrin. Crown gall has been troublesome at times on EM VII and IX, but has been controlled commercially by persistant rogueing of infested plants.

In the fall of the year the mounds are pulled down and the rooted shoots cut or torn from the mother plants. Some apple clones mature earlier than others. Harvesting should not be done until the leaves show a yellowish cast. Much rooting occurs late in the fall. EM I matures early followed by EM IV, VII, and XIII. EM XVI and, especially, EM XII, matures late, and may even, of necessity, in cold regions be left unharvested until the following spring.

Yield of rooted shoots varies per plant with the material. EM I, IV, VII, IX, and XIII apple rootstocks will produce more shoots than EM II and XII. MM 104, 106, 109, and 111 have rooted exceptionally well; namely, 16, 10, 20, and 19 shoots per plant respectively, averaging 85 to 100 percent rooting. Records in New York State show yields of 68,230 rooted shoots per acre for 20-year-old stoolblocks of EM IX; 45,070 of EM VII; 21,750 of EM II; 48,460 of EM I; and 47,500 of EM XIII.

Propagation by mound-layering is most successful in areas of equable climate, with neither extremes of winter cold nor summer heat and drought, and with either a minimum of two or three inches of rainfall during the summer months or with standby irrigation available.

In addition, the growing season must be sufficiently long to permit the shoots to root, as well as to provide an open period of weather adapted to harvesting the rooted shoots and carrying on the operations necessary to put the stoolblock into a good condition for winter. It is a common and disappointing experience to examine a stoolblock in late September or early October, and find very few roots formed on the shoots arising from the mother plant. It is then just as common, but a more satisfying experience, to examine the stoolblock two to four weeks later and find excellent rooting.

The place in America most similar to the above-mentioned climatic conditions is along the Pacific Coast, west of the Cascade Mountains, in northwestern United States and southwestern Canada — in Oregon, Washington, and British Columbia.

It would seem that these are the areas in which large commercial enterprises must eventually be developed to meet the demand for clonal dwarfing rootstocks.

Propagation by *trench layering* differs from propagation by mounding in that instead of the new shoots arising from the crown of the mother plant, they come from arms of the mother plant which have been laid in the row in a horizontal position. In addition, the plants are covered with an inch or so of light friable soil before bud break in early spring so as to prevent — for a time — light from reaching the young shoots. The method is especially useful for materials which do not root readily from cuttings, mounds, root cuttings, or hardwood cuttings.

It is noticeable that trench-layering is usually abandoned by nurserymen when sufficient planting stock is available to permit close planting and propagation by mounding. Extra labor is required for pinning the plants down. Perhaps more decisive, horizontal shoots or arms which develop from the mother plant become large, extensive, and lie close to the surface of the ground. They are thus poorly protected against winter cold and they are often caught by cultivating tools and ripped out, making great gaps in the block and causing considerable damage to the plantation.

Propagation By The Nurse-Root Method.

Another method of increasing rootstocks, especially those which are difficult to raise by hardwood cuttings, is by the use of nurse-roots. This method consists in grafting a dormant scion of the desired rootstock onto a short piece of some available root. The grafted combination is set deep to induce scion rooting, and the piece of root serves to sustain the scion until that is accomplished.

The grafts are handled as any other grafts, or like hardwood cuttings. At the end of the growing season, the grafts are dug, the seedling root is cut off, and the rooted scions are graded and stored for spring planting as lining-out stock. An improvement in the method is to tie a thin copper wire, such as used for nursery labels, tightly around the graft at the union. As the grafts grows, the wire tends to girdle the root-piece and promote scion rooting. Forty-one to seventy-six percent rooting of Malling apple rootstocks has been secured by this method. In about half the cases, the wire had cut off the nurse-root. With the others it was necessary to snip off the nurse-root.

The Trees In The Nursery.

The handling and performance of trees propagated as clonal rootstocks is essentially the same as for similar operations with seedling rootstocks. One difference is, however, in the height of budding. In the propagation of standard trees, the bud is placed about two inches above the collar of the rootstock. For clonal apple trees, the trend has been to place the buds an inch or two higher (three to four inches above the collar) so as to reduce the chances of scion rooting when the trees ar planted in the orchard. In fact, the bud may be placed six or seven inches above the collar or about four to five inches higher than usual for standard trees.

Some nurserymen regularly bud dwarfed apple trees as high as eight inches, so as to provide a stem-piece of rootstock which is twelve or more inches in length. This permits deep planting in the orchard and has been shown to give better anchorage for the first few years for trees that are inclined to lean. New roots arise from the stem-piece to provide better bracing. High budding can be used to advantage also with varieties of apple which are susceptible to collar rot. The Coxe's Orange Pippin apple is, for example, subject to this disease, whereas the following rootstocks are resistant, namely EM IX, VII, II, and XXV, and MM 104, 106, and 111. Coxe has been successfully budded on these rootstocks at a height of 12 inches above the ground line. The trees have been satisfactory in the nursery, and have performed well in the orchard.

Double-Working.

Double-working, as the name implies, involves more than a single union between two consorting parts. It has been used to produce a dwarfed tree by placing an intermediate stem-piece of dwarfing material between a rootstock and the scion, as with the so-called Clark Dwarf. It may be accomplished by making a double-graft during the dormant season, by combining budding and grafting, or by budding during two seasons.

In the case of double-grafting, a 3 to 3½-inch piece-root from a straight-root seedling is grafted with a 6-inch stem-piece of the material desired for the intermediate, as EM IX, VII, Clark Dwarf, A2, K41, and so on. Onto this, the scion variety is grafted, and the entire combination is handled as a hardwood cutting or as a bench graft.

If the procedure is by grafting and budding, a dormant graft is made in winter, composed of a 5-inch piece of dwarfing interstock, as Clark Dwarf or EM IX, whip-grafted onto either a seedling or a clonal rootstock. The graft is lined-out in the spring and budded with the desired scion variety.

If the method is to be by budding alone, the desired rootstock, material is lined-out in the nursery. This may be a seedling rootstock, as a French Crab or Delicious seedling, or it may be a clonal rootstock, as EM XVI. Budding is done as for standard trees, the bud of the dwarfing intermediate being placed about 2 inches above the ground line.

The next season, the top of the rootstock is cut off just above the bud, forcing the development of a shoot from the dwarfing intermediate material. This, in turn, is budded during the summer with the chosen scion variety at a height on the intermediate which will provide a 2 to 3 inch length of stem-piece in the finished tree.

The third season, the top of the intermediate is cut off so as to force the scion variety to develop as a strong budling. The tree is thus composed of a scion variety and a rootstock, between which is interposed, just above the crown, a 2 to 4-inch section of dwarfing stock.

Another double-working technique is double-shield budding. It consists of placing one bud-shield upon another so that they unite with the rootstock as well as each other, and so form a three-tier tree in one budding operation. The intermediate tier may be a dwarfing rootstock so that a dwarfed tree is formed by the introduction of the stem-piece of this material.

This operation is essentially the same as for shield budding. However, the T-shaped incision must be sufficiently large to accommodate the two buds, one upon the other. A small budless shield is cut from the plant material which is to supply the intermediate. It is prepared in such a way that a portion of the bark of the shield is removed from the top side, thus exposing the cambium on both the inner and the outer sides of the shield. The shield is slipped well down into the bottom of the T-shaped incision. Then a bud-shield of the chosen scion variety is cut from the budstick and inserted in the T-shaped incision in such a manner that it rests not upon the stock but upon the outer exposed cut section of the budless shield. With a good season and good technique, a double-worked tree will be formed which is approximately the same height as a single-budded tree — all in one season.

A modification of this technique was proposed by F. Nicolin of Germany, about 1953. The method has assumed the name, "Nicolieren," after its originator. A budless shield is taken from a stem of the interstock material as described in the paragraph above. However, care is taken to take a thin strip of bark from the outer face of the shield. This exposes an oval ring of cambium on the outer face of the shield. The budless shield is then slipped into the T-shaped incision. Then the shield-bud of the chosen scion variety is similarly slipped into the incision but on top of the prepared budless sheild. Here again, the budless shield unites with the stock as well as with the scion bud. The next year. a tree forms from the double-budding combination which consists of the rootstock, a short intermediate stem-piece, and the scion variety.

Summary and Conclusions.

1. The apple industry of America has reached the age in development where the refinement is desired which clonal rootstocks offer.

2. The clonal apple rootstocks which are available provide a range of control of orchard performance demanded by modern orcharding, including the need for early cropping, high acre-yields, economical spraying, pruning, harvesting and general management, and adaptation to specific local conditions.

3. The use of clonal rootstocks increases rather than de-

creases the competitive problems of orcharding just as the refinement of any operation demands a perfection of fit which a more gross operation does not require.

4. The clonal apple rootstocks under special consideration at this time are: EM I, II, IV, VII, IX, XIII, XVI, XXV, and 26; MM 104, 106, 109 and 111; and perhaps A2 and Robusta 5. Each has it's special characteristics, it's advantages and disadvantages, quite aside from various degrees of size control and fruiting yields.

5. Generalizations are dangerous. Each stock-scion combination must be considered as a special entity, and each must be considered also in relation to the soil, climate, management procedures, and general environment in which it is to be placed.

6. Clonal apple rootstocks may be propagated in a variety of ways, depending upon the facilities available, the environment, the nature of the particular rootstock, and the special needs for which the rootstock is being propagated. Double-working, involving the use of a dwarfing intermediate stem-piece is another method of developing size-controlled fruit trees, employing clonal material.

7. Clonal rootstocks are with us to stay, from which the industry will not turn back, but will move steadily towards even greater refinement and exactness in predictability and controlled orchard performance.

8. The Pacific Northwest is well suited to the propagation of both clonal fruit tree sootstocks and fruit trees on clonal roots, and is in a position, with proper leadership, certification, cooperation, and organization to play a most important role, if not to dominate, the production of clonal apple rootstocks in America.

MODERATOR MELOTT: Are there any questions for Dr. Tukey?

MR. ARNESON: I would like to ask what Dr. Tukey thinks of the future for Malling-Merton 109?

DR. TUKEY: Well, 109 is a large tree. It propagates well. It has a place. I wouldn't predict anymore than that at the moment. Our thinking is in terms of smaller trees, so I would not be too sure about MM 109. In some places ,yes I am sure; but we are looking for things smaller than 109.

MR. ARNESON: How about E.M. 25 and E.M. XVI?

DR. TUKEY: Well, XVI also makes a big tree. That is one of those old Spaeth rootstocks from Germany — very, very old; it is called E.M. XVI now. It is marvelous over on the Continent where they want a bigger tree that is well rooted. It is a good cropper. They like it pretty well in some areas. I think that it has a place; they talk of it as a standard full-grown tree, but I agree with you that XVI would get to be a pretty big tree, so I wouldn't think there would be too much demand for this as a dwarfing stock.

MODERATOR MELOTT: Dr. Mel Westwood of Oregon State University is going to talk on hardwood pear cutting propagation. I give you Dr. Westwood!

DR. MEL WESTWOOD: Before getting into my prepared talk, I would like to give a little background on the Old Home pear. In 1915 before Professor R. C. Riemer made his extensive exploration trips to China, Japan, and Korea to search for blight-resistant pear rootstock materials from those areas, where many species grow wild, he went to the eastern and mid-western United States in search of blight-resistant pears which could be used for frame stocks in the West to protect the main body of pear against that devastating disease. He found an amateur gardener at Farmingdale, Illinois, who had in his backyard a number of pear trees, among which were the Old Home pear and the Farmingdale pear. At that time, in 1915, Professor Riemer collected cuttings from this small planting of Mr. Benjamin Buckman and brought these cuttings of Old Home to Oregon where he grafted them to a seedling rootstock at the Medford Experiment Station. He tested this for blight and he had selected it because it had shown no blight in an area where most of this gentleman's trees were dying from fire blight. He found that it was a French type, very highly resistant to fire blight. It was a very vigorous grower as a trunk stock. It made very wide angle crotches, a very desirably-shaped tree on which one could topwork or scaffold-work the variety, such as Bartlett, and have a very productive tree in which the body stock was protected against fire blight. In 1921, with some reluctance, Mr. Buckman sent Professor Reimer the Farmingdale variety, and as far as we know some time shortly after that Mr. Buckman died and his heirs rooted out his little collection of trees. As far as we know, and someone may want to correct me on this, there was no other budwood of those two varieties taken by any research person, and ultimately then many people went to Professor Reimer at the Oregon Agricultural Experiment Station to get their supply of Old Home or Farmingdale budwood from which to make their blight-resistant body stocks. Subsequent to the time when both of these types were obtained, Professor Reimer made crosses of Old Home by Farmingdale and collected the seeds and found that from 90 to 97% of the seedlings of these crosses were also highly resistant to fire blight and, in general, compatible as seedlings with the major pear varieties that we were growing. So then there came along in the late forties in British Columbia, in the fifties in Washington, in the late fifties and early sixties in Oregon and now in California, a devastating new disease called pear decline. In a search for something which would give us a resistance or tolerance to the disease which was learned to be a rootstock-induced disorder, it was learned that Old Home trees, that is trees with Old Home trunks which had been planted many years ago for blight resistance, had in many cases rooted-off above the union so that the trees were double-rooted.

