And for the lessons Thou dost teach us daily, we give Thee thanks. We too, prone to unfruitfulness, are in great need of Thy pruning shears. We too, weak and struggling, are in need of the sustaining fertility of Thy love, the nurture of Thy cultivation and care. Our minds and hearts are beset with devastating diseases, from which only Thy healing and restorative power can save us. God of All Trees and All Men, as these trees grow sturdy and strong in our nursery rows, so help us to grow in Thy nursery. Amen.

I want to go right on and will turn the meeting over to our first moderator, Steve O'Rourke from Michigan State University. His panel will discuss the propagation of pines.

MODERATOR O'ROURKE: Will the members of the panel please come up? Roy Nordine, Aart Vuyk, Hoy C. Grigsby, Hans Hess, and Jim Wells. Dr. O'Rourke presented the following talk.

THE PROPAGATION OF PINES

F. L. S. O'Rourke
Department of Horticulture, Michigan State University, East Lansing

Plant propagators serve both horticulture and forestry in the production of pines. Superior forms must be selected and multiplied, from seed if possible, if not, by vegetative methods. Whether the ultimate use is for utilitarian or for ornamental purposes, the objective is the same; to perpetuate the desired characteristics of a genetic strain or a selected individual tree.

BY SEED

Seed from pine trees, like seed from most other woody plants, should be gathered when mature and only from well-nourished trees of the desired type (3). The seeds are usually removed from the cones by Kiln-drying and may be stored in sealed containers at 32° to 41° F for 10 years or more without loss of viability (31). In a series of germination tests with several species of northern pines, Heit and Eliason (14) noted that different lots taken from the same species of pine reacted differently. They attributed these responses to poor Kiln-drying, to injury incurred in extraction or in handling, or to high temperature of high humidity in storage.

Unlike the seed of many deciduous woody plants, pine seed will germinate without cold-moist stratification but slowly and continuing over a period of several months. The resulting seedlings therefore differ in uniformity of growth at the end of the growing season. Barton (2), in 1928, reported that the germination of southern pine seed could be hastened and made more uniform by cold-moist stratification at 41° F for 30 to 60 days. In more recent experiments Wakely (33) found that a period of 15 to 30 days would usually suffice in stimulating quick and uniform germination. The U. S. Forest Service (31) has listed 30 species of pine in which seed stratification, ranging from 15 to 90 days according to species, is considered beneficial. Usually seed which has been stored for a long period of time will benefit more from stratification than freshly-gathered seed.

A simple method of stratification of pine seed has been reported by Hosner et al. (16), Lehto (19) and Malac (21). It consists of thoroughly wetting 5-pound lots of seed, pouring each into a polyethylene bag and placing in a 34^{o}-38^{o}F cold room for 15 days. Larger lots of seed in one bag did not germinate as well. According to Hosner et al. (16) no differences in germination were apparent between loblolly pine seed soaked in plain water and in a fungicidal suspension of Captan 50 at the rate of 2 lbs. per 100 gallons of water before placing in polyethylene bags for 60 days.

Kozlowski and Gentile (18) found that removal of the seed coat of white pine seed, or even puncturing with a razor blade, accelerated germination. They indicated that the seed coat was a barrier to oxygen diffusion and water absorption. Fowler (10) reported more rapid germination either by removing the seed coat or by soaking in aerated water for 3 days. Gudcev and Romanov (13) reported "vernalization" and 10 days earlier germination of Scots pine seed by soaking in water for 9 days at room temperature and then storing on ice at 34^{o} F for 30 days before planting.

Many nurserymen plant pine seed in the fall of the year so that it is stratified naturally in the seed bed over winter. Fall planted seed must be protected from the elements by sufficient mulching and from birds and rodents by screening or other devices as described by Vuyk (32).

BY VEGETATIVE METHODS

The vegetative propagation of the pines is well discussed in the excellent review paper of Nienstaedt et al. (27) which cites 181 references. Much of the investigational work has been carried out by forest tree plant breeders in order to multiply selected clones for future hybridization and to establish "seed orchards" of clonal material in isolated areas to serve as a source of superior seed in future years (27, 29).

By Cuttings and Marcots

A number of investigators (8, 15, 23, 24, 36) have resorted to air-layering (marcottage) not only to produce new plants from a selected clone but also to study the factors relating to root initiation and development which are the same irrespective as to whether the girdled branch is still attached to the tree as in layerage, or entirely removed as in cuttage.

The most dominant factor is the age of the tree from which cuttings are taken or marcots made. Rooting is highest on very young trees and gradually decreases with the age of the trees. (4, 5, 6, 23, 24, 27, 28, 30). Cuttings from many mature and senile trees do not form roots under any known method (4, 6, 27, 28, 30).

Cuttings taken and marcots made on the lower portions of the tree usually root better than those on the upper branches (27, 28, 30), apparently due to the residual "juvenility" or retention of a younger meristem in the lower epicotyledonary region (28, 30). The percent success with either marcots or stem cuttings of any species of pine to date has been too small to justify any commercial use of these methods.

Investigations with cuttings of Pinus strobus by Deuber (4) showed that rooting varied markedly from tree to tree within a similar age class and that while rooting decreased with tree age, it was possible to root a few cuttings from some specific clones 40 to 60 years of age. Deuber also noted that rooting was higher when the resin exuding at the base of the cutting was not removed. Farrar and Grace (7) reported 60 percent rooting with white pine cuttings taken in August from the lower portions of 15-year old trees. Doran (6), however, indicated that cuttings taken in late winter root more quickly.

Cuttings taken from branches of maritime pine (P. pinaster) which were girdled and left on the tree until callus formed were compared with uncallused cuttings by Mangenot (22). The amount of water taken up by the callused cuttings in the bench was much greater than by the uncallused and consequently, the callused cuttings did not dry out nearly as much as the uncallused ones.

One of the more recent phases of plant propagation with pines has been the use of needle-bundles as cuttings (17, 37). A needle-bundle cutting is somewhat similar to a leaf-bud (single eye) cutting with woody deciduous plants as a small piece of stem tissue is removed with the needle fascicle. Zak and McAlpine (38) rooted P. elliottii as high as 58 percent from needle-bundles but only a few of these developed shoots and survived.

According to Ishikawa and Kusawa (17) shoot buds may be developed on needle bundles if the new growth leader is cut back the previous year. This type of pruning is a standard horticultural practice to induce lateral buds and branches. The "predeveloped" leaf-bundles when treated with indole-butyric acid rooted well and developed strong shoots.

By Grafting

The horticulturist is interested in multiplying the various selected clones of pines that have unique characteristics which make them desirable for landscape purposes. Since the rooting of cuttings and layers is not commercially practicable, these pines are usually grafted on potted rootstocks in the greenhouse.

In 1891 Fuller (11) stated that "varieties are propagated by veneer grafting under glass in August." He advised using either P. nigra or P. resinosa as stocks for the two and three-needle species and P. strobus for the five-needle group. Bailey (1) advocated P. sylvestris and P. nigra for the two and three-needle pines and P. strobus for the five-needle ones.

More recently Wells (34) has reported that *P. sylvestris* was superior to either *P. nigra or P. densiflora* as a stock for *P. sylvestris fastigiata*; that the stocks should be potted nearly a year preceding grafting; that grafting is best done in late February or early March; that the side graft is much superior to the veneer graft; that the caliper of the scion should not be less than pencil thickness and that aftercare on an open bench in a cool (60° F) greenhouse is superior to a double-glassed case.

The forester has also been concerned with the multiplication of selected clones, but usually in order to establish a stand of uniform clonal trees in a "seed orchard". This area is isolated from other plantings to prevent contamination from undesirable pollen and thus is expected to produce seed of higher quality (27, 29). Grafting is commonly used to establish the desired clone on seedling stocks. Usually it is done outside rather than in the greenhouse and consists either of the use of dormant scions in the spring or of soft-tissue succulent scionwood in the summer.

Zak (35) working with *P. echinata* scions and stocks in the greenhouse in February reported 76 percent survival from veneer grafts and 75 percent from side grafts. Methods to remove or hold back resin by the use of blotting paper, warm water, or cold storage markedly reduced the number of successful grafts. Cleft grafting out-of-doors in early summer with succulent soft-tissue scions resulted in "takes" of 72 percent with shortleaf and 80 percent with loblolly pines.

Fowler (9) achieved 96 percent survival with cleft-grafts of several *Pinus* species on *P. mugo* stocks made July 16 in the nursery by covering the grafts immediately with an inner pliofilm bag and outer kraft paper "shade" bag. Mowat and Silen (26) also used the double bag method with success on *P. ponderosa*, leaving the bags on for 2 months after grafting.

Greene and Reines (12) used the bottle-graft method on slash and loblolly pine in summer. The cut-end of the scion rested in a bottle of water to which Ferbam had been added to prevent decomposition. Survival was 50 percent with bottle grafts and 10 percent with soft-tissue grafts covered with moist sphagnum moss and pliofilm. Mergen (25) reported 95 percent success with bottle grafts of slash pine in the open under partial shade.

In Finland, Leskinen (20) reported that approximately 85,000 grafts of pine have been made since 1949, principally for seed orchards. Summer grafting from June 20 to July 15 has been superior to spring grafting; scions must be grafted immediately after collection; survival is higher when grafted on the leader of the current seasons growth; rubber strips are slightly better than spring clothes-pegs for holding scions; and warm weather is superior to cool.

The success achieved by the investigators mentioned above and many others which are not listed due to limitations of time and space, indicate that grafting both within species and between species of pine is commercially feasible. The variations in form and color in many of the species should stimulate plant propagators to select and graft clones having unique landscape value.

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MODERATOR O'ROURKE: I will now ask Mr. Roy Nordine to present his portion of the program.

SOME UNUSUAL PINES

Roy M. Nordine
The Morton Arboretum
Lisle, Illinois

The genus Pinus contains about 70 species that range throughout the Northern Hemisphere from the Arctic Circle to Mexico, the West Indies, and North Africa. This genus is the largest and most important of the coniferous group. They have long been very useful and valuable plant material for both large and small plantings, and unlike spruces and firs, their beauty increases with age, and they become more picturesque.

The usual plant forms, such as prostrate, globe, spreading, dwarf umbrella-like, columnar, pyramidal, weeping, and colored foliage are found in about a dozen species. Occasionally a new plant is found.

There are four very excellent books on conifers. One is by Murray Hornibrook: DWARF AND SLOW GROWING CONIFERS, published in London in 1923. This book lists and describes many forms that were found in Europe and now do not exist or, because of quarantine regulations, were never brought to this country. Another equally fine book is L. H. Bailey's CULTIVATED EVERGREENS, published in 1925. This book also contains a number of dwarf forms that have now apparently been lost. Two later books are CONIFEREN by Peter den Ouden, published in Holland in 1949; the text is in Dutch. And the latest

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The largest single collection of dwarf conifers in the entire world is owned by William Gotelli, 66 Crest Drive, South Orange, N. J. In this collection each plant is handsomely displayed as though it were a rare jewell.

The following is a record and brief description of all the unusual pines now known in this country plus a finding list for the various plants.

Pinus banksiana Dwarf. Plant at Arnold Arboretum found by Albert G. Johnson in 1954; plant at that time a small, dense, dwarf pyramid, making short annual growth. About 2' high.

Pinus banksiana Weeping. Plant at Richfield, Minnesota, found by Albert G. Johnson in 1959. Plant probably 5' high on a stem about 3" in diameter, with weeping branches that almost reach the ground.

Pinus cembra columnaris Beiss. A form of narrow columnar habit; a large old plant at Morris Arboretum.

Pinus densiflora oculus-draconis Mayr. Each leaf marked with two yellow bands; if seen from above, show alternate yellow and green rings; therefore the name, meaning "dragon's eye". Plant at Morris Arboretum.

Pinus densiflora globosa Mayr. A dwarf form of globose habit. Our plants, now 35 years old, are 12' high with a flat top.

Pinus densiflora pendula Mayr. Weeping Japanese Pine. A form with pendulous or prostrate branches. Good specimen at Huntington Botanical Garden, San Marino, California.

Pinus densiflora umbraculifera Mayr. Japanese Umbrella Pine, the Tanyosho of the Japanese. Dwarf, dense form, becoming 12' tall with spreading branches, forming an umbrella-like head. Found in most arboretums.

Pinus griffithi zebrini. Long leaves with two broad yellow bands, similar to P. densiflora oculus-draconis and P. thunbergi oculus-draconis. Plant at Morris Arboretum, Philadelphia.

Pinus flexilis fastigiata. Found by Robert E. Moore in 1946 at Hot Sulphur Springs, Colorado, 9000 ft. elevation. Tree was 50' high, 8-10' wide, 10" diameter trunk. Small plants now at the D. Hill Nursery that were grafted about 1948 on Pinus flexilis are now 3-4'.

Pinus heldreichii aureospica. Low globe-shaped, to 9' high, needles remaining yellow at their tips. Introduced to the trade about 1955 by Hesse Nursery, Germany. Plant at Plant Introduction Station, Glenn Dale, Maryland.

Pinus mugo compacta Slavin. A dwarf, slow-growing, compact plant, with a flat top; it is several times wider than tall. Plant at Arnold Arboretum and Morton Arboretum.

Pinus mugo slavinii. A dwarf, compact, dense, and slow-growing plant, becoming round and mound-like. Old plant in Durand Eastman Park, Rochester, about 3' high and 4' wide.

Pinus nigra globosa. A slow-growing plant developing with several stems into a globe-like plant. Morton Arboretum has several plants of various ages; also at Morris Arboretum.

Pinus nigra hornibrookiana. Dwarf, compact, slow-growing, and mound-like plant, twice as wide as high. Old plant in Durand Eastman Park, Rochester, New York, about 3' high, 6' wide.

Pinus nigra monstrosa. A tall plant with a narrow form; the lower 2/3 of the tree has branches that extend horizontally or deflect downward; the upper 1/3 has normal growth pattern. A large plant in Durand Eastman Park, Rochester.

Pinus parviflora nana Carr. A plant with a few short and erect branches, making a small, flat-topped bush. Reported by Andrew Leiser.

Pinus ponderosa pendula W. H. Sarg. Tall-growing, like the species, with drooping branches. An odd-shaped plant. A fine old specimen in Durand Eastman Park, Rochester, N. Y.

Pinus pumila Regel. Dwarf Stone Pine. Shrub to 4' high with the main branches usually prostrate; from high mountains of Korea and Japan. Does not succeed under cultivation in this country.

Pinus resinosa Narrow Upright. Plant at North Lake, Wisconsin, by Albert G. Johnson, 1955; young plant about 6' high, very narrow. All branches ascending, plant about 18" wide at base.

Pinus strobus densa. A dwarf, compact, and very dense, slow-growing plant, becoming a rounded plant. Morton plant dates from 1940.

Pinus strobus fastigiata Beiss. A form with ascending branches forming a narrow-pyramidal or nearly columnar head. Becoming wider with age. Morton plant bought in 1937.

Pinus strobus nana Knight. Dwarf White Pine. A dwarf, compact round bush with short leaves. A neat and handsome form. Arnold and Morton, dates from 1937. Morris Arboretum has an old plant.

Pinus strobus Ontario. A dwarf and mound-like plant with short needles (1½") height 28", spread 46". Found in a seedling block of White Pine in Durand Eastman Park on Lake Ontario, Rochester Parks.

Pinus strobus pendula Beiss. Needles of typical length, but branches are long and truly pendulous, bending down with tip ends turning upward. Plant gradually becomes taller, but of most odd and irregular form. Morton plant bought in 1937.

Pinus strobus umbraculifera Carr. Dwarf and dense, of slow growth, forming a wide globe-formed plant. Plant at Arnold Arboretum about 3' high and 5' wide.

Pinus sylvestris fastigiata Carr. With ascending branches forming a narrow columnar plant. Most arboretums have plants.

Pinus sylvestris Grand Rapids. Found by C. E. Morris in a Scots Pine planting on park land of Grand Rapids, Michigan. Original plant about 4' wide and about 15" high; a dwarf form with prostrate branches and good green color.

Pinus sylvestris nana Carr. A dense, slow-growing plant with a central leader, and pyramidal in form; needles are steel blue. Old plant in Durand Eastman Park, Rochester, is about 6' high and 4' wide.

Pinus sylvestris watereri. Waterer Pine. Dense, slow-growing, globe-like in form, steel blue needles. Large plant at Morton Arboretum now 38 years old; 10' high, 15' dia.

Pinus thunbergii oculus-draconis Mayr. The leaves are marked with two broad yellow bands similar to the variety by this name in Pinus densiflora. Plant at Rochester Parks and Morris Arboretum.

A List of Unusual Pines and Where They May Be Found

Pinus albicaulis nana #3
- banksiana dwarf #11
- banksiana weeping #11
- cembra columnaris Beiss #3, 5
- cembra sibirica Loud. #1, 3
- contorta latifolia prostrata #3
- densiflora aurea Mayr. #3, 6
- densiflora globosa Mayr. #3, 5, 8
- densiflora oculus-draconis Mayr. #3, 4, 5
- densiflora pendula Mayr. #1, 3, 6, 9
- densiflora umbraculifera Mayr. #1, 2, 3, 4, 5, 6, 9, 10
- flexilis fastigiata #13
- flexilis pendula #3
- griffithii zebrina #3, 5
- heldreichii aureospica #3
- heldreichii leucodermis (Ant.) Markgraf & Fitschen #1, 3-6
- kwangtungensis Chun & Tsiang #12
- monticola pygmaea #3
- mugo compacta slavin #1, 3, 5, 8
- mugo mughus (Scop.) Zenai #1

Pinus mugo pumilio (Haenke) Zenai #1
mugo rostrata (Ant) Hoopes #3, 5, 6, 8, 10, 12
mugo rotundata Hoopes #1, 2, 3, 6, 8, 10
mugo slavinii #3, 6, 8, 9
nigra globosa #3, 5, 10
nigra hornibrookiana #1, 3, 6, 8, 12
nigra monstrosa #3, 6, 8
nigra pendula Rehd. No source.
nigra prostrata Rehd. No source.
nigra pygmaea Rehd. #3, 6
parviflora nana (Beiss.) Carr. #3
ponderosa pendula H. W. Sarg. #3, 6, 8
pumila Regel #3, 9, 12
resinosa narrow upright #11
strobus brevifolia Loud. #1
strobus contorta #1
strobus densa #3, 6, 8
strobus fastigiata Beiss. #1, 2, 3, 4, 6, 7, 8, 10
strobus nana Knight #3, 4, 5, 6, 7, 12
strobus ontario #8
strobus pendula Beiss. #1, 3, 4, 6
strobus prostrata Maat. #3
strobus umbraculifera Carr. #1, 3, 6
sylvestris aurea Beiss. #3
sylvestris beuvronensis Transon #3
sylvestris fastigiata Carr. #2, 3, 4, 6, 8, 12
sylvestris Grand Rapids #6, 14
sylvestris nana Carr. #3, 4, 6, 8
sylvestris pendula Carr. No source.
sylvestris pumila Beiss. #1, 3
sylvestris watereri Beiss. #2, 3, 4, 6, 8, 10
thunbergii oculus-draconis Mayr. #3, 4, 5, 8

#1 Arnold Arboretum, Jamaica Plain 30, Mass.
#2 Dominion Arboretum, Ottawa, Ontario, Canada
#3 Gotelli Arboretum, 66 Crest Drive, South Orange, N. J.
#4 Holden Arboretum, Mentor, Ohio
#5 Morris Arboretum, Philadelphia 18, Pa.
#6 Morton Arboretum, Lisle, Ill.
#7 National Arboretum, Washington 25, D. C.
#8 Park Department, Rochester, N. Y.
#9 Strybing Arboretum, San Francisco 17, Calif.
#10 Scott Horticulture Foundation, Swarthmore, Pa.
#11 University of Minnesota Arboretum, St. Paul 1, Minn.
#12 University of Washington Arboretum, Seattle 5, Wash.
#13 Hill Nursery, Dundee, Ill. Have stock plants - none for sale.
#14 Park Department, Grand Rapids, Mich.

Now the balance of our time we will spend looking at slides. We have tried to stay close to the subject title of unusual plants, and I am deeply indebted to friends in various arboretums and botanical gardens - Morton Arboretum, Rochester Park, Bob Moore, and several other people for the loan of these very, very wonderful slides.

The first several pictures we have are evergreen collections in several arboretums. This one is the Morton Arboretum and shows the unusual forms planted among the ordinary species of pine.

This is Rochester Park. We show you these to invite you to visit the arboretums because they contain a lot of valuable plants. This area is a very beautiful place, the delta of an ancient river. This is the Pinetum in one of the valleys of Rochester Park.

This is Pinus aristata - the Bristle Cone Pine in the Rocky Mountains and some of you know this has now been determined to be the oldest plant in existence and predates the redwoods of California. Bristle Cone Pine - a very excellent picture.

Here is a close-up of the Bristle Cone Pine as it grows under cultivation. That is a picture by Bob Moore. Can you see the close-up of the branch in the slide? We have a peculiar waxy secretion from the foliage. It comes out and remains, and has been known as Mealy Bug. I have also been told and have known some folks to spray this with DDT to get rid of the Mealy Bugs. That is a waxy secretion and is a very unattractive thing.

This is Mexican white pine - Pinus Ayacahuite at Mexican Park, but unusual in Mexican white pine being hardy as far north as Rochester Park. It is a member of the White pine group.

This is a Weeping Jack Pine - Pinus banksiana. This pine was found just recently by Albert Johnson in the University of Minnesota at Richfield, Minnesota, which is a suburb of Minneapolis.

This again is familiar to a great many of you, but to many of you, it isn't. We will show you these peculiar forms - this is Pinus banksiana, a pine of China, a lace-like plant. It is from Morris Arboretum. The unusual part of Pinus banksiana, or lace-bark pine, is a mottled condition very similar to that of sycamore, a very beautiful and attractive thing.

This is a picture of Pinus cembra and Swiss Stone Pine. It is a slow growing, pyramidal shaped plant.

This is Pinus cembra columnaris Morris, a very, very old plant. I don't know exactly how old it is. A very narrow form of the Swiss Stone Pine. There is another form that is also narrow - Pinus cembra siberica, which is from the northern limits of the cembra, but we are unable to find it throughout the North.

This is Pinus densiflora oculus-draconis. The Pinus densiflora is Japanese red pine and that is one of the few colored foliage pines we have. This picture I believe is from the Morris Arboretum. It does grow with a trunk but Japanese red pine is one of the scrub pines of Japan with an irregular trunk. It maintains that same irregular shape. It has two bands of yellow foliage around the needle and the eye in the center, giving it that particular name, "dragon's eye".

This is the oldest plant we can find of the Pinus densiflora pendulum - the pendulum form of the Japanese red pine. This was put in here for our California members. It is in the Huntington Botanical Garden in California.

Here is the same pine on a standard, grafted up high and allowed to weep down. This work is done by a Holland nurseryman who is now living on the West Coast. I don't know how long he has lived there but he is able to graft on a standard outside in the spring of the year. (See paper by Spaan)

Pinus densiflora umbraculifera - the umbrella form of the small Japanese red pine. It grows quite well, not slow in growth. Here again is another one of these things on a standard also done by Spaan on the West Coast, making unusual effects.

The next picture will show a very large old plant. This plant I think is at Morton and is some 35 or 40 years old, and probably 15' high and of course, more than that in spread. It is Pinus densiflora umbraculifera.

Here is one found by Bob Moore. It is Pinus flexilis fastigiata. It covers a great part of the West Coast. This is one of the western white pine group. He found this old plant high in the mountains and growing in this form. It is the principal timber tree growing in the ordinary type method in the West. He found this one plant, and the next picture will show the first reproductions from that particular plant. Now whether this is going to remain fastigiata or not, we don't know, but these plants were produced from that first plant. These plants are from the D. Hill Nursery. They have some 20 odd plants.

The next picture is a mugo group at Morton Arboretum. It does not show, but mugo from seed varies tremendously, and we have one mugo at the arboretum which we delight in showing people. It is a mugo pine compacta, a very old plant, hardly three feet high and a great deal wider than it is high. A great many arboretums have dwarfs of Pinus mugo compacta.

This is not a very good picture, but this is Pinus mugo slavinii which is at Rochester Park. The Slavins were prominent people in Rochester Park system. This is one they found 40 years or more ago. This was found in the fall and shows the shading of the needles and shows it very poorly but it shows the compact form at great age and remains in very excellent condition.

This is Pinus nigra globosa - the Austrian pine, if you wish, the globe form. This is a rather young plant. I think this plant is probably 10 or 12 years old, at the Morton Arboretum. I have another picture showing the development of numerous stems. This plant, I presume, is 35 years old, and it is hardly 10' high.

Here is another plant in Rochester Park - Pinus nigra hornbrookiana, named after that particular author, a plant found at Rochester Park and reproduced. This plant is 30 years old now. It is about 3' high, about 4' wide, and they tell me it is about 12' long. You can see it is found near a little stream or a ditch, so it has folded itself over very well in this particular area.

This is Japanese white pine - Pinus parvifolia. All of them do not have this peculiar, but very interesting form, with a flat top or layered branches. It is very picturesque and certainly looks Japanese.

This is a picture of Pinus pence. It looks similar to Pinus cembra. This, too, is at Morris Arboretum. It is the Macedonian pine coming from very much the same region and area as the Swiss Stone Pine. They both have very much the same shape - and both have five needles, but cembra has pubescence, a very noticeable pubescence on the new growth, and it is a characteristic you can always depend on, to sort them out.

This is a pine recently found by Albert Johnson at the University of Minnesota, an upright form of our native red pine - Pinus resinosa.

This is Pinus strobus densa, our eastern white pine, and densa is not recognized in the literature at all. This is something we bought at the nursery under the form densa. I believe it is something else, but at least we carry it under densa. You will see it is quite similar to others we have. The plant is a little more than five feet high but retained this form through all of these years.

Pinus strobus fastigiata. This is a younger plant. It does become wider of course, with age and I think the Arnold Arboretum people said at great age, it becomes quite wide. But for a long time it remains narrow.

This is Pinus strobus nana from the Arnold Arboretum and showing you a little bit of their Pinus collection. This is very old and dwarfed.

This is Pinus strobus Ontario. It is a seedling form that was found at Rochester Park in a block of seedling white pine of great age. They brought it out and planted it in the garden near the herbarium. It has a bluish cast and short needles.

Our next picture shows Pinus strobus pendula. This plant is at Morton Arboretum. The plant was obtained about 1935 or '36. This is just a recent picture and it weeps or droops very, very gracefully.

It makes a very interesting plant because it is most irregular. All branches come up and come down right to the ground.

Here is another dwarf form - Pinus strobus umbraculifera. This is again in the Arnold Arboretum, showing the beautiful arrangement in their Pinus, showing the dwarfed old plants of great age, well arranged.

This is the Pinus sylvestris fastigiata form of Scotch Pine. This is from the D. Hill nursery. I don't know if these are stock plants or not, but they show very well the narrow form. They are of considerable age.

This is another seedling form of Scotch pine found at Grand Rapids, Michigan in a forestry planting of Scotch pine. It is of great age and it is almost the approximate form of Scotch. It is Pinus sylvestris Grand Rapids.

The next picture will show you Pinus sylvestris nana. This is from Rochester Park and this is a plant of great age. It has maintained a central leader through the years but growing rather slowly and remaining dwarf.

This is Pinus sylvestris waterii, and that dates to about 1933 or so. It has a bluish cast to the foliage but grows in this particular form and habit, no leader at all, just a large round, very interestingly shaped plant.

This is Japanese black pine or Pinus thunbergii, interesting from a landscape point. You see these very, very crooked trunks. I know they have no sale as far as cash and carry. Everybody has to buy a tree with a straight trunk, but landscape people are extremely interested in this type of growth. I will show this next picture of a group of them. This looks like something in the nursery that the horse stepped on.

I only want to say in closing, whenever any of you have any unusual form, if you contact any arboretum we will be very, very happy to save them, because many of these things are found on occasion and they are immediately lost. The arboretums have provision to maintain woody collections and keep forever these very interesting forms that appear. I already have one who has approached me in the meeting so far and offered a different form of Pinus strobus. These things we appreciate very much. Thank you.