They had roots of Old Home and they had roots of the original seedling; where trees were well-rooted above the union there appeared to be a tolerance to this disorder, pear decline. The trees were healthy, where those — in many cases — on susceptible rootstocks, where no rooting of the Old Home had occurred, the trees were dying. That leads us then to the topic of how to get production of rooted cuttings or vegetative propagation of a rootstock which is highly resistant to pear decline and which also has other desirable characteristics.

PROPAGATION OF HARDWOOD PEAR CUTTINGS

M. N. WESTWOOD, *Oregon State University, Corvallis*
and
LYLE A. BROOKS, *Daybreak Nursery*
Forest Grove, Oregon

Old Home pear (*Pyrus communis*) has been used for about 40 years as a blight-resistant trunkstock and as a compatible interstock for quince. If the graft-union is placed below ground, the Old Home stem will root above the union. Such trees, with a predominance of Old Home scion roots, are resistant to pear decline disease, a disorder which causes tissue injury at the union when the rootstock is a susceptible type. Seedlings of domestic and imported French pear (*P. communis*) and those of *P. calleryana* are more or less resistant to decline. However, 10 to 20 percent of the seedlings will be susceptible and are thus unsatisfactory. Trees propagated on self-rooted Old Home or self-rooted varieties do not develop decline and are thus superior in that respect.

In 1958, Dr. H. T. Hartmann and Prof. C. J. Hansen at the University of California, Davis, reported that cuttings of Old Home rooted quite well if taken in November, the bases soaked 24 hours in 200 ppm indolebutyric acid (IBA), callused in moist peat for 4 weeks at 65° F., then planted immediately in the nursery. But, if after callusing, the cuttings were stored for 10 weeks at 40° F. before planting, only about 1/3 as many survived. Further work by Hartmann and co-workers indicated that late October was the best time to collect Old Home cuttings for rooting, and that 100 ppm IBA soak was better than 200 ppm.

Extensive tests have been made in Oregon during the past 4 seasons to determine the best methods for rooting hardwood pear cuttings under Oregon conditions.

In addition to work done with Old Home, one of us (Lyle Brooks has, for 8 years, rooted hardwood cuttings of Old Home x Farmingdale seedlings on a commercial basis. Such cuttings are much easier to root than Old Home, but in general, the same treatments can be used for both types. We have rooted Bartlett, Anjou, Bosc, and Seckel pear by the same methods, but generally only about 15 to 30 percent of them rooted At this time we do

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EXPERIMENTAL PROPAGATION OF OLD HOME PEAR AT O.S.U.

Type of Cuttings

The condition of the mother trees prior to taking the cuttings is important. The following factors were found to enhance rooting:

1. Use of non-fruiting mother trees.
2. Use of quince-rooted mother trees.
3. Ringing trunks or leaders of mother trees with a single knife cut in August.
4. Use of mature shoots of about 1/4 inch diameter in which terminal buds have set prior to the time cuttings are taken. (Very large cuttings root poorly.)
5. Use of horizontally-growing shoots in preference to upright ones.
6. Use of shoots devoid of flower buds.
7. Use of juvenile mother plants.

Time of Taking Cuttings

Cuttings can be taken any time from late October to November 15th in Oregon. Leaves may not have fallen, but they can be stripped off. Cuttings should be placed in cold storage at about 35° F. and kept moist until one gets time to treat them with IBA. The IBA treatment should not be delayed more than a week after the cuttings are taken from the field.

Treatment of Cuttings

1. Cut shoots into 6 to 8 inch lengths just before treating with IBA. Better results are obtained by sawing the cuttings rather than using pruning clippers. A small circular power saw works very well.
2. Soak the basal ends of cuttings for 24 hours in a 200 ppm IBA solution, made by dissolving 750 milligrams of IBA in a small amount of ethyl alcohol, then diluting it to one gallon with water.
3. After cuttings are removed from the IBA soak, place them in moist (not wet) peat or sphagnum moss and hold at 65°-70° F. for about 3 weeks. Do not allow roots to elongate during this callusing period.
4. When cuttings are well-callused and showing an occasional small root, either plant them directly in well-prepared nursery rows or rooting beds, or store them in moist peat or sphagnum at 35° - 37° F. until February or March and then plant them. We have rooted 65 to 85% of cuttings in the spring following this post-callusing storage.
5. Cuttings shoud be planted carefully so as not to injure the callused bases. Plant them with two buds above ground. Keep soil moist (but not wet).

General Comments

As noted later, one of the big problems in callusing or storage of cuttings is infection of the bases with mold. Once started, it spreads rapidly in the container. For that reason, it is best to place the cuttings in several containers rather than all in one large one.

Moisture loss from cuttings may reduce the percentage survival. We have found that dipping the cuttings in "Wilt-Purf" (polyvinyl chloride) just after the IBA dries, increases the survival rate.

A quick-dip of 5 seconds in high concentration IBA in 50% alcohol has not been as satisfactory as the 24-hour soak of 200 ppm. If a quick-dip is used, it should be at 2,000 ppm. Results were very poor in 1963 when we used a quick-dip of 1,000 ppm IBA. (See Table 1.)

Partial shading of the rooting beds until mid-summer may aid in survival of cuttings, but is not a necessity under the relatively cool summers in the Willamette Valley of Oregon.

As long as the cuttings are mature and about pencil size, it is unnecessary to girdle mother trees or use quince root although both practices increase rooting.

COMMERCIAL PROPAGATION OF OLD HOME X FARMINGDALE PEAR AT DAYBREAK NURSERY

First, let's say the Willamette Valley probably is a poor location for open field planting of hardwood cuttings because it is subject to a wide range of weather conditions during the months of February through May. Rainfall, changing soil conditions, and off-season heat waves can raise havoc with a well-planned planting venture. To be successful in rooting cuttings on a commercial basis, where a competitive price limit is involved, production costs show that it is necessary to obtain over a 50% stand of saleable plants. One should have 70%. Survival of Old Home x Farmingdale (OH x F), in the better years, has been around 65%, and down to 30% when weather conditions delayed planting until May.

Type of Cuttings

To obtain a high percentage of rooting, one must have an ample supply of cutting wood available. Medium-sized cuttings, around pencil size, are best. Large sizes (3/8" up), which are usually from vertical terminal growth, should be discarded. Small sizes, especially if from mature lateral side limbs, will grow quite well and should be used if large scale production is desired. These we grade as medium-small size, discarding all below 3/16" diameter.

Method of Rooting

Two distinctly different methods for rooting hardwood cuttings are being used. Either fall cuttings taken in late October, leaves stripped, and with a 24-hour soak using 100 or 200 ppm IBA, — or dormant cuttings taken in late January using the quick-dip, 5-second immersion, of 1,000 to 2,000 ppm (4 to 8 gm of IBA per gallon of 50% alcohol). All OH x F cuttings rooted to date have been with the quick-dip method. Old Home cuttings tried with quick-dip in Oregon, both in October and in January have resulted in only 10 to 15% survival of poorly-rooted plants. It is quite likely that OH x F, using the full 24-hour soak, could be rooted up to 90%. Such a test will be run this fall (1963). However, OH x F, being in a juvenile state, will develop spur thorns on the lower section of the limb, which is the most desirable for cuttings. Weaker-growing limbs will spur almost the entire length. Since leaves cannot be stripped, it would be necessary to pick them off one at a time. Thorn removal is a necessary procedure, and in doing so, one must not injure the two dormant buds on each side. This will result in wounding the cutting and allow slow dehydration during the 3 to 5-months storage necessary here in the Northwest, unless steps are taken to seal off the wound. Dipping the two top buds in "Wilt-Pruf" will seal off the top of the cutting along with the two buds that are normally exposed after planting.

Length of Cutting

Here again, one has to decide what is best for each variety. Old Home, which does not grow spur thorns, and produces new growth on the cuttings which has the tendency to grow out on 45° angle, should be cut to 8 to 10 inches long. This will allow space for the fruiting variety bud to be set below the top growth in the nursery row after transplanting. OH x F will produce upright top growth, and since spur thorns develop at each bud, we find it difficult to bud into the original cutting scion. We have gradually reduced the length of cutting to 5½ inches. This type of plant will allow budding into new top growth.

This short cutting will have less food storage and could result in a lower percentage of rooting. This we have been unable to determine, since, over a period of 8 years, our percentage of rooting has never twice been the same. Also, short cuttings usually produce only one bud shoot and could result in root development on only one side of the cutting, especially with hard-to-root varieties, such as Old Home. With OH x F this has not been too much of a problem. Losses from these one-sided cripples has not exceeded 5 to 7%. Longer cuttings, where 2 or 3 bud shoots develop, could eliminate this loss, but again the greater the number of shoots the sooner the cutting would develop water stress, unless weather conditions were favorable for early rooting.

COMMERCIAL ROOTING OF OLD HOME PEAR AT DAYBREAK NURSERY

Results of storage and rooting of Old Home hardwood cuttings (treated with IBA and callused at 70° F. in late October, 1962) are shown in Table 1.

Table 1 Rooting of Old Home pear cuttings on a commercial scale. (Cut in late October, treated with IBA, callused 3-4 weeks in November, stored over winter 34° to 38° F and planted March 13, 1963)

Kind of wood	Size[1]	IBA treatment	Number counted	Percent rooted
Mature	Medium	200 ppm-1 day	1900	78
Mature	Small	200 ppm-1 day	2350	55
Mature	Medium	1000 ppm-5 sec.	3300	15
Mature	Small	1000 ppm-5 sec.	960	10
Soft	Medium	200 ppm-1 day	1680	30
Soft	Small	200 ppm-1 day	3300	14
Soft	Small	1000 pmm-5 sec.	1950	3

[1]/Medium = pencil size (about ¼ inch diameter)
Small = smaller than ¼ but at least 3/16 inch diameter

No girdling of trees was done and no "Wilt Pruf" was used on this lot. Packing material used was sphagnum moss in the live state, direct from moss beds. After IBA treatment, cuttings were packed in crates, 2,000 per crate, standing in a vertical position with a layer of sphagnum under and over cuttings. Boxes were lined with polyethylene-coated paper. Post callusing storage temperature was from 34° to 38° F. Length of storage time was 3½ months.

Of the 7 different treatments (Table 1) only 2 gave good enough rooting to be of commercial value. Mature, medium-sized cuttings rooted very well (78%) when treated with 200 ppm IBA, 1-day soak. Mature, small-sized cuttings rooted fairly (55%) with the similar IBA soak. Soft-wood cuttings, with active terminals and cuttings treated with a quick-dip of 1,000 ppm IBA, did not root well.

Notes at Planting time

Very little mold showed on mature wood. Nursery side limbs, in some cases, were badly infected, resulting in some bundles of 100 cuttings being entirely discarded. Others were opened and infected cuttings discarded. All material had been sprayed with Bordeaux 8-8-100 previous to being cut from the trees.

Wilt Pruf has not been used on Old Home cuttings. It has been used on OH x F and various plum cuttings and found to be beneficial in reducing mold infection. Complete immersion is not advisable. Dip the basal ½" and the top portion to the ground planting level. Allow to dry before packing. Callus action will break the seal and it *could be* beneficial to re-dip the basal end before over-winter storage with as little light exposure as possible. This experiment should be tried. Care should be taken in handling to avoid bruising the callus.

MODERATOR MELOTT: Thank you, Dr. Westwood. Are there any questions?

MR. DAN SCHMIDT: Would it be advisable to plant the cuttings directly in the nursery row so that they could be budded the same year.

DR. MEL WESTWOOD: We do that in research work because we like to gain all the time that we can. It is quite successful in our plots where we pay attention to what needs to be done and we force them along. We allow at least two sprouts to grow, though, so that the root system will be symmetrical and grow on both sides of the base. Where we don't do that, and the root system isn't well-formed it should be transplanted one season to form an acceptable nursery tree for the trade. We use the dogleg trees and that sort of thing in research because we know that it does not make any difference in the ultimate performance of the tree in the orchard.