MODERATOR O'ROURKE: Thank you, Roy. I know we are appreciative not only of the wealth of material we have just seen but the fact that Roy Nordine has been able to collect pictures of all of those forms. I am sure it is something that is quite unusual and I know we are all deeply appreciative of the opportunity to see them.

There are probably quite a few questions and at the close of the period we will have a question and answer period, I hope, but now in order to move on - we are going to ask Mr. Vuyk to speak on "The

Propagation of Pine by Seed." Mr. Aart Vuyk.

THE PROPAGATION OF PINES BY SEED

Aart Vuyk
Musser Forest Inc.
Indiana, Penna.

Seed Source

I would like to go over a number of pine varieties grown in the northern part of the United States, beginning with Pinus sylvestris or Scotch Pine. Native in Europe to western and northern Asia, seeds from Spain and France have proven to be the best suitable strains for Christmas trees and ornamental purpose with good color and straight stems. Both strains are considered short needle pines. We also collect some seed in upper New York State, which is faster growing and with much longer needles.

Pinus strobus (White Pine) natural range from New Foundland to Manitoba south to Georgia, Illinois and Iowa, seeds from the lake states and upper New York are considered the best.

Pinus ponderosa, range from British Columbia, south to Mexico and east to Nebraska, Colorado and western Texas. We think seeds from the eastern rockies are the best.

Pinus mugo mughus (Mugho Pine) central and southern Europe seeds preferable from the Swiss Alps region.

Pinus nigra (Austrian Pine) central and southern Europe.

Pinus resinosa (Red Pine) Nova Scotia to Manitoba, south to Pennsylvania, Michigan and Minnesota, the lake states and upper New York is good.

Pinus thumbergi (Japanese Black Pine) Japan.

Pinus cembra (Swiss Stone Pine) Alps, central mountain of Europe and Siberia. We never got any germination on this variety, but the book says seeds are edible, so if I get hungry enough, I'll eat them. All jokes aside, we graft this variety.

Soil Preparation

Now we have discussed the seed source, we are ready to prepare the seed beds for fall seeding. A cover crop of sedan grass has been plowed under in late summer and beds are thrown up with a gravely garden tractor and tilled to a width of four feet. An application of Vapam is applied, which cuts down considerable the first two weedings in the spring, and fall seeding will give excellent results. Fertilizer consisting of 10-6-4 is also applied.

Seeding Procedure

Our beds are 100 feet long and seeds are broadcast by hand. We use a 10 X 4' square and the amount of seed per bed is divided into ten equal parts to get an even distribution. The seeds are coated with red lead against rodents. Then the sand shaker straddles the bed and covers the seeds according to the size of the seeds. In other words a light cover for small seeds and a heavier coat for larger ones. Next comes the haywagon and a coat of salt hay is applied and shade racks put on top of the hay. As soon as germination starts the hay is removed and shade racks raised to eighteen inches which remain until September before taken off. In the spring the remainder of our seeding program is done in the same manner.

Maintenance

All the seedbeds are under a portable irrigation system but used only when it is strictly necessary. All one year seedlings are sprayed to prevent damping-off. The first application with Fermate and the second one with Captan. Equipment used for all spray program is a 200 gallon Meyer sprayer with a boom.

All two year seedlings and older are sprayed for control of the pine shoot moth regardless if the moth is present or not. The timetable varies a little according to weather conditions but as a rule the first application is applied the first week in June and the second two weeks later. The beds are all kept weedfree by girls and the men take care of the weeds in the path by cultivating them.

By September a large amount of seedbeds are root pruned. For this job an Oliver caterpillar tractor is used. In December all one year seedlings are covered with salt hay to prevent heaving.

Fertilization

In the last couple of years we have changed our fertilization program quite drastically. We always used a 20-20-20 liquid before, but now we have eliminated all liquid fertilizers and are using 10-6-4 organic only. We apply this with a regular spreader, right over the seedlings without doing any harm, and the results are better.

Seed Storage

We store the seeds in five gallon jugs and label for species, year of seedcrop, origin and maintain a temperature of 35-40^{o} F. Many of the pine varieties may be stored for many years without losing much viability.

I thank you.

MODERATOR O'ROURKE: Thank you, Mr. Vuyk. I am sorry we have no time for questions. If we have time at the end we will entertain questions.

Now from Arkansas Mr. H. C. Grigsby has come to tell us about loblolly pine cuttings. Mr. Grigsby!

PROPAGATION OF LOBLOLLY PINE BY CUTTINGS [1/]

Hoy C. Grigsby
Southern Forest Experiment Station
Forest Service, U. S. Department of Agriculture

My interest in learning to root the pines came through work in forest tree improvement. We propagate vegetatively to test the heritability of certain features of superior phenotypes. Once selected, trees have proved their ability to pass along desirable traits to their clonally propagated offspring, they are multiplied to obtain material for seed orchards.

Pines are often propagated by grafting, and with considerably more success than by rooting. Grafting, however, has some drawbacks that would make rooting, when perfected, more desirable. Sometimes stock and scion are incompatible. If a tree's superiority is due to its root system, this superiority will be masked when the scion is grafted to the rootstock of an ordinary tree. A reasonably successful technique should make rooting cheaper than grafting.

The following techniques are the ones found most successful with loblolly pine (Pinus taeda L.) after seven years of research involving trials with more than 15,000 cuttings.

The medium of half coarse sand and half perlite was maintained at 78 to 80° F. with heating cables. The greenhouse ambient temperature was kept at 75° F. during the night with hotwater pipes 18 inches below the benches. Daytime temperatures were often higher.

Cuttings from 6 and 25 year old trees were made in mid-November, transported to the greenhouse in dry burlap bags, and placed in the medium the same day. The material was taken from throughout the crowns of the trees, but only the new growth was used.

The growth regulator was an 0.8 percent concentration of indolebutyric acid (IBA) in talc.

Mist was provided with A-6 Humidomist self-cleaning nozzles, which are capable of discharging six quarts of water per hour in continuous operation. The water pressure was 50 p.s.i. Nozzles were placed horizontally in staggered positions on either side of a 5 ft. wide bench. Water lines were set over the walkways in order to keep the drip outside the benches. There was one nozzle for each seven square feet of bench space. The mist system was in operation only during sunlight hours and the mist cycle was 45 seconds per minute. To insure maximum drainage, bench bottoms were made of wire netting covered with a screen. No greenhouse shading was used.

The cuttings were lifted after 19 weeks. Thirty-eight percent of those from 6 year old trees and 47 percent of those from 25 year old trees produced roots. Of the 293 cuttings, one-third received no IBA treatment; of these, 24 percent from the younger trees and 18 percent from the older trees produced roots.

In another test with 293 cuttings taken in mid-December from 6 year old trees and kept in the medium 25 weeks, 52 percent rooted. An additional 41 percent remained alive at the close of the study. This was the best rooting obtained in the several trials where mist duration, rooting media, IBA strength, and temperatures were varied. In some tests, no rooting was obtained.

Air temperatures from 68 to 75^{o} F. have been tried; rooting was best in the upper part of this range. Temperature of the medium has usually been kept from 3 to 5 degrees higher than greenhouse temperatures.

Peat moss, vermiculite, coarse sand, perlite, and a sand-perlite mixture have been used as rooting media. Peat moss and vermiculite do not appear to provide sufficient drainage where mists are used. Pure perlite does not stimulate root formation as well as a sand-perlite mixture does, but roots that do form are better distributed and tougher.

Cuttings were taken throughout the year; those made from November through January rooted best. Succulent material cut in the spring and summer did not root at all, but the failure may have been due in part to unavoidably high greenhouse temperatures.

IBA has proved to be one of the very best root-inducing hormones for pines. Some rooting has been secured from concentrations of 25 ppm in long soaks to 20,000 ppm in quick dips. At the upper end of this range IBA is too toxic for optimum rooting.

Best results from the quick dips have come with concentrations of 2,000 to 7,500 ppm. Cuttings from younger trees rooted best toward the low end of this scale and cuttings from the older trees rooted best with the higher concentrations. The long soaks have been best with treatments of 100 ppm from 3 to 24 hours. However, 0.8 percent IBA in the powder form has given the best rooting in almost all tests.

In a small informal study last winter, IBA crystals were treated with potassium hydroxide to form a water-soluble salt and hence avoid the need for an alcohol solvent. The results were better than from IBA powder and indicate that further study is warranted.

Various nutrients and metabolites such as sucrose, urea, thiamine, nicotinic acid, and adenine were not beneficial. Adenine appeared to be inhibitory.

The Humidomist A-6 self-cleaning nozzle produced the finest mist, the best coverage, and the least amount of clogging of the various nozzles tried. To keep mist particles small, pressures should be from 50 to 100 p.s.i. One, four and ten-minute cyclers have been tried.

In very dry weather the four and ten-minute cyclers allow desiccation of the foliage. Humidifiers, such as the Defensor units with automatic controls, have not been tested but should be superior to nozzles operated by timers.

An antitranspirant wax applied to the foliage did not lengthen the life of cuttings.

1/ Some of the work described herein was done in cooperation with Professor C.O. Box, Mississippi State University, while the author was employed by the Mississippi Forestry Commission.

MODERATOR O'ROURKE: We will next have Hans Hess, who you all know, and who has spoken before on grafting. He will give us his method of grafting pine. Mr. Hess.

PINES BY GRAFTING

Hans Hess
Hess Nurseries
Wayne, New Jersey

The Program Chairman very kindly alloted me ten minutes to talk on the grafting of Pines. I believe this is about eight minutes more than is necessary to cover this method of production which is rapidly growing extinct.

A few more years experience with mist propagation and some new additions in the field of root inducers and inhibitors and all of us old grafters are going to be without a trade.

There is only one reason for producing Pine Selections by grafting; up to this time no better or cheaper method has been found. What are some of the Pines reproduced by grafting? All of the selections of White Pine, the fastigiate, the pendulous, the globe and dwarf form, the various selections of Scotch Pine and also Swiss Stone Pine. This last Pine can be grown from seed, however, it is a very slow process and the variation in the seedlings is considerable.

The various Pine Selections that are being grafted today are either sports which are quite common among seedlings or the result of witches brooms. For the most part these many types of Pines are not actually new, they have been known for many years but are just now again becoming popular.

The successful grafting of Pines is dependent on several factors. Most important is the selection of a compatible root stock, two needle for two needle varieties, and five needle stocks for five needle scions. Second in importance is a scion which is vigorous and the base wood of which does not exceed two years in age. Older scion wood can be used but the percentage of take generally decreases using this older wood which has less vitality.

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A rootstock which has been potted the spring before the grafting season is far better than a fall potted stock. The next factor in order of importance is temperature. Pines are fond of cool temperatures and a range between 60 and 70 degrees in the grafting case generally gives the best results. We have found that a little ventilation of the grafting case during sudden warm spells is preferable to shading, which reduces light intensity.

A side graft has been our most successful method, although a veneer type can also be used. Finished grafts are placed upright in the bench the union covered with sand which is watered lightly to exclude air pockets. A plastic cover is put over the bench during daylight hours and removed at night. The plastic cover is entirely removed when the scions begin to grow, this we find causes the least amount of shock to the newly healed graft. The root stock is reduced by some 50% when the plastic cover is removed and the balance removed as new growth on the scion begins to mature.

Nurserymen graft Pines to reproduce the many types now of such keen interest. Foresters graft Pines to reproduce good seed bearing types, observed in stands of forest plantings. These grafts help increase good seed bearing trees since they begin producing seed much earlier than would a seedling.

A recent article in a Forestry Magazine showed a forester obtaining his scion wood from trees forty feet or taller with the aid of a riffle. This would not be a profitable method for the nurseryman but I can see the advantage to the forester in saving all those steps.

In conclusion, for successful grafting of Pines, spring pot your rootstock, be sure you use compatible scions and stocks, keep your grafts on the cool side and use the most vigorous scion wood available.

Thank you.

MODERATOR O'ROURKE: Mr. Wells, would you prefer to give your paper now or hold it until Friday evening?

MR. JAMES WELLS: As you wish, Steve. It is actually a resume of Mr. Spaan's work which Roy mentioned earlier.

MODERATOR O'ROURKE: Suppose we have your paper now, because it ties right in with the others you have just heard. (Mr. Wells presented the following paper prepared by Mr. John Spaan.)

GRAFTING PINES OUT-OF-DOORS

By John Spaan
Hillside Nursery
Rosburg, Washington

A rootstock which has been potted the spring before the grafting season is far better than a fall potted stock. The next factor in order of importance is temperature. Pines are fond of cool temperatures and a range between 60 and 70 degrees in the grafting case generally gives the best results. We have found that a little ventilation of the grafting case during sudden warm spells is preferable to shading, which reduces light intensity.

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By John Spaan
Hillside Nursery
Rosburg, Washington

AUGUST-SEPTEMBER-OCTOBER

Probably the most blame for failure of the grafts can be traced to the condition of scions at grafting time. Scions should be taken only from the season's new growth, and must be made of firm, semi-mature wood.

While several Pinus sylvestris types produce fairly even textured new growth, others have variable stages of growth, containing both firm and soft wood over a period of time. Pinus sylvestris fastigiata is very good for an even supply of scion wood, while many types of Mugho pine vary as much as 6 weeks or more. Scions should be 2-1/2 to 3-1/2 inches in length, and all needles, excepting one inch at the top, removed. Fifty or sixty scions at a time can be prepared, for the operator to carry in a container under a damp cloth.

The side graft method should be used when grafting pines at the ground level in nursery rows this time of year. Since the scion must always be placed on the north side of understock, the rows of understock should be planted in north to south direction.

The understock should be polished clean, 4 to 5 inches just above ground. At the lowest part make a one inch cut downward and inward. At the bottom of slash, cut again slightly downward to remove slash cleanly. This cut should be as deep as half the thickness of the scion to be used. Cut scion to fit slot, smooth in bottom and sides, and tie in place, which should be firm but not too tight. Then, since rubber is probably used, tie once again, but a little looser as protection for the possible loss of the first band. Scions can be a trifle smaller, but never larger than the cut made in understock.

Grafting and tieing should be done by the same person for utmost efficiency, and anyone with even a rudimentary knowledge of grafting should be able to perform this work in a short while in a comfortable manner.

Tieing can be done with raffia, cotton twine, or rubberbands, but rubber is easiest and quickest but requires more checking unless tied twice.

No waxing is required, but the actual grafted part should be covered with sawdust mulch, leaving just the top with needles sticking out. Mulch prevents weeds and helps protect grafts in wind or frost conditions. Twenty days later, 30% to 40% of understock tops should be removed, and the following spring, just before growth starts, the lower part should be cut, leaving a 3/4 to 1 inch stub just above the graft.

SPRING

Graft failures, can at this time be replaced with a saddle type graft, if larger scions are available.

Slice off the understock just below the old sidegraft leaving a

2 to 2-1/2 inch stump which is evened by a 1 inch cut on either side. Place a scion of the same size with the triangle removed, and tie downward two times and replace sawdust mulch. Although somewhat slower to make than the sidegraft, the saddle graft, in this favored part of spring, is far superior in every way for producing more and stronger living grafts. However, grafting time is quite short, but could probably be extended for an indefinite time, if dormant scions could be kept in good condition. This, I have never tried.

For standard or multiple grafting, side or saddle grafting is optional, with the operator, of which there do not seem to be any, although it is by far the most interesting, since any pine from small Bonsai up to seed producing trees can be grafted.

When topgrafting, after the graft has been tied once, pull up needles right below the graft, or pull a small bundle from another part of the tree, and wrap them around the tied graft, tie two or even three times as protection for first band, since erosion is faster than on the ground. The so-called pigmy pines must be either veneer grafted or on pieceroots since rooting cuttings is seldom practical and too slow. The softer needled P. parviflora and longer tender needled P. Tanyosho and other Densiflora types are much more sensitive to outdoor grafting, and are probably best grafted with a veneer type of graft. Such a graft must be made in spring's favorite days, since a veneer graft would be a poor risk for winter weather except in some much favored locality. However, if firm and large scions of P. Tanyosho are available, they can be side or saddle grafted quite satisfactorily and will make a standard tree that is out of this world.

Both Spruce and Hemlock all can be grown and grafted in the open, but haven't done very much work with them, and pines are the leaders anyway.

Happy landing to the future pine grafters.

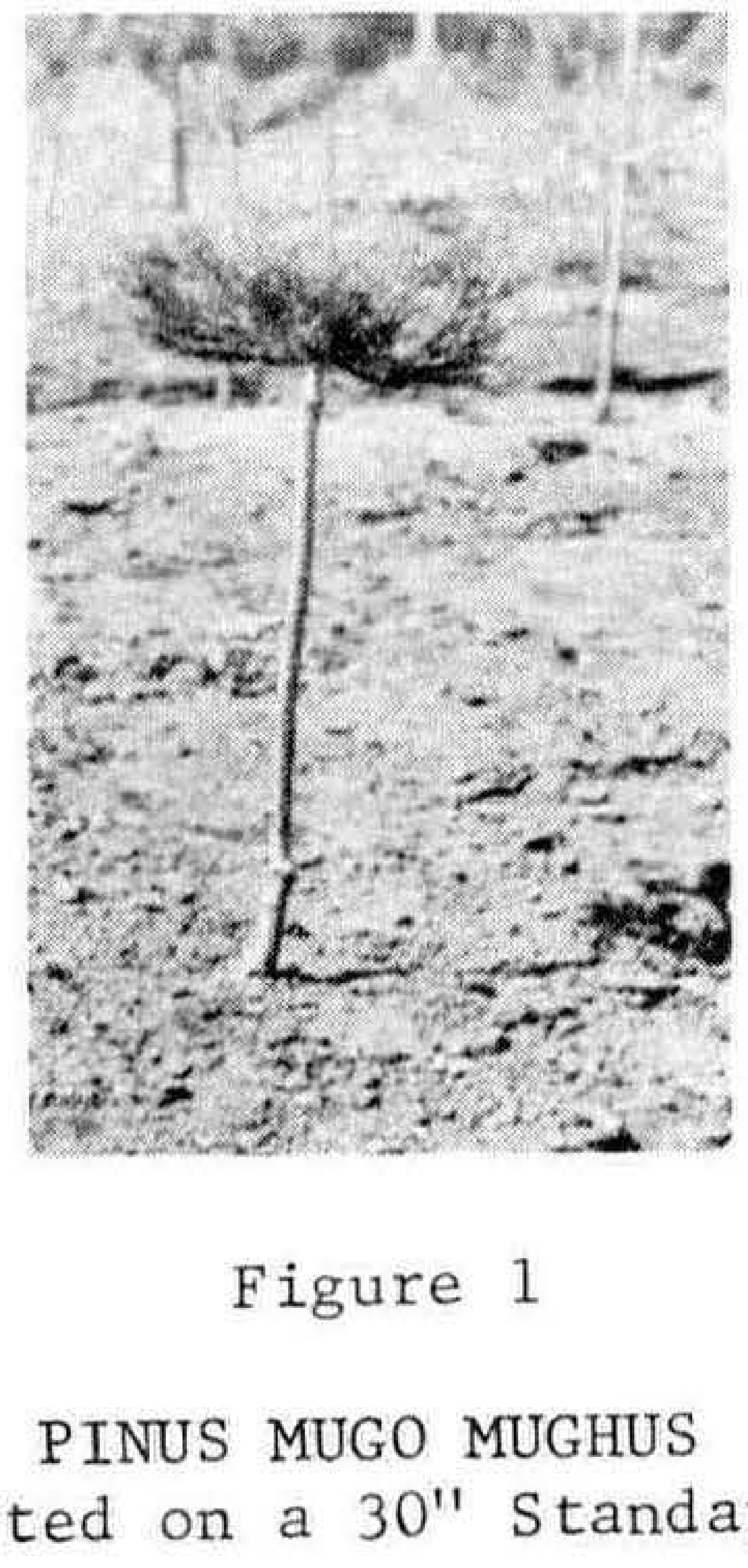

Figure 1

PINUS MUGO MUGHUS
Grafted on a 30" Standard

Figure 2

Six 3 year old grafts of dwarf
PINUS MUGO MUGHUS
on a standard 5 feet tall, 7 years old.

(Editors Note: After a brief recess the morning sessions resumed with a panel discussion on root cuttings. The moderator was Mr. Fred C. Galle, Ida Cason Gardens, Pine Mountain, Georgia).

MODERATOR GALLE: Root cuttings, of course, is an overlooked phase of propagation. I think it is one of those phases you have to dig into the group to find out and then you realize it is not as unusual as some of the other media. If you check the literature there is just one page in the Standard Propagation Book. That is all that is mentioned. The rest is left up to you. You can find some references in books out of this country, more references than we have in American literature.

With that, I am going to introduce Ken Fisher, who will be the first on the Propagation of Root Cuttings from Perennial Plants.

MODERATOR GALLE: We will go on with our next speaker, Bill Flemer from Princeton Nurseries.

PERENNIAL PLANTS FROM ROOT CUTTINGS

Kenneth B. Fisher
Kingwood Nurseries
Mentor, Ohio

There are a limited number of perennial plants that can be propagated by root cuttings. However, throughout the country there are many thousands of plants produced by this method, since among others, Oriental Poppies and _Phlox decussata_ are handled in this manner.

Perennials that are to be propagated by root cuttings, are no different from woody plants in that their roots must be capable of producing shoots. Such shoots are developed from latent (dormant) buds laid down in the initial period of growth, or from adventitious buds formed after the root cutting has been made. Such adventitious buds usually occur in the larger portion of the roots, closer to the crown of the plants.

Generally speaking, in our area (Lake County, Ohio) root cuttings are made in late fall or early winter. For this purpose the desired number of plants are dug in late fall and stored in a cold frame or similar place, until the propagator is ready for them.

The one exception is Oriental Poppies (_Papaver orientale_), which must be handled during the summer while dormant. July is about the best time. This gives the root cuttings time to make new roots and tops before the onslaught of winter, and the young pot plants can be kept outside in a cold frame over winter.

Healthy one year parent plants are selected and the firm roots about an eighth to three sixteenths of an inch in diameter are broken off at the crown, by an upward pull. Keep them on the bench all

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Healthy one year parent plants are selected and the firm roots about an eighth to three sixteenths of an inch in diameter are broken off at the crown, by an upward pull. Keep them on the bench all lying in the same direction. While older parent plants can be used, you will find that well grown one year plants give a higher percentage of usable roots.

While some references claim the cuttings should be made and stored to callous, we, and I believe all others in our area, pot them immediately.

Some growers make a straight cut across the top of the cutting and a slanted on across the bottom, to make certain that proper polarity is kept. This requires extra handling since you make several cuttings from each root, and it entails squaring off the upper end each time.

A faster way is to use what we term a cutting board. This latter is any piece of smooth wood about eight to ten inches long and six inches wide. This is then marked with arrows to one edge. The roots are cut on this board with the tops to the marked edge. In this manner several roots can be cut off at the same time, slicing them off about one and one half inches long, until you get down to too small a diameter. In doing this you do get some small diameter roots on the cutting board as well as some that are too short. These are discarded at potting.

When the board is reasonably full with the cuttings it is taken carefully to the potting bench, and the roots are potted, top end up, into the pot selected. We used to use 2" clay rose pots, but have gone over to Jiffy Pots. We try to get the cuttings just under the surface of the soil. The pots are watered and set immediately into the cold frame where they are to stay all winter.

Even though potted, I cannot stress early planting to the field too strongly, if you are to have salable plants for fall. So set them out as early in the spring as you can work the soil.

Phlox decussata. While they can be handled in much the same manner, Phlox decussata lend themselves to a simpler treatment. The propagating plants are dug in the fall. (For our area it is usually just before or just after Thanksgiving.) We leave some soil on the plants and store them in apple boxes in an unheated building where they will not freeze or dry out. Here again we are talking of one year plants.

After the first of the year, the larger roots are pulled from the crowns of the plants and cuttings made in the same manner as described for poppies. From the cutting boards we place them into boxes or crates of soil.

We usually use grape crates. The bottoms of the crates are covered with about an inch of soil. With these boxes tilted on end, soil is placed against the end, and a row of cuttings, top up, is placed against the soil. Alternate rows of soil and roots are used until the crate is filled. We use enough soil to keep the rows of cuttings about an inch apart. We find it best not to cover the roots entirely until the crate is placed level on the bench. Then a layer of soil is used to make certain that the tops of the root cuttings are covered about one quarter of an inch. These boxes or crates are watered once rather heavily and if necessary more soil added to cover any exposed root tops.

These crates are then placed into a cool greenhouse, where new roots and tops are formed. The house we use is a plastic one with one heating pipe so that we can prevent freezing. In other words, temperatures range from 35° to 45° F. most of the time. The cuttings are left in the crates undisturbed until planting time. When they are to be planted, the crates are taken directly to the field and the small plants troweled into the soil. If planted out in April or even late May, they will make sturdy young salable plants by fall.

The growing of Anemone japonica is a combination of the above methods. Generally speaking this plant should only be planted in the spring, and therefore it is offered as a Spring Pot item. The field plants are dug usually in mid-November, at which time the cuttings are made and boxed as with the Phlox just mentioned. Instead of leaving them in the crates or boxes, they are potted off after they have made new roots and the tops have begun to grow. These pot plants are then grown on in the greenhouse for late spring sales or to be planted to the field.

Anchusa myosotidiflora and named Stokesia such as Blue Danube, are readily propagated by root cuttings. In our operation we usually sow the cuttings on top of the bench, in a section that has been filled with good potting soil, and then cover the cuttings with about half an inch of sand. This can be done in January or February. If given some bottom heat they come right along, and in about a month are ready to pot. Here again we use Jiffy Pots. After the potted cuttings are well rooted and growing well, they are transferred either to a frame or an unheated plastic house to gradually harden them off so that late spring frosts will not damage them. The plants are ready to go to the field in late April to mid-May.

Named Rudbeckia such as The King are also propagated by root cuttings. We stand the cuttings up in rows as we do with Phlox decussata, and then pot them off after they have begun to grow. I will have to admit that our percentages of take are rather low most seasons.

Gaillardia may also be made in this manner, and we do so with the variety The Warrior. The more common named varieties come quite true from seed if obtained from a reliable source.

Echinops can also be increased by root cuttings. Ritro of course comes true from seed, but selected named varieties such as Taplow Blue can be increased by this method.

Several authors mention Dicentra spectabilis from root cuttings. We prefer to use the eyes for potting in late fall. (They can also be set directly to the field if done early enough in the spring.)

Stem cuttings under mist in the summer also give good results. The information on this method I find is scanty. A couple of references mentioned pieces of roots three inches long to be planted deeply in the soil. This to be done right after foliage turns yellow in the summer. Perhaps that is how it is done in Holland, since imported plants have a long "neck" with most of the eyes along that part, indicating that they were planted quite deeply. One nurseryman I talked to said he understood that such a method required two years. Perhaps that is why it is only mentioned in references I have seen.

Listed below are other perennials which, in one text or another, give root cuttings as a method of propagation, but without further details. Since we either do not grow the plant at all, or if we do it is by another method, I cannot give further details:

Arabis
Asclepias
Dictamnus
Gypsophila panicultata
Lobelia
Plumbago (Ceratostigma)
Saponaria
Saxifraga
Trollius
Yucca

I rather imagine that in some of the above instances there may be confusion of a technical nature, as for instance on first thought we think of Plumbago larpentae as being propagated by root cuttings. Since however, one selects the growing tip end of the "root", more technically we are dealing with an "underground stem". Off-shoots of Yucca, I think, would be classified as rhizomes, which technically are underground stems.