VOICE: If you only have a 30% stand, then what? You would have a pretty bare field.

DR. MEL WESTWOOD: That is correct. That would be one of the risks. If one worked his system out so he knew how thickly to plant to get a stand and if one could predict the weather, he could probably do it. I think perhaps a satisfactory method would be, as Lyle Brooks has done, to plant the cuttings close together — two or three inches apart — in rooting beds, cover them with sawdust, or mulch them with sawdust and furnish partial shade during the first part of the summer. Then, by giving the cuttings fertilizer through the season and irrigating frequently, a good growth is obtained. Then the rooted cuttings are transplanted to the nursery. If the roots need a little trimming to get a good root system you can do that in the transfer.

MR. FRANK SMITH: Is there any difference between saw-cutting in making the cuttings and cutting them with pruning shears?

DR. MEL WESTWOOD: Cutting with a saw does less tearing damage to the bases and usually results in a more symmetrical, more well-balanced root system than when pruning shears are used. This is, I think, true in every test where we have made the comparison. Perhaps Dr. Hartmann or some of the others might have had some other experience.

DR. H. T. HARTMANN: We did make such a comparison one year — cutting with a power band saw versus cutting with pruning shears. The rooting percentage was just the same, but the saw was much faster in preparing the cuttings so that is what we have used since then.

DR. C. J. ALLEY: When you are callusing the hardwood cuttings in boxes to develop the root primordia do you ever experience any development of mold in these boxes?

DR. MEL WESTWOOD: Yes, I think that this is perhaps one of the things that anyone going into hardwood cutting propagation will very soon realize — that molds are there all the time.

The whole business is inoculated with mold spores. We find that mature wood will go through this callusing period much better than the softer wood. Many times the low percentage rooting of softer hardwood cuttings is the result of heavy infection of molds in the storage room, either in the callusing room or in the storage following, if one has to over-winter them in storage. So that one should probably put only a few hundred cuttings per box so that if mold should get started — and it spreads very rapidly from bundle to bundle, then you won't lose so many.

DR. C. J. ALLEY: Do you ever use any treatments to prevent the mold from developing on the cuttings?

DR. MEL WESTWOOD: No, we have not.

DR. H. T. HARTMANN: Development of mold on the cuttings during the callusing period is certainly a problem in this method of hardwood cutting propagation. Ths hazard can be greatly reduced by keeping the medium the cuttings are stored in — we use peat moss — just barely damp, just wet enough to keep the cuttings from drying out. Excessive moisture will most likely cause mold problems.

DR. C. J. ALLEY: On the girdling of your large leaders to get a harder type wood, is this a single ring, or is it a double ring that you use?

DR. MEL WESTWOOD: We use a single cut with a sharp, thin-bladed knife. We remove no bark and make no treatment of the wound. It heals quite quickly. That is, it forms callus. The callus later develops and differentiates into the conducting tissue so that a single cut appears to be satisfactory in our work.

MR. DAVID A. LAWYER: I would like to ask if you ever tried or thought of using etiolation as a means of preparing more favorable wood?

DR. MEL WESTWOOD: Of course, layerage is generally a matter of etiolation followed by rooting. That is where one covers the bases of the stems with sawdust or soil or some other thing that excludes the light. Lyle Brooks has done some of this with cuttings. The Old Home pear does not seem to root readily as layers, but it does etiolate well. He had fairly good success by taking these etiolated cuttings off the layering bed and treating them with hormones, just as he would the cuttings. He had better success initially than he did with the hardwood cuttings. This was with a different timing than we have now found to be the best for the Old Home cuttings.

MR. DAN BANA: In connection with pear decline, I have often heard that Old Home pear is susceptible to measles. Would you elaborate on that.

DR. MEL WESTWOOD: Well, I am not a plant pathologist and I don't want to get too deep into this subject. Old Home pear itself does not develop any bark measles condition, but in many cases Old Home, somehow or another, has picked up this conditions, although it is latent and cannot be seen in the Old Home. When you graft Bartlett on top of infected Old Home then Measles show up in the Bartlett. This trouble causes poor growth, inadequate fruiting, etc. As I understand it, this is supposed to be a virus which the Old Home could carry and which affects the scion variety. Now we have propagated several hundred trees from what we call the parent tree — the original tree of Old Home from Medford which Frank Reimer made from the cuttings he got from Illinois. These rooted cuttings, having been top-worked to Bartlett, have never shown a measles condition. I don't know a single instance where one could say that it has. In some cases where Old Home has been on quince, either as a holding tree, in a scion block or budwood block, or whether they took their budwood from Old Home that had been on quince at one time or another, some of those trees of scion-rooted Old Home have developed the bark measles on the Bartlett tops.

MODERATOR MELOTT: To clarify this a little more, is it not true that this tree you referred to is known as "Talent Old Home"?

DR. MEL WESTWOOD: Yes, the Talent Agricultural Experiment Station, which is in a suburb of Medford, Oregon, is where the tree grew. It has now been moved to the new Station. It's quite a job to move a 46-year-old pear tree, but we moved it It is growing now for the third season after moving, at the new Handley Farm at Medford. But it is the so-called "Talent" sources of Old Home pear.

MR. BILL CURTIS: I was just wondering why not wrap these individual bundles of cuttings in polyethylene then you wouldn't have any trouble with infection problems in bundling them up. Is it impractical because its too much trouble?

DR. MEL WESTWOOD: It can be done. We have kept the moisture around our cuttings by putting them in polyethylene in our small-lot research work. It is up to the nurserymen to decide whether this sort of thing is practical.

MR. IVAN ARNERSON: Just one comment about Myro 29-C and Marianna 2624 hardwood cuttings. We have been putting about 1000 or 1500 cuttings in polyethylene with a little fine shingle tow. They callus very nicely. They have no mold. The moisture content is very good. It's perfect for that.

MODERATOR MELOTT: Our next speaker is affectionately known here in Oregon as just plain "Al." Dr. Roberts from Oregon State University, Professor of Horticulture, is going to talk to us on the subject, Propagation of Cherry Rootstocks. Dr. Roberts!

PROPAGATION OF CHERRY ROOTSTOCKS

A. N. Roberts, *Department of Horticulture*
Oregon State University
Corvallis, Oregon

Recent studies at Oregon State University show that rootstocks for cherries can be materially improved and refinements in tree adaptation gained by selecting superior genotypes of *Pruns avium, P. mahaleb,* or their hybrids, for propagating as seed lines or clones (1, 2). This approach to standardization of the nursery tree and further improvement in orchard tree performance is supported by research results (3, 4, 5), showing that differences in tree size and vigor, fruit production and soil adaptability can be achieved by such selection.

Seedlings of Mazzard and Mahaleb are still the principal rootstocks used for sweet and sour cherry varieties, respectively. Since both species require cross-pollination for production of fertile seed, their seedling progeny are quite heterogeneous. The extent of this variability is dependent on the genetic make-up of the two parents and the degree of isolation provided the seed orchard. Led by plant pathologists seeking virus-free rootstock materials, nurserymen have made great strides the past ten years establishing seed orchards for the production of virus-free, uniform seed lines. This seed is far superior to the old mixtures of pre-World War II days. Wholesale seedling producers in the Pacific Northwest are using such seed lines of Mazzard and Mahaleb almost exclusively.

If some of the specifically desired rootstock effects (tree size control, tree structure, early fruit bearing, soil adaptation, winter hardiness, and disease resistance) imparted by specific seedling selections are to be perpetuated without change and the nursery tree thus standardized, we must resort to clonal propagation. The propagation of clonal rootstocks of apple and plum trees has become well-established in recent years. Pear and walnut trees are also being extensively propagated in some areas on vegetatively-propagated rootstock materials. The use of named, clonal rootstocks is almost universal in England and Europe for not only fruit tree nursery stock but for many ornamentals. It is small wonder, therefore, that there is a growing interest in using named understocks for cherries and in methods for vegetatively propagating them. The use of root suckers of Stockton Morello cherry as a semi-dwarfing stocks for cherries on certain heavy, wet soils in California was probably the first instance of vegetative propagation of a cherry rootstock in this country.

There are various means to clonally propagate cherry rootstocks, some being more successful than others, depending on the species and variety in question. Layerage (mound, continuous and air), cuttage (root, hardwood or softwood stem), and nurse-root grafting of rootstock materials has been previously described (6). Systematic research and the experience of nurserymen have set forth the most successful techniques for propagating the clones deemed to have desirable characteristics.

Mahaleb Clones and *Hybrids*—(P.I. 163091, 193701, 194098 and certain Mazzard x Mahaleb hybrids now under test)

These Mahaleb clones have proved superior for Montmorency sour cherry in our tests at Oregon State University (2), and are worthy of trial. Tables 1 and 2 show the effects of these various stocks on tree size and early fruit production. California workers are interested in select Mahalebs for high-working to sweet cherry.

Propagation of Mahaleb by layerage or by hardwood cuttings has been almost a complete failure. The use of root cuttings has only limited possibilities. Research (7, 8, 9, 10) shows that softwood cuttings provide the most economically feasible means of increasing Mahaleb cherry and its hybrids on a large scale. Rooting such cuttings under mist is no longer difficult, but handling large numbers of such cuttings and achieving high transplant survival is a problem that must be solved before this procedure can be considered economically practical for nurserymen.

Table 1 Tree size and yield of Montmorency sour cherry on selected clones of *P mahaleb* rootstock and a clone of *P avium* or Mazzard cherry Lewis-Brown Horticultural Farm, Corvallis, Oregon, 1958-62

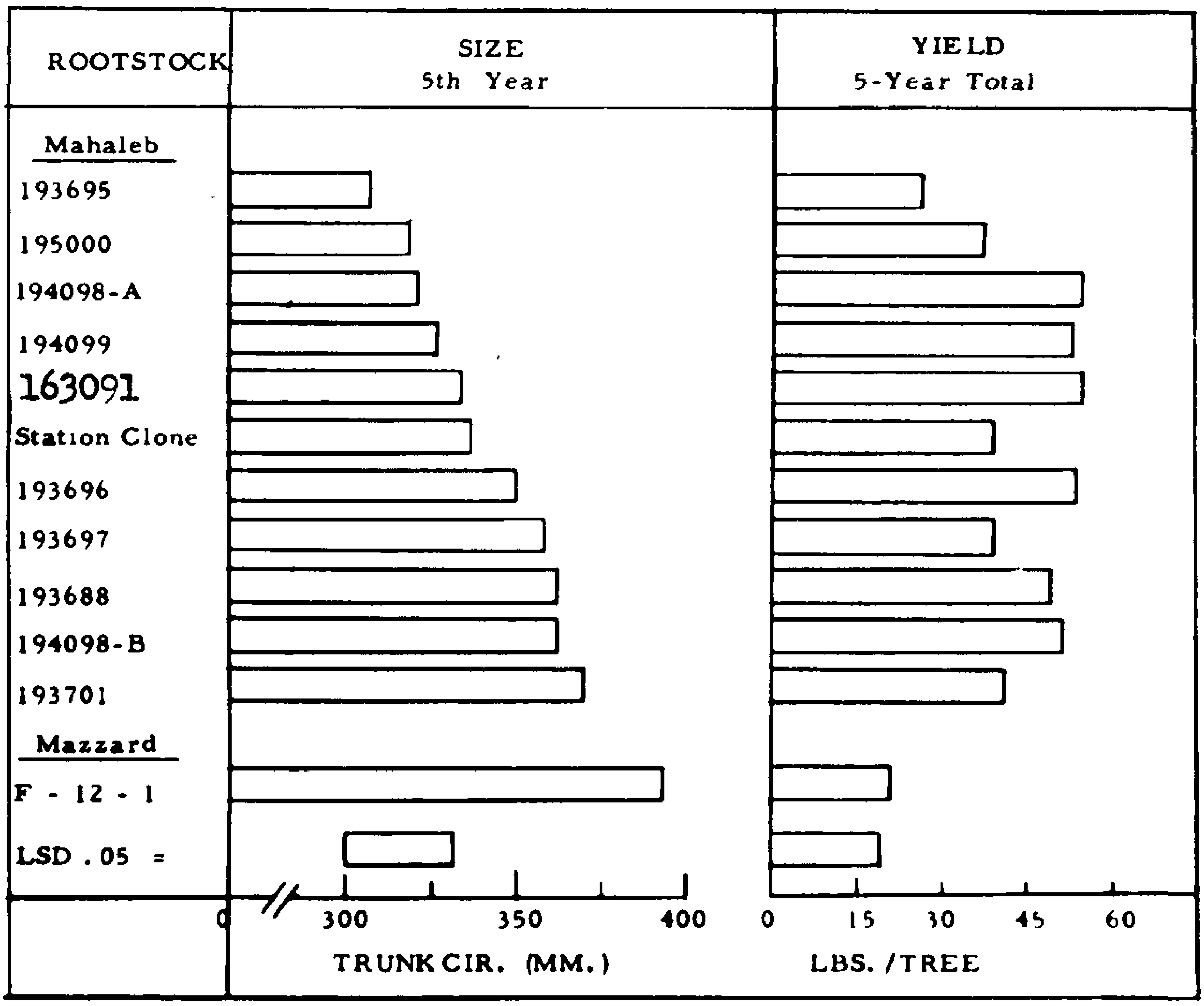
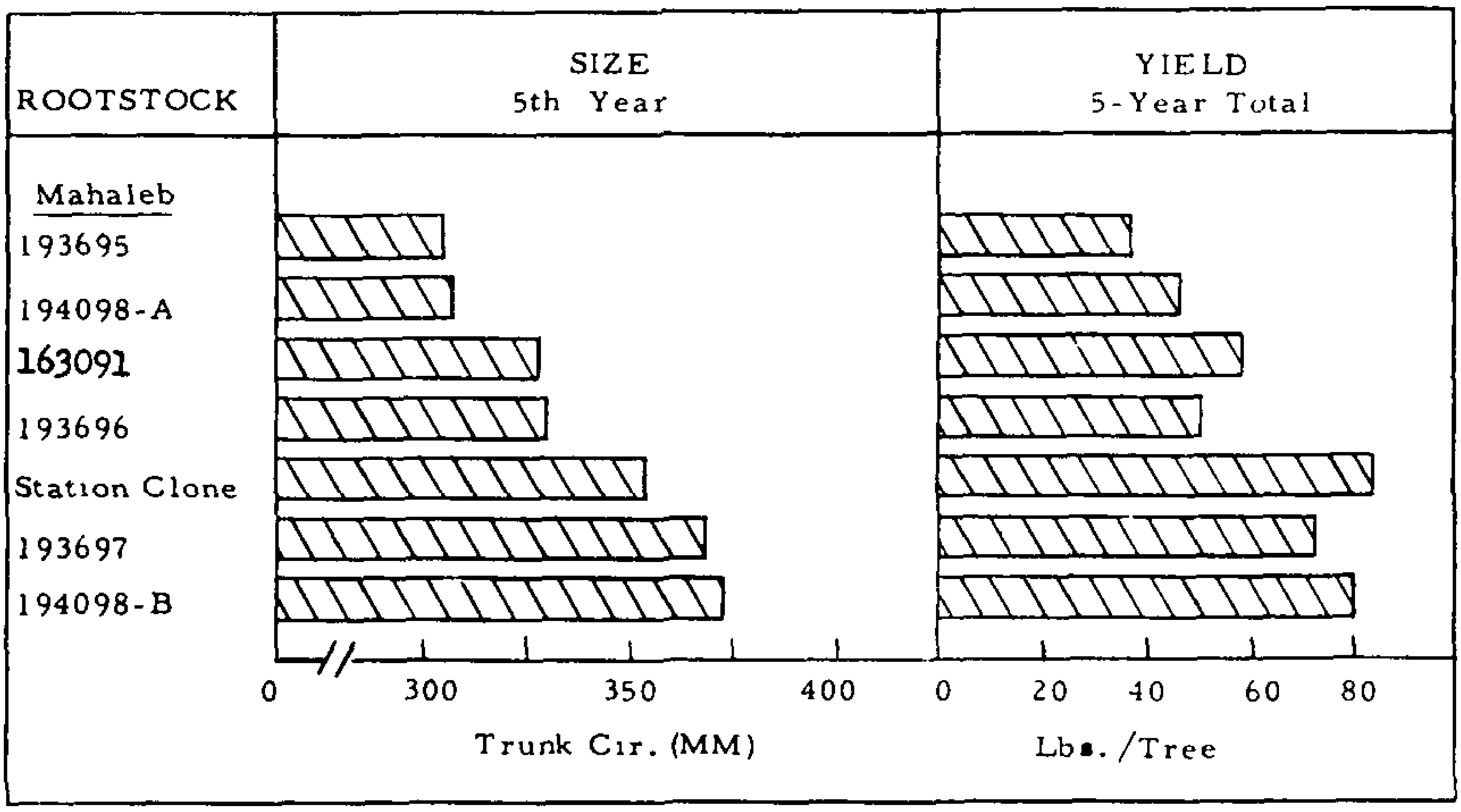


Table 2 Tree size and yield of Montmorency sour cherry on selected clones of *P mahaleb* rootstock Page Walton Orchard, Junction City, Oregon, 1958-62.



Sweet (7) rooted certain clones of Mahaleb in 15 days, 98 per cent rooting within 25 days. Graham (8), who has made the most exhaustive study of rooting Mahaleb, showed that terminal cuttings of current season's growth were most apt to root. He found 70 per cent of such cuttings rooted if they had an apical bud and were treated with Hormodin No. 2 powder. Cuttings without an apical bud did not root when treated with Hormodin No. 2 powder alone. However, 80 per cent of such cuttings rooted when treated with indolebutyric acid and adenine, with more and longer roots than those having an apical bud. Adenine, plus Hormodin No. 2 powder, was significantly better for succulent cuttings than was Hormodin No. 2 powder alone. As the tissue of cutting became more woody, the growth regulator alone increased rooting until no difference was apparent between cuttings treated with the growth regulator and cuttings treated with the growth regulator plus adenine. Hartmann (9) rooted leafy softwood cuttings of Mahaleb under mist in relatively high percentages (70-100) when terminal cuttings were taken in late spring and early summer from shoots in active growth and treated with indolebutyric acid (2000 ppm, concentrated-solution-dip treatment).

Mazzard Clones — (British F-12-1, German Huttnerschen and others under test)

British (11) and German (5) workers have selected several superior Mazzard types for rootstock purposes. Such uniform material is particularly desirable when top-working sweet cherry to gain gummosis-resistant trunks. Seedling variability is most pronounced when trunk and scaffolds, as well as the root, are seedling tissue in the "built-up" tree.

Mazzard clones have been propagated most readily by continuous layering. The vigorous Mazzard selection, F-12-1, from the East Malling Research Station in England is being propagated commercially by Oregon nurserymen using layers, and to a lesser extent, root cuttings. The superior vigor of this stock over that of common Mazzard seedlings is illustrated in Table 3. Cherry layering beds must be carefully tended. New shoots arising from the stools must be kept mounded as they elongate to sufficiently etiolate their bases for satisfactory rooting. The underground portion of the layering bed should be renewed frequently by laying down new shoots that have been left at time of harvesting the rooted layers.

Hardwood cuttings of Mazzard cherry are very difficult to root, and softwood cuttings are only slightly better. Hartmann (9) in comparing the rooting of Mazzard with that of Stockton Morello and Mahaleb found that cuttings of sweet cherry rooted with much more difficulty. However, Graham (8) found that *Prunus avium* (Mazzard) could be induced to root satisfactorily (70 per cent) if retreated with Hormodin No. 2 powder three weeks after initial treatment with the same material. All unrooted cuttings again retreated after the fifth week rooted by the end of the eighth week.

It appears that with proper management both Mazzard and Mahaleb can be successfully rooted from softwood cuttings and on a commercial scale. At the present time this cannot be said of hardwood cuttings.

Table 3 Comparison of tree size of sweet cherries* growing on common seedlings and a selected clone of Mazzard, Page Walton Orchard, Junction City (trunk circumference)

BLOCK	F-12-1 MAZZARD (MM)	MAZZARD SEEDLING (MM)
A	364	422
B	472	376
C	466	372
D	447	390
E	441	376
F	494	463
G	413	376
H	449	436
I	373	356
J	436	397
K	381	307
L	388	338
M	363	270
Average	422	275
Total Number Trees	40	39

* Composite of data for both Royal Ann and Black Republican trees

Morello Clones — (Principally Stockton Morello for dwarfing)

Now that virus-free sources of Stockton Morello cherry are available, there is considerable interest in propagating these as semi-dwarfing rootstocks for sweet cherry varieties in certain districts. The practice of taking root suckers from existing orchards is no longer considered advisable in light of the virus complication. California workers have demonstrated the feasibility of propagating this stock on a large scale from softwood cuttings. Hartmann and Brooks (9) rooted leafy softwood cuttings of Stockton Morello cherry in relatively high percentages (77-85) under mist sprays when terminal cuttings were taken in late spring and early summer from shoots in active growth and treated with indolebutyric acid (2000 ppm, concentrated-solution-dip treatment). Greenhouse mist beds gave satisfactory results early in the season (May), but out-of-door beds gave better rooting later in the season (June).

The specific benefits to be derived from vegetatively propagating certain select rootstocks of cherry justify the development of commercial procedures. Research has shown how they can be rooted in quantity. Both research and industry must solve the problem of large scale handling of such materials to assure greater survival of the rooted cuttings than has here-tofore been demonstrated.

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SATURDAY EVENING SESSION

October 5, 1963

This session convened at 8:00 P.M. with Moderator L. T. Blaney, presiding.

MODERATOR BLANEY: On the tour yesterday I noticed quite a lot of plastic houses. It brought back to my mind the fact that since the second World War we've really had quite a revolution in the technology and science of growing plants. We have plastic houses. We have growth-regulating chemicals. We have seen more and more the increased use of this marvelous thing which I, for years, have been interested in — the response of plants to photoperiod or length of day. We have this evening on the program several people who are going to talk about the use of plastics, these marvelous new products of the chemical laboratories. We also have a man who basically is going to be talking about the response of plants to photoperiod. We will start tonight by a talk from Mr. Ed Schultz on "Propagation in Plastic Houses", Ed!

PLANT PROPAGATION IN PLASTIC HOUSES

EDWARD W. SCHULTZ
Calorwash Nursery
Aurora, Oregon

The use of plastic houses for propagation by our nursery is a method of keeping the cost of production down.

Two houses have been in use for the last six years. The smaller one has an overall dimension of 10′ X 40′ and the larger one is 20′ X 40′. They were placed in a north-south direction in order to utilize the more direct rays of the sun in the early morning and late afternoon. This may be a superior position for October and March. It did not allow enough sunlight during the four winter months when heat and light are at a minimum in this area. Future houses will be built in an east-west direction.

A 20′ X 40′ plastic house using a concrete foundation and rafters has a material cost of less than $200. A 32″ rafter spacing was designed for future use of fiberglass sheets for a permanent roof. Experiments with fiberglass the past three years proved to be very successful for propagation. It would be more adaptable to summer propagation when regular plastic becomes brittle.

At the present time we delay covering our propagation houses until September. By installing 4 mil plastic at that time of the year it remains intact until about July of the following year. Sometimes a slight shading of the plastic is given by using a white, latex-base, paint which is thinned with water by as much as five parts water to one part paint. This is sprayed on the outside of the plastic with an insecticide sprayer. Later in the winter the rain removes most of this paint and the plastic is left relatively clear until warm spring weather warrants painting again.

Propagation beds are heated by electric cable. In one of the houses this was the only source of heat throughout the winter. In the larger plastic house a heater using fuel oil was set up to keep the air temperature higher during the rainy season.

In the plastic house without supplemental heat the propagation beds were kept at 70° F. and the air temperature varied according to the weather conditions. In general, the temperature remained around 60° F. during the rainy part of the winter. This is considered to be slightly lower than is desirable. During cold periods when the outside temperature fell below 25° F. frost often formed on the leaves of cuttings near the sides of the house. It did not appear to decrease the rooting percentage of most of the hardy nursery plants. It did delay the speed of rooting of cuttings.

In the plastic house with the additional heat, the temperature of the air was kept about 65° F. Since most of the heat rose to the top of the plastic house, an oscillating fan was used to keep the air circulating. This brings us to the major problem in plastic house propagation — adequate ventilation.

During the winter months our rainy and cloudy weather keeps humidity high both inside the house and out. Ventilation can be accomplished by the opening of the doors at each end.

Unlike a glasshouse that lets in a little air between the panes of glass, the plastic house is too airtight for optimum conditions for plants or cuttings. If it is too humid and airtight to grow a potted plant of any particular species, such as azaleas, one can be sure that cuttings of that species cannot root or even maintain a healthy condition for any period of time.