References:
Plant Propagation - Mahlstede & Haber
Propagation of Plants - Kains & McQuesten
Commercial Flower Forcing - Laurie & Chadwick
The Book of Perennials - A. C. Hottes
Contemporary Perennials - Cumming & Lee
Popular Perennials - T. W. Sanders

PROPAGATING WOODY PLANTS BY ROOT CUTTINGS

William Flemer III
Princeton Nurseries
Princeton, New Jersey

The root cutting method of propagation is one of the least frequently used of all the methods of vegetative propagation. The primary reason for the relative rarity of this method is that the plants for which it is the best technique are infrequently grown in the average nursery. A secondary reason is that it is relatively inconvenient to

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The root cutting method of propagation is one of the least frequently used of all the methods of vegetative propagation. The primary reason for the relative rarity of this method is that the plants for which it is the best technique are infrequently grown in the average nursery. A secondary reason is that it is relatively inconvenient to secure the cuttings. Either the whole plants to be propagated must be dug up to secure suitable roots for propagation, or else the soil around stock plants must be excavated to expose the roots prior to their removal, at best a rather tedious procedure.

Despite the difficulties involved in securing propagating material, root cutting propagation is by far the best method for increasing certain special plants which will not root from stem cuttings. It is also useful for increasing certain clonal varieties of plants which do not come true from seed, do not bear reliable seed, or are staminate clones of dioccious genera. Here are a few examples of plants which are efficiently propagated by root cuttings. The staminate or male plants of Ailanthus glandulosa bear unpleasantly scented flowers, but the scentless pistillate clones, including the colorful red fruited form can be easily propagated by root cuttings. The wilt resistant clones of Albizzia julibrissin, "Tryon" and Charlotte", do not give reliably resistant seedlings and those of the hardy form "Rosea" are not all of equal hardiness. All three can be grown from root cuttings but not from stem cuttings. Stem cuttings of the D. E. D. and Phloem Necrosis resistant Christine Buiseman Elm (Ulmus carpinefolia) are very difficult to root but root cuttings are entirely satisfactory, and cutting propagation is necessary to preserve the resistance of the clone. Unlike most other poplars, Populus tremula and our American P. tremuloides are almost impossible to propagate from stem cuttings, but their roots regenerate new plants very easily.

The seeds of the pithy, stoloniferous species of Rhus such as copallina, glabra and typhina, germinate slowly and irregularly and the attractive cutleaf forms of the latter two species will not reproduce by seed, but all will grow from root cuttings. The many ornamental varieties of Bamboo do not set reliable seed in this country and are entirely reproduced by the spreading underground stolons (in this case underground stems and not true roots).

Propagation from roots is also a most valuable but neglected tool for restoring a state of juvenility in certain plants where this is a most valuable condition for subsequent propagation. For example many strains of valuable clonal Apple understocks are reproduced by mound layering. This method is most successful (and sometimes only successful) if the mother plants are in a physiologically juvenile condition (thorny, twiggy, and non-flowering). If the mother plants are allowed to grow up for a few years and change to the mature (flowering, smooth, less twiggy) condition, layering or cutting propagation becomes most difficult. Such clonal understocks which have for one reason or another been allowed to grow out of the juvenile condition, can be easily and rapidly restored to it by growing new plants from root cuttings, even if secured from thoroughly mature specimens. We have experimentally produced truly juvenile plants from 40 year old specimens of Malus baccata at Princeton, by this method. The advantages of this technique in work with clonal root stock selection and evaluation are obvious.

Techniques

The methods used in root cutting propagation are relatively simple. As mentioned above, the main problem lies in securing the propagating material. The timing of the propagation is very important. Roots taken in the fall will callus over and eventually form adventitious buds and sprout new aerial stems, but the process is much slower than in the early spring and losses from rotting over the winter are excessive. We have never been successful in fall outdoor root propagation at Princeton and the cuttings taken at that time invariably either heave out of the ground or not before spring if they remain in the ground. Roots of Robinia and Rhus taken from fall dug plants have not been successfully overwintered in cold storage either, whether stored in plastic bags, damp peat, or dry sand. Consequently, the roots needed for propagation are dug as soon as the frost goes out of the ground in the spring, usually in late February or early March. In the case of varieties which are propagated out of doors, the roots are cut up into 2 and 3 inch lengths and packed in layers in boxes of almost dry sand. They are stored in a cool place for three weeks to permit partial callusing of the cuts. Roots of 1/2 to 1 inch diameter are selected for the propagation of Rhus, Campsis, Ailanthus, Robinia, Sassafras, and Populus. Roots of smaller rooted species such as Rosa nitida, lucida, blanda et al, Comptonia, Clerodendron, and Zanthorrhiza, should be of a minimum 1/4 inch diameter. When the ground has dried out sufficiently for plowing, a sandy piece of soil is plowed, disked thoroughly and boarded smooth. Then it is marked out in rows about 2 inches deep. The roots are sown by hand in the rows and soil is raked over the roots. The rows are marked with small stakes driven in every 25 feet and at the ends of the rows as guides for cultivation until all the cuttings have sprouted and the tops are visible above the ground. The rows are also burned over several times prior to sprouting with a liquid propane flame thrower which destroys the crops of weeds which germinate prior to the emergence of the cutting shoots. After sprouting of the cuttings, normal nursery culture is followed and the cuttings are hilled up moderately in cultivation for weed control and to prevent lodging of the plants during summer wind storms.

In the case of valuable trees such as the Albizzia varieties, Christine Buiseman Elm, and Staminate Morus clones a difficult procedure is followed. Here the roots are cut into 3 inch lengths and potted in a mixture of sand and peat into 2-1/2" deep peat pots. All roots, like stem cuttings, exhibit "polarity". That is to say, the new sprouts emerge at the "top" of the root section or the portion nearest the trunk or stem of the parent plant. Consequently, the cuttings should be potted up vertically with the "top" of the cutting at the surface of the potting mix and with the lower part from which the roots will emerge, at the bottom. To avoid confusion in potting, the cuttings when cut up with shears or knife should be cut square across the "top" and on a slant at the "bottom". After potting in the moist but not wet mix, the pots are set up in a cool sash house or frame and not watered for two weeks to permit callusing and prevent rot. Of course the pots must not become bone dry, so a light sprinkling may be necessary if the weather is bright and dry. In four weeks the cuttings will have begun to sprout and after danger of frost is past, they can be planted out in the nursery pot and all, and irrigated when necessary until well established. Once they are established, the several sprouts arising from the top of most cuttings should be trimmed off, leaving the strongest and straightest one to form the trunk of the young tree.

There are several interesting points in the propagation of Bamboos (of which the genus Phyllostachys contains the hardiest species of the reasonably tall varieties). They are included in this discussion because they propagated from spreading underground stolons even though these are not true roots. The stolons are dug up in early spring, choosing young stolons without aerial culms or stems or with only short ones. The stems are cut off, if present, and the stolons are cut up into 3 or 4 jointed sections and planted in 3 inch deep furrows or directly into containers, and covered with soil. New stems or culms sprout from the joints in about 4 weeks' time. If the stolon sections are planted horizontally, a typical spreading clump develops. If they are planted vertically with the tip-most or apical portion up, a compact, non-spreading clump develops which is much more useful in landscape work as it does not spread out excessively. Bamboos, being grasses, respond to heavy nitrogen fertilization.

It is not frequently realized that certain desirable shrubs such as named clones of Japanese Quince (Chaenomeles), French Hybrid Lilacs, and Wisterias are easily propagated by root cuttings removed when the plants are dug for sale in the early spring. Of course in these clonal varieties, own rooted plants must be first started from soft wood cuttings to get a start of the true variety, as grafted plants are useless for this purpose. Similarly, pistillate or fruiting strains of Celastrus scandens, (which roots very poorly from stem cuttings) can be propagated from cuttings taken from sizable roots. Such cuttings are best handled like tree root cuttings and potted up in peat pots for later lining out.

Root cuttings, although admittedly of limited usefulness in the whole field of propagation, are of great value in the production of a few special plants. The technique should not be forgotten, for it is often an inexpensive substitute for more costly grafting or very low yielding attempts at soft wood cutting propagation. The chart which follows summarizes some of the more important plants which can be propagated by root cuttings and the methods used.

PLANTS OFTEN GROWN FROM ROOT CUTTINGS

Genus	Species	Variety	Dimension of Cutting	Where Propagated
Iilanthus	glandulosa	pistillate	1" X 3"	Pot Vertically
Aesculus	parviflora	-	½" X 3"	" "
Albizzia	julibrissin	"Charlotte"	½" X 3"	" "
		"Rosea"		" "
		"Tryon"		" "
Amelanchier	stolonifera	-	¼" X 2"	Outside
Aralia	spinosa	-	½" X 2-3"	"
Bamboo	(see Phyllostacys)	-	-	-
Campsis	radicans	-	½" X 3"	Outside
Celastrus	scandens	pistillate	¼" X 2-3"	Pot Vertically
Chaenomeles	lagenaria	Names Clones	¼" X 3"	" "
Clerodendron	trichotomum	-	½" X 2"	" "
Comptonia	peregrina	-	¼" X 3"	Outside
Hydrangea	quercifolia	-	¼" X 2"	Pot Vertically
Malus	species	Dwarfing Under-stocks	¼" X 3"	Outside - vertically
Morus	species	Staminate clones	½" X 3-4"	Pot Vertically
Myrica	pennsylvanica	Pistillate	¼" X 3"	Outside
Phyllostachys	species	Hardy Bamboos	3 or 4 joint stolons	Outside
Populus	alba	"Bolleana"		
		"Richardsoni"	½" X 3"	Pot Vertically
	tremula	fastigata	½" X 3"	" "
	tremuloides	-	½" X 3"	" "
Prunus	glandulosa	Dbl. Pink or white	¼" X 2-3"	" "
Rhus	copallina	-	½"-1" X 3"	Outside

Genus	Species	Variety	Dimension of cutting	Where Propagated
Rhus (continued)	glabra	laciniata	½"-1" X 3"	Outside
	typhina	laciniata	½"-1" X 3"	"
Robinia	hispida	-	½" X 3"	"
	pseudoacacia	"Shipmast" vars.	½"-1" X 3"	"
Rosa	blanda	-	¼" X 2-3"	"
	nitida	-	¼" X 2-3"	"
	virginiana (et al)	Alba	¼" X 2-3"	"
Rubus	species	-	¼" X 2-3"	"
Sassafras	albindum	-	½" X 3"	Pot Vertically
Syringa	Vulgaris	French Hybds.	¼" X 2-3"	" "
Ulmus	carpinifolia	"Christine Buiseman"	¼"-½" X 3"	" "
Wisteria	species	Names vars.	½" X 3"	" "
Zanthorrhiza	simplicissima	-	¼" X 2"	Outside

MODERATOR GALLE: We have a little time. There are a few other plants that might be mentioned, of which buckeyes are one, which are easily rooted from root cuttings, also some of the rhododendron. It might also be mentioned that variegated plants will not propagate true to form by root cuttings. You have to go to stem cuttings.

Are there any questions on this subject you would like to ask the members of the panel here?

MR. LOWENFELS (White Plains, N. Y.): Mr. Flemer, have you tried lilacs from root cuttings?

MR. FLEMER: Yes, we have, Mr. Lowenfels. I think it is a method we are going to use more in the future. This is a case such as Ken Fisher mentioned earlier. What you propagate from are not true roots, they are really spreading underground stems. If you have been propagating lilacs from stem cuttings, it may take several years before they begin to spread out and form stolons. But once you start propagating from that type of underground stolon, then the plants produce stolons very readily. Also, some varieties produce stolons are easily propaged by this method and some of the others, particularly some of the dwarf dark red types, produce very few stolons and are not by any means successful.

MODERATOR GALLE: Any other questions?

MR. H. R. HUROV (Cornell): There is just a point I want to point out about rooting pine cuttings. The Japanese apparently have done quite a bit of work on this the past ten years and they have tried a number of different species. They found in the older pines there is an inhibitor and they have managed to remove or inactivate the inhibitor by dipping the cuttings in silver nitrate. I don't know the concentration. They then treat it with auxin and have gotten fairly good results.

MR. JIM WELLS: Fred, I would like to ask Mr. Grigsby if he has done any treating of the unrooted cuttings with hot water? I understand that is being done in Holland. The method is to remove the resin from the base of the cutting.

MR. GRIGSBY: No, I have not. Last year in the notes of Mr. Payne he mentioned hydrogen peroxide. We used that among others. I plan to try that this year.

DR. O'ROURKE: Mr. Moderator, I would like to add a comment. In checking the literature I found that a great many workers had removed the resin from the bottom of the cutting and in every case, rooting and survival was better than when they left it on.

MR. ROLAND De WILDE, JR.: I was going to ask Bill Flemer if I heard rightly that he said he had trouble rooting Celastrus scandens.

MR. FLEMER: We have never been successful in rooting them from stem cuttings, either hard wood or soft. Most of these Celastrus scandens which are sold in the trade, I am sorry to say, particularly from our brother nurseries in the South, is orbiculata, and that is an easy plant to propagate. The true scandens with the long fruit clusters out on the end of a little terminal shoot, is very, very difficult to propagate from stem cuttings. Root cuttings are quite successful.

It is easily grown from seed but you have to wait for a long time, you see, until they get old enough to flower and you can determine which are male or female. If you get the established female plants, you can reproduce it by root cuttings.

DR. THOMAS F. CANNON (North Carolina State College): I would like to ask Mr. Grigsby if he had any difficulty in getting the rooted cuttings to grow. The reason I am asking, we have rooted a few cuttings of fir but we have not been able to get them to produce new root growth after they have rooted.

MR. GRIGSBY: No. most of our cuttings that we have rooted, and cuttings that we have potted, have grown quite well.

MR. HANS HESS: I would like to ask one question about these pines from cuttings. What sort of a root system develops on the plants when they are set out? Does it continue as a one-sided root system? If they are like the firs or spruces rooted from cuttings they continue lateral root growth without making a balanced root structure which can be dug.

MR. GRIGSBY: I have in mind to check just what sort of a system the root does develop into. I hope that they will develop a system similar to the parent plant. I don't know.

MR. JIM WELLS: I would like to ask if any work is being done by Mr. Grigsby on checking the rooting of different plants, because it obviously does vary from plant to plant.

MR. GRIGSBY: Yes, I have. However, most of my cuttings have been taken from at least ten trees in any one study.

MR. WELLS: You haven't segregated the cuttings?

MODERATOR GALLE: I think earlier work showed there was some variation within parent plants.

MR. WELLS: I was astonished a few years ago when a man came to see me and we talked about the rooting of hemlock. He said he had a plant in his garden which he had trimmed in the autumn, thrown the cuttings on the rubbish pile and in the spring they were all rooted. I know the man and I went to see the plant and I took about 20 cuttings of it and stuck them in the bench and all 20 rooted without any trouble whatsoever.

I never did any more about it because I wasn't interested in hemlock. There is a plant which will root.

MR. CASE HOOGENDOORN (Newport, R. I.): What variety?

MR. WELLS: Just a seedling, a plant in somebody's yard.

MODERATOR GALLE: Too bad that wasn't weeping hemlock.

MR. HUROV (Cornell): Mr. Grigsby, what do you attribute your success with on pine - temperature, or a number of factors?

MR. GRIGSBY: I think it is a combination of the factors. We can possibly get rooting by varying some of those but there has to be a balance. I think the temperature, high temperature, higher than most people are using, is partially responsible and the mist system. I was using 45 seconds per minute mist, which is more than most people are using.

MR. HUROV: You didn't have shade?

MR. GRIGSBY: No shade. I think that had a lot to do with it.

MR. FLEMER: On the pine business, about 25 years ago at the Yale School of Forestry they did a great deal of work in rooting white pine from cuttings. What they were trying to do was select plants which were highly resistant to blister rust, which was then a big problem in Connecticut and they developed seed orchards which would give them rust-resistant seedlings. They found an enormous clonal variation in rooting ability. Cuttings from certain trees which were selected would root as high as 75 or 80 percent and with certain other trees which didn't seem to differ in any way, would only root 3 or 4 percent. But with all of the trees tried, the cuttings taken from the lower third of the tree rooted much better than those from any higher portion. In other words, the rooting got progressively worse as you went from the bottom of the tree up to the terminal leader.

MODERATOR GALLE: I believe we have used up nearly all our time. We want to thank all the members of the panel this morning.

THURSDAY AFTERNOON SESSION

December 7, 1961

The second session convened at 1:30 o'clock, President Van Hof presiding.

PRESIDENT VAN HOF: We are ready to go ahead with our program again and I am happy to present to you Dr. Charles Hess, Purdue University. I think he talked on this subject last year, and this is a continuation.

CHARACTERIZATION OF THE ROOTING COFACTORS EXTRACTED FROM HEDERA HELIX L. AND HIBISCUS ROSA-SINENSIS L.

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Following the discovery of four root promoting substances in the easy-to-root juvenile form of Hedera helix. L. and the red flowering Hibiscus rosa-sinensis. L. (2), a procedure was developed to isolate and purify the substances in larger quantities. The rooting cofactors will be referred to by numbers, ie., cofactor 1, etc. The basis of the numbers was the relative position of the cofactors on a chromatogram developed in isopropanol and water (8:2 v/v) solvent system. The R_f values of the cofactors in this solvent system were as follows: cofactor 1, 0.0-0.13; cofactor 2, 0.33-0.53; cofactor 3, 0.60-0.73; and cofactor 4, 0.80-0.93.

Materials and Methods

Figure 1 shows the procedure which was developed to separate the cofactors in larger quantities than was possible with paper chromatography. A methanolic or ethanolic extract of lyophilized tissue from juvenile Hedera or red Hibiscus was evaporated to dryness. The dried residue was taken up in a mixture of 25cc of chloroform and 25cc of water and was transferred to a separatory funnel. The upper, water, layer contained cofactors 1, 2 and 3. The lower, chloroform, layer contained cofactor 4 and the chlorophyll pigments.

Cofactor 3 was separated from cofactors 1 and 2 by adjusting the pH value of the aqueous layer to 3.5 and then partitioning with ether. The upper, ether, layer contained cofactor 3. Up to the present cofactors 1 and 2 have been separated only by paper chromatography.

After partitioning cofactor 4 was purified by one of two methods. The chloroform fraction was concentrated and applied to a paper chromatogram, and a solvent system consisting of methanol and water (7:3 v/v) was used for development. The chlorophylls stayed at the origin and cofactor 4 moved to an R_f value of 0.73. An alternative method the chloroform fraction was passed through a column of Darco G-60 charcoal mixed with celite (Johns-Manville filtering aid). The two parts charcoal and one part celite on a weight basis were used. Most of cofactor 4 in the extract passes through the column in the clarified chloroform. Recovery was improved by flushing the column with a few portions of fresh chloroform after the initial extract had passed through the column. The clarified chloroform containing cofactor 4 was concentrated under vacuum to a few cc. The small amount of extract was then transferred to approximately 0.25 gm of sillica gel and evaporated. The sillica gel containing the extract was then placed on top of a 1 X 12 cm column of silica gel and the column was developed with a 7:3 (v/v) mixture of methanol and water. When the eluate was collected in 3 cc fractions, cofactor 4 was eluted in the third fraction.

Chemical and Physical Characteristics of Cofactor 4

Cofactor 4 is an oily, yellow liquid at room temperature. It is only slightly soluble in water, but is soluble enough to be physiologically active. An aqueous solution of cofactor 4 is slightly acid. The solubility of cofactor 4 in other solvents is presented in Table 1.

Cofactor 4 has an outstanding deep blue fluorescence in ultraviolet light (254 mu) but does not have a characteristic ultraviolet absorption curve. Only end absorption was obtained. Cofactor 4 was subjected to a number of reagents. The procedure was to spot a small amount of the cofactor on Whatman No. 3 mm paper and spray the area with a reagent. The reagents and the results are presented in Table 2.

Biological Activity of Compounds Structurally Related to Cofactor 4

From the solubility characteristics, the fact that cofactor 4 was slightly acid in aqueous solution, the positive reactions with diazotized sulfanilic acid, and the coupling reaction with B-napthol, there was an indication that cofactor 4 was an aminophenol. Ortho aminophenol was tested in the mung bean rooting test and did have activity. The question was then asked whether the amino group or the dydroxyl group affected the promotional activity. To answer this question o-amino phenol was compared with aniline, phenol, anthranilic acid, and catechol. All compounds were supplied to the cuttings in combination with IAA at 5×10^{-6}M. A range of concentrations was used for each compound although only one concentration is shown in Figure 2. The average number of roots in the 5×10^{-6}IAA column was used as the control.

As can be seen in Figure 2 aniline did not have any activity and may have been slightly inhibitory. Phenol did promote rooting slightly, and anthranillic acid had no activity. It was concluded that the amino group on the benzene ring did not affect biological activity insofar as promoting root initiation was concerned. However, the hydroxyl group did affect activity, particularly when two hydroxyl groups were present as in catechol.

Next the activity of other di- and trihydric phenols was determined. As can be seen in Figure 3 the position of the hydroxyl group determines whether or not a phenolic compound will stimulate root initiation. Resorcinol, hydroxyl groups in the meta position and hydroquinone, hydroxyl groups in the para position, were not active. Pyrogallol having three hydroxyl groups in a vicinal arrangement was highly active. Phloroglucinol, with a symmetrical arrangement of the hydroxyl groups, was not active.

Caffeic acid was included in the test because it was found in the extracts of Hedera and Hibiscus and from a structural standpoint seemed to meet the requirements for activity. However, even though there were two hydroxyl groups in the ortho position, caffeic acid was not active. This result suggested that perhaps the para position must be open in order for a compound to be biologically active in the rooting test.

To investigate this hypothesis several more compounds were tested. As can be seen in Figure 4, the para position must be free. Gallic acid with a carboxy group in the para position eliminated the activity of pyrogallol, and a hydroxyl group in 1,2,4- Benzenetriol eliminated its activity. Also, chlorogenic acid and caffeic acid were not active.

Therefore, structural requirements for a phenolic compound to stimulate root initiation are that at least 2 hydroxyl groups be present in an ortho relationship and that the para position must be free. The mode of action of catechol and pyrogallol are presently under study. As can be seen in Table 3, although catechol will stimulate root initiation alone, it reacts synergistically with IAA. Since the mung bean is a rich source of phenolase enzymes and since catechol is readily oxidized to a quinone it may be possible that oxidation of the ortho-dihydroxy phenol is one of the first steps leading to root initiation as suggested by Bouillenne and Bouillenne-Walrand (1). Furthermore, Leopold and Plummer suggest that IAA forms addition products with quinones produced by the action of phenolases upon catechol and other phenols (3). In order to determine if oxidation of catechol is one of the first steps, 2 phenolase inhibitors (4-chlororesorcino and diethyldithlocarbamate), and two reducing agents (ascorbic acid and cysteine) were added to the incubation solution. In other experiments the inhibitors and reducing agents were used to pretreat the mung bean cuttings prior to incubation with catechol or catechol and IAA. In either case the activity of catechol or catechol plus IAA was not reduced.

The question of the mode of action of catechol remains to be answered as does the identity of cofactor 4. Although the R_f's of catechol and cofactor 4 are similar, the ultraviolet absorption spectrum of catechol is entirely different from the end absorption obtained with the cofactor. Solubility characteristics are also different. However, preliminary information from infrared analysis indicates that hydroxyl groups are present in the structure of cofactor 4.

Summary

A procedure for purifying the rooting cofactors obtained from Hedera and Hibiscus is described. The chemical and physical data obtained to date suggest that cofactor 4 is a phenolic compound. It is shown that in order for a phenolic compound to be biologically active in the mung bean rooting test, an ortho-dihydroxy structure with an open para position is required. Although indirect evidence suggests that the first step in the stimulation of rooting by catechol is oxidative, phenolase inhibitors and reducing agents have not reduced the biological activity of catechol.

TABLE 1

SOLUBILITY CHARACTERISTICS OF COFACTOR 4 AT ROOM TEMPERATURE

Heptane	Insoluble
Petroleum ether	Insoluble
Carbon tetrachloride	Soluble
Benzene	Soluble
Chloroform	Soluble
Ether	Soluble
Acetone	Soluble
Ethanol	Soluble
Methanol	Soluble
Water	Very slightly soluble

TABLE 2

REACTION OF COFACTOR 4 TO SEVERAL REAGENTS

Reagents*	Result
Diazotized Sulfanilic Acid	Red Color
Coupling with B-anphthol	Pink Color
Sucrose in HCl and Ethanol	Red Color
$FeCl_3$ Solution	Slight grey color
Nitrobenzenediazonium Fluoroborate	Brown changing to red

*From Block, R. J. et al. 1958. A Manual of Paper Chromatography and Paper Electrophoresis Academic Press, Inc., New York. 710 p.