The pitch of the roof has a direct bearing on unfavorable damp conditions of the air and the cuttings. In a glasshouse, if the pitch is steep enough, water vapor forming on the underside of the blass will run off to the lowest point without dripping on the plants below. A plastic house will do the same on a still day. On a windy day the plastic has a whipping action that continually shakes moisture on the plants below. This constant cold mist is uncomfortable to people inside and probably has an adverse effect on rooting. Some varieties of plants defoliate under these conditions and others have a tendency to rot.

Air circulation by means of a fan inside the house is helpful in decreasing water condensation and its ultimate dropping. Upper vents or the use of double plastic could also help control this problem.

Although there have been reports of less plant "shock" when plants are moved from plastic houses to the outdoors, this does not seem to hold true for propagation material. Plants need an adjustment from one environment to another, the amount depending on the degree of change and the species of plant.

In summation, plastic houses can be as successful as glasshouses in propagation. Poor results in one or the other can generally be traced to improper attention to certain fundamentals of plant propagation.

Advantages of plastic can be listed as lower construction costs, construction by unskilled labor, less heat loss, less breakage repair and possibly a tax saving.

Disadvantages include necessity of careful ventilation, excessively high humidity, and yearly replacement of plastic.

The writer has had excellent results under glass, fiberglass, and plastics by following the proper basic plant propagation techniques.

MODERATOR BLANEY: Last night we promised you that we would have Bill Goddard talk about the propagation and growing of azaleas under artificial light. I see he has some very nice plants to show you down there. Frankly, I am very much interested in hearing what he has to say because this has been something that has interested me for quite some time. Any of you people who have attempted to grow or propagate deciduous azaleas and then grow them on from cuttings know what a problem it is. I think that all of you are looking forward to hearing Bill Goddard tell us his way of achieving the results he has on display right here before us in cans. Mr. Bill Goddard!

FORSTALLING DORMANCY AND INDUCING CONTINUOUS GROWTH OF AZALEA MOLLE WITH SUPPLEMENTARY LIGHT FOR WINTER PROPAGATION

WILLIAM GODDARD
Flora Vista Gardens
Victoria, B.C., Canada

The following is a resume of my experience in breaking dormancy and in winter propagation of *Azalea molle* with the aid of supplementary light which, until the past season, I have not been able to do under our climatic conditions.

Three hundred and sixty plants from June cuttings were used in this test. They were potted in 3-inch square plastic pots in August. The growing mixture by volume was 45% friable loam, 45% coarse nursery grade Canadian peat, and 10% coarse washed sand. From August to early October the potted plants were grown outdoors under heavy shade after which they were transferred to a heated plastic house. The minimum temperature was 45° F. Though air and soil were almost saturated with moisture, these conditions apparently had no ill effects on when plants are moved from plastic houses to the outdoors, this does not seem to hold true for propagation material. Plants need an adjustment from one environment to another, the amount depending on the degree of change and the species of plant.

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Similar August-potted plants, not subjected to the supplementary light treatment but in the same plastic greenhouse. remained in a dormant state until April, approximately.

From the foregoing, it is obvious that the winter propagation of *Azalea molle* is possible with the aid of supplementary illumination.

Although these results are based on a continuous light period, it is readily realized that other possibilities exist in which supplementary illumination might be reduced without adversely affecting the growth of stock plants.

On the basis of encouraging results in other trials it is my intention to explore further possibilities of winter propagation of both rhododendron and azalea seedlings with supplementary illumination.

Now, a further observation. From the forcing which has been done considerably in Europe of the *Azalea mollis,* I see no reason why we cannot use *A. mollis,* by proper timing, as you do other plants, to bring them in as a winter flowering pot plant and have something out of the ordinary from the regular clone. This season we have so far taken around 1300 cuttings to test under lights. We put the lights on immediately after the cuttings are flatted up and placed under the mist. Previously the lights were not used. For quite a while they were rooted under the mist but with no additional light. The growth at this time this year is superior to our last year's production. Evidently this was due to the additional illumination. The rooting was faster and heavier. I noted one fact that we didn't notice at first. On the side of the lighted bench were flats of rhododendron, Jock and Elizabeth. It was strange to see that the Jock and Elizabeth plants were leaning north towards the source of artificial illumination rather than to the light that was directly

[1]Manufactured by Sylvania Electric Products, Inc.

overhead. I thought that was quite strange. Further, they made much more growth and were almost twice the size of normal Jock plants, which we find makes at least one flush of growth during the winter. Instead of that, under lights they make two, and start to bud on the ends of the terminals of the second flush of growth. Further than this, we have this year given our Experimental Farm 200 plants which have been potted in 3″ square pots for the purpose of determining whether we need all this light and to find out the minimum light requirements of this deciduous group. This work is under the direction of Mr. Jack Crosley. Cuttings are being tried under at least I think, five or six photoperiods of various lengths We will know a lot more about it next spring. They have already been pinched back, by the way. The new growth on them is already ¾ inch to an inch long since the pinch. I don't know if any of you are familiar with the rhododendron, Robin Hood, which tends upon rooting to go into dormancy and sometimes will go through the summer without showing any growth whatever. So we put a few pots of this rhododendron under light and the response was instantaneous. We have also rooted for test under lights various species of azaleas. I'm quite interested to see how these will make out for fast propagation. However, the real intent of why I tried these lights was not for the intention of producing particularly a named clone to a faster or saleable plant. Rather I had the idea in mind of hybridizing some of our own named clones which are being introduced through the Dutch growers to see how fast I could push a generation through so that I could see the results of some of the breeding work in my life time and not in my son's. So I think, to a hybridizer, it offers tremendous possibilities for seeing some of their products, particularly of slow-growing rhododendrons that require such a long time to reach a flowering stage. The variety, Mrs. A. T. de la Mare, is one in mind. It certainly doesn't come up to size fast enough. In 1964 we will be having seed of our classes of azaleas which have been given different doses of irradiation for sowing under lights to see whether we have any mutations or differences occurring from possible alteration of the chromosomes.

MODERATOR BLANEY: Thank you, Mr. Goddard. Yesterday on the tour I didn't get a chance to see Jo Klupenger's place. I have seen it earlier. It was still under a stage of construction a year or so ago. I am just amazed every time I see the scope with which he is growing azaleas. I am sure we will all enjoy hearing and will benefit from what Joe has to say of his experience in growing azaleas under plastic. Joe Klupenger!

GROWING FORCING AZALEAS IN PLASTIC HOUSES

J. H. KLUPENGER
Klupenger's Nursery and Greenhouses
Aurora, Oregon

Eight or twelve years ago nurserymen and florists in different areas of the country developed the idea that a temporary construction could be built and covered with poly film and used in the spring and summer to finish some of the various crops such as azaleas, foliage plants, and many types of cut flowers. As time went on there has been many types of construction and various shapes of structures erected and used for growing under polyethylene.

Our first experience in the use of polyethylene was in 1953 for growing azaleas for the final year, or the final season of spring and summer, to bud them up for market. After having good results the first year, we continued the following year with more such structures for azaleas.

In building the first structure we checked to see which widths of polyethylene would be available in our area in four-mil thickness. We found the 20′ x 100′ in four-mil was most popular in wide sizes. We constructed our houses 24′ wide with about 5 to 5½ foot on the eaves. A twenty-foot roll would reach from the ridge to the ground on a side, or one-half of the house.

As time went by we decided to try other types of structures. We finally settled on a quonset-type construction, using ½ inch galvanized pipe, set on gutters similar to greenhouse gutters six feet above the ground to give head clearance and also cross ventilation.

Heating the houses was much easier to control with open houses joined together. Polyethylene film will construct a very air-tight house but will not protect plants from cold if they are not heated. With no heat in the houses and temperatures outdoors down to 32° F., a good breeze blowing and no frost, we would find frost inside the polyethylene houses; this is because there was no breeze inside of the poly houses to move the cold air.

We have run checks on outdoor temperatures against indoor with heaters; at 20° F. outdoors a 100,000 B.T.U. heater would maintain 34° F. inside the covered area of 3,200 square feet. For cooling, or to move the proper amount of air necessary to do a job of growing, it takes three 4′ fans, at ¾ horsepower each; this will move 60,000 cubic feet of air per minute.

Our poly houses are built in sections 100 feet long and 11 to 16½ feet wide. If air during warm weather is pulled a longer distance than 180 feet there will be 8 to 10° difference at the end of the house where the fans are installed than at the opposite end where the air enters the house. Without water cooling pads it will get quite warm at times, but with this amount of air movement, growing conditions have been very good. In growing azaleas under polyethylene using these conditions we find we can finish off a more compact plant with a much heavier body than we can under glass.

Saran cloth is used under the poly for shade in the summer months. When the weather warms up (late June and July) the poly film is removed, fans are turned off and the azaleas are then finished off in open air; the same conditions are under lath. About mid-or late-September new poly is placed on the roofs for the coming year; the saran remains under the poly which works two ways; first, it helps to support the polyethylene and second, eliminates part of the condensate drip in the winter months.

In growing azaleas under polyethylene through the months, we have to be careful not to get too much condensation; this will cause mold on the foliage, also foliage-drop, the same as on many other crops grown under poly. During the warmer days in the winter months we run the ventilation fans as much as possible for two purposes: to eliminate condensed moisture and to move fresh air over the azaleas, which is very important for growing conditions. Our method of heating is also done with fan-type heaters. whether it is gas or hot water heat — again for two reasons: to keep air moving over growing plants and to eliminate condensation.

We are quite certain other crops can be grown successfully under poly as under glass with as good, if not better, quality. Under present cost of growing, with a small mark-up, it is impossible to build enough glass-covered area, which many of us need today, to protect our crops at the price of glass per square foot. The reason for looking into fiber glass is to eliminate recovery every year, and the danger of tearing during storms, which can happen with polyethylene.

In the spring of the year, or in early summer, when we spread out our azaleas that are growing in containers, moving them from glass-covered areas to the poly houses — in a very short period of time they have a heavier, dark-green foliage and become stronger plants. Our explanation for this is that under glass you will get so much sun that the rays will burn; if you shade the glass too heavily to eliminate this condition, then you cut down the growth, which again requires high light. We eliminate shading under poly except for saran cloth; this gives us plenty of light and seems quite hot at times, but if the stock is well-watered you will not get any damage to the foliage.

Our feeding program is the same under poly as under glass. After azaleas are planted in containers or beds and well-established in early spring, we start feeding liquid food (25-10-10) at the rate of one pound per hundred gallons of water about every two weeks. In late spring and summer we feed 25-10-10, one pound to one hundred gallons of water, about every eight days or as weather conditions permit. If we have a lot of cloudy weather and the plants do not dry out, we will cut down or skip a week.

We feel that the stock should be watered occasionally with no added fertilizer so as to eliminate salt build-up. Salt problems can develop if the stock is not watered so the water will go on through the container or bench. We feel that many plants have been damaged or killed in the past in this area due to overwatering with liquid feed at times when we have overcast skies and cool weather. You will get a fertilizer build-up; then when the sun comes out and temperatures rise you will get a fertilizer release ,which will damage the roots, sometimes to the extent that it will kill the plant. The same problem will develop if you are feeding regularly in warm weather then let the plants get too dry following feedings. I will sum it up in this way: when growing plants, we can not be too careful in any one phase of growing a crop.

MR. BILL ROBINSON: I would like to ask Joe what form of nitrogen he uses.

MR. JOE KLUPENGER: We use quite a bit of mix per year. It runs into tons, so we have this special, 25-10-10 fertilizer; its ammonia nitrate, di-ammonium phosphate, and muriate of potash.

MR. BRUCE BRIGGS: In your original dry mix, are you using any nitrogen in it?

MR. JOE KLUPENGER: We have a dry formula that we use. but I can't give you the exact figures. I don't have them with me, but we do use blood meal, dolomitic lime, a small per cent of super phosphate and small per cent of potash, lesser potash than super phosphate. The per cent of bulk weight per hundred would be pretty near 45 for lime and blood meal and the difference — the balance — would be super phosphate and potash We use this formula for our basic soil mix or peat mix — peat with a little shavings. When we plant we mix this ahead of planting and we use it at the rate of about six or seven pounds per cubic yard. Now that sounds heavy, but nearly 50% of it is lime.

MR. BRUCE BRIGGS: Then, Joe — the other question is, did I understand you right that you were using a 25-10-10 liquid feeding program for your containers; is that right?