TABLE 3

REACTION OF CATECHOL WITH INDOLEACETIC ACID (IAA)

Treatment	Ave.No. of Roots Per Cutting
H_2O	7.3
IAA 5 X 10^{-6}M	16.0
Catechol 2 X 10^{-4}	27.3
Catechol + IAA	55.1

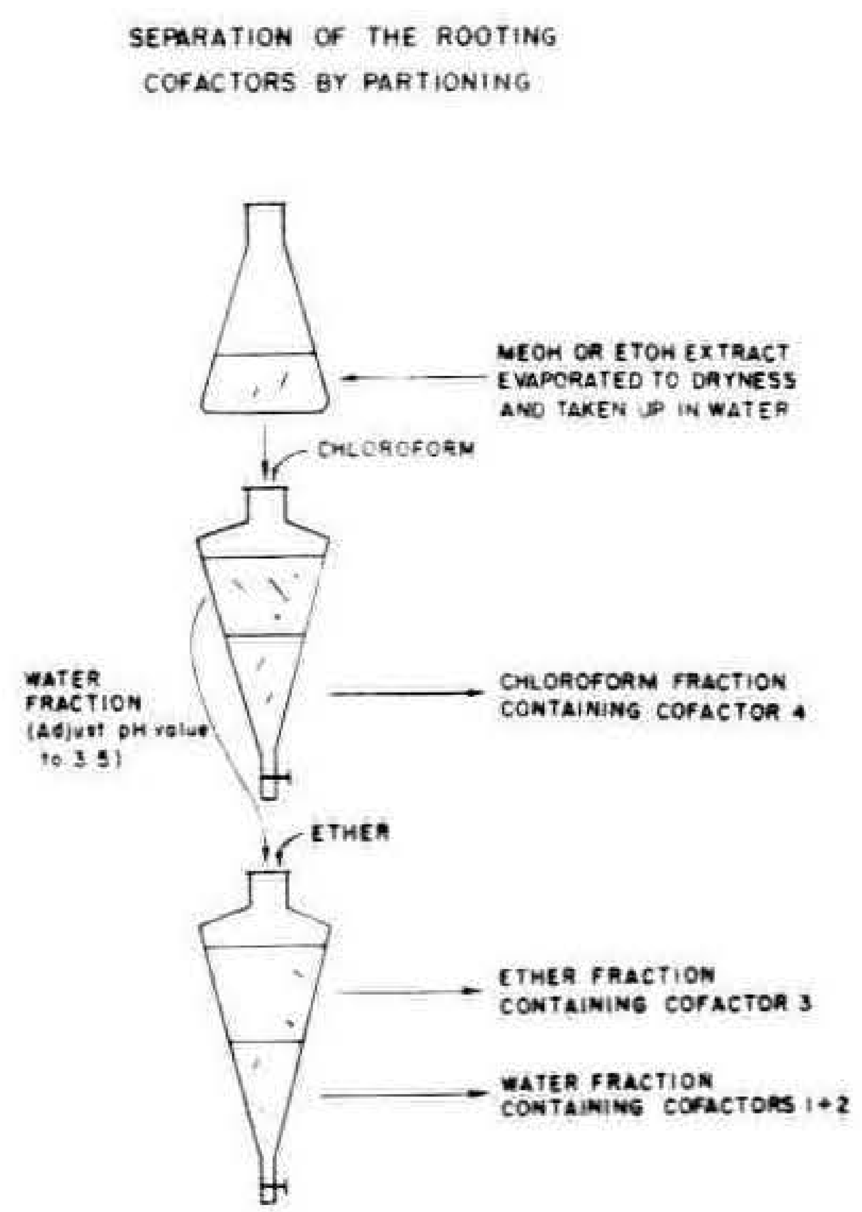

Figure 1

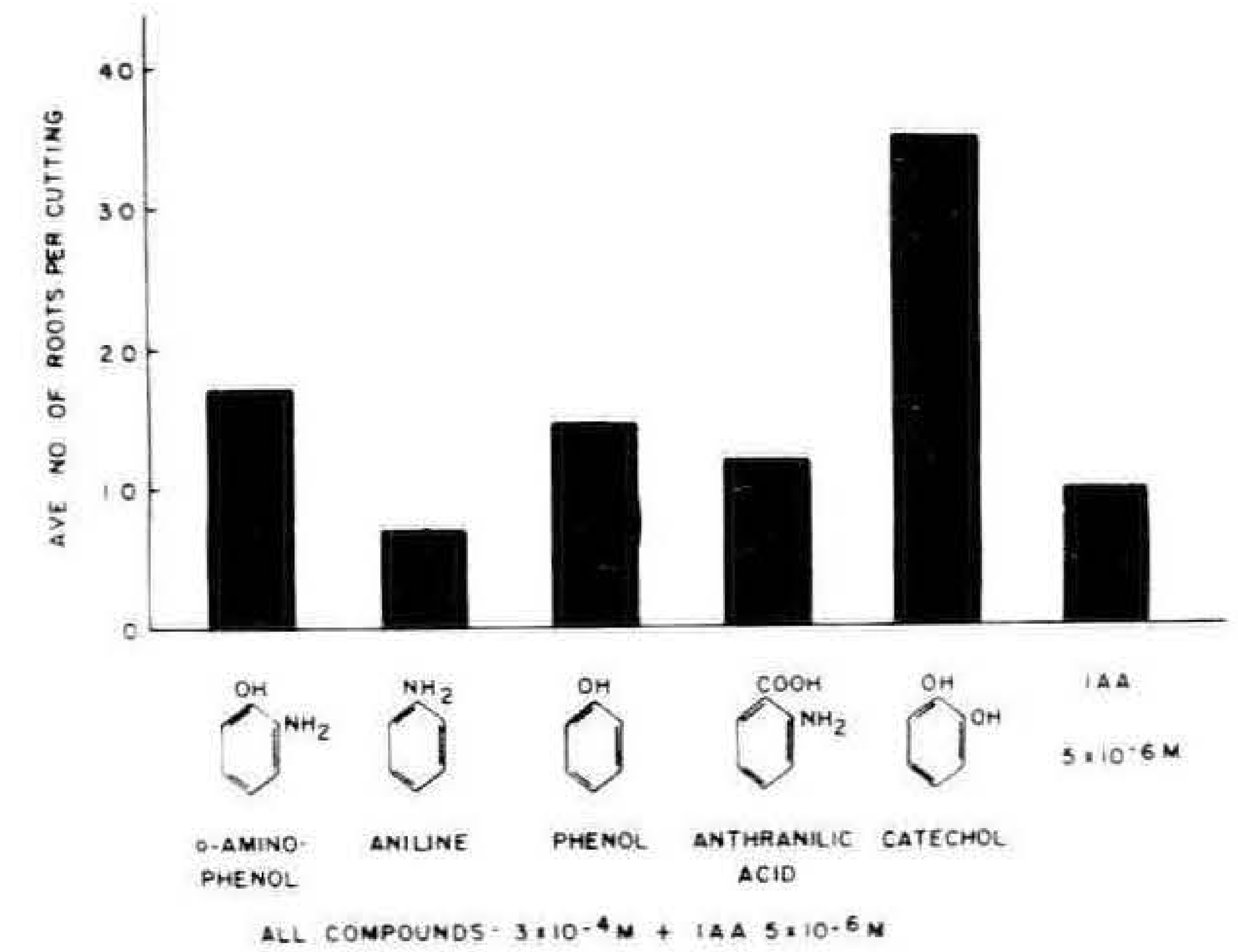

Figure 2
The effect of amino and hydroxyl group substitution upon root initiation in mung bean cuttings.

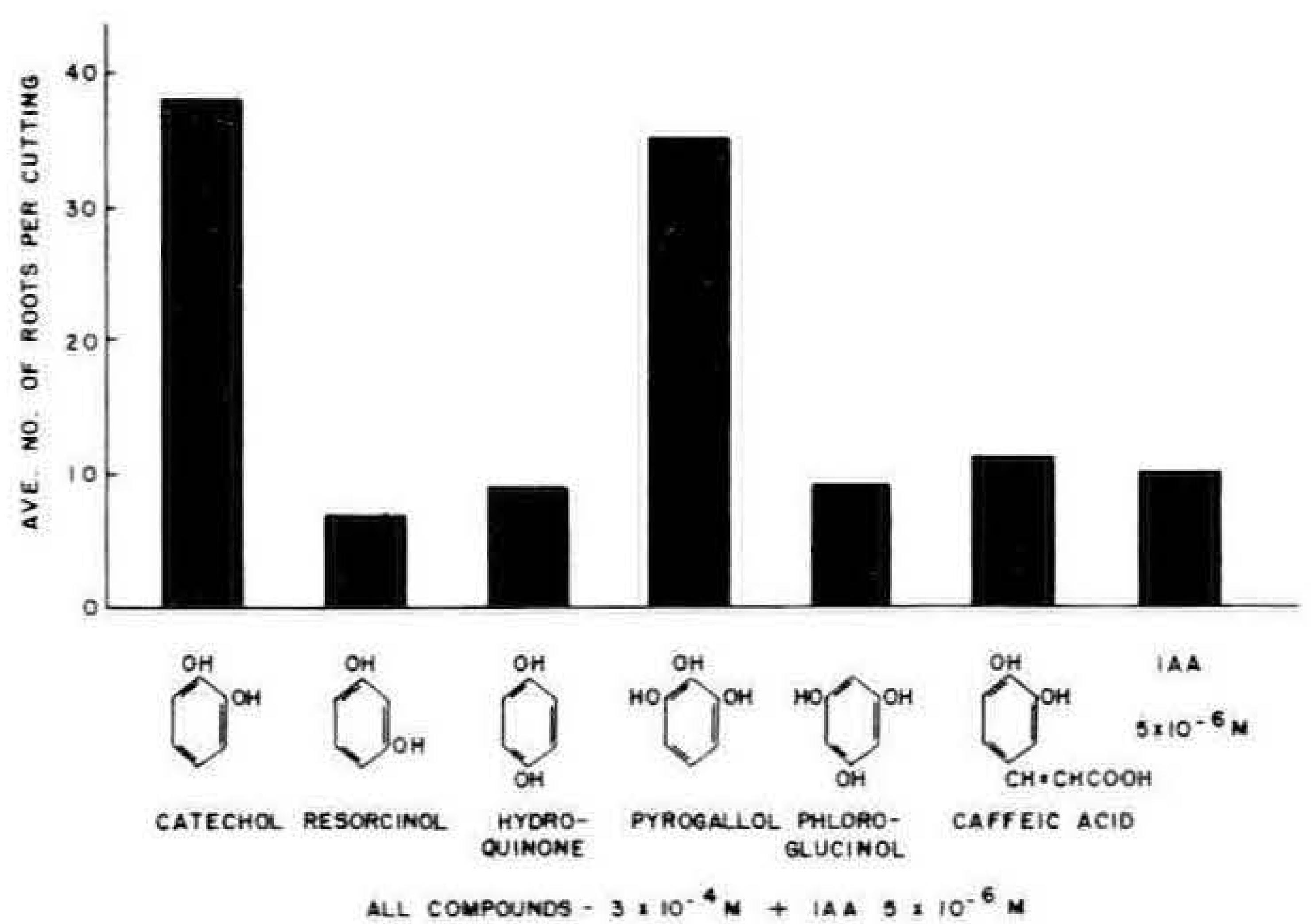

Figure 3
The effect of the position of hydroxyl group substitution upon root initiation in mung bean cuttings.

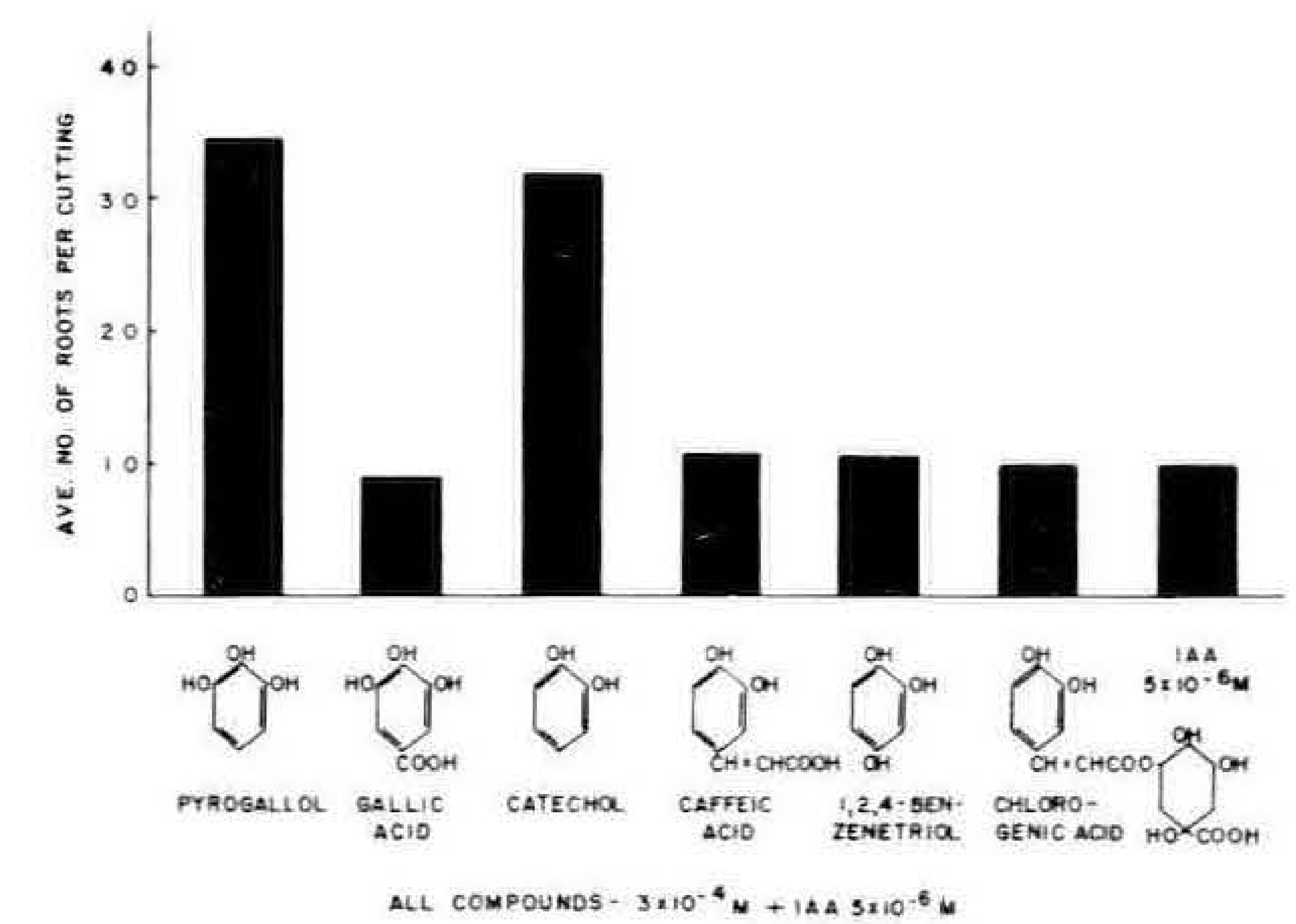

Figure 4
The effect of para substitution upon root initiation in mung bean cuttings.

Literature Cited

1. Bouillenne, R. and M. Bouillenne-Wairand. 1955. Auxines et Bouturage. Report 14th Internat. Hort. Congress, Vol 1: 231-238.

2. Hess, C. E. 1959. A Study of Plant Growth Substances in Easy and Difficult-to-Root Cuttings. Proceedings Plant Propagators Society, Vol 9:39-45.

3. Leopold, A. C. and T. H. Plummer. 1961. Auxin-Phenol Complexes. Plant Physiology 36:589-592.

PRESIDENT VAN HOF: Are there any questions?

MR. ROBERT HARE (Long Beach, Miss.): Have you tried the fourth cofactor itself?

DR. HESS: Most of the work so far has been on using the mung bean, although we have had some experiments with it on chrysanthemum.

If a plant is very difficult-to-root it will lack probably all of the cofactors, and if it is intermediate in rooting ability, it may lack two or three out of the four. When we reapply the cofactor, whether we get a response or not is dependent on whether that is the cofactor which is missing. In other words, we feel that we won't really have the complete answer until we have all of the cofactors identified and reapply all of them simultaneously.

MR. RONALD DeWILDE, JR.: Do you feel other species would have additional factors?

DR. HESS: We have checked Hibiscus, chrysanthemum and Hedera, and we find in all these tissues the four cofactors. We have been working with the fourth cofactor primarily from two plants. Hedera and chrysanthemum turn out to have a large amount of the fourth cofactor. We find there is a slight difference in the two. Whether this will affect the promotive ability of the cofactor, we don't know as yet.

MR. ROBERT HARE: Apparently the mung bean is deficient in all four cofactors.

DR. HESS: That is true. It has a small amount of cofactors present. Some have to be present in order to get expression of a single cofactor.

PRESIDENT VAN HOF: Next on our program is Wyatt Osborne, who is going to tell us all about soil sterilization.

DR. WYATT W. OSBORNE: Thank you, Mr. Chairman, Ladies and Gentlemen: It is a pleasure to be here and I listened with great interest to Dr. Hess' presentation on the cofactors that influence the rooting of plants. My work, I think, is vital in the rooting of plants. I couldn't help but reflect upon it at the time he made his presentation. My work at VPI is in the field of plant pathology and nematology, that particular field of proper protection from various plant diseases.

Dr. Osborne presented the following paper.

SOIL STERILIZATION AND FUMIGATION

W. W. Osborne
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Blacksburg, Virginia

Plant diseases become a limiting factor where plant propagation areas are used intensively. There are four general groups of causal agents of plant diseases; fungi, bacteria, nematodes, and viruses. Following are some pertinent characteristics of each of these disease producing organisms. Fungi - generally microscopic, filamentous organisms that reproduce by spores (seeds), commonly air borne. Spores produce germ tubes that may penetrate directly into the plant tissue or through natural openings or wounds, and cause infection. Bacteria - microscopic, one-celled organisms which cannot withstand desiccation. None of the plant disease bacteria produce spores, thus they cannot remain alive while being carried great distances in the air as can fungi. Bacteria enter plants through natural openings or wounds. Nematodes - Eel-shaped, microscopic organisms that may inhabit the soil in immense numbers. They require water for movement. Most frequently injury is caused by feeding in or on the roots but some can infect the upper part of the plant. Nematodes reproduce by eggs. They are not commonly transported by wind as are fungus spores. Viruses - Submicroscopic entities which must be transported from plant to plant by man's activities or by insects or mites. Viruses cannot penetrate directly but must be placed into a wound or injected during insect feeding. So far as is known, viruses cannot multiply outside their host plants or insect vectors and in some cases become non-infectious when the host plant dies.

Many disease causing organisms referred to as soil inhabitants are capable of residing in the soil for a period of several years, without access to its host. This is especially true of certain fungi; notable examples being *Rhizoctonia* the principal cause of seedling camping-off and stem canker, *Fusarium* and *Verticillum* which cause wilts and *Pythium* which causes damping-off and root-rot of seedlings and cuttings of susceptible plants. Other organisms, called soil invaders, do not persist as long in the soil. Many of them survive only as long as the host material, either living or dead, persists as a substrate for their existence. When these disease organisms are not eliminated from the soil plant growing, at best, is an inefficient operation that does not realize the maximum profit potential.

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PEST CONTROL WITH HEAT

Heat is considered by many authorities to be the most effective disinfectant for the destruction of pests in soils. Nematodes are killed when exposed to 120° F. for 30 minutes. Most plant disease-causing fungi are killed at 140° F. for 30 minutes. All disease-causing bacteria and most viruses are killed at 160° F. after the same period. Weed seeds are usually killed at 180° F.

Dry Heat Treatments

Dry sources of heat such as flame and electricity are being used to a limited extent. Newhall and Nixon (3) discuss methods of disinfesting soils by electric pasturization when steam is not available. Portable oil or kerosene burning "flame pasturizers" are now being marketed. One such apparatus consists of a heated, hexagonal, slightly sloping cylinder, 20 inches in diameter and 8 feet long, that revolves about 40 times a minute. A flame is directed into the lower end of the cylinder against the direction in which the soil moves. Soil shoveled in the upper end reaches a temperature of 175° to 190° F. as it drops from the lower end of the cylinder.

Steam Treatments

Steam is a very efficient source of heat and, therefore, is the best method of heat treating soil. It quickly kills all disease causing organisms, without causing injury to nearby plants or humans. Cole (2) reports that "While there are many methods of applying steam to soil, in each case its movement is by diffusion through the continuous pores of the soil to the cold area where it condenses. Although a temperature of 180° F. for 30 minutes is recommended to destroy pests, to reach a 180° F. in the coldest corner of a stationary soil mass, most of the soil will have had to reach 212° F. To steam soil at less than 212° F., moving soil and mechanical mixing of steam and soil must be used, or equipment must be built for producing steam-air mixtures of less than 212° F.

When steam under pressure is released into a stationary soil mass which is at 70° F., the steam expands and drops to atmospheric pressure and 212° F. temperature. It condenses quickly on the cool particles at its point of entry. Condensation continues and the temperature of the soil at that point rises, from the heat being released, until 212° F. is reached in the area next to the outlet, the steam accumulates and moves on through the soil pores to condense on the next cooler zone. The temperature rises as the air is pushed out until 212° F. is reached, at which time the pores contain all steam.

Steam moves upward through soil about twice as fast as it does downward or sideways. A given soil has a maximum rate for condensing steam and, if the steam input exceeds this rate, "blow outs" occur. Once a "blow out" of steam from the soil occurs, steam is bled from the rest of the treatment area and heating is greatly reduced. Greatest efficiency is obtained at just below this point, through balancing the steam flow rate and the quantity of the soil treated.

Since steam penetrates very poorly into compacted soil, benches or beds should be thoroughly cultivated to the desired treatment depth. All clods and lumps should be broken up. Soil moisture, in excess of that required for good planting tilth, decreases efficiency because wet soil requires more heat to reach the same temperature and the reduced pore space slows steam passage.

Treatment Methods

Buried Tile Method

This is a very efficient method of treating soil in greenhouse benches, beds, or outdoors. It consists of placing three or four inch clay drain tiles in rows 18 inches apart and 12 to 16 inches deep in soil to be treated. Steam is released into the tiles until a soil temperature of 180° F. is maintained in the coldest corner for 30 minutes.

Surface (Thomas) Steaming

Steam is applied to a covered area of the soil surface, and diffuses downward through the pores. Disadvantages in this method are: 1) steam moves less rapidly downward than upward through the soil, 2) soil conditions must be ideal for effective penetration of the steam, 3) provisions must be made for the escape of air from the soil pores as it is displaced by steam, therefore, this method is generally not as effective as the buried tile method.

Vault Steaming

Containers of soil are steamed in a chamber tight enough to hold steam but not so tight as to allow a pressure build-up. Containers should be separated by ½ inch in each direction to permit ready flow of steam. The chamber can be modified for bulk soil steaming by placing tiers of steam pipes throughout the chamber. The design should be such that no soil is more than six inches from a steam outlet.

Steam Rake

Steam is released into the soil through pipes attached to vertical chisels mounted eleven inches or more apart on a hollow steam header pipe. A powered winch draws the device through the soil at the rate of 6-8 inches per minute. Baker and Olsen (1) have found this device to have the following disadvantages: "Because steam is released at points eleven inches or more apart, the rake must not be moved forward so fast that the expanding spheres of steam do not have time to meet, or else strip treatment will result. Practically, this means moving only 6-8 inches per minute. The large volume of steam is injected into a small volume of soil and the condensing capacity of the soil is frequently exceeded, with consequent "blow outs". In clay soils the trailing pipes tend to form mud tubes which conduct the steam to the rear and away from the area to be heated. It is impractical to increase forward speed by decreasing the distance between chisels, because this would increase the mechanical drag and cause soil to pile up ahead of the header pipe. This device, although presently much used, is likely to be dropped because of its deficiencies."

Steam Blade

This device is currently being developed in Holland and California. Steam is released from the trailing edge of a horizontal flat blade which is moved through the soil at depths of 12 to 16 inches. The soil surface is heated by steam released under a trailing surface tarp. Forward speed of the steam blade can be increased over that of the steam rake because of the large area of contact between soil and steam released from the blade. The steam blade is reported to have a high thermal efficiency.

PEST CONTROL WITH CHEMICALS

Steam sterilization is recognized as the most effective means of disinfesting soil; however, the use of chemicals has gained wide acceptance under certain conditions. Fumigants offer an effective and practical means of controlling certain soil-infesting pests in large outdoor areas and locations where steam sterilization is not available.

Chemical soil fumigants are not effective against all types of disease organisms. The value of fumigants used to control certain wilt diseases caused by fungi such as *Verticillium* or *Fusarium* is doubtful except where chemicals are used at high concentrations. Generally the efficacy of a fumigant also is governed by soil type, temperature, and moisture. Most fumigants are toxic to animals and plants and cannot be used in enclosed areas. Fumigants generally require a waiting period to elapse between treatment and planting. Several fumigants, even after an adequate airing or waiting period, leave a residue which is toxic to certain crops. One major disadvantage of fumigants is that generally they are not effective when used at a soil temperature below 50° F.

Methyl bromide is highly effective against nematodes, weeds, and certain damping-off organisms such as *Pythium*, *Rhizoctonia* and *Fusarium*. It can be applied to beds of well prepared soil by covering the area with a plastic tarp and injecting under the cover 2 pounds of the compressed methyl bromide gas for each 100 square feet of bed surface treated. Soils containing a high content of organic matter will require double this amount. Improved liquid methyl bromide solutions may be injected into the soil using mechanized metering equipment. After application of the fimigant the plastic tarp should remain in place from 24 to 48 hours. After the cover is removed, the soil should be aired for 3 to 14 days before planting. One should read the manufacturer's directions carefully before applying methyl bromide.

Chloropicrin

Chloropicrin (trichloronitromethane) is sold as a liquid in cylinders or in aerosol self-emptying containers. Because of its high cost this material is used mostly for fumigating potting soil, or soil in greenhouse benches and seedbeds. When properly applied at adequate rates it is effective against nematodes, most weed seeds, and all except a few of the more resistant fungi. For maximum effectiveness, measures must be taken for confining the gas, such as sprinkling the treated area with water or placing over it a gas-tight cover. Chloropicrin is toxic to animals and plants; a gas mask is essential when it is used in the greenhouse and all plants should be removed from the area being treated. No harmful residues are left in the soil.

Formaldehyde

Formaldehyde is relatively inexpensive and generally available as a 40% solution in water known as formalin. A formaldehyde liquid drench may be used for treating benches, beds, and hotbeds. The drench is usually prepared by diluting 1 gallon of commercial formalin with 50 gallons of water. It is effective against most disease producing fungi and bacteria but in the usual strength is ineffective against nematodes. After application the soil should be covered with a gas-tight cover for 24 hours. After removing the cover the soil should be aired for 10-14 days. Formaldehyde may cause irritation to the skin, eyes, nose, and throat. Avoid prolonged breathing of the fumes and use in well ventilated areas.

Vapam.

Vapam is formulated as a water solution containing sodium methyl dithiocarbamate. This material can be readily diluted with water and applied as a drench, in irrigation water, or by injection into the soil. It is said to have herbicidal, fungicidal, and nematocidal properties. After application Vapam produces a gas which diffuses through the soil. Immediately after applications the soil should be watered at a rate sufficient to wet the soil to a depth of 4 inches to form a water seal and thus prevent the escape of the gas. Three weeks should elapse between treating and planting. Soil temperatures should be at least 50° F. for treatment.

Mylone

Mylone is the trade name for a white, crystalline solid, identified chemically as 3,5-dimethyl-tetrahydro-1,3,5,2H thiadiazine-2-thione. It is reported to be effective for controlling nematodes, fungi, soil insects and weeds. The usual application rate is 3/4 lb. of 85% Mylone to 100 square feet (300 lbs. per acre). Mylone may be applied to the prepared bed in the dry form using a fertilizer spreader and rototilled into the soil, or it may be suspended in water and applied to the soil surface as a drench. Regardless of the application method, the soil surface should be irrigated after chemical application with 150 gallons of water for 100 square yards of treated area. Three weeks should elapse between treatment and seeding; a longer waiting time is required when the soil temperature is below 60° F.

CHEMICALS USED ONLY AS NEMATOCIDES

One of the most recent and economically important technological advancements in plant pathology has been the discovery of nematocides which give effective and practical control of soil-borne plant parasitic nematodes. The chemicals previously mentioned possess nematocidal, fungicidal, and herbicidal properties whereas chemicals listed under this topic are effective only in controlling diseases caused by soil-borne nematodes.

CHEMICALS USED ONLY AS PRE-PLANTING TREATMENTS

Dichloropropene-Dichloropropane Mixtures and Dichloropropenes

These materials, marketed under various trade names, are very effective nematocides. They are prepared as liquids and may be applied with any of the common soil chisel injectors or on the plow sole as the soil is plowed. The dosage rate is generally 20 gallons per acre (over-all treatment) at a cost of approximately $30 per acre for the chemical. Soil temperature at time of chemical application should be from 40-80° F. Two weeks should elapse between fumigation and seeding.

Ethylene di-bromide

This material is an effective liquid soil fumigant which is applied with injection chisels or plow sole applicators. Dosage recommendations range from 20 to 4.5 gallons per acre depending upon the formulation, soil type, and in the row or over-all treatments. The cost per acre is approximately the same as for the previously mentioned nematocides. A 2-3 week waiting period should elapse between treatment and planting. Soil temperatures should be above 40° F. This material cannot be used for certain bromine-sensitive plants like onions.

Chemicals Used Both as Pre-Planting and Post-Planting Treatments:

Dibromo Chloropropane

This material is sold under various trade names. Formulations of liquids emulsifiable in water, and solid granules are available. The relatively low degree of phytotoxicity of this material allows it to be used at both pre-plant and post-plant applications. It is an effective nematocide and has produced excellent results as pre-plant treatment as well as when used to control nematodes in established woody ornamentals. As with other fumigants, best results are obtained when this material is injected 6-8 inches deep in the soil. A water seal is not necessary; however, it is beneficial to slightly compact the soil surface to prevent a rapid escape of the gas. The rate of application depends upon the formulation used, soil type, species of plant being grown on the area to be treated, and time of treatment (pre-plant or post-plant). This information is generally available from the supplier or county extension agents.

Plants reported sensitive to dibromo chloropropane are beets, Fordhook lima beans, garlic, onions, peppers, sweet and white potatoes, and tobacco. This material is most effective when applied at soil temperatures in the 40^{o}-80^{o} F. range.

Zinophos (0,0-diethyl 0-2-pyrazinyl phosphorothioate)

This material is formulated as a solid granular, and an emulsifiable contrate. This material does not change into a gaseous state in the soil and is therefore not considered a fumigant. Zinophos is generally applied in a granular form to the soil surface and rototilled into the soil or it may be mixed with water to form an emulsion and applied to the soil surface as a drench. Recent research shows this material to be nematocidal and possess systemic properties. It is quite low in phytotoxicity and therefore may be used to control nematodes on established plants.

References:

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2. Cole, H., 1960. Soil sterilization fumigation. Mimeograph, Agricultural and Home Economics Extension Service of the Pennsylvania State University, University Park, Pennsylvania.

3. Newhall, A. G. and N. W. Nixon, 1935. Disinfesting soils by electric pasturization. Cornell University Agricultural Experiment Station. Bull. 636: 20 p.

4. Sanderson, K. C., 1961. The use of chemical fumigants on greenhouse soil. The Maryland Florist, No. 83. Edited at the University of Maryland, College Park, Maryland.

PRESIDENT VAN HOF: Are there any questions?

MR. JOHN ROLLER (Scottsville, Texas): What type of cover crop will eliminate nematodes?

MR. OSBORNE: I don't know of any cover crop that will eliminate all nematodes from the soil. There are a number of species of the root nematodes but they find most of these species are not capable of reproducing on grasses. Grasses may be used on rotation to help control it. However, grasses are preferred host for certain species of metanematodes.

MR. PETER VERMEULEN: Have you used sugar?

MR. OSBORNE: I noticed the report which may have some merit, but the amount of sugar that would have to be used would be prohibitive in cost.

MR. ARIE JAN RADDER (Bloomfield, Conn.): I have used nematocides but the soil temperature should be above 50° F.

MR. OSBORNE: I failed to mention that most of the fumigants, the soil temperature must be 50° F. or above for the most effective control measures.

MR. WELTY: I understand you have to have quite a long aeration. Isn't this something like a month or so?

MR. OSBORNE: Yes, that is another aspect I failed to mention. With the fumigants there is a waiting period required. In my own laboratory it would be at least three weeks and in a number of certain soil types and certain temperature conditions, it may be a matter of months you should wait before planting.

MR. WELTY: I understand it is longer with Vapam. At the end of three weeks by tilling it once a week after you put the Vapam on and once again before planting it is safe to plant.

MR. OSBORNE: Vapam, only three weeks.

MR. RICHARD H. FILLMORE (Durham, N. C.): I have observed among the herbaceous plants in the Sarah P. Duke Gardens, the growth of Tagetes (Marigold) doesn't seem to be inhibited in the least by nematodes. Neither does the Sempervivum or Salvia splendens. Those three will not be inhibited by nematodes. If my observations are correct, the slightest touch of a nematode on a Chrysanthemum and it just doesn't grow.

We have approximately 56 flower beds in the area in question and we try to work out a rotation so that we treat a dozen or more of those beds and plant them to Chrysanthemums and as they become infested we work them around the Salvia, Tagetes and other things. I know it is absurd to say so, but they almost seem to make Salvia grow faster, come out with enormous blossoms. For all practical purposes, they neither prohibit the plant vegetatively nor in flower. I wonder what the explanation could be for that.

MR. OSBORNE: The Dutch workers have made an extract which is being used in Holland around roses and other plants to reduce the nematode population.

MR. SHORE: Has anybody ever used red clover?

MR. OSBORNE: I think red clover is susceptible to a species of the root nematode as are most legumes. Nematodes will attack over 2,000 different plant species and legumes are quite susceptible.

MR. WILLIAM FLEMER, III (Princeton): Can you recommend a safe dip to dip the roots of bare root linears prior to planting that will kill nematodes on and in the roots?

MR. OSBORNE: I have used a number of materials as a root soak in an effort to eliminate the nematodes from the root system of living plants. Of the materials that I used so far the most effective has been the DBCP material but there was not absolute control of the nematodes. The population was greatly reduced but I didn't control them entirely. In other words, to my knowledge there is no eradicator available at the present time.

MR. RALPH SHUGERT (Neosho, Mo.): Sir, is there a relationship between crown gall and a nematode?

MR. OSBORNE: I don't know of any correlation between the two.

MR. DICK ANDREWS (Faribault, Minn.): Of the three materials, Vapam, methyl bromide, and Mylone, is any one of those superior to the others as far as weed control is concerned?

MR. OSBORNE: With my experience I have gotten better control using methyl bromide than we have using the other two materials. There may be some reports in the literature contradictory, but I know methyl bromide is very effective as a weed control.

MR. ANDREWS: Do you have to use methyl bromide stronger when you want to get rid of weeds?

MR. OSBORNE: One pound per 100 square feet would kill nematodes and give effective weed control.

QUESTION: You mentioned the nematode. Every nurseryman would not have a microscope. Would it not be feasible to take a portion of tissue that you suspect of having nematodes and put it in water 24 hours and see the nematodes?

MR. OSBORNE: I don't think I would be able to determine what species. All you would see would be a rather turgid solution or suspension of nematodes in the water.

SAME QUESTIONER: That would establish the fact that you had nematodes.

MR. OSBORNE: Most of the states now will offer a service either from a research or extension responsibility of running assays to determine whether or not nematodes are present. We offer this service in Virginia and I know a number of other states are offering this service. What would be required to determine whether or not you had a nematode problem would be your checking a plant which you think may be infested with nematodes, and digging the plant with the root system and the soil adhering to the roots. It should be enclosed in a plastic bag or some similar material that would prevent it from drying out while being transported to the laboratory. From that sample we would be able to extract the nematodes and tell you which species are present and also give control recommendations.

MR. JIM WELLS: You said, I think I am right, that steam was the best method of sterilizing and fumigating and eliminating the trouble.

MR. OSBORNE: I consider steam to be the best method of controlling the various disease organisms in the soil if applied properly.

MR. WELLS: Well, I read a report in an English paper recently that tests were made over there in greenhouses where they are troubled with all manner of things which indicate that Vapam is the nearest approach to steam sterilization that we have.

MR. OSBORNE: The nearest approach to steam sterilization or the comparable?

MR. WELLS: That Vapam is the nearest approach. It achieves the nearest similar effect to steam of anything yet available.

MR. OSBORNE: I don't know. I would like to read that paper. I would like to know the method of application.

MR. WELLS: It was exactly as you described it. They were putting on Vapam diluted with water, rototilled in, and sealed with water. They stated that in their opinion this achieved the same result in a greenhouse as steam.

MR. OSBORNE: I am not questioning their results but I would like to read the paper to know the method of application. Perhaps they are using certain methods that have not been used in our experiments.

MR. WELLS: Let me rephrase then. With the work you have done, would you class Vapam as being equal to steam?

MR. OSBORNE: With the work I have done I don't consider it equal to steam.

DR. JOHN MAHLSTEDE (Iowa State University): I have often been disturbed by the recommendations we make. We say, for example, on methyl bromide we take a 3 foot bed or a 5 foot bed and run our tarpaulin down and sterilize the soil with whatever chemical we might be using. What about the 3 foot path or 2 foot path you leave in between?

MR. OSBORNE: That is true, you would need to use some means to prevent bringing in of this untreated soil into the treated area. It is a matter of sanitation. In view of the limited migration activities of the nematodes, I don't think there would be a problem with the nematodes approaching the area in one year's time. It is mainly a matter of sanitation.

MR. AART VUYK: A moment ago the question was methyl bromide versus Vapam. We have tried both of them and the methyl bromide undoubtedly gives you better weed control but due to the work involved in treating a large area, the Vapam is better. You can apply it quicker and you don't have to bother with plastic cover.

PRESIDENT VAN HOF: Now we will continue with our interesting program, and it is a real pleasure to give you Dr. Wallace A. Mitcheltree to talk on Soil pH: What It Is, How to Measure It, and How to Change It. Dr. Mitcheltree is from Rutgers University.

THE MYSTERIES OF pH

Wallace A. Mitcheltree
Extension Specialist in Soils
Rutgers University
New Brunswick, New Jersey

"pH" means "potenz" Hydrogen or strength for Hydrogen. It is a German term devised by a German chemist to explain the measurement of acid in a media. pH is a chemical term and when one thinks in terms of Chemistry he must think in terms of Electricity and when thinking in terms of Electricity you think in terms of "plus" and "minus" electrical charges. We go back into our high school Physics, - we learned that there was a law in the study of magnetism that said, "Like poles repel each other and unlike poles attract each other". The same law holds in Electricity that "Like charges repel each other and unlike charges attract each other." Two magnets that are placed in such position that like poles are opposite each other repel each other and force one magnet away from the other. If the magnets are so arranged that the unlike poles are opposite each other, then there is an attraction and the two magnets are immediately attracted together.

In chemistry, for instance, water has the formula of H_2O. If it were written structurally it would be written as HOH. Water is written structurally as HOH because it is made up of Hydrogen which has a plus charge $H+$ and Hydroxal which has a negative charge $OH-$.

Hydrogen in the gaseous form as an element is an explosive gas. Hydroxal is a white, elusive liquid very few people have had the opportunity of seeing. It is an extremely unstable ion. When the Hydrogen and the Hydroxal are brought together, the positive charge of the Hydrogen attracts the negative charge of the Hydroxal and they immediately attach themselves to each other, forming a highly essential and relatively indestructible and extremely stable compound called Water HOH.

The essential component of all acid is Hydrogen. An essential component of all hydroxides or alkalies is Hydroxal. Water, therefore, has the main components of the two absolute opposites in Chemistry. It has the main component of acid which is Hydrogen $H+$ and the main component of an alkali which is Hydroxal $OH-$. Water, therefore, when pure, would have a neutral pH - a pH of 7.0 because it would have the same number of Hydrogens and the same number of Hydroxals.

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If we were to take the same Hydrogen ion that we had in Water and attach it to a Chloride ion, Chloride being the main component of Chlorine, which when in the gaseous form is a World War I poisonous gas, bringing these two together H+ Cl-, we form Hydrogen Chloride or Hydrochloric Acid HCl. If this Chloride had been attached to a Potassium ion K+Cl- it would have formed Muriate of Potash KCl or Potassium Chloride, which is a neutral salt. It is a Hydrogen in combination with Chlorine that forms the strong Hydrochloric Acid.

Another basic factor of Chemistry is the fact that these ions are in constant movement when they have the opportunity and are bouncing back and forth within the attraction zone of their various charges. In other words, if one were to pour some Hydrochloric Acid into a waterglass, the Hydrogen and the Chloride would not remain together but would operate separately, bouncing back and forth rather rapidly within the confines of the glass. We still, in this instance, have the same number of "plus" and the same number of "minus" charges even though they are not strictly combined into what we think of as a Hydrochloric Acid molecule. This separation and action of the ions, one to the other, is referred to by the chemists as "ionization" or "dis-association". In other words the ions disassociate from each other but remain within the confines of the container.

There are basically two types of acids - mineral acids and organic acids. The basic difference between these acids is that the organic acid is slightly ionized while the mineral acid is referred to as being highly ionized. Mineral acid, such as Hydrochloric Acid (HCl), Sulphuric (H_2SO_4) and Nitric HNO_3) are all highly ionized, almost completely dissociated and highly susceptible to reacting with some other ion that may be introduced into their midst.

The organic acids are slightly ionized, or in other words, do not split up or dissociate to the same degree as the mineral acids. When an organic acid is poured into a glass, a small number of the Hydrogens split up and operate separately, but the bulk of the acid remains in the molecular stage, not dissociated and not nearly as highly reactive when some other ion is introduced into the container. In the case of Carbonic Acid, H_2CO_3 less than half of one percent would probably ionize with a few single Hydrogen ions and a few single HCO_3 ions floating around, H+ HCO_3- and the bulk of the acid in the H_2CO_3 conbination.

Examples of organic acids are Carbonic Acid (H_2CO_3), Acetic Acid (CH_3-COOH) and Oxalic Acid ($HO_2C.Co_2H$). The strength of an acid is measured by the amount of Hydrogen in a given volume. In Chemistry a liter is a basic measure and when a gram milliequivalent of Hydrogen is in a liter of an acid, the acid is a normal acid or said to be 1 normal.

pH is a measurement of Hydrogen - ionized Hydrogen in a solution. The pH meter, through the use of electrodes or terminals, counts the number of free-floating Hydrogens in the solution. In other words, it counts the dissociates or the ionized Hydrogens that are not attached.

A highly ionized mineral acid of 1 normal strength, and a slightly ionized 1 normal organic acid would have identically the same strength and require the same amount of alkali to neutralize them. However, if one were to measure the pH in a mineral acid they would find that it would have a very low pH because the machine would show a great number of free-floating Hydrogen ions that had been dissociated or ionized whereas in the organic acid the pH meter would register a higher pH since there would be many less free-floating or dissociated Hydrogen ions. This is one of the basic differences, therefore, in the two types of acid, and it is a place where we frequently run into trouble when interpreting the pH of a soil. If a soil has been in sod for a great many years, had a good bit of raw organic matter plowed back and received very little if any, commercial chemical fertilizer, it is conceivable that a great deal of the acids in that soil would be organic acids, which would require a given amount of time to counteract. However, the pH meter would register a considerably higher pH than if this soil had been managed without organic matter and completely with commercial fertilizers that had created strong mineral acids in the soil, even though the total acidity was the same in both cases.

The expression of the measurement of pH in itself is not simple. We know the pH scale is a straight line divided into fourteen (14) equal parts running from zero to 14. Seven is in the exact middle of this scale and is a neutral pH. Everything from 7 down to zero is acid, getting progressively more acid as we approach zero; everything from 7 to 14 is alkaline and getting more alkaline as we approach 14. As we said when discussing the formula of Water, that Water had the same number of Hydrogens as it had Hydroxals and, therefore, it was neutral and has a pH of 7.0. A pH of 1 would have considerably more Hydrogen than Hydroxals in order to make the solution more acid. A pH of 13.0 would have considerably more Hydroxals than Hydrogens in order to make the solution more alkaline.

If we were to try to express this ratio of Hydrogen to Hydroxals in pounds or grams it would be extremely unwieldy, therefore, the chemists went to the mathematician and borrowed the logarithm scale. When we are working with something that is less than one (1), logarithms can be expressed as 1X10 to the minus sub-number, the sub-number meaning the number of digits to the right of the decimal point. In other words, 1X10-1 would give us a concentration of 0.1. 1X10-3 would give us a concentration of 0.001. In the case of 1X10-5, it would give us a concentration of 0.00001. In the case of 1X10-1, one could say that this is one-tenth of a percent concentration or one-tenth of a pound, or one tenth of a gram. 1X10-3, one could say that this is one-thousandth of a percent, or of a gram or of a pound. In the case of 1X10-5, one could say that it is one-one hundred thousandth of a percent, or a pound or a gram. This is unwieldy enough at this level, - what would it be and how would you designate 1X10-14, where it is written 0.00000000000001. The chemists who devised the pH scale therefore, took the sub-numbers off the 1X10- and made the pH scale of these numbers. Therefore, 1X10-1 shows a concentration of one-tenth of a percent Hydrogen and one times 10 to the -14 would be 0.00000000000001 percent Hydrogen. It now becomes evident that the larger the number on the pH scale the smaller the percentage of Hydrogen, because 0.0000000000001 is considerably less Hydrogen than 0.1 percent Hydrogen. The pH scale, therefore, becomes a reciprocal of the actual concentration and a pH of 1 is considerably more acid than a pH of 6. Another factor that will come out later in the discussion is that the amount of Hydrogen between 1X10-2 or 0.01 and 1X10-1 or 0.1 is not just twice as much Hydrogen but 10 times as much. In other words there is 10 times more Hydrogen in a pH 1.0 as in a pH 2.0.

How do we neutralize an acid? We take HCl, which is a mineral acid, highly ionized, with equal amounts of Hydrogen and Chloride, and we neutralize it with some alkali, which is an opposite to the acid. Let us take alkali commonly known to farmers, such as Calcium Cydroxide, which is really Hydrated Lime. If we put Calcium and Hydroxal $Ca^{++}OH^-$ together we find that something is wrong because the Calcium has two plus charges and Hydroxal has only one negative charge. You must, therefore, arrange for two Hydroxals to join with the one Calcium so as to have two negative charges counteracting the two positive charges of Calcium. $Ca\begin{matrix}OH^-\\OH^-\end{matrix}$ or $Ca(OH)_2$.

Now, if we have one molecule of Calcium Hydroxide and one molecule of Hydrogen Chloride to react together, we find that on the alkali side we have two plus charges and two negative charges and on the acid side we have only one plus and one negative charge. H^+Cl^- $Ca^{++}\begin{matrix}OH^-\\OH^-\end{matrix}$. Therefore, in order to balance the equation properly, we are going to have to use twice as much acid as alkali. $\begin{matrix}H^+\\H^+\end{matrix}\begin{matrix}Cl^-\\Cl^-\end{matrix}Ca^{++}\begin{matrix}OH^-\\OH^-\end{matrix}$ We now have two plus charges in the form of Hydrogen on the acid side, and two negative charges in the form of Chloride on the acid side; two plus charges in the form of Calcium on the alkaline side and two negative charges in the form of Hydroxal on the alkaline side. When these compounds react with each other, there is a simple exchange of the Calcium tying up with the Chloride and the Hydrogen tying up with the Hydroxal $Ca^{++}\begin{matrix}Cl^-\\Cl^-\end{matrix}$ $\begin{matrix}H^+\\H^+\end{matrix}\begin{matrix}OH^-\\OH^-\end{matrix}$ forming one molecule of Calcium Chloride with two plus charges and two negative charges, and two molecules of Water, each molecule having one plus charge of Hydrogen and one of Hydroxal, or a total of two plus charges in the Hydrogen form and two negative charges in the Hydroxal form. The results of this reaction now, instead of having an alkali and an acid, has a neutral salt, Calcium, Chloride $CaCl_2$ and Water, Hydrogen Hydroxal (HOH) which is neutral and has the same number of Hydrogen and Hydroxal charges which counteract each other. The strong acid now has been counteracted to a neutral compound with the use of a strong alkali. The same situation takes place in an acid soil.

Soil is made up basically of sand, silt, clay, organic matter, air, and water. The clay and the organic matter are chemically active and contain negative electrical charges. The negative electrical charges on the clay and the organic matter in the soil are satisfied by positively charged ions, such as Hydrogen, Calcium, Magnesium, and Potassium. If we have a soil that is very acid, these negative charges are predominantly loaded with Hydrogen, since Hydrogen is the main component of an acid. A particle of clay or organic matter can be visualized as having these negative charges around its outside surfaces and in soil there is a film of water around each one of these particles. This film of water acts very much as a glass of water and the Hydrogen, here in this particular case, operates exactly as it did when we poured the acid into a water glass. A certain amount of it dissociates and floats around separately within this film of water. In other words, the Hydrogen in this soil is ionized the same as it is in the water glass. When we check the pH of a soil, the pH meter does the same job here as it did in the water glass. It counts only those Hydrogens which are floating in the film of water separately.

We assume when we run the pH, therefore, that if there are a certain number of these Hydrogens floating around in the film, that there must be a certain given number Hydrogens attached to the clay or organic matter particle. This is an estimate that is made from past experience in working with soils and their chemical properties. The pH, therefore, does not give us the total acidity of that soil but it gives us the active acidity or the ionized Hydrogen and we must, from experience and knowledge, interpolate what we think is a reasonable number that would be attached to the clay and organic matter and then compute from these two, the actual measurement of the ionized Hydrogen and the assumed measurement of the attached or associated Hydrogen, as the total acidity of that particular soil. We therefore calculate the amount of Lime that would be necessary to raise the pH to where we feel would be desirable and then introduce this amount of alkali or Lime into the soil in order to do the job that we are trying to accomplish. In neutralizing an acid soil with a Hydrogen clay, we will use Calcium Hydroxide again, since the chemical reaction is a little less complicated and a little easier to understand. Normally, we recommend the use of Calcium Carbonate, but the Calcium Hydroxide reaction is a simpler reaction and is basically the same reaction that takes place and Calcium Hydroxide or Hydrated Lime is also a commonly used liming material. When Calcium Hydroxide is introduced into the soil, as liming material, the same reaction takes place as when we introduced it into Hydrochloric Acid.

$\begin{matrix} H^{+}\ Humate^{-} \\ H^{+}\ Clay^{-} \end{matrix}\ Ca^{++}\begin{matrix} OH^{-} \\ OH^{-} \end{matrix}$ The Calcium splits off from the Hydroxide and satisfies the negative charges on the Humate and Clay, the Hydrogen leaving the Humate and clay and going to the Hydroxide, forming water.

$Ca^{++}\begin{matrix} Humate^{-} \\ Clay^{-} \end{matrix}\ \begin{matrix} H^{+}OH^{-} \\ H^{+}OH^{-} \end{matrix}$ We now have a Calcium clay and Humate, which takes the place of the neutral salt, and water, which of course is neutral.

In order to ascertain the right amount of Lime to neutralize the acidity, this necessitates coping with another rather difficult problem. In order to determine the total acidity of a pH measurement we must know the amount of Humate and Clay that is in the soil. We find that a soil which has a pH of 6.0 to 6.5 has the negative charges satisfied with approximately 65 percent Calcium, 20 percent Hydrogen, 10 percent Magnesium, and 5 percent Potassium. Now then, if a soil has 55 percent Calcium, and 30 percent Hydrogen, our job is to reduce the Hydrogen and raise the Calcium proportionately. How much Lime does this take per acre?

In a heavy clay soil, there is generally a rather large amount of organic matter, due to the natural soil-forming processes. With a large amount of clay and a large amount of organic matter, we would therefore, have a considerable number of negative electrical charges. In a sandy soil, with a small amount of clay, again because of the natural soil-forming processes, we frequently have a relatively low amount of organic matter. This small amount of clay and a small amount of organic matter would, therefore, have a relatively small number of negative electrical charges. Let us take a "for instance".

If we had a soil with 100 negative electrical charges and were to raise the percent saturation from 55 percent to 65 percent we would have 10 negative electrical charges to change and this would require five (5) Calciums, since Calcium has two positive charges. Now, on the other hand, if we had a soil that had a thousand negative electrical charges, to raise that from 55 percent to 65 percent would be 100 negative electrical charges to replace rather than 10 and it would, therefore, require 50 or ten times as many Calcium ions to do the job.

There are ways of determining the number of negative electrical charges in a soil, but it is a very long, drawn out and difficult analyses. Therefore, through experience and research we have learned to estimate this, and someone with plenty of experience can estimate this relatively closely. It is, however, a variable that causes our liming recommendations to be not an absolute thing but a good calculated, educational guess.

Another factor that can be thrown into the pot as causing difficulty in trying to develop a perfect recommendation each time, is the fact that pH varies. It varies both from day to day and from place to place in the soil.

Soil is a natural, heterogeneous geologic body and anytime we work with a material of this nature, we find that there is considerable variation in it. The pH of a soil is a natural equilibrium which develops over millions of years. Man can change it temporarily but it will constantly fight to get back to its natural equilibrium. This can be compared to our outside weather or climate and a man building a house to protect himself from this weather and climate. If a man lives out in the weather and climate, at all times, he must adjust himself to this. He builds a house to protect himself from the rigors of weather and its changes. Just building a shell of a house does not prevent the temperature from the inside of the house being the same as the temperature on the outside, nor the inside of the house getting just as cold as it does outside. So, in the house, he puts a stove, which in turn heats the house. So long as he continues to bring in wood, and put it in the stove, he maintains a temporary change of temperature in the house from that outside. But the minute he gets lazy and does not bring in wood, and lets the fire go out, the temperature immediately reverts back to the equilibrium of the outside temperature. Now, when he does have the fire built in the stove in the kitchen, he has a certain temperature near the stove. But if he were to hang a dozen different thermometers in the living room, in the bedroom, and in the corners of the kitchen as well, he would find that no two thermometers would register the same temperature, because the heat has not been equally distributed throughout all corners of the house. It is true, it would be warmer in some of the corners, but not as warm as near the stove. This same affair happens inside of soils that have been limed. The temperature or the pH is not identically the same in all areas.

As this fire dies down and before he gets it rebuilt again, the temperature will drop and as soon as he adds more wood to the fire, it will immediately come back up, so his temperature is not constant; it varies from day to day and from hour to hour. The same is true with the pH of the soil.

Now, if one were to try to average the temperature in a house, he would read all of the thermometers, add up the total temperatures and divide by the number of thermometers and he would have the average temperature of that house. Remember now, that not all areas are the same, but he does now have an average temperature for his house, which is the thing we must do when making recommendations for using Lime on an acre of land. We must use the average conditions.

Since the pH, as we measure it, is not a straight arithmatical factor but that each pH is ten times greater than the pH next to it, we cannot add these and divide and come out with an average. Still, we must have an average pH for a field. The way we average the pH for a field is to take sub-samples in ten or 15 different places throughout the field, throw these samples of soil into a bucket and stir them up and mix them as well as possible, and then take a representative sample of these sub-samples. This we analyze and consider our average pH for the area. As you can see, it is highly essential and very important that a good average be made. Therefore, a good sample must be taken. If he were to take temperature readings near the stove, and have only one sample, he would certainly not have a very good average of the temperature of his house.

Just what does pH do in the soil? pH is the adjustment valve on the releasability of nutrients. In very acid conditions, Iron, Manganese, and Aluminum are extremely soluble and are highly available to the plant. They are so available to the plant that they become toxic to it and retard its growth. In a soil of a relatively high pH of between 7.0 and 7.5, the Iron, Manganese and Aluminum are thrown completely out of solution and become unavailable to the plant. At this point, instead of being toxic to the plant, the plant is suffering from a lack of nutrients and will have deficiency symptoms showing up and a retardation in growth. The only natural source of Nitrogen in soil is organic matter. At very low pH's, the microorganisms that decompose organic matter cannot function properly and, therefore, do not break down the organic matter very rapidly and consequently little natural Nitrogen is released. In extremely high pH's, the soil is too alkaline for the micro-organisms of the soil to function properly. Here again, organic matter is not broken down and we do not get the return to the natural Nitrogen from organic matter decomposition that we should.

At very low pH's when the Iron and Aluminum are extremely active, they react with the Phosphorus, forming Iron-Aluminum Phosphates which are extremely insoluble and unavailable to plants and the plant, therefore, suffers from the lack of Phosphorus. At an extremely high pH there is sufficient Calcium in the soil that the Phosphorus reacts with the Calcium, forming Tri-Calcium-Phosphate, which also is insoluble and unavailable to the plant.

When we adjust the soil with the use of Lime so that the pH lays between 6.0 and 6.5, we have just enough Magnesium, Iron, and Aluminum to satisfy the plant, yet it is not in toxic amounts. We have the most favorable microorganism climate and, therefore, the organic matter is decomposed most rapidly and we get our greatest return from Nitrogen release.

In a zone of 6.0 to 6.5 the Phosphorus is neither being tied up by Iron and Aluminum to any excessive amount nor is it reacting with the Calcium and it stays in the Mono- and Di-Caldium form which is readily available to plants. pH is, therefore, the adjustment valve in the soil. We adjust the soil by applying Lime and we measure our adjustment with the pH meter.

There is one other place where we do run into trouble in trying to ascertain the amount of Lime necessary to adjust the soil. Clay particles are thin plates and they resemble a stack of dinner plates. In certain soils these plates adhere very tightly together and between these plates are a large number of negative electrical charges and in an acid soil these negative charges are satisfied with Hydrogen. When Lime is added to the soil the Hydrogen from the outside of the "stack of plates" is removed and after the reaction is over, the reserve acidity between the plates is forced out to become active. The man could test the soil this year and find the pH to be 5.5, lime it, go back and test it next year, and find it had a pH of 5.5 again because the reserve acidity had come into play. He may lime it again and go back and check again later, and find the pH is still 5.5 because the reserve acidity has been pushed out. He might Lime again next year and suddenly find his pH goes up to something like 7.5 or 8.0, simply because all the reserve acidity had been removed and the total acidity of the soil was not nearly as great as ascertained by the use of the pH meter.

Someone who has had a lot of experience with soils can frequently determine this situation, explain it to the farmer beforehand and then allow a little longer waiting after an application of Lime has been made. In this particular case the equilibrium adjustment is slower and must be accounted for.

The acidity of soil is an extremely important phase in soil management. pH, at its best, is an estimate. Total acidity analyses of course are quite absolute. Since they are such difficult, slow, and expensive analyses, we sacrifice accuracy for speed and economy. When we do this, we must use in its place good training and vast practical experience. It is not difficult to make a pH analysis.

It is, however, quite difficult to make a good pH interpretation and recommendation from it. This needs knowledge and experience.

PRESIDENT VAN HOF: Thank you, Dr. Mitcheltree.

MR. RADDER (Bloomfield, Conn.): Didn't you say that the availability of iron is in relation to the pH?

DR. MITCHELTREE: Very definitely.

MR. RADDER: I have a problem where my pH was four and a half and I still had chlorosis.