MR. JOE KLUPENGER: That is right.

MR. BRUCE BRIGGS: You also mentioned that near the end of summer you applied some iron. What form of iron do you apply so that you won't tie up your phosphate.

MR. JOE KLUPENGER: FTE 3-30, I believe it is, This is for azaleas — the chelated form. Of course, we use it very sparingly. We have used considerably larger amounts in the past. I believe that this year we were using it anywhere from

2 to 4 ounces per gallon in 100 gallons of water; so it is not very heavy.

MR. FRANK DOERFLER: Can somebody discuss methods of shading in fiberglass houses?

MR. JOE KLUPENGER: Frank, our thinking along this line is if you are going to use fiber glass you get high light intensity and it gets pretty hot. Now it costs a little more money to get set up and do it, but I think that you would find it would pay to put in air-conditioning fans. Check out the size you would need for the amount of air you would want to move. I'll give you this information: a four-foot, three-quarter H.P. fan will pull 20,000 cubic feet of free air per minute, so this will give you some idea of your area. We're using three, four-foot fans, with three-quarter H.P., 220 volt, motors on each bank of saran houses or poly houses; that would be moving 60,000 feet of free air per minute. Now what I mean by free air; if you're not restricting your air through filters with water, why you'll drop down about five per cent. We find that we don't have to shade. It is much better if you are using fiber glass or polyethylene to go into this little greater cost at the start. I think you'll wind up in the best shape at the end. Forget the shading. I think we'll find eventually we'll be doing more of that on glass because they are coming out now with what they call diffused glass. There is some greenhouse being built with this in Eugene, Oregon, right now. I know there is some already built in California, the same as they use in Europe, and I guess they are not shading that at all. It's clear glass, but it is diffused. It looks like water ripples on the glass. It is equivalent to double strength, and in many crops they're not using any shading at all. I think we should look at our air conditioning and try to get all the light we can and forget a lot of the paint, white-wash, and shading.

MR. RAY BURDEN: I would like to direct a question to Mr. Goddard. On your deciduous azaleas, do you find that some varieties root better than others or do you have equal success with all varieties you try?

MR. BILL GODDARD: No, they do not root at the same speed. Therefore, I would say to keep a given variety together in one flat and not mix half a flat of one and half a flat of another variety. I have found them all equally easy to root, but definitely some are faster than others.

MR. ED. WOOD: I would like to ask Mr. Goddard if he would give us a quick resume of his method of handling azaleas ready for sticking for propagating.

MR. BILL GODDARD: The average cutting is taken sometime during the month of June, depending upon the variety. The average cutting I would say, has a length of 3½ to 4 inches. It would contain then, approximately 6 leaves. The bottom leaves are, of course, removed. The cutting is merely cut straight across with an ordinary pair of secateurs, no knives or anything else is involved. We haven't used too much in the way of the various hormones, although we have used at times Chloromone, Seradix, Hormodin 2, and, I believe, Rootone; and frankly we have found them I believe, all of equal response; if anything, results are actually in favor of Chloromone. The percent of peat in the rooting medium runs about ten percent, which is an average medium grade. The balance would be at least 40-45% Styrofoam and the rest would be a quite coarse sand. We find that the azaleas and rhododendrons will root solidly across the flat whereby you can take hold of the plants and lift the flat. The medium, of course, is quite light being so high in Styrofoam which, being a plastic, is quite light in weight.

MR. BILL CURTIS: My understanding is that with deciduous types of azaleas that if you take out the tip bud that they will branch better. Do you take out the tip bud?

MR. BILL GODDARD: Yes, I believe that is a general practice but, of course, at the time of taking the cuttings, practically no buds are visible. They develop later in the propagation bench. We go over the cuttings at that time and remove them.

MR. BRUCE BRIGGS: Mr. Goddard, can you take long cuttings and cut them into pieces, or must you take all tip cuttings?

MR. BILL GODDARD: That brings us into seasonal variations. The length of growth at a given season is dependent upon temperature and precipitation. If you have sufficient shoot length of a sufficient firmness it will make one, two and possibly three cuttings. Three would be exceptional because that would denote quite high growth.

MR. BILL CURTIS: Should you cut back the plant from which you are going to take the cuttings, or does growing the plants under the light contribute something which makes the cuttings more easily rooted?

MR. BILL GODDARD: To that question, I think it would depend a lot upon the type of plant that was taken. If it was a nice, bushy plant with plenty of stems, I wouldn't cut it back; but if it was a somewhat straggly plant, yes, I would definitely cut back quite hard. I would cut back hard even the wood that was a quarter of an inch or more thick to induce heavy branching. I would then, of course, take cuttings from the first flush of growth. I believe after the secondary growth has arrived, you could take some more cuttings, but further than that I honestly believe that the constitution of the plant would not stand it. You would tend to get weaker cuttings.

MR. BILL CURTIS: I would like to have Dr. Clarke give us some information about his use of Clorox in propagation.

DR. HAROLD CLARKE: We have been making all of our cuttings into a tub of Clorox solution for seven or eight years. One of the reasons I like to use it, among others, is that we take a lot of cuttings from all small plants and at this time of year in our sandy soil they are well splashed with mud and sand. In a Clorox solution they do get washed clean and we think it has helped in the control of fungus infections. Now we use it at about 5% as it comes out of the bottle — a gallon bottle would make 20 gallons of the final solution. Clorox is 5.25% sodium hypochlorite, the same as Purex and several other of those cleaning solutions. I don't think it makes any difference which brand you use. We started using it because we were interested in something that would prevent rotting of cranberries and we tried this sodium hypochlorite dip. I got to thinking why not use it for cuttings. At one of the Science meetings an Extension man from Iowa said that all the chrysanthemum growers there were using Clorox dip. So we've been using it to our satisfaction.

We started in a number of years ago using straight peat for rooting rhododendrons. They all rooted very well. In our area peat is cheaper than sand. There's no reason to spend the extra money to make a mixture of peat and sand. We started out with a continuous mist before there was any intermittent mist apparatus. The continuous mist worked fine and we still use it. A lot has been said about the timing of the taking of cuttings. We have a very scientific approach to that one. We take all of our cuttings alphabetically. That sounds rather queer, but actually when you're talking about the timing of cuttings you have to consider the growing conditions. We're right down at the beach and right now everything is growing very lushly. To say that we should take the cuttings in August, September, or October, or on May 13th — it just doesn't make any particular sense, when we have practically continuous growing weather. I think that one should consider this matter of timing very much in that respect; so since with all our rhododendrons — we propagate as many as 300 varieties — it is a lot easier to take them alphabetically and then we plant them out in the plastic house alphabetically and from there out into the field. If you have 300 varieties and you have four or five fields where you have one-year, two-year, and three-year plants and someone comes in and wants a particular variety, it is awfully nice to not have to look over the whole field to find it. Go down the row alphabetically and it's there.

VOICE: How long do you leave the cuttings in the dilute Clorox solution?

DR. HAROLD CLARKE: Well, we make the cuttings on a table. We have a tub with the Clorox solution at the end. We shove them in there. If it's lunch time or coffee time, we leave them in. It doesn't make any difference. I think they're better off in the solution than out in the air. There is one other short cut that perhaps I might mention and that is in making the cuttings. We do it all with sharp pruning shears. In making the cutting we cut right back to the node or just beyond it so that there won't be a stub left there. We take the cutting, the leafy part, in the left hand and the shears in the right hand and whack them off, straight across, and then almost in the same motion we turn the shear just a little bit and give it a scrape that way. A wound is made with the shear in almost one operation.

MR. MIKE ZELASKI: Does anyone know about the use of CO_2 enrichment in greenhouses?

MR. JOE KLUPENGER: That's been experimented in the pot plant departments up in Seattle and I think a couple of places in the Portland area. We can vent heaters most of time through the winter when it's necessary and get all the CO_2 we need without applying it to the greenhouse. The cost was running quite high for the noticeable difference in the plants. There's been more work done at Seattle on it than there has at Portland, but I think it's dying on the vine at the present time — in this area.

I was going to answer one question here that Mr. Goddard brought up awhile ago in reference to the different types of media used for propagation of rhododendron cuttings. Some use 25% peat, some 50%, and some 75%. Dr. Clarke says peat moss is cheaper over where he is than sand. Mr. Goddard here says that he gets good results with sand and only a small per cent of peat. That has been proven around this area by the commercial growers for quite some time. We're all propagating twice or three times as many cuttings in a given area than we should. We chop the leaves off, cut them short, and put them as close together in the benches as we can. If you put them too close together in the bench with straight sand, or with very little peat, when you remove them after they're rooted in the benches, you have to take a knife and cut them apart. The sand is quite heavy and in many cases, on many varieties, you lose the entire root system in removing them from the bench. I believe, among the commercial growers, that is basically why — where we have both peat moss and good sand in this area — we use proportions of around 30 to 50 to 60% peat in the rooting mixture.

SUNDAY MORNING SESSION

October 6, 1963

This session convened at 8:30 A. M. with Moderator Joe Klupenger, presiding.

MODERATOR JOE KLUPENGER: I would like this morning to introduce one of the growers from this area of conifers and other nursery stock. He is one of the most progressive in the use of Plantainers and is doing a lot of experimental work on growing mediums. At this time, I would like to introduce Mr. Don Nuffer of Mt. View Nurseries.

MR. DON NUFFER: Thank you, Joe. I brought a few items with me. That is peat moss in the raw state. It came directly from one of the bogs up in Canada. We found that in getting our supply of peat moss it was advisable to go and see what we were getting. This is actually what our peat moss comes from. You'll note that in it there is very little wood or other material. This sample is perlite. It is in the raw state also. It is a rock. It has in it a good deal of moisture captured right in the molecules — in its molecular structure. When you heat it, it pops like popcorn and becomes extremely light. Now for my talk:

PEAT-PERLITE MIXTURES IN CONTAINER GROWING

DON NUFFER
Mountain View Nurseries, Inc.
Aurora, Oregon

The mixture by volume consists of 50% sphagnum peat moss, 50% horticultural perlite, and a basic fertilizer mix.

Let us first list the advantage of this type of mix:

1. Good drainage: In an area of heavy winter rainfall, this is particularly important. It also provides a safeguard against overwatering, both of which brings on fungus problems.
2. Lightweight: This feature provides ease of handling of material and economizes in the shipping of the finished product to the customer.
3. Weed free: The fact that the material is for the most part free of weeds in its natural state eliminates (at least for most crops) the need for fumigation.
4. Stimulates a fibrous root system.
5. Materials relatively inert and chemically uniform. This is a desirable quality which enables one to use standard fertilizer formulae for all batches of mix.
6. Mix does not pull away from the sides of the container when dry.

7. It is adaptable to a wide range of plant material.

Next let's look at some of its problems:

1. Containers tip over easily.
2. Seems to require more water: This may be due in part to the vigorous growth the plant is making.
3. In the Portland area the supply of graded material is not constant.
4. Difficult to get wet.
5. Cost is high: 35c per cu. ft. as compared to 25c for sand-peat mix and 26c for sand-bark, and 5c for bark alone.

Cultural Practices

1. The mixture is mixed in a batch mixer capable of handling two yards at one time. It is mixed dry for three minutes and then the water is added and mixed for three more minutes.
2. From the mixer it goes to the canning machine. Being light and free from sand it causes little wear on the canner parts.
3. The plants are placed in the field where they are watered along with the other plants in the field.
4. Irrigation is all done by Rainbird #30 sprinklers with 3/32″ and 5/32″ nozzles at 40-60 foot spacings. We have tried other nozzles and spacings, but find these give the most even coverage.
5. Fertilizer is injected in all irrigation water. We also incorporate fungicides and insecticides in the irrigation water as needed. The amount of fertilizer to be used is determined by soil samples sent monthly to the Soil and Plant Laboratory, Inc., Orange, California.

Conclusions

We feel the peat-perlite mixture is a very satisfactory growing medium, but that it has some limitations and that the original cost, while not excessive by the can, becomes quite an investment when carried over a period of two or three years..

MODERATOR JOE KLUPENGER: Thank you, Don. A very interesting talk on mediums. Our next speaker on Soil Mixtures and Fertilizers is a man in our local area that has been progressing forward very fast and is doing a wonderful job of growing; he needs very little introduction. I think he is pretty well acquainted around here so we will now introduce to you Floyd Rigby of Rigby's Nursery!