DR. MITCHELTREE: I knew somebody would bring that up. When we get into this situation we apparently have another problem. Now this is an Ericaceous plant, I presume. Here again I am with people who know a lot more about this than I know, but let me say that on the ericaceous plants we have a symbiotic microorganism that grows on it. A lot of people have tried to work with it and never determined why it is there. I am still of the opinion that it must be somehow involved with the assimilation of iron.

Another thing we run into when we run into iron chlorosis at low pH is frequently garden centipedes, and I think maybe this nematode business. Any place these lighthaired feeding roots are taken off the plant I don't think the iron can get into the plant. We have run into lots of these cases, taken the soil and analyzed for iron and found all kinds of iron. It is there but the plant is not getting it. Therefore, it is something about the plant that gives the trouble, not the soil.

MR. C. H. HENNING (Niagara Falls, Ont.): Could you tell me about the relationship of adding gypsum as a substitute for lime?

DR. MITCHELTREE: Gypsum is a neutral salt, calcium sulphate. When it breaks down in the soil it forms sulphuric acid rather than water. The sulphuric acid counteract the neutralizing effect of the calcium. So gypsum cannot be under any stretch of the imagination considered as a liming material. It is a material that will add calcium to the soil. Once in a while we run into a soil that has a very low calcium saturation and extremely high pH from too much potassiumor too much magnesium, so here we recommend gypsum to help bring the calcium into balance without affecting the pH. We also in New York recommend gypsum because of the flocculating action and will be of advantage in clay colloid and allows space for drainage.

MR. DeWILDE: Shouldn't you have a complete soil analysis if you are asking somebody to recommend a low pH?

DR. MITCHELTREE: I paid you $5 for asking me this question, but I didn't think you would come up with it. In soil testing we want a complete analysis. We don't rely on a pH because the balance of the nutrients in it mean as much as this, as their presence is concerned. Don't stop with just the pH.

MR. DeWILDE: As a part of my question, is it true in a good many types when you have iron chlorosis or what the average person says is iron, that if you up the magnesium that the iron chlorosis will disappear?

DR. MITCHELTREE: In some plants it is very difficult to tell the difference between iron chlorosis and magnesium problems. You have to look carefully at the physiological position. I don't like these symptoms myself to go by. They are only indicative.

MR. JIM WELLS: Mitch, I have noted your comment about the value of aluminum on ericaceous materials. Would you elaborate?

DR. MITCHELTREE: Not very much, Jim, because I am not in a position to say positively that aluminum is valuable in ericaceous plants. However, people who have worked with ericaceous plants have indicated to me that they feel aluminum is essential. Aluminum is in the soil in two or three different forms. We do know that when we have low pH we always have a high availability of aluminum content.

MR. WELLS: What about the other trace elements? Do you think they are of vital importance?

DR. MITCHELTREE: All trace elements are of vital importance. Let me make this statement: Properly limed soil will eliminate 99.9 percent of all minor element properties. We will run into a modified minor element problem on other conditions but it is very slight. Liming is your big factor.

MR. KERN (Cincinnati): In southern Ohio all our soils are on a clay basis and our trouble is just the opposite. We have plenty of our lime. We have our pH sometimes running between 7 and 8 and mostly we are concerned with how to bring it down. We like 6.5 or something like that. What do we do to make that correction?

DR. MITCHELTREE: I am going to split your question into two phases. If we were on an acid soil, basically natural acid soil, and we raised the pH way up, we would expect trouble and we are going to have to do something about it. On most conditions with the naturally high pH soils that have developed under natural calcareous conditions, we don't run into these problems. I have seen salvias growing very nicely on 7.5 where the soils are limestone soils and have been calcareous throughout millions of years and we don't run into these problems. Why, I cannot tell you, but we did.

Now if you are experiencing this problem of iron chlorosis on a highly calcareous soil, the only thing we have to offer to you is the use of sulphur. I detest making this recommendation because when we put sulphur on a soil we recommend in New Jersey never to put more than 300 pounds per acre. Then you have to mix it with the soil to the very best of your ability because when you put sulphur on a soil you can get pockets of pH of 1 and down. I always am afraid of a sulphur recommendation, but if you have got to bring the pH down, the only recommendation we have to date is sulphur, and never more than 300 pounds per acre.

MR. WALTER PEFFER (Trafford, Pa.): Will you please comment on the toxicity of dolemitic lime?

DR. MITCHELTREE: Dolemitic lime is simply a combination of calcium and magnesium carbonate. It has both calcium and magnesium. It ranges anywhere from 2 percent magnesium up to about 25 percent magnesium. 25% is about as strong as you can get. Dolemitic lime, in our estimation, is an excellent liming material. Some places we have to recommend it specifically because we have a major shortage. However, we have never had the experience of anybody getting toxicity from dolemitic lime.

MR. SHUGERT (Neosho, Mo.): Sir, we treated 35 acres of ground two weeks ago. It had a pH of 4.6. Two tons of brown limestone and 1,500 pounds of rock phosphate per acre. When do we take the next soil test?

DR. MITCHELTREE: I would recommend the next soil test be taken next spring.

PRESIDENT VAN HOF: Gentlemen, we will have to put a stop to this now and all the rest of the questions can go into the question box.

With thanks to Dr. Mitcheltree, we will close this session for today. Tonight at 8 o'clock, everybody is invited to come to the Special Session on Teaching by Harvey Gray. Thank you.

(The session recessed at 4:40 o'clock.)

FRIDAY MORNING SESSION

December 8, 1961

The third session convened at 9:30 o'clock, President Martin Van Hof presiding.

PRESIDENT VAN HOF: Please be seated. We have a tight schedule this morning, all day, in fact. Dr. Sylvester March will be moderator of the Speaker Exhibitor Symposium.

MODERATOR MARCH: Thank you very much.

As Martin said, we are on a very, very tight schedule and I would like to ask that if there are any questions we save those for this evening in the question box.

I would like to present the first speaker, David Leach of Brookville, Pennsylvania, who will speak on "Hardiest and Best Rhododendrons for Commercial Propagation".

HARDIEST AND BEST RHODODENDRONS FOR COMMERCIAL PROPAGATION

Mr. David G. Leach
Brookville, Pennsylvania

When Sylvester March called me on the telephone and asked me to talk on the "Hardiest and Best Rhododendrons", I said sure, without giving it a second thought, and then it soon occurred to me that the best rhododendron are very seldom the hardiest. So in preparing the talk this morning it seemed the only thing that was reasonable to do was to define the regions and then say these are the best rhododendron that are hardy in each of these regions.

I am going to use for this purpose the U. S. Department of Agriculture Plant Hardiness Zone Map, prepared by Henry Skinner, which is much better and more accurate than the old map. We will have a quick look at novelties, all new rhododendrons introduced in the East whthin the last couple of years which are suitable for each of the principal hardiness zones in the principal parts of the United States starting at the Middle East climate and working up to the most severe.

Beginning with the Dexter hybrids, we will show a number of them. (Slides of each of the varieties were shown.)

Mrs. W. R. Coe. Dexter hybrids as a group are prominent among the new introductions in the last several years - larger flowers, clearer colors. Most of them are fragrant and they bloom earlier than the old standard ironclads. They all sell very readily. This is Mrs. W. R. Coe, one of the best Dexter hybrids. Mrs. W. R. Coe, not as hardy as many of the others, still is hardy in Zone 7A, which is the climate of Philadelphia and metropolitan New York. This is a glowing color, an unusual raspberry color, about four inches in diameter, twice the size of familiar clones. Good foliage. Introduced by Westbury Rose Company.

Belle Heller. Beautiful large white flower here, better than Mrs. P. D. Williams, introduced by Tony Shammerello of South Euclid, Ohio. It is highly satisfactory in a climate such as New York.

Skyglow. An unusual champaign color, very fragrant. Foliage is a little yellow but color is a great novelty. A Dexter hybrid, originated at Sandwich, Massachusetts, introduced by Warren Baldsiefen Nursery, Rochelle Park, New Jersey. Good for Zone 7A.

Tom Everett. Another Dexter hybrid, introduced by Jim Wells, Red Bank, New Jersey. Good, reliable rhododendron for years at the New York Botanical Garden under #205. Much better quality than old ironclads, not so hardy, but still quite satisfactory at metropolitan New York and in Philadelphia, and similar climates. Fifteen to twenty flowers to truss, good foliage, a very fine rhododendron.

Now we are going to step up one zone in hardiness, to Zone 6B, Pittsburgh, Cleveland, and Boston.

Scintillation. This is the first of the Dexter hybrid clone to be introduced. Up to this, only seedlings were available. This is a fine selection, almost a perfect rhododendron, introduced by Westbury Rose Company.

Here we have Wheatley, by Howard Phipps, introduced by Westbury Rose Company. It is a reliable rhododendron for Zone 6B. Remember now, these all are extending your blooming season on the early side. When the customers come into your nursery you have a very outstanding rhododendron that will bloom ten days before the commercial clones come in. All of them have much larger flowers, clearer colors, and many are fragrant.

Brown Eyes. Introduced by the Bosley Nursery of Mentor, Ohio, a Dexter hybrid in a different group. Mr. Bosley went up to Mr. Dexter's estate at Sandwich, Massachusetts, the year before he died and Dexter picked out a carload of rhododendron which he thought were his hardiest, and sent them to Mentor, Ohio. In the course of the next several years almost all died except 10 or 12 of these. Mr. Bosley picked out 8 or 10 and he is selling them now mostly under number. This is one that is available and he calls it Brown Eyes. All of this Bosley group are unbelievably floriferous. I have checked and 97% of the terminals have flower buds year after year. It is characteristic of this entire Bosley group of rhododendrons.

BD1020. Another Dexter now offered by Bosley. It doesn't have a very good habit, but it fills in nicely as it gets older, and you can see it has great clarity of color. There is nothing like it at all among the ironclad rhododendron.

Cheer. Cunningham's White hybrid, introduced by Tony Shammrarello. It blooms May 5th, before the Dexter hybrids. It is very valuable for extending the season on the early side.

Elie. Another Shammarello, valuable for early bloom, but I think it is only fair to say it is not suitable everywhere, where Cunningham's White and its hybrids tend to open florets in the fall in some climates, and the balance of the buds are lost to winter cold. For example, Cunningham's White hybrids are not satisfactory at Washington, D. C. for this reason. The best comment I can make is if Cunningham's White is satisfactory for you, these will be also, and will give color in early May, not available from any other rhododendrons. Elie blooms about May 10th.

Spring Glory. Another of Cunningham's White hybrids from Mr. Shammarello. Very attractive, highly satisfactory rhododendron for Zone 6. In Zone 7 probably it would have a tendency to bloom partially in the fall.

I don't want to put you fellows off on these because in a warmer climate than your zone, they tend to bloom in the fall. If you are in Zone 6 you will find they are highly satisfactory and they will sell very readily at a time when you don't have color for any other rhododendron.

Tony. Shammarello hybrid, blooms later, about May 20th, and about a week earlier than any red heretofore available. Boule de Neige hybrid. There is no problem about this opening florets in the fall. Satisfactory in Washington, Zone 7, just as it is in Zone 6, anyplace that is cold hardy. We are recommending this for Zone 6 or anyplace else where the climate is similar to Pittsburgh, Cleveland, and Boston.

David Gable. Gable hybrid introduced simultaneously by Warren Baldsiefen Nursery, Rochelle Park, New Jersey, and by Josephy Gable, Stewartstown, Pennsylvania. Some of Mr. Gable's rhododendrons are primarily for the connoisseur. This is one that is highly commercial, full truss, large flowers, very early blooming, handsome foliage, and vigorous plant. It is very fine for Pittsburgh, Cleveland and Boston.

Now we are going to step up to Zone 6A, which is the climate of Morgantown, West Virginia, Altoona, Pennsylvania, and Waterbury, Connecticut.

Pink Perfection. Introduced by De Wilde's Rhodo-Lake Nursery, Shiloh, New Jersey. It has large flowers, clear color, good foliage, and good growth habit. It is a first rate rhododendron.

Pink Cameo. Shammarello hybrid. Blooms about May 20th, and it seems to be satisfactory anywhere in Zone 6A.

King Tut. Another Shammarello hybrid, good habit and exceptionally showy. Those of us who have more than casual interest in rhododendron knows that our friend supplies the King type and this carries its good characteristics.

Here we have Pink Dawn. This is another Shammarello hybrid, a midseason bloomer. These Shammarello hybrids may have to be moved up another half zone with further testing, perhaps in the 5B instead of 6A. I am placing them tentatively in 6A, because I am trying to be conservative in evaluating the hardiness of all these rhododendron this morning. You fellows have to put these out in the nursery and you are not like a hobbyist who will protect them and give them preferred sites, so I feel in the zone for which these are recommended you can line these out in the field and you are not going to have any trouble. All the same, this is a very conservative listing and they probably deserve to be a little hardier than the categories I am putting them in this morning.

This is Pinnacle, another Shammarello hybrid, very outstanding, midseason bloomer, one of the most impressive of all the new introductions of rhododendron in the last several years - Pinnacle. This

I feel will be a good rhododendron in commercial use 50 years from now.

Pioneer. This is an entirely different type of rhododendron, is very early blooming, a scaly-leafed rhododendron. It was introduced simultaneously by Joe Gable and Warren Baldsiefen, at Rochelle Park, New Jersey, and I believe now offered for sale by Sherwood Hill Nursery at Brewster, New York. It has been a great commercial success. It blooms very early in April. This hybrid has small leaves, compact cushion-like growth habit, which doesn't show too well in the picture. When it is mature it is about four feet. It is an ideal foundation plant for single story houses. It has myriad trusses of clear pink flowers. It is a fine plant for 6A and for Waterbury, Connecticut, a little colder than we have been talking about. These are propagated early in July.

A lot of fellows say, "I can't propagate these scaly leafed hybrids, they don't seem to root." The cuttings have to be taken in different seasons, early in July and they root as readily as evergreens and azaleas. There is no problem at all.

I am going to step up to Zone 5B, which is Youngstown, Ohio; Scranton, Pennsylvania; and Worcester, Massachusetts.

BD1016 - Another Dexter hybrid, introduced by Bosley of Mentor. This is the hardiest single hybrid I know of. Of the hundreds I have tested on the trials, this is the hardiest, probably hardier than the parent. This comes very, very close to being as hardy as any standard ironclad that has been in the nursery industry for 100 years, but it is far better. It has a flower almost twice the size. It has fragrance and good habit of growth.

BD1009 - Another of the extra-hardy Dexters introduced by Bosley of Mentor, a very beautiful plant.

Now we are going to come to the coldest zone, 5A, of which I can speak with a first-hand knowledge. This is the climate of Augusta, Maine; Concord, New Hampshire, and my own trial grounds at Brookville, Pennsylvania. This is a climate that routinely experiences 20 degrees below zero.

Ramapo. This is probably sold in larger quantities than any rhododendron, introduced in the last 100 years, another scaly leafed. It looks like a blue flowered azalea. The nursery that handles it sells out every spring. It is a Nearing hybrid and not introduced formally by anyone as far as I know. It is now offered for sale by the Westbury Rose Company and Warren Baldsiefen Nursery in Rochelle Park, and several others.

Windbeam. Another Nearing hybrid in the scaly leaf group, small leaves, early blooming, emphatically evergreen over winter. It might grow to five feet at maturity. Pale pink flowers aging white. Hardy to 25 degrees below zero, and comes through beautifully at 32. This is available from Warren Baldsiefen and Westbury. Again, these scaly leaf hybrids need to be propagated early in July.

Conewago. Another of the scaly leaf hybrids, produced by Joe Gable. It is very attractive, early blooming, and hardy anywhere Rhododendrons will grow but has a defect of only being partially evergreen over winter. It was introduced simultaneously by Joseph Gable, and Warren Baldsiefen. This, incidentally, is hardy. In an older plant they are just smothered with rose-pink flowers that make a good showing. I think there is one near Joe Gable's place near Stewartstown.

LaBars' White. This is a fine form of catawbiense album introduced in 1961 by LaBars' Rhododendron Nursery, Stroudsburg, Pennsylvania. This has superior habit, fine foliage, dead white flowers, freely produced. This is probably hardier than any hybrid rhododendron. If any of you fellows are from Vermont or New Hampshire, this will grow for you when no hybrid will grow at all. This is a very fine ornamental, and takes care of itself. It doesn't need to be pampered.

MR. HOOGENDOORN: Isn't this a catawbiense?

MR. LEACH: It is a selected form of catawbiense and Russ Harman found it in the mountains, I believe, of North Carolina.

Sefton. There is nothing new about this, but it is a fine, hardy Rhododendron which lives after 25 degrees below zero. It has a unique plum color and comes after the midseason blooms have gone. It has large blossoms of distinctive color. It has seemed to sell out quickly. The only source I know for it at the present time is Westbury Rose Company. This is in bloom when all the others have gone.

Finally, Lady Armstrong - another first rate rhododendron rarely seen. Anthony Water brought it over in 1876. Again, I don't know why this isn't freely available, because it is one of the better rhododendron I have in my place. This particular picture was taken by Life Magazine photographer who came out to get a picture. Out of literally hundreds he thought this was one of the most handsome and attractive on the place. It is very free blooming; looks like this every year. Possibly there are other sources, but I know Westbury has it and I believe possibly Sherwood Hill Nursery has it. I am not too sure about the latter, but I think it certainly deserves to be a lot more popular than it is. It is a first-rate Rhododendron in every way and the newer introductions have not displaced it.

Thank you. You have been very patient, and my time is up.

MODERATOR MARCH: Our next speaker will be Mr. Richard Fillmore from the Department of Botany, Duke University, Durham, North Carolina. He will speak on Rooting a Sport of Cephalotaxus.

ROOTING A SPORT OF CEPHALOTAXUS SPECIES

Richard H. Fillmore
Department of Botany
Duke University
Durham, North Carolina

I wish to discuss briefly the rooting of a Cephalotaxus sport and I shall begin by describing the stock plant from which the various lots of cuttings were taken.

The cuttings for this test were taken from a plant of Cephalotaxus species growing on the grounds of the Sarah P. Duke Gardens at Durham, North Carolina. This plant is probably thirty or forty years old. It is about eight feet tall and six feet in diameter. Its main mass is stiffly erect with comparatively large, coarse branches. It would be generally unsuitable for the home grounds unless the home grounds were very large, but nonetheless, it has a place in a garden such as the garden which I am describing.

Very near the base it has developed a large fan-shaped spray of softer foliage with branches suggestive of a spreading Taxus species. This fan-shaped spray is probably five feet in circumference, and is readily traced to a single point on one of the main erect stems. It has probably developed within the last ten or fifteen years and obviously represents a mutation or sport on the normal type plant.

It would, if it were put into production, very likely have some value in the southeast especially in the warmer area where most taxus varieties do rather poorly and are regarded as being unreliable in any situation unless it be a quite shady or otherwise very favored location.

On March 20, 1958, one hundred sixty six-inch tip cuttings were collected, 120 from the sport spray and 40 from the normal main body of the plant.

The 120 from the sport spray were divided into three lots of 40 each. Lot No. 1 was treated with 0.8% indolebutyric acid in talc (Hormodin 3), Lot No. 2 with 2% indolebutyric acid in talc, while Lot No. 3 received no treatment. Two years later, when the cuttings were examined and potted, there were no important differences between any of these lots. The precise figures for Lot No.'s 1, 2, and 3 were 25, 28 and 29 rooted cuttings respectively.

We got no effect whatsoever from the addition of the hormones of the type which we used and at the concentrations which we used with respect to increased or improved rooting of these three lots of cuttings.

At the same time we took 40 cuttings from the normal main body, which were designated as Lot No. 4 and treated with 0.8% indolebutyric acid in talc (Hormodin 3). In Lot No. 4, only 16 cuttings rooted and there were fewer heavily rooted cuttings than in Lot No.'s 1, 2, and 3.

When Lot No.'s 1 and 4, which received identical treatment, were compared directly, Lot No. 1 yielded 25 rooted cuttings of which 21 were heavily rooted while the corresponding figures for Lot No. 4 were 16 with only 10 heavily rooted. These differences are attributed to some imperfectly understood juvenile characteristics of the sported or mutated tissues. Increased rootability of such tissues is widely known in such genera as Picea and Abies, but to the best of this writer's knowledge, it has never been reported in the genus Cephalotaxus.

MODERATOR MARCH: Thank you, Mr. Fillmore.

Our next speaker will be Mr. Hurov of Cornell University. His topic is "The Propagation of Semi-hardwood Leafy Cuttings Using Polyethylene Bags and Sheets with Aluminum Reflectors".

THE PROPAGATION OF SEMI-HARDWOOD LEAFY CUTTINGS USING POLYETHYLENE BAGS AND SHEETS WITH ALUMINUM REFLECTORS

H. R. Hurov
Department of Pomology
Cornell University
Ithaca, N. Y.

In the wet tropics there is a need for a method in which leafy cuttings of tropical arborials can be rooted directly in situ in containers or in the nursery row. Elimination of transplanting problems and excessive installation costs are the main reason.

Plastic Bags: A number of workers methods have shown that plastics can be used for propagating softwood cuttings. Among these Nichols (1958) showed that, in Trinidad, softwood cuttings of cacao could be rooted successfully in plastic bags. This prompted us to investigate the use of plastic bags in British North Borneo. Our investigations showed that plastic bags could be used successfully for propagating leafy semi hardwood cuttings from 96 different tropical arborials. Some of the more difficult rooting species rooted included: Mangifers indica, Hevea brasiliensis, Achras sapota, Lansium domesticum, Eucalyptus deglupta, Psidium guajava, Nephelium lappaceum, Artocarpus integra, Annona squamosa, Tamarindus indica, Cinnamonum Zeylanicum, Euphoria malaiense and Anacardium occidentale.

The method generally entailed setting cuttings in .02 mm guage, 14 X 8 inch polythene bags containing a mixture of 80 parts decomposed padi husk and 20 parts fine river sand. The bags were set in a position where they received early, cool morning, sunlight until 9:30 a.m. and 50% shade approximately for the rest of the day. These conditions were found on the eastern side of a rubber plantation. Cuttings were taken from adult trees and were treated with several root inducing stimulants prior to setting. Cuttings usually rooted in 1-2 months.

When Lot No.'s 1 and 4, which received identical treatment, were compared directly, Lot No. 1 yielded 25 rooted cuttings of which 21 were heavily rooted while the corresponding figures for Lot No. 4 were 16 with only 10 heavily rooted. These differences are attributed to some imperfectly understood juvenile characteristics of the sported or mutated tissues. Increased rootability of such tissues is widely known in such genera as Picea and Abies, but to the best of this writer's knowledge, it has never been reported in the genus Cephalotaxus.

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No watering and very little maintenance was needed during the rooting period.

Best results were obtained with cuttings taken from epicormic shoots in the dry season when rainfall averaged between 3 and 5 inches a month and when temperatures varied from 65° F at night to 92° F in the daytime.

The advantages of the polythene bags technique for tropical arborial cuttings includes low cost of installation, no need for transplanting into containers; reduced tropical labor costs, ease of transportation and ease of adaptation.

Polyethylene Bag-Aluminum Reflector Method:

An attempt was also made to root leafy cuttings directly in polythene bags in the sun. To these bags were attached aluminum sisal craft reflectors which faced the afternoon sun in such a manner that the cuttings received sunlight in the early morning and shade thereafter. By this method preliminary rooting successes were recorded with Annona muricata, Citrus nobilis, Eucalyptus deglupta, Acacia auriculaeformis, and Psidium guajava.

Polyethylene Tunnel-Aluminum Reflector Method:

Preliminary results with rooting leafy cuttings in the nursery row in tropical Borneo were unsuccessful. In these trials white plastics and various forms of shade were used. Aluminum reflectors however, were not utilized. These trials were continued at Cornell in the summer of 1961. Initial results showed that tomato, coleus and Forsythia intermedia cuttings could be rooted up to 100% in sand under polyethylene sheeting protected on the top and west sides by aluminum foil. This is somewhat similar to Harvey Grays reflector deflector vapor proof case method.

During these trials various attempts of supporting the polyethylene were tried. Among these the best results were obtained with "Twist Ems". Wire supports proved awkward and expensive. As the summer progressed we found that supports were not needed and that north light was as good as east light. By late summer we felt that we were ready for field trials. Leafy semi-hardwood cuttings were taken on August 23, 1961 and measured approximately 6 inches long. They were set about 3 inches apart in the row. After that they were well watered and covered with polyethylene sheets. Aluminum foil reflectors were placed on the south side. In other words, we used north light. There were 50 cuttings of 6 different ornamentals in the trials. Half the cuttings were treated with Seradix B3 (IBA) powder. Observations after 3 weeks showed that the auxin treated cuttings rooted as well or better than the non-auxin treated cuttings.

The rooting results with the auxin treated cuttings were as follows: (1) Under Dow Handiwrap Film one foot wide, Philadelphus coronarius 22%, cornus alba 22%, and Berberris thunbergia Atropurpurea

33%. (2) Under Dow 401 Polyethylene Film two feet wide and .00075 inch thickness, Rhodotypos tetrapetala 43%, Ligustrum ovalifolium 63%, and Forsythia intermedia (Spring Glory) 85%. There is thus an indication that various plastics may give different results depending on their density and thickness.

In the future the methods of supporting the plastic may prove a problem. However in 1962 we hope to try using humidified airblowers to hold up the polyethylene.

Bibliography

1) Hurov, H. R. 1960. Double stimulant polythene bag method of rooting cuttings: illustrated description Pamphlet #11 North Borneo Dept. of Agriculture, Jesselton.

2) Nichols, R. 1958. Propagation of cacao in plastic bags. Nature 181: 580.

MODERATOR MARCH: Our next topic "Industry's Role in Screening New Herbicides and Rooting Hormones" will be presented by Mr. John H. Kirch, Amchem Products, Inc., Ambler, Pennsylvania.

INDUSTRY'S ROLE IN SCREENING NEW HERBICIDES AND ROOTING HORMONES

John H. Kirch
Amchem Products, Inc.
Ambler, Pennsylvania

Probably the most simple way of defining the chemical industry's role in the plant growth regulator field is to say that it is their responsibility to discover, formulate and market new compounds for man's use in regulating plant growth. More specifically, to the plant propagator this means providing chemicals that stimulate the formation of roots on cuttings, inhibit or stimulate plant growth, break seed or bud dormancy, control weeds, initiate the formation of flower buds and regulate fruit set or maturing.

Most people are aware that many new chemicals have been introduced in this field of plant growth regulators during the past twenty years. What is perhaps not too familiar to many are the methods used by industry to find these compounds. The remainder of this paper describes a method used by the author's company in its research toward finding useful chemicals in the plant growth regulator field.

This method involves three steps: 1) primary screening, 2) secondary screening, 3) field development.

Primary Screening

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Primary Screening

The first step toward finding a new growth regulator is to screen chemicals and determine whether or not they may have biological activity. Standard screening flats are prepared, each containing 16 representative weed and crop species.

The new chemical is applied as a pre-emergence spray to one set of flats and a post-emergence spray to another similar set. In this manner the compound's activity on newly germinating weed and crop species as well as its activity through the foliage can be observed.

Observing the biological activity of a compound in these flats is the critical part of primary screening. It is here that the first leads on the compound's potential are picked up. All biological activity, however slight, is carefully noted. Typical of the activity shown by the various compounds in this stage of screening would be stunting, epinasty, stem elongation, discoloration, proliferation, death and selectivity. Based on the degree of this activity a decision as to whether to drop the compound or pass it on to secondary screening is made.

Secondary Screening

In secondary screening the activity exhibited in primary screening is investigated more thoroughly. For example, compound "X" has shown the following activity in primary screening: Epinasty on snapbeans and stimulation of brace roots on corn. The compound is referred to secondary screening with a notation, "Test for root initiating properties."

The first step in secondary would be to run a series of concentrations of this new chemical in a rooting test in comparison with the same concentrations of 3-indolebutyric acid, which is a standard rooting compound.

Concentrations ranging from 500 to 20,000 ppm are used in this step. This broad range is used to give reasonable assurance that no compound with activity will be missed. Liquid quick-dip treatments are employed because it is usually simpler to prepare a liquid than a dry formulation when only a small amount of material is available. It might be of interest to note here that at this stage of screening only microgram quantities of a new compound may be available and these are frequently costly.

The cuttings selected for this test are generally two species representing two different rooting response groups, such as easy-to-root and difficult-to-root. Chamaecyparis obtusa var. aurea, the difficult-to-root Golden Hinoki Cypress, and Taxus cuspidata, the easy-to-root spreading yew, are used most frequently.

Cuttings are made following standard propagating procedures for these species. Since fall and winter appear to be the best time to take cuttings of these two species most of the promising rooting compounds are held for testing until this time.

Ten cuttings of each species per treatment are usually sufficient for this initial test. The cuttings are treated and inserted in a medium of 1/3 peat and 2/3 sand.

Evaluation of the cuttings is made at periodic intervals, usually 30, 60 and 90 days. Percent rooting is recorded and appropriate notations are made on the quality of rooting, such as heavy, medium or light.

After the initial test to determine the approximate concentration at which rooting occurs, additional tests are run to narrow the concentration down to the optimum for the compound and species tested. Tests are also run on a broader range of species at this time.

The variation in rooting response to a given compound is quite marked in these tests. Table I shows the rooting response of two evergreen species to six different compounds applied as a quick-dip treatment at 10,000 ppm. Table 2 shows the variation in rooting response due to differences in concentration of three of the six compounds on the same two evergreen species.

In addition to concentration, formulation is also a variable in testing compounds for root initiating properties. Table 3 shows the difference in rooting response of six evergreen species to three different formulations of 3-indolebutyric acid applied at 20,000 ppm.

Recently considerable emphasis has been placed on the quick-dip liquid method of treating cuttings rather than the powder treatment. In formulating rooting compounds for use in liquids solubility is a key factor. For example, 3-indolebutyric acid in its pure form is not soluble in water. However, prepared as a diethanolamine salt or the sodium or potassium salt it is readily soluble in distilled water. From Table 3 the importance of selecting the proper formulation can be seen. For rooting Japanese holly, the potassium salt appears to be better than either the acid in a talc carrier or the diethanolamine salt. On English holly the diethanolamine salt would be preferred. There is apparently little difference in formulation when 3-indolebutyric acid is applied to Japanese yew.

Continuing with our example of indolebutyric acid, though the salts of indolebutyric acid are generally soluble in water they may not be soluble in hard water. In such a case a formula containing the salts of indolebutyric acid might form a white precipitate when added to hard water. This precipitate is generally the calcium salt of indolebutyric acid which is very difficult for cuttings to absorb. To remedy this the salt formula could be used in alcohol, or it can be sequestered to go into hard water. These are typical problems that the formulating chemist must solve.

When the optimum concentration and formulation for a new compound has been established and some knowledge of the rooting response it produces on certain species is known, the compound is ready for field development, the third step in finding a new rooting substance.

Field Development

Before a compound can be sold as a product in the growth regulator field, it must be tested throughout the country on as many different species and under as many different conditions as possible. This is the purpose of field development. The compound is sent out to various cooperators at universities, experiment stations or commercial establishments with research facilities for this testing. Here it is applied on a large-scale basis in comparison to the best known material available.

Going back to our example of the rooting compound, this material would have to have outstanding new advantages when compared to indolebutyric acid or naphthalene acetic acid in order to find a market. Another factor enters here. Though the compound might not root the majority of species any better than indolebutyric acid or napthaleme acetic acid, if it were to give good rooting on blue spruce only, for example, it might still be a very valuable compound to the propagator. The demand for rooted blue spruce cuttings must, of course, be sufficiently great to assure a profitable market for the chemical. Otherwise packaging, labeling, distributing and advertising costs may not justify marketing the compound, regardless of its activity on blue spruce.

As the reports from the cooperators in the field development stage come in, they are summarized and the results studied to determine whether the material has a real potential. If the compound does the job and the demand appears to be good, a label is prepared and the compound will be sold.

This is the general procedure that is followed in the introduction of new compounds in the growth regulator field by the author's company. What we have talked about here in the short span of ten minutes requires two to three years or longer in actual practice. Only a few compounds ever reach the marketable stage, though many hundreds are screened annually by the chemical industry.

Undoubtedly; a number of propagators have problems rooting specific species on which some of the compounds we now have in screening would be effective. It is only by hearing about these problem species that suggestions can be made as to compounds that might be tried. Through cooperation between commercial propagators, university research men and the chemical industry it should be possible to improve the results now obtained on some of the difficult-to-root species. The chemical industry would be very pleased to hear these problems and to cooperate in their solutions.

MODERATOR MARCH: Thank you, Mr. Kirch.

Our next speaker, Dr. Chadwick of Ohio State University, will tell us about the "Origin of Adventitious Roots and Callus on Stem Cuttings of Ilex opaca as Influenced by Wounding and Synthetic Growth Substances." Dr. Chadwick.

TABLE I

COMPARATIVE ROOTING INDUCED ON TWO EVERGREEN
SPECIES BY SIX COMPOUNDS AT 10,000 PPM CONCENTRATION

Cuttings Stuck November 28 -- Data Taken January 28

COMPOUND	PPM CONC.	SPECIES	PERCENT ROOTING	PERCENT DEAD
2,4-dichlorophenoxy		Spreading Yew*	100	0
ethyl bromide	10,000	Golden H. Cypress**	0	0
3-amino 2,5-dichlorobenzoic		Spreading Yew	50	30
acid	10,000	Golden H. Cypress	0	0
2,3,6-trichlorophenyl		Spreading Yew	0	80
acetic acid	10,000	Golden H. Cypress	0	20
2,5-dichlorophenoxy		Spreading Yew	60	80
acetic acid	10,000	Golden H. Cypress	0	10
2,4,5-trichlorophenoxy		Spreading Yew	0	100
propionic acid	10,000	Golden H. Cypress	0	100
3-indolebutyric acid	10,000	Spreading Yew	100	0
		Golden H. Cypress	0	0
Check	0	Spreading Yew	20	0
		Golden H. Cypress	0	0

* Taxus cuspidata
** Chamaecyparis obtusa var aurea

TABLE II

COMPARATIVE ROOTING INDUCED ON TWO EVERGREEN SPECIES BY THREE COMPOUNDS AT THREE CONCENTRATIONS

Data Taken After 60 Days in the Rooting Medium

COMPOUND	PPM CONC.	SPECIES	PERCENT ROOTING	PERCENT DEAD
2,4-dichlorophenoxy ethyl bromide	1,000	Spreading Yew*	30	0
		Golden H. Cypress**	10	0
	10,000	Spreading Yew	100	0
		Golden H. Cypress	0	0
	20,000	Spreading Yew	50	0
		Golden H. Cypress	0	0
2,4,5-trichlorophenoxy propionic acid	1,000	Spreading Yew	10	20
		Golden H. Cypress	10	0
	10,000	Spreading Yew	0	100
		Golden H. Cypress	0	100
	20,000	Spreading Yew	0	100
		Golden H. Cypress	0	100
3-indolebutyric acid	1,000	Spreading Yew	70	0
		Golden H. Cypress	0	0
	10,000	Spreading Yew	100	0
		Golden H. Cypress	0	0
	20,000	Spreading Yew	100	0
		Golden H. Cypress	60	0
Check		Spreading Yew	20	0
		Golden H. Cypress	0	0

TABLE III

COMPARATIVE ROOTING INDUCED ON SIX EVERGREEN SPECIES BY THREE FORMULATIONS OF 3-INDOLEBUTYRIC ACID AT 20,000 PPM

Cuttings Inserted December 29 -- Data Taken February 20

SPECIES	POTASSIUM SALT* % Rooted	POTASSIUM SALT* % Dead	TALC CARRIER % Rooted	TALC CARRIER % Dead	DIETHANOLAMINE* % Rooted	DIETHANOLAMINE* % Dead	CHECK
Andorra Juniper (Juniperus horizontalis var Andorra)	70	0	40	10	30	0	70
Hybrid Rhododendron (Rhododendron catawbiense) (purple)	50	10	50	0	0	10	0
English Holly (Ilex aquifolium)	20	70	50	20	100	0	20
Japanese Holly (Ilex crenata)	100	0	70	0	90	0	30
Golden Hinoki Cypress (Chamaecyparis obtusa var aurea)	60	0	20	0	60	0	0
Japanese Spreading Yew (Taxus cuspidata)	100	0	90	10	100	0	50

* Potassium and diethanolamine salts are liquid formulations and were applied as a quick-dip treatment.

ORIGIN OF ADVENTITIOUS ROOTS AND CALLUS ON STEM CUTTINGS OF ILEX OPACA AS INFLUENCED BY WOUNDING AND SYNTHETIC GROWTH SUBSTANCES

L. C. Chadwick and K. W. Reish
Ohio State University
Columbus, Ohio

The remarks that I have this morning are going to concern the problem of the effect of wounding and synthetic growth substances on callus formation and the initiation of adventitious roots on American holly.

I think I should mention at the start that I want to give credit to Dr. Reisch, who supervised much of this problem, and to Donald Kling, who carried out many of the actual experiments.

The purpose of the experiment was to determine the effect of wounding and the use of synthetic growth substances on callus formation and on root formation on Ilex opaca, and perhaps more important, to study the anatomy of the origin of callus and adventitious roots.

I am sure that most of you are familiar with the literature that would indicate that wounding of cuttings of Ilex opaca have resulted in stimulation of root formation and also the fact that use of synthetic growth substances have also resulted in increased root formation. Some of the literature would indicate that wounding was perhaps more important than the use of synthetic growth substances.

In the way of procedure, these cuttings were taken on December 28. They were made up six to seven inches in length of terminal growth and stuck on January 6. Four treatments or one control and three treatments were used. One consisted of simply wounding the basal end of the cuttings with 3 three-quarters of an inch slits on the stem. Synthetic growth substances were used in another treatment. The substances were naphthalene acetic acid and naphthalene acetamide. The fourth treatment was a combination of both wounding and the use of synthetic growth substances.

Three hundred cuttings were used in each of the treatments for a total of 1,200 altogether.

As far as the anatomical study was concerned, ten cuttings were removed from each plot every four days and an anatomical study made on those sections. We will not go into detail on that particular part.

As far as the results were concerned, based on the evidence in this piece of research at least, there was no advantage at all of wounding. This, I realize, has been differed with and contrary to what has been reported previously, in fact, contrary to some of the work we had done previously. We did find, on the other hand, considerable stimulation from the use of the synthetic growth substances from the standpoint of increase in roots, quickness of rooting, and the number of roots.

After approximately 45 days with the cuttings that were treated with synthetic growth substances, the rooting performance was essentially 95% to 100%. At the same time, the control cuttings were about 30%.

I think now if we can have the few slides we can cover the anatomical aspects of this problem.

This is a slide of the basal end of the cutting at the time the cutting was made. I point out the pith which made up about a third of the diameter of the stem. The xylem was very extensive in comparison with the amount of phloem tissue, in fact, there was about one phloem cell to eight xylem or the xylem was eight times as extensive as the phloem tissue. We will refer to that a little bit later.

This is a longitudinal section through the basal end of the cutting, indicating callus formation, and I think you can see that the callus here is developing from the cambium tissue. That was true in all cuttings regardless of whether they were treated or not treated.

This shows a cross section of the start of root initiation. This was apparent in about ten days after the cuttings were taken.

Here is a little later stage in the development of a root initial and this slide indicates the situation that exists where synthetic growth substances are used, and not on control cuttings. I might indicate that this root initial is forming from the relatively new phloem cells. That appeared to be true in practically all cases where synthetic growth substances were used.

I might also indicate with the use of synthetic growth substances we had a proliferation of phloem cells to the extent that considering the total cross section of the stems involved, the phloem was practically equal to the size of the xylem. I mentioned previously the xylem was eight to one of phloem. After treatment it was about one to one. I might indicate perhaps as a point of interest that there was no differentiation of the cells in the new root initial until after emergence had occurred.

This is a longitudinal section of a control cutting and here is where there was a decided difference in root origin, depending on whether or not the cutting was treated with a synthetic growth substance. As I have indicated, with the treated cuttings, roots originated in the phloem tissue. When they were not treated they arose in the cambium cells that had extended down into the callus and that appeared to be true in all cases.

On the treated cuttings the roots arose along the basal inch of the cutting. On untreated cuttings, only down at the very base and the actual root origin was in cambium which developed down into the callus.

Just in summary, I would make this remark, that wounding did not seem to be important either in the formation of callus or root origin as far as this piece of work was concerned.

Secondly, that the origin of adventitious roots varied depending upon whether or not the cuttings were treated with a synthetic growth substance. With growth substances the origin was in phloem tissue. Where no treatments were given, the origin was in callus tissue. This is one of about two reports in the literature that I know of where roots have actually been shown to originate in callus tissue.

Thank you.

MODERATOR MARCH: The next item on the program is "Pocket Planting Mixer", which will be the topic of our next speaker, Mr. Harvey Gray, New York State University, Agricultural and Technical Institute, Farmingdale, New York.

POCKET PLANTING MIXER

Harvey Gray
New York State University
Agricultural and Technical Institute
Farmingdale, New York

Propagators and plantsmen dealing in ericaceous plants recognize the importance of fibrous, acid organic matter in the production of their crops.

In commercial production costly operations and organic matter must be recognized and reconciled with. Young plants either seedlings or cuttings, in their first and/or second year present no great problem nor cost, when grown in beds containing up to 50% peat. It's in the field product with plants in their second, third, fourth years that the organic matter requirement becomes a costly production problem.

Large quantities of organic matter added to mineral soils in an overall application is costly. Small quantities of fibrous peat to create an organic pocket for planting presents a costly operation if a uniform pocket mixture is to be created. It is here that the pocket mixer comes into play.

To make use of the pocket mixer for ericaceous plants, the mineral soil is first deeply tilled with a rotating tiller. One large shovelful of soil is removed along the planting line. Each hole will be filled with sphagnum peat that has been nicely shredded. The "Go-Kart mechanized wheelbarrow" is used to transport the peat to the

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MODERATOR MARCH: Our next topic "Comments on the Propagation of Native Azaleas" will be presented by Dr. Henry T. Skinner, National Arboretum, Washington, D. C.

COMMENTS ON THE PROPAGATION OF NATIVE AZALEAS

Henry T. Skinner
Director, U. S. National Arboretum
U. S. Department of Agriculture
Washington, D. C.

The deciduous Ghent, Mollis and Knap Hill hybrid azaleas have found a restricted market in this country for two principal reasons: They are not as readily propagated as the semi-evergreen types and, though generally hardier, they are not as easy to grow in the average garden. Vegetative propagation of named clones is essential but many, particularly in Mollis azaleas, remain difficult to root from cuttings. As garden plants, too many selections, especially again in the Mollis types, are ill adapted to our eastern climate. In resenting our summer heat, they lack vigor or, if they grow reasonably well, they too often have poor habit or poor late season foliage too frequently disfigured by mildew. Not all selections have these faults, but many do. I have yet to see even a Knap Hill or Exbury hybrid which combines top quality flowers and flower truss with top quality habit, vigor, and clean, attractive foliage interestingly colored in fall - as it could - and as many semi-evergreen azaleas do.

Recognizing this situation, a number of hybridizers are now re-using our native azaleas to breed with the large-flowered introductions for improvement of these characteristics including their susceptability to more ready cutting propagation.

Ignoring matters of climatic adaptability, habit, disease resistance, etc., let us briefly compare some of the native species with respect to case of vegetative propagation. Those with potentialities for breeding purposes may be roughly grouped as follows:

1. Most difficult to propagate by cuttings. Outstanding in this category are the two northern and very hardy pink azaleas, Rhododendron roseum and nudiflorum, in that order.

2. Most easy to propagate by cuttings. Listing the easiest first, we would group eight species in about this order:

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2. Most easy to propagate by cuttings. Listing the easiest first, we would group eight species in about this order:

(a) The four white-flowered swamp azaleas: R. serrulatum from the Gulf Coast, viscosum from the north, atlanticum from the coast, and oblongifolium from Texas;

(b) The southern pink R. cancscens, southern yellow austrinum, and the southern upland white R. alabamense; and

(c) The sweet azalea, R. arborescens.

3. Intermediate in ability to root. Included here are R. prunifolium, the late red azalea of Georgia which may be easy or somewhat difficult according to the selection, R. spaciosum, the early red azalea of Georgia, R. bakeri, the late flame azalea, and R. calendulaceum, the earlier flame azalea which, according to the selection, may be intermediate to very difficult to root.

For most practical purposes, it would be inadvisable to waste time on attempting to root cuttings of R. roseum and nudiflorum, and I would think twice about using them as breeding parents because of their stubbornness in this respect in spite of the undoubted usefulness of their color, perfume and hardiness. Seed propagation would be more practical and I would consider the Virginia Blue Ridge to be the best habitat for good forms of R. roseum, and the ridge area of southern Pennsylvania to North Carolina to be the best for desirable samples of R. nudiflorum. R. nudiflorum is sometime a stoloniferous and such individuals may be increased by division but not all specimens exhibit this tendency, and none do so freely as R. atlanticum, viscosum, and typical alabamense. Plants which are stoloniferous may also be the most likely to root as cuttings.

Among the more easily rooted species, and with the possible exception of R. viscosum, the southerly representatives of a species exhibit an apparent tendency to root more readily than those from the north, as in R. arborescens which occurs from Pennsylvania to Georgia. In R. canescens, the southern pink azalea, Florida representatives of the species not only root more readily than plants from north Georgia or Tennessee, they also exhibit less dormancy in winter and will often retain their foliage and continue to grow as long as temperatures remain favorable. Such plants produce very vigorous offspring when mated with slower-growing northern species. Certain specimens of R. serrulatum growing in central Florida are known to flower in July and continue to produce and open new flower buds into November. They root readily from cuttings but, transferred to Washington, D. C., the same plants produce only one set of flowers - if the buds are not killed over winter. They are somewhat tender.

In the intermediate category, R. prunifolium roots fairly readily from half-ripe cuttings, but both the flame azaleas are haphazard to difficult. Late-flowered R. bakeri is diploid, is perhaps a parent of the earlier, tetraploid and larger-flowered R. calendulaceum and roots a little more easily, but both are unpredictable. One clone or selection may be rooted with fair ease, while another may be very difficult indeed. Individuality of rooting response is noticeable in all species but it acquires added significance in the harder-to-handle types.

Ability to root is doubtless a segregating genetic character to be carefully watched and tested in breeding work. Good as a selection from a species or a hybrid clone may be with respect to its size or color of bloom, its shapely habit or its highly-colored and mildew-resistant fall foliage, the same selection is still virtually worthless if it cannot be vegetatively propagated with relative ease. It is unfortunate that this point has been overlooked by so many amateurs and professionals who have selected and named new plants, including deciduous azaleas.

MODERATOR MARCH: The next subject deals with the germination of Koelreuteria seed. It is by Mr. Robert L. Gonderman and Dr. Steve O'Rourke. The paper will be presented by Dr. O'Rourke.

FACTORS AFFECTING THE GERMINATION OF KOELREUTERIA SEED [1/]

Robert L. Gonderman and F.L.S. O'Rourke
Department of Horticulture, Michigan State University

The Golden-rain tree (Koelreuteria paniculata Laxm) is a desirable small-sized neat landscape tree of unique merit for its lacy pyramids of yellow blooms in mid-summer and its persistent fruit capsules during the fall and winter. Apparently, there are few selected clones of this species and propagation by vegetative means is seldom practiced. Bailey (1), Creech (2), Fuller (4) and Hartmann and Kester (5) note that root cuttings may be used successfully and both Bailey (1) and Fuller (4) indicate that layering is also employed.

Propagation by seed is the usual method as the species is generally homogeneous and there is little variation among seedling trees. Fordham (3) states that a soak of 1 hour in concentrated sulfuric acid and immediate sowing of the seed resulted in germination within 13 days. The U. S. Forest Service (6) reports that 1 hour in sulfuric acid followed by stratification at 41° F for 90 days gave the best germination.

Methods and Materials

In order to determine the effects of pregermination treatments, seed was gathered from trees on the M. S. U. campus in early October, 1960, and divided into eight lots, seven of which were treated with chemicals as shown in Table 1 and the other left untreated for comparison. All the chemicals were used in a full strength concentration. After the chemical treatments, one-half of each lot was soaked in 10 ppm of gibberellic acid and the other half in distilled water for 48 hours. Finally, each lot of seed was halved again, one portion being placed in moist 41° F cold storage for 30 days and the other for 78 days. After these periods of stratification, the lots of 15 seed each were planted in flats of shredded sphagnum moss in a 70° F greenhouse. Germination records were taken at weekly intervals. Opening and spread of the cotyledons was used as an indication of germination.

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Results

The differences due to soaking with gibberellic acid after the chemical treatment were too slight and variable to be considered of any consequence. The period of stratification was definitely important, as may be noted in Table 1. Seed stratified for 78 days germinated earlier and gave a higher percent of total germination at the 20 week close of the experiment.

Early germination, especially during the second and third week, was most marked with sulfuric acid treated seed. At the tenth week, the three superior treatments were sulfuric acid, diethyl ether and acetone. At the 20-week close of the experiment, the total percent of germination was highest with sulfuric acid treated seed, followed in descending order by those treated with diethyl ether, acetone and carbon tetrachloride. Those treated with xylene and petroleum ether were lower than the untreated control in percent of germination.

Summary

Treatment of Koelreuteria seed with seven different chemicals and two periods of after-ripening indicated that scarification with concentrated sulfuric acid for 30 minutes followed by 78 days of stratification at 41° F was an effective method to induce early Koelreuteria is apparently due both to the impermeability of the seed coat and to a condition of internal dormancy.

Note 1/ Journal Article No. 2896 of the Michigan Agricultural Experiment Station.

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6. U. S. Forest Service. Woody Plant Seed Manual. U.S.D.A. Misc. Pub. 654. June, 1948.

TABLE I

PERCENT GERMINATION OF KOELREUTERIA PANICULATA SEED
AS AFFECTED BY CHEMICAL TREATMENT AND PERIOD OF STRATIFICATION

Chemical Treatment	Minutes of Exposure	Days Stratified	After 3 Weeks	After 10 Weeks	After 20 Weeks
	0	30	0	7	40
Control		78	0	17	43
		30	0	3	70
Sulfuric acid	5	78	90	90	90
		30	10	10	60
	30	78	97	97	97
		30	0	50	63
	5	78	0	47	60
Diethyl ether		30	0	3	57
	30	78	47	50	50
		30	3	0	47
	5	78	40	43	47
Acetone		30	3	7	37
	30	78	40	50	57
		30	0	7	50
	5	78	0	17	17
Toluene		30	0	0	73
	30	78	0	3	10
		30	0	7	30
	5	78	0	3	10
Petroleum ether		30	0	7	37
	30	78	3	7	17
		30	0	3	43
	5	78	0	0	0
Xylene		30	0	0	27
	30	78	0	0	7
		30	0	0	53
	5	78	0	0	10
Carbon		30	0	3	17
Tetrachloride	30	78	0	20	24

MODERATOR MARCH: "Observations on Some Plant Distributions in Japan" is our next topic, which will be given by Dr. John L. Creech.

OBSERVATIONS ON SOME PLANT DISTRIBUTIONS IN JAPAN

John L. Creech
United States Department of Agriculture
Agricultural Research Service
Crops Research Division
Bettsville, Maryland

The main objective of this discussion is to emphasize the significance of the origin of parental species material used in breeding programs for woody ornamental plants. We are inclined, frequently, to use a species as a parent without first-hand knowledge of the background of the material in relation to the extent of natural distribution of the plant or the variation that exists within the species. Some of these points are illustrated by the accompanying slides taken during an exploration for ornamental plants in Japan from April to July 1961. Rhododendron japonicum, R. obtusum var. kaempferi, and Camellia japonica particularly illustrate the great range of variation in habitat and plant habit of the woody plants of Japan.

Rhododendron japonicum inhabits the grass and scrub-wooded moorlands of Japan, including Kyushu, Shikoku, and Honshu. It does not occur naturally on Hokkaido although plants said to have escaped from cultivation are scattered in the hills around the city of Matsumae, near Hakodate.

Wilson (1) recorded the distribution of R. japonicum as restricted to the main island of Honshu as far north as Mt. Hayachine. This azalea has a considerably greater distribution than Wilson was able to realize under the circumstances of travel that existed when he visited Japan. On Kyushu, R. japonicum occurs on low rolling hills not far from Kurume and is scattered through pastures where most other plant species have been grazed off by cattle. Except for pine and chestnut trees, the azaleas dominate these hot, sunny plateaus.

At its northern limit of natural distribution, R. japonicum is abundant on Mt. Hakkoda, Honshu. Here the azaleas grow around the perimeter of moist sphagnum bogs at elevations up to about 3000 feet, under such swampy conditions that one sinks into several inches of water when invading these bogs. Occasionally, R. japonicum can be found in lightly wooded coastal areas along the Pacific coast of Honshu, but essentially it is an upland, sun-loving plant and grows to a height of 3 to 4 feet, producing stout, erect stems from a somewhat stoloniferous base. It flowers from late April to late June, according to latitude. The flowers, which appear with the leaves, vary from clear golden yellow to brilliant orange-red. These are borne in terminal clusters of 6 to 12 flowers, each bloom 2 to 3 inches across.

Despite the long history of R. japonicum as a cultivated plant, information as to its flowering habit is rather incomplete. It is doubtful that there is material in cultivation that is representative of variation which can be seen in the wild in Japan. For example, the yellow-flowered plant was considered to be so rare that Wilson regarded it as a distinct form which he named R. japonicum f. aureum, based on material cultivated in the Tokyo Botanic Garden. Had he been fortunate enough to see R. japonicum in Kyushu, Wilson might not have considered the yellow character of such importance, for about a third of the plants on the hills around Kita-yamada have yellow flowers. The other colors range through various yellow-orange mixtures and pink to orange-red. It was reported to me that seed gathered from plants with yellow flowers produces populations that are almost exclusively yellow-flowered.

As one follows the distribution of R. japonicum northward through Honshu, it is true that the yellow-flowered type ceases to be common. At Hakkoda-san, all the plants are uniformly orange-red, so much so that one could regard this as a distinct biotype. It is interesting to note that the greatest range of flower color is confined to the warmer end of the distribution with more tendency toward yellow flowers. The only close relative of this azalea in the Orient is R. molle. That azalea comes from even warmer localities of south China and is exclusively yellow-flowered.

Rhododendron obtusum var. kaempferi has the broadest distribution of the evergreen azaleas native to Japan. It occurs from the coast of southern Kyushu to the mountains near Lake Shikotsu, Hokkaido. It probably has been used more often as a parent than any related azalea species. Despite this extensive use, R. obtusum var. kaempferi has never been evaluated with respect to the merits of local types which exist in this broad range of environments. In kyushu, it inhabits the highly volcanic soils of the cool, humid slopes of Sakurajima and is found on grassy upland plateaus on Mt. Takatoge, Mt. Kirishima, and Mt. Aso. Along the Pacific coast of Honshu, Kaempfer's azalea occurs around the edges of pine forests and ascends to the tops of the mountains where it may be found among deutzias, hollies, and deciduous azaleas. In Hokkaido, it flourishes around the sulphur beds and in the volcanic soils of Mt. Esan and in the cutover fields around Lake Shikotsu. Traveling from south to north, it was possible to see this azalea in bloom from April 20 to July 18 and collections were made at 24 distinct localities representing a wide variation in habitat.

Camellia japonica is a maritime plant and even in an island environment like Japan occurs extensively in only the coastal forests. Despite this general limitation, there is still leeway for future improvement of the Japanese camellia in relation to plant hardiness, for the garden varieties we grow are derived from parents from only a limited portion of the natural distribution of C. japonica.