GROUND BARK AS A GROWING MEDIUM FOR CONTAINER NURSERY STOCK

F. A. RIGBY
Rigby's Nursery
Portland, Oregon

Our first experiments with growing in ground bark were started in the spring of 1954. These experiments were motivated by our search for a material that was economical and light in weight, could be easily handled, and was readily available and still would have good appearance when used as a growing medium. The first year we planted 200 *Azalea mollis* in three different lightweight media: fresh sawdust, aged sawdust, and ground bark. The plants grown in fresh sawdust showed a marked deficiency of nitrogen under the culture they received. There was very little difference in the growth of the plants grown in aged sawdust and ground bark. Aged sawdust was eliminated, however, as being not too readily available. Since 1955 we have planted in ground bark and have grown a variety of plants including pine, fir, rhododendrons, azaleas, pieris and heather.

We have used both Douglas fir bark and hemlock bark and have found little difference between them as far as growth is concerned. Hemlock bark breaks down somewhat faster than fir bark which is a disadvantage when plants are to be left in the container for periods greater than one growing season. We use fir bark exclusively for this reason.

Even though we began using bark because of its low cost and light weight, we soon found that bark has other properties that are far more important and that the use of bark would substantially reduce our production costs. Bark is an organic substance that contains appreciable amounts of plant food, enough in fact that nutrients that are not supplied by the bark can be inexpensively added in solution through the water system. Also, if the bark is not ground too fine, the larger particles will hold up indefinitely and a perfectly drained medium is always available. The bark should be passed through a 3/8 inch mesh screen. It can then be used without fertilizer additives and without the addition of sand or other materials usually used to promote drainage. This, of course, eliminates the costly labor of mixing before planting.

Think a moment of what this means to us in dollars and cents. The University of Georgia Agriculture Experiment Station, in a recent study of the cost of producing container nursery stock, found that peat moss and sand mixtures average 3.5 cents per gallon container when all costs, including the cost of mixing, are considered. Compare this with 0.4 of a cent for bark, a material that will give comparable results. Peat moss and sand mixtures cost $35.00 for the material for 1000 gallon containers. The same amount of Douglas fir bark costs only four dollars.

Let us take a look at the nutrients in ground bark as it is delivered from the mill. Each load is tested before it is used, even though there is never much variation. Tests are made with the Simplex soil test kit and the test results are computed to pounds of nutrient in 1000 square feet of bark six inches deep. This measure is convenient for computing fertilizer requirements. As our containers are about six inches deep, this is the amount of nutrient for 1000 square feet of growing area.

Fresh bark does not contain much nitrogen. There is a trace of nitrogen in the nitrate form and usually about one pound per 1000 square feet in the form of ammonium. We carry five pounds of total nitrogen for each 1000 square feet of growing area and easily add the additional four pounds through the sprinkler system. Low-biuret urea and diammonium phosphate are used principally as nitrogen sources.

Bark contains about one-half pound of available phosphorus, which is about one-fourth of our continuous level. However, bark contains a reserve of phosphorus that slowly becomes available as the bark is weathered. A continuous level of two pounds to 1000 square feet of growing area is maintained by the addition of diammonium phosphate as required.

Bark is well supplied with potash. A typical load will contain the equivalent of three pounds per 1000 square feet which is our desired level. In addition, more potash becomes available as the bark breaks down and the plants are usually supplied with an adequate amount of potash for the first year. Potassium chloride is used when the additions of potash become necessary.

In addition to the three basic nutrients, bark contains appreciable amounts of iron and magnesium.

Bark is quite acid in reaction. The initial pH averages about 5.0. No correction of pH is made for rhododendrons and other acid-loving plants, but pH is raised for the conifers to about 6.5 by the use of calcium nitrate as a nitrogen source. Calcium nitrate used periodically with our slightly alkaline water will hold the pH at the desired level.

Overhead sprinklers are used for irrigation. Sprinklers are placed twenty-five feet apart so that the water from each sprinkler overlaps those adjacent to it. Half-round sprinklers are used around the perimeter. This arrangement gives a fairly even distribution of water which is essential when fertilizer is applied through the water. Each block of sprinklers covers an area of approximately 15,000 square feet. Water is given according to the needs of the plants, the main consideration being that the plants never become dry. However, if any water at all is given, then enough is applied so that some water drains from the bottom of the container. This is a precaution against the build-up of soluble salts in the container.

Fertilizer is injected into the water system with a GEWA fertilizer injector. The fertilizer is dissolved in an oil drum to which a ¼ h.p. pump is connected. The device makes fertilizer mixing an easy chore. The drum is filled about half full of water, the pump started, and the required amount of fertilizer added. After a few minutes the mixture is ready to be pumped to the injector.

We test for nutrients and fertilize once a week throughout the growing season. A sample from each irrigation plot is obtained with a soil sampling tube so that the sample is representative of the full depth of the container. Samples are taken from several containers in the plot and thoroughly mixed so as to obtain an average sample. The results of the test determines the amount of fertilizer to be added to the irrigation water. Our standard nutrient level in the containers is five pounds of nitrogen, two pounds of phosphorous and three pounds of potash for each 1000 square feet of growing area. These levels are maintained in the conifer plots from early spring until frost. The fertilizing of our rhododendron plots are discussed below. This system of testing and fertilizing is simple and puts the feeding of our plants on a scientific basis. The difference between the test results and the standard nutrient level is injected into the water during the next irrigation. Fertilizer is injected at the rate of two or three pounds of fertilizer to 100 gallons of water. Higher rates of injection are perhaps possible but, from experience, these levels will not cause leaf burn from too strong a concentration of fertilizer.

A somewhat higher level of phosphorous and a lower level of nitrogen is held in the rhododendron plots. Phosphorous is held at three pounds, nitrogen at four pounds, and potash at three pounds. These levels are maintained through the first part of the growing season but as soon as the terminal bud begins to form, the nitrogen and potash are reduced to one pound each. We have enjoyed excellent color and bud set with these conditions.

The use of bark has some disadvantages. More of an annoyance than a disadvantage are the many small, sharp slivers that make the wearing of gloves necessary while the plants are being potted. Hemlock bark does not contain these slivers but, as I mentioned before, hemlock bark is not suitable for long-term growing.

Bark is hard to wet initially. For the first few weeks after planting, the plants must be watched very closely to prevent drying out. After the bark is thoroughly saturated, however, it has very good water-holding properties.

Newly-planted material will require additional nitrogen fertilizer for the first few months. When possible, we place all newly-planted material under a separate sprinkler system to facilitate giving the required nitrogen. When it is necessary to intersperse newly-planted material with older material, we top-dress the containers with a teaspoonful of an organic nitrogen fertilizer, such as blood meal.

To summarize:

Douglas fir bark is of low cost and light weight.

Bark contains appreciable amounts of plant nutrients.

When properly screened, ground bark can be used without sand or other material. usually used to improve drainage.

With proper water and fertilizing practices, bark is an excellent material for producing good quality container nursery stock at substantial savings.

MODERATOR JOE KLUPENGER: Thank you, Floyd, for a very interesting talk on a growing medium using bark dust. Our next speaker on soil mixtures, is one that needs no introduction here this morning either. He has come along from many years back in pioneering a lot of container-grown material in this area, as well as gadgets and gimmicks to increase production, and now studies with different types of soil mixtures. He is Dan Schmidt with Schmidt Brothers Nursery. Dan!

SOIL MIXTURES

DAN SCHMIDT

Schmidt Bros. Nursery

MIX — To unite or blend into one mass.

MIXTURE — Compound formed by mixing.

SOIL MIXTURE — Several ingredients mixed together.

Soil mixtures for containers should have four important qualities:

1. SUPPORT
2. MOISTURE
3. AERATION
4. FERTILITY

1. SUPPORT — Firm enough mix to hold up the plant.
2. MOISTURE — Soil mix should have ability to hold moisture between irrigations . . . it also should have good drainage.
3. AERATION — Soil mix should be porous enough to let the gases in and out of the soil. If the soil mix is too fine, water will fill up these pores and will reduce aeration.
4. FERTILITY — Mineral nutrients: Most green plants are known to require at least twelve chemical elements:

1. Nitrogen	5. Magnesium	9. Manganese
2. Phosphorous	6. Sulphur	10. Copper
3. Potassium	7. Iron	11. Boron
4. Calcium	8. Zinc	12. Molybdenum

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The first three major elements are not enough. Plants also require the last nine minor elements to get satisfactory growth. If you lack anyone, the plants have trouble. Fertile soil contains all of these elements.

SOIL - MIX INGREDIENTS:

Peat moss
Sand
Medium loam soil

It is almost impossible to have just one soil mix for every kind of plant and purpose. Greenhouse plants require one type mix . . . outside containers, another.

GREENHOUSE — Seed growing and potting compost:

40% leaf mold or medium loam
40% peat moss
20% sand, medium
8 lbs. dolomite lime per cubic yard.
5 lbs. organic fertilizer mix with all 12 elements.

This mixture can be used for anything we grow in ornamental shrubs, conifers and broadleaves, except daphnes.

Daphne mixtures would be:

40% leaf mold
40%medium loam and 20% sand
or 70% medium loam, 30% sand
8 lbs. dolomite lime and 5 lbs. organic fertilizer

This mix can be used in the greenhouse and also in containers outside.

OUTSIDE container mix: (per cubic yard of mix)

40% medium loam
40% peat moss
20% medium sand
3 lbs. single superphosphate
1 lb. muriate of potash
5 lbs. calcium carbonate lime
5 lbs. dolomite lime

I consider these mixes to be the best in our experience of container growing. Other mixtures can be used; other growers have had good success with such as:

U.C. SOIL MIXES:

	Sand	Peat moss
A	100%	0
B	75%	25%
C	50%	50%
D	25%	75%
E	0	100%

#B is considered to be the best all-around mix . . . 75% sand and 25% peat moss.

USING SAWDUST or BARKDUST:

B	75% Sand	25% Sawdust
C	50% "	50% "
D	25% "	75% "
E	0 "	100% "

USING COMPOST:

A	75% topsoil	25% leafmold	
B	50% "	25% "	and 25% manure
C	50% "	50% "	
D	0 "	100% "	

Item B, I would consider very good, but more expensive and old-fashioned, also the leafmold and manure are in pretty short supply. Ten years ago we used this mixture and had very good results.

I consider about two soil mixes to be sufficient in raising a wide variety of plants. There are quite a few disadvantages in having 3 . . . to say . . . 8 or 10 different mixes:

1. Added labor cost
2. Takes too much space
3. More expensive
4. *More complicated as to feeding*

In conclusion, I would suggest you use the materials most readily available in your locality that are moderately priced and work out a formula with a soil chemist or a plant laboratory. Remember most of all, whether you are growing plants chemically or organically, you should think about the customer purchasing the plant material which has been grown in your particular soil mix. What is it going to look like in 2 weeks or a month after delivery? Nice and healthy or yellow, pale and sick looking? The remedy . . . if the plant material is chemically grown; before it leaves your nursery, feed one to two teaspoons per can of a complete mix of the 12 chemical elements for a good healthy looking plant.

If the mix in the container was organic, this is not necessary; because of the mix, the chemical elements are slower-releasing and will last longer in feeding the plant. How much of this is being done? Very little. I have seen plants grown in containers which look very healthy and vigorous at the wholesale nursery but a month later, in the retail nursery, look sick and pale. Let's remedy this situation and keep the customer coming back . . . that's what keeps us in business and makes us a success.

MODERATOR JOE KLUPENGER: Our next speaker is one from the Western Washington Experiment Station at Puyallup. He is known throughout Washington. He is a man that has been doing a lot of work in past years and is here to bring us forward with good information. He is going to speak today about how to put buds on rhododendrons; here is no one other than Art Myhre!

INCREASING BLOOM PRODUCTION IN RHODODENDRONS BY FERTILIZING PRACTICES

ARTHUR S. MYHRE
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A fertilization practice that will initiate good flower bud formation on young rhododendron plants is a need expressed by commercial growers and home gardeners alike in western Washington.

A review of American and English rhododendron publications reveals much information on general cultural practices but very little specific information on fertilizing rhododendrons that could serve as guides for this region. Since grower practices and experiences in fertilizing this crop vary widely, information from this source is not always reliable. Therefore, a research study to determine the fertility requirements for rhododendrons when grown under field conditions as measured by plant growth, flower bud formation, and chemical composition of the plant was initiated at the Western Washington Experiment Station in 1957.