The northern biotypes of C. japonica and also individuals growing at high elevations should be evaluated for hardiness. Camellia japonica grows along both coasts of the island of Honshu. On the Japan Sea side, it reaches Cape Kogane (40°40'N) with an additional isolated colony at Kominato (40°55'N). These are localities with considerable snow in winter. Along the Pacific coast, C. japonica occurs as far north as Raga (39°55'N), but this region is characterized by bright, sunny winters and is influenced by the cold Oyashio current which flows down from the Kuriles to the 38th parallel bringing cold winds from the Pacific Ocean. In these northern areas, C. japonica flowers as late as mid-May. Until the current series of USDA-Longwood explorations were undertaken, none of the camellias from these localities had been introduced into cultivation. As a result of our efforts, more than 33 collections of cuttings and seeds have now been established in the United States.

A final observation on the woody plants of Japan concerns the general northward distribution of broadleaved evergreen species into environments seemingly beyond their scope of adaptation. Certain plants occur in Hokkaido and northern Honshu and survive only because they grow as decumbent plants covered by snow during most of the winter. The most striking of these are the dwarf or decumbent forms, such as:

Aucuba japonica var. borealis Miyabe
Daphniphyllum humile Maxim.
Ilex crenata var. radicans Tatewaki
Skimmia japonica var. repens Makino

Whether these varieties will maintain their habit under conditions of little or no winter snowfall can only be determined after we have observed them in less severe climates. Essentially, this will determine if these taxonomic entities are true genetic segregates or merely responses to local environmental conditions.

Literature Cited

1. Wilson, E. H. and A. Rehder. A Monograph of Azalea. Cambridge. 1921.

MODERATOR MARCH: The next topic is "Horticultural Paintings" by Mr. James S. Wells of Red Bank, New Jersey.

HORTICULTURAL PAINTINGS

James S. Wells
Red Bank, New Jersey

I don't know how far from propagation this association is going to allow its members to wander, but I think this is pretty far, and I hasten to add that I am not responsible for the paintings. I wish I were. The man who does them I had hoped would be here to explain the method by which he does the paintings.

The story very briefly is this: I go every summer to a little island off the coast of Maine for a holiday, called Monhegan Island. This last summer I met the man who does these paintings. He is a Dutchman with the unique name of Tecco Slagboom, a most charming and unassuming man, who lives for the most part of the year on the island occurs as far north as Raga (39°55'N), but this region is characterized by bright, sunny winters and is influenced by the cold Oyashio current which flows down from the Kuriles to the 38th parallel bringing cold winds from the Pacific Ocean. In these northern areas, C. japonica flowers as late as mid-May. Until the current series of USDA-Longwood explorations were undertaken, none of the camellias from these localities had been introduced into cultivation. As a result of our efforts, more than 33 collections of cuttings and seeds have now been established in the United States.

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I think that this is a very fine example of real craftsmanship and that is the only reason it is here.

MODERATOR MARCH: Thank you, Mr. Wells.

Our next speaker will be Mr. William Flemer, III, of Princeton Nurseries, Princeton, New Jersey, and his topic is: "Further Experiences in Propagating Sciadopitys verticillata from Cuttings."

FURTHER EXPERIENCES IN ROOTING SCIADOPITYS VERTICILLATA CUTTINGS

William Flemer, III
Princeton Nurseries
Princeton, New Jersey

Like many other members of the Plant Propagation Society, I was greatly intrigued by Sidney Wasman's report in the 1960 meeting on his work rooting cuttings of Sciadopitys verticillata, which had always been a plant we considered impossible to root. We had always taken these cuttings in the mid fall, and although all cuttings calloused heavily and lived for long periods, they never rooted although we kept them in flats for up to one year. The sole result was a gradual enlargement of the callus. However, when we took cuttings in the late winter and early spring following Sidney's suggestions, the picture improved very greatly. This little report summarizes our results.

As Sidney noted last year, a great problem in cutting experiments with Sciadopitys is the very limited amount of wood available. Unlike working with Junipers or Taxus you cannot set up experiments with hundreds of cuttings for each treatment, and hence the results in this report must be viewed with some scepticism as only 10 cuttings were involved in each treatment reported. Briefly, we attempted to elucidate the effect of three factors in rooting; time of taking the cuttings, strength of hormone used in treatment, and variations in wounding. All our cuttings were taken from a single 38 year old tree to rule out differences in the rooting ability of various clones. All cuttings were of the past season's growth, and all were taken from the lower half of the tree, which is 15 feet tall. The rooting medium used was 50% peat, 50% perlite.

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The first experiment was concerned with the proper time to take cuttings. In this series, all cuttings were wounded by drawing a knife blade down opposite sides of the cutting, creating two wounds. The basal portions of the cuttings were dipped in water and then heavily dusted with Hormodin No. 3 powder. Ten cuttings were taken every two weeks and the results after five months in the flats of mix were as follows: (Cuttings not rooted were well callused.)

Date of Sticking	Date of Potting	Percent Rooted
February 1, 1961	July 1, 1961	40%
February 15	July 14	60%
March 1	August 1	80%
March 15	August 15	90%
April 3	September 6	70%

The second experiment was with cuttings all made on March 1, 1961 and concerned the strength of hormone used. The cuttings were all wounded on opposite sides of the cutting by drawing a knife blade along the cutting, creating two wounds. The cuttings were all potted on August 3. Cuttings not rooted were well callused and might have rooted later had they been re-stuck and carried on.

Strength of Hormodin Powder	Total % Rooted	% Well Rooted
Hormodin #1	60%	40%
Hormodin #2	90%	50%
Hormodin #3	80%	70%

The term "well rooted" was a rather subjective concept and meant five roots or more, two or more inches in length, per cutting.

The third experiment involved cuttings again taken on March 1st, 1961 and potted on August 3rd. All cuttings were treated with Hormodin #3 powder. The cuttings were wounded by drawing a knife blade down the side of the lower 1/3 of the cuttings on 1, 2 or 3 sides of the cutting, producing 1, 2 or 3 wounds per cutting.

Number of Wounds	Total Percent Rooted	Percent Rotted
1	70%	0
2	90%	1%
3	70%	3%

As will be seen from the above results, under our conditions three wounds apparently opened up too much area of the cutting epidermis and some of these heavily wounded cuttings rotted after callusing had started but before it was completed. We did not have any significant rotting in experiments in which two or less wounds per cutting were made.

In closing, it must be emphasized again that only very small numbers of replicates were made and the results come out in nice round percentages because only 10 cuttings were used for each treatment. We hope this year to test these findings by larger scale experiments, although because of the shortage of wood even these tests will be limited in scope.

One further consideration should be mentioned and that is whether cutting grown Sciadopitys will ever make shapely, saleable plants. M. Leon Chenault in this little work L'Art de Bouturage mentions in discussing layering of Sciadopitys that it should be only used as a last resort if no seed is available because misshapen plants requiring years of staking result. It may be that Sciadopitys is like Araucaria excelsa, the Norfolk Island Pine, in which unsymmetrical and unsaleable plants result from side branch cuttings even though they root quite satisfactorily. Given the leisurely rate of growth of Sciadopitys, however, we shall all be aged and doddering men before we find out!

MODERATOR MARCH: Thank you, Mr. Flemer.

"Plastic Greenhouses for Propagation" will be the topic of our next speaker, Mr. Harvey Gray.

PLASTIC GREENHOUSES FOR PROPAGATION

Harvey Gray
New York State University
Agricultural and Technical Institute
Farmingdale, New York

The propagation house I am about to speak of is designed to produce ericaceous plants from seed or cuttings in a year-round program. The supporting frame is made of 1-1/4" galvanized pipe and Lord and Burnham split tees.

The ridge, sash bar-rafters, eave and sill plates are home-made from rough cut redwood bench lumber. The lower section on the sides and end are enclosed with Johns Manville 1/4" asbestos wallboard.

Four mil polyethylene is attached to 4 ft. wide sash. The sash is portable, made of fir 2 X 2's, treated with copper naphthalate, and covered with two layers of plastic with 1-5/8" dead air space between layers. The plastic is held in place with thin strips of redwood and tacker staples. The house is readily ventilated by the sliding sash.

A feature of the house is an upper and lower five foot wide center bed. The lower bed is for summer propagation, using either the vaporproof chamber or the mist system. The upper level is used for winter propagation.

The house is heated by hot water, two inch pipe coils, and each bench has its own heating coil. The heat is caused to flow on command of the thermostat in the medium (the type used in the electric cable heating units).

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The house is heated by hot water, two inch pipe coils, and each bench has its own heating coil. The heat is caused to flow on command of the thermostat in the medium (the type used in the electric cable heating units).

During the summer season the house is covered with Lumite Saran Shade, the plastic covered sash are in storage at this time, making it possible to get two season's use out of the plastic.

Turkey wire frames are used to support the plastic on the vapor-proof case on the lower level of the center bed. The plants are taken from the propagating house and put in the shade house in May. This planting operation is stepped up through the use of a plug planting board. At the end of the day, the planted area is given a good drink, making use of the portable two inch lines with low angle, shade house Rainbird nozzles.

MODERATOR MARCH: Thank you, Mr. Gray.

Our last talk, "The Application of Supplemental Lighting to Increase the Growth of Deciduous and Evergreen Seedlings", by Dr. Sidney Waxman, University of Connecticut, Storrs, Connecticut.

THE APPLICATION OF SUPPLEMENTAL FLASHING LIGHT TO INCREASE THE GROWTH OF DECIDUOUS AND EVERGREEN SEEDLINGS

Sidney Waxman
The University of Connecticut
Storrs, Connecticut

The use of artificial light in commercial nursery operations may soon become common practice. Some of you may recall the slides I showed several years ago of a flowering dogwood that grew nine foot tall in one year from a cutting by lighting it during the night.

Although getting plants to grow tall in a relatively short period of time has its value, there are many other purposes for which photoperiodic treatment can be applied. By using long or short day-lengths we can control growth of many, but certainly not all, trees and shrubs. Actually it is a tool that we can use to our advantage under various circumstances.

Before suggesting any of its applications there are several facts that I would like to discuss concerning the response of a plant to photoperiodic treatment.

First, many people confuse photoperiod with photosynthesis, the manufacture of sugar by the leaves in the presence of light. The production of sugars by the leaves requires a relatively high intensity of light in the range of several hundred to several thousand foot-candles.

A photoperiodic response, on the other hand, does not require such high light intensities; the plant that grows taller when we artificially light it at night does not make any more sugars in each of its leaves than a similar plant that is not artificially lighted at night.

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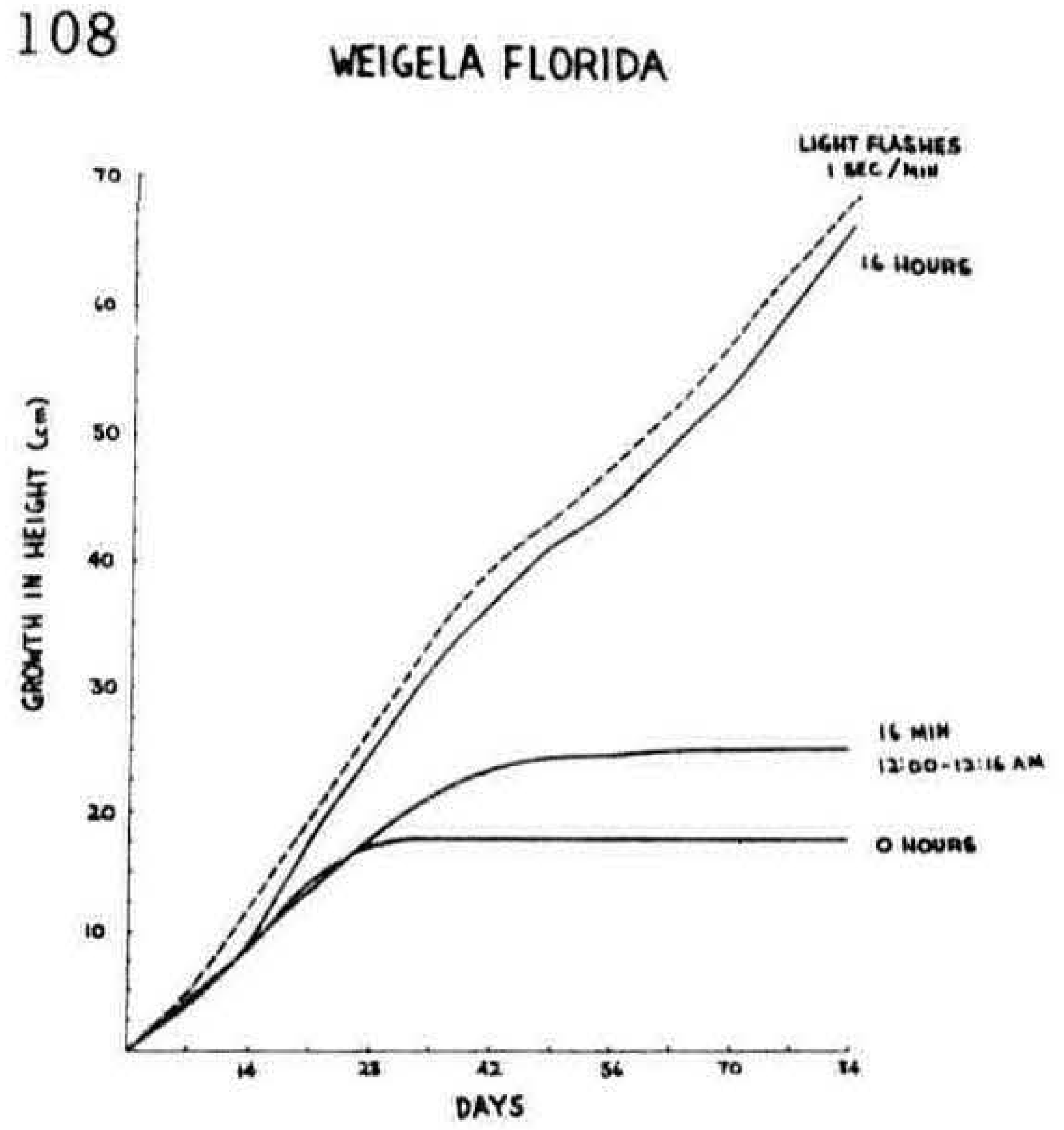

Figure I

WEIGELA GROWTH

All plants received sunlight from 8 a.m. to 4 p.m. Incandescent light (25 footcandles) was provided while plants were shaded with black cloth for 16 hours, 4 p.m. to 8 a.m.

Light Treatment	Total Accumulated Incandescent Light Used Nightly
A. 1 Second of light each minute	16 Minutes
B. Continuous light	16 hours
C. 16 Minute "light-break"	16 minutes
D. No supplemental light - (8 hours of sunlight only)	0 hours

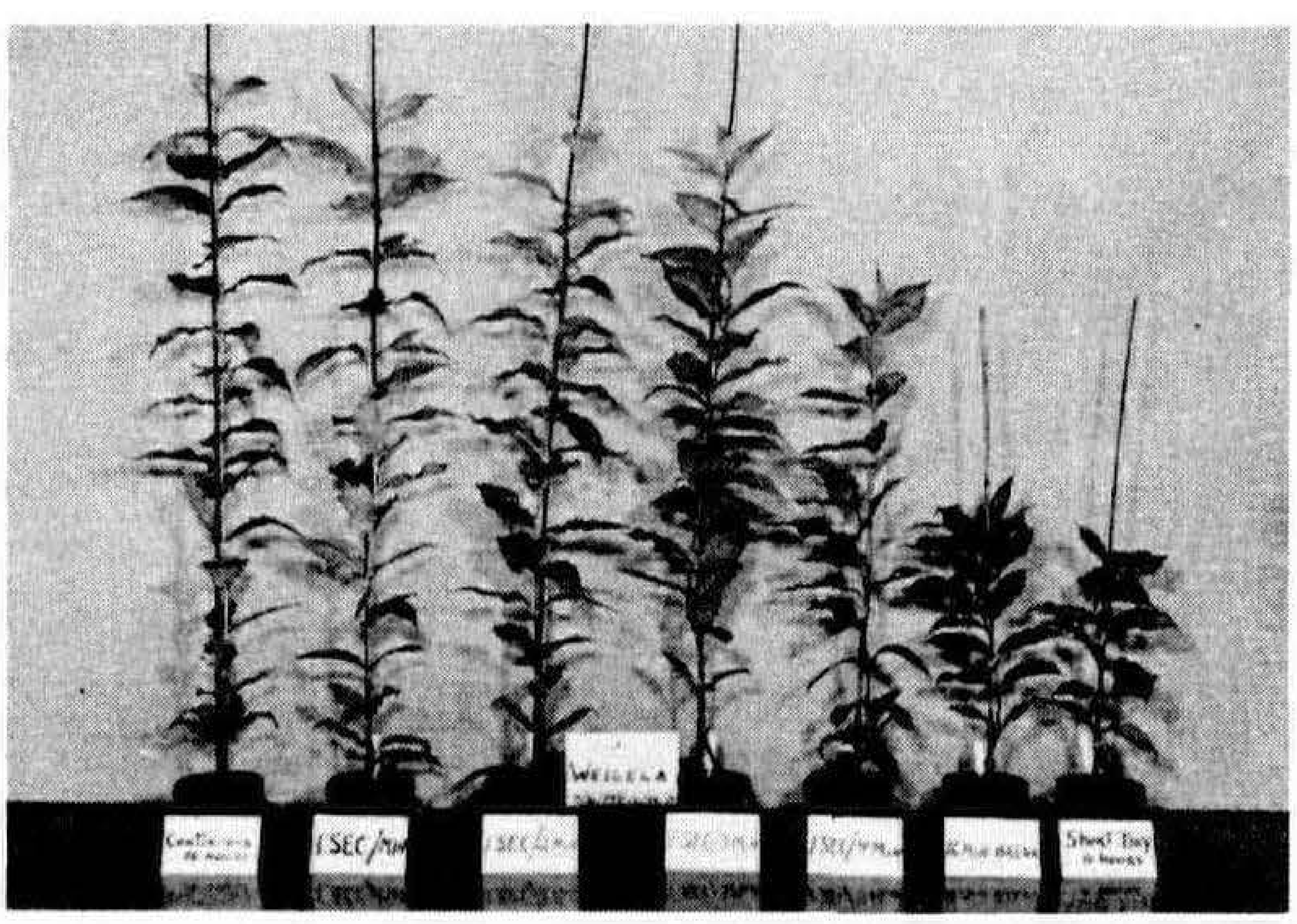

Figure II

WEIGELA

Plants were illuminated with 25 footcandles of incandescent light during the 16 hour dark period. All plants were exposed to sunlight from 8 a.m. to 4 p.m.

Light Treatment	Total Accumulated Incandescent Light Used Nightly
A. Continuous incandescent light	16 Hours
B. 1 Second each minute	16 minutes
C. 1 Second every 2 minutes	8 minutes
D. 1 Second every 3 minutes	5-1/3 minutes
E. 1 Second every 4 minutes	4 minutes
F. 16 Minute "light-break" 12:00 - 12:16	16 minutes
G. 8 Hours sunlight only	0 minutes

Groups C, D, and E, soon became dormant.

A plant will or will not produce new leaves and stems according to the length of the period of darkness it is exposed to each night. If the daily dark period is long, the plant will stop its growth. If it is short, the plant will continue to grow.

If during a long dark period we turn on a light for several hours we would have shortened the length of the dark period and the plant would start growing once again.

The light that shortens the dark period need be no more than 30 footcandles and not the hundreds or thousands of footcandles that are necessary for food manufacture.

Now what about this all-important dark period? Under natural conditions, outdoors, the gradual lengthening of the night, as the summer progresses, causes many plants to stop growth and become dormant long before cold weather approaches. The plants thereby have plenty of time to harden off before winter.

If plants such as these are grown in the greenhouse during the long nights of fall, winter, and early spring, they would either grow very slowly or not grow at all. The short days of winter need not be dormant ones as far as plants in the greenhouse are concerned.

By the correct manipulation of night lighting, we can use this time of the year to our advantage. Two researchers, Hammer and Bonner, in 1938, showed that it was the length of the dark period that controlled the flowering of cockleburr.

We know now that interrupting the darkness with short periods of light will, for many plants, cause them to grow as if they received continuous light.

Substances that accumulate in the leaves during darkness become ineffective by the frequent exposures to light. For example, Weigela grows at a constant rate of approximately 1/4" per day when exposed to continuous light. Similar plants given light for only one second out of each minute during a 16-hour dark period, grew equally as well. (See Figures 1 and 2).

With the cost of lighting cut to such a low figure, the use of such intermittent lighting should certainly be considered. It might be pertinent to mention at this time that not all photoperiod sensitive plants respond in the same degree to flash-lighting. Some species respond very slowly and would perhaps best be given continuous light to avoid a long delay between periods of growth.

Intensity

To get the plants to respond to night lighting there are several requirements to be met, all of which are important. The first is the intensity of artificial light. Although there are many plants that are sensitive to very weak light, say one to 10 footcandles, I would recommend that you use 15 to 30 footcandles to be on the safe side.

You'll find that different species of plants may have different light requirements, some need more than others. The critical intensity for each species can be learned with experience. Although growth may occur under a range of say 5 - 30 footcandles, it will most likely be more rapid at 25 footcandles than at 5 footcandles.

Temperature

As a rule, growth of plants given light at night is influenced by temperature. Experiments conducted outdoors in Connecticut during the summers of 1958 and 1959 have shown that the relatively low night temperatures prevalent there delayed the plants' response to both flashlighting for 1 sec/min as well as to continuous light.

The mean night temperatures for June, July, and August were 52^{o}, 61^{o}, and 59^{o} f. The increased growth of the lighted plants over those not lighted did not occur until October - a rather unfortunate time to get new growth. Of course, many of the varieties that were lighted were killed during early winter.

It appears then, that the application of night lighting should be restricted to the greenhouse unless it is done in an area where night temperatures do not go below 65^{o} F. Experiments in greenhouses with a controlled minimum temperature showed a good response at a minimum temperature of 65^{o} F. but a more rapid response at 70^{o} F. Plants lighted in greenhouses with a minimum temperature of 50^{o} F. produced little or no growth.

Of course there are exceptions to all rules; there are many varieties of plants that ordinarily grow well at temperatures of 55^{o} to 60^{o} F. Undoubtedly, they would respond to night lighting at those temperatures.

What Parts of the Plants Are Sensitive to Photoperiod?

The leaves most sensitive to photoperiod treatment are those nearest the growing points of each branch. The newly developing leaves are extremely responsive, whereas the older leaves that are located further down the stem do not respond as well. This is fortunate because it requires us to illuminate only the tops of the plants rather than the entire plant structure.

Type of Growth

A major difference between plants grown under natural conditions and those grown with supplemental lighting is in the development of the lateral buds. Let us use the Japanese maple as an example. A seedling that had been grown outdoors for three years to a height of about two feet would be fairly well-branched. A similar seedling Japanese maple, given supplemental light, could be grown to that height in six months except that it would not be well-branched but would be a single whip.

The type of growth that occurs with night lighting can be compared favorably to the normal growth of an individual terminal shoot.

The only difference is in the length of time of active growth. The shoot on the outdoor-grown plant will reach a length of approximately six inches; the lighted plant will, with time, be considerably longer and have many more leaves, but neither shoot will have any lateral branches.

It would be necessary in both cases to expose the lateral buds to winter temperatures to break their dormant condition before they can develop into branches.

Therefore we shouldn't expect a plant grown continuously, under long photoperiods for several months or more, to have the same ratio of height to spread, as a plant of the same height that was grown outdoors and has had its buds overwintered two or more times. After the whip is removed from the light treatment, and subjected to natural outdoor conditions, its normal branching habit will eventually prevail. Incidentally, not all species produce a whip-like growth. Some will develop lateral branching while being subjected to night lighting. A good example of this can be found with Cornus kousa.

Perhaps those plants that normally develop lateral branches on the current year's wood will also do so while being subjected to lighting at night.

Purposes For Which Night Lighting May Be Used In Nursery Practices

(A) To extend the normal period of growth for the purpose of:

1. Hastening the growth of seedlings of species that normally require a year or two of close watching and careful handling, before they can be lined out. Rhododendron, azalea and umbrella pine seedlings would fit into this category.

2. Hastening the flowering of those species that normally require three to four or more years growth before flowering occurs. This would be of benefit for the plant breeders among you.

3. Increasing in size seedlings of those species that are difficult to overwinter the first year. The point being that a larger seedling would stand a better chance of survival than a small one, provided it has hardened off sufficiently.

4. For the rapid production of understocks for grafting.

5. Having a constant source of cuttings. By this means a large number of plants could be propagated from only a few original stock plants in a relatively short span of time. New or rare varieties could be multiplied considerably by the constant illumination of the rooted cuttings as well as the stock plants from which they were taken. While under constant growth cuttings can be taken from cuttings, etc. This was actually accomplished with a dwarfed variety of arborvitae. With only two cuttings at the start, it was possible to produce 1200 rooted plants in two years.

(B) To renew the growth of plants that have become dormant.

1. When it is desired to obtain additional growth on plants that have completed their natural period of growth, illumination of such plants during the night will break the dormancy of the terminal and perhaps some of the lateral buds without having to expose them to low temperatures.

For the foliage to respond to light at night, it is necessary that they should not have been dormant for too long a time. If the foliage has started to begin to take on fall color, it would be extremely difficult to break the dormancy of the buds. The deeper the dormancy; the more difficult it is to overcome.

Although flashing light for one second each minute has been found to be effective in breaking dormancy for some species, I would recommend that continuous light be applied until new growth is produced.

The new growth should be evident within four weeks from the date the plants are first lighted. The flashing light treatment may be used after new growth has started.

2. The lighting of dormant winter grafts of evergreens to get an extra spurt of growth early enough to allow time for them to harden before setting out in the spring.

3. To obtain a flush of growth on cuttings that are difficult to over-winter after being rooted. Some plants that might fit into this category are *Cornus florida rubra* and some of the deciduous azaleas.

I've tried to give you briefly an idea of what you might expect when lighting plants at night. You'll find if you try lighting, that your timing will be quite different from what you ordinarily expect. Some varieties will be in constant growth and will become pot-bound in a short time. Also, you may have to fertilize sooner than you expected to. You'll observe some varieties producing extremely large leaves. Unless you are careful and remove the lights in time, you'll have plants that are too tender to over-winter.

Using a proper timing sequence is one of the main things to take into consideration, especially before lighting plants that are to be set out in late summer and fall.

There is much to be learned concerning the use of supplemental lighting for the nursery industry. I would, therefore, suggest that if you want to try it, do so on a small scale at first and play it safe.

(Editor's Note: The following paper was not presented during the Speaker-Exhibitor Symposium, but was submitted for inclusion in the proceedings by Mr. Roy Nordine.)

PROPAGATION OF WITCHES'-BROOMS

Roy M. Nordine
The Morton Arboretum
Lisle, Illinois

Witches'-brooms consist of thick bunches of small twigs emerging from one point on a normal branch. They may continue growing for many years and apparently do no damage to the branch or the tree. They are called witches'-brooms because it was once believed that the trees and shrubs bearing them had been flown over by witches on their nocturnal flights.

These abnormal growths are caused by fungi, rust, Black Mildew, virus, mites, and other organisms. They have been reported from a large number of trees, shrubs, conifers, and herbaceous plants.

Dr. Henry Teuscher of the Montreal Botanic Garden reported to the International Dendrology Union in 1953 that some of these witches' brooms are caused by disease or insects, while others may be a bud sport. Teuscher reported that the witches'-brooms cannot be propagated by cuttings but must be grafted. He also reported that abnormal growths arising as a side shoot on a normal tree are the result of bud sporting and that they can be readily propagated from cuttings but may revert to normal growth.

In the magazine HORTICULTURE, July, 1960, page 372, is an article entitled "Witches Brooms" by Donald R. Yeager. The article lists the following dwarf plants that have been originally propagated from witches'-brooms:

- Picea abies tabulaeformis
- Picea abies maxwelli
- Pseudotsuga taxifolia astleyi
- Pinus sylvestris beauvronensis

Yeager reports that Pinus nigra hornibrookiana was grown from a witches'-broom found on an Austrian Pine about 40 years ago by B. H. Slavin. The first plant grown from this broom is now 30 years old and of irregular outline, being about four feet high, six feet wide, and