1958 Plots

Rooted cuttings of *Rhododendron* variety, Cynthia, were taken directly from the propagation bed and set out in randomized, replicated field plots on Puyallup silt loam March, 1958. These plants were fertilized in April, 1958, 1959, 1960, 1961, 1962, with 30 different nutrient treatments. Treatments included comparisons of three different sources of nitrogen (ammonium sulfate, ammonium nitrate, urea-formaldehyde) ; rates of application of nitrogen, phosphorous, and potasium (40, 80, 120 pounds N, P_2O_5, K_2O — actual pounds per acre) ; phosphorus applied preplanting and incorporated in soil in plant root area as a three-year supply (dicalcium phosphate 240 pounds P_2O_5 per acre) vs. annual surface application of treble phosphate (80 pounds P_2O_5 per acre) ; addition of magnesium, minor elements, iron chelates to certain plots; and sawdust mulch vs. no sawdust mulch. Data were recorded each year for plant growth (measured as plant volume) and flower bud formation.

The 1959 results showed that phosphorous greatly increased flower bud formation. Plants that were treated with dicalcium phosphate, plus a surface application of ammonium sulfate (80 pounds N), produced a total of 159 flower buds for 21 plants as compared to 119 for surface application of treble phosphate plus ammonium sulfate (80 pounds N), 42 for plants receiving only nitrogen, and 13 for non-fertilized plants. Best performance of the nitrogen sources tested was obtained with ammonium sulfate Some slight potash response was noted in flower bud set when potassium sulfate was added to ammonium sulfate-treated plants. Significant increase of plant growth and some increase in number of flower buds formed was obtained with the use of sawdust mulch.

The 1960 results showed that phosphorous continued to increase the number of flower buds formed, but less differences occurred between treatments as plants increased in age. The following figures indicate this difference decreases in average number of flower buds per plant for 1960, 1961, 1962: phosphorus plus nitrogen — 26.1, 81.9, 163.5; nitrogen only — 12.6, 53.7, 130.5; check — 11.7, 46.9, 107.0. The effect of sawdust mulch also became less pronounced as plants increased in size and more shading of roots by foliage occurred.

1959 Plots

Rooted cuttings of *Rhododendron* variety, Cynthia, were set out in field plots on Puyallup silt loam in March, 1959, and fertilized in April, 1959, 1960, 1961, 1962, 1963, with 34 different nutrient treatments. Since phosphorus applied preplanting appeared promising for initiating flower buds on young plants in the previous experiment, different sources of this element were incorporated and compared. Other treatments included the use of starter solutions (52% phosphoric acid applied at 1:50 and 1:100 dilution), and a comparison of time of fertilizer application.

The 1959 results showed that on this particular soil type (32% sand, 47% silt, 21% clay; pH=5.6) phosphorus again proved beneficial in increasing bloom production. With certain treatments 40 per cent the rooted cuttings produced flower buds in the fall of the same year in which they were set out No flower buds were formed on non-fertilized plants or those that received surface applications of nitrogen, phosphorus, potassium in June.

Data taken in 1960 showed the following average number of flower buds per plant: no fertilizer — 2.8; phosphorus incorporated preplanting (480 pounds P_2O_5) as dicalcium phosphate — 9.8, treble phosphate — 9.3, rock phosphate — 8.8, bone meal — 8.3; treble phosphate applied on soil surface (80 pounds P_2O_5) — 6.8; starter solution — 10.5. Plants that received nitrogen, phosphorus and potassium in April produced almost twice as many flower buds when compared to June applications at similar fertilizer rates. As was noted in the 1958 plots, differences in number of flower buds formed were less pronounced between treatments as the plants increased in age. Average number of flower buds in 1961 and 1962 for non-fertilized plants were 19.3, 51.6, respectively; 43.9, 90.6 for phosphorus-incorporated treatments.

1961 Plots

Rooted cuttings of Cynthia variety were set out March, 1961, on a lighter soil type than used in the two previous experiments. Treatments given included only those that gave good results on the heavier soils. The data obtained in 1962 may be summarized as follows:

Plants that received phosphorus produced more flower buds per plant than non-fertilized plants — 3.5 and 0.0, respectively.

Plants that received phosphorus, incorporated preplanting, produced slightly more flower buds than surface application of phosphorus — 3.5 and 2.6, respectively.

Plants with no sawdust mulch produced more flower buds than mulched plants. Increased nitrogen rates from 40 to 120 pounds N per acre decreased this difference considerably. No doubt, a shortage of available nitrogen occurred with the use of fresh fir sawdust and, with added amounts of nitrogen, an increase uptake of nitrogen increased plant metabolic activity with subsequent increased phosphorus uptake.

The effect of phosphorus on plant growth is well known and its use is valuable since it seems to counteract some of the detrimental effects of overfeeding with nitrogen by hastening maturity and increasing the root system. As evident from research being conducted at the Western Washington Experiment Station, phosphorus also plays an important role in flowering. It seems advisable, therefore, that rhododendron growers in this area use fertilizers that contain adequate amounts of phosphorus. If fertilizers with low phosphorus content are to be used, then supplemental preplanting soil incorporation of phosphorus is suggested. Placement of phosphorus within close proximity of the root system, rather than an overall broadcast practice, is recommended.

MODERATOR JOE KLUPENGER: I know that with these experienced men here in soil mediums and with Art Myhre with his good set of buds on rhododendrons, that we want to get under way now with the question and answer period. At this time anyone who would like to ask a question may. Don't be bashful. Get up because here is where we're going to get an answer of some kind.

MRS. JEAN WHALLEY: Dr. Myhre, about how many flower buds did you average per plant on the second year in your rhododendron study?

DR. ARTHUR MYHRE: Our experiments in 1959 were with incorporation of dicalcium phosphate, but similar results could be had with treble super phosphate, or potassium calcium pyrophosphate, or potassium mono phosphate. The second year we got forty-two buds per plant. In the treatment without phosphate, we only got nineteen. In the surface application of eighty pounds every year — eighty pounds of actual phosphorus — we got seven buds per plant. With fish fertilizer we only got three. With June application — remember in all that first season we didn't get any buds — with June application we got four buds compared to surface application of seven buds. Then as you increase it, the final year, or the third year, with this annual application we got seventy-four buds per plant. With June application we got sixty-two, so it's coming up. So you're building up your phosphate so that by spring you're having phosphate there that's available. It's just the first year that the later application didn't give us the developing buds.

Our plants were set out in March and our fertilizer applications were applied in mid-April; it got so rainy one year that we tried the latter part of April. I might mention that our June applications did not give the low branching that we got with the early application. Then we had some late growth too, on the June application. We always had that second flush of growth. I might say in all our plants we did not have that second flush of growth — only on our container-grown plants where we had to water them a lot.

MR. JACK: This is for Don Nuffer. Do you use fungicides and insecticides in overhead sprinkling?

MR. DON NUFFER: We have been using Morton's Drench C for control of fungi that gets into junipers. It also has helped control mosses. We have used copper sulphate for the control of liverworts which make a regular mat over the top of the cans. As to insecticides, it has been more or less experimental, but I have used Malathion for cut worms in the nursery. While they didn't seem to be bothering our junipers, they were there and we didn't want them.

MR. BILL CURTIS: What concentration of fungicides and insecticides do you generally use in your sprinkler system along with your fertilizer?

MR. FLOYD RIGBY: We have 15,000 square foot plots that we irrigate at one time. We have an injector that allows us to inject varying rates, one to fifteen, or clear up to one to three hundred. When we use insecticides, we've had no insects and we have not been out with the sprayer now for two years. We use ½ gallon of Malathion, which is put into our injector. We fill the injector with water, and then we inject this at the rate of one to fifteen. It takes us about six minutes to spray the whole 15,000 square feet. We've had exceptionally good results with this method. The injector that we have holds 15 gallon of water, so we put ½ gallon of Malathion into the injector and then we fill the injector with water. This is at a rate of one to thirty. Then we inject this diluted solution into the sprinkler system at the rate of one to fifteen.

MR. ROBERT BODDY: This is a question for Art Myhre. In your rhododendron experiments, as I understand it, phosphate in all instances was incorporated into the soil except where it was compared with surface applications. In all instances, in all of your experiments, there was a pre-planting application then?

DR. ARTHUR MYHRE: Yes, where we had a five-year supply, or three-year supply.

MR. ROBERT BODDY: I have a second question. You said that you were starting to conduct experiments with plants in egg cans on growth retardents and so forth. Are you going to do the same with your fertilizers? Are you going to, in all instances, incorporate phosphate into your planting mix?

DR. ARTHUR MYHRE: Yes, you bet we are.

MR. BRUCE BRIGGS: Did you not use on your rhododendrons 480 pounds of triple super phosphate; that was standard?

DR. ARTHUR MYHRE: The question was about that 480 pounds — that is a high rate; where you are planting and taking them out in a few years; personally I wouldn't do that, but you might for the three year's supply. We just incorporated it, right in that square foot area, and set the plant right in there.

MR. BRUCE BRIGGS: Then that would be approximately ¾ ton per acre; so that would mean that if you are tilling the whole ground, you'd want at least 2 or 3 tons to give you the same effect. Would that be right?

DR. ARTHUR MYHRE: I wouldn't suggest just going out and scattering it because, at least in our area, a lot of the phosphate is going to be tied up. We want this fertilizer right there where the plant is. That is a heavy shot; unless you're going to leave the plants there a long time there really isn't any advantage of going to that heavy rate if you're using a fertilizer that is high in phosphates. You could put it right down the row. I personally wouldn't just scatter it all over because its expensive and you can place it right around the plant. Maybe you'd rather do that in other ways that are more economical.

MR. BILL CURTIS: Many of us in this area grow rhododendrons set quite closely together. I plant them on 24-inch centers. I was wondering if we could apply phosphate over the entire area. What would you apply per acre if you are to cover the whole area because it would be too bothersome if you put a handful or spoonful where you put it on each plant? It would be much simpler to take a spreader and spread the fertilizer over the entire area, then rototill it in.

DR. ARTHUR MYHRE: I can see no reason why that would not be feasible. We just placed it around our plants because our plants were set wider apart. The rate of application depends on what kind of fertilizer you use and how long your plants are going to be there.

MR. BILL CURTIS: Our plants would normally be moved out in three years. We would just love to sell them in two years —then we can make a little money. But if we can get buds in three years and get a 21 to 24 inch size in two year's time, why, we move them out in two years. We figure three years as the maximum.

DR. ARTHUR MYHRE: I would suggest you use treble-phosphate. We have been using super-phosphate but treble is quite soluble and I would suggest that you use, maybe 240 pounds of this three-year supply per acre. I'd put it on early, as early as you can get it on.

Maybe I'd just better mention one other thing. I happen to be a rhododendron hobbyist. I like rhododendrons. I have a hundred varieties on my place, one of each thing. Some one said, "Well, do you go up there and spoon feed like you do down here?" I said "No" and they want to know what I used. I might just mention what I use up there. I use 11-48-0 which is very soluble, and then, every other year, I add a little sulfa-Mag which gives a little magnesium and potash, and I've never had any trouble on my varieties, but it's a fast way — ammonium phosphate and sulfa-Mag.

MR. BRUCE BRIGGS: This is directed to Dan Schmidt. Can you substitute pine needles or some other form of either pine or fir in place of your leaf mold?

MR. DAN SCHMIDT: Where we get our leaf mold there are some fir trees, although most is alder and maple. I think you'd have a different reaction, probably you'd be getting into something more like the bark dust if you used pine needles or fir needles or something like that.

MR. RAY BURDEN: Mr. Myhre, all my life I have heard about sawdust tying up the nitrogen in the soil, and especially with the mulches. Yet these fellows go out and plant rhododendrons in 90% sawdust with good results. I was just thinking, why no lack of nitrogen? As you know, in the spring, the sun warms the soil up and creates a bacterial action that makes nitrogen more readily available. I was wondering if the fact that the sawdust, instead of tying up the actual nitrogen, just kept the soils cooler and prevented the bacterial action, and therefore, made the nitrogen less available rather than just tying it up. I have been trying to figure this out for five years and it just sounds logical to me.

DR. ARTHUR MYHRE: My answer is, I don't think so. It may cause a little difference, but I think we all know about the process of the microorganisms which need energy and use up the carbohydrates, etc. I just think whenever you add sawdust there, you just don't have, at that time, available nitrogen. It is true, that it will have some effect, but at that nursery where we saw a lot of sawdust in the soil there has been a good supply of nitrogen previously. There's nothing wrong in incorporating sawdust. We do it a lot with blueberries. We rotovate and plant our rhododendrons and then add sawdusts and mulch it in just for the winters — providing we have the extra nitrogen. I would like to use, however a fast-acting form of nitrogen, like ammonium sulphate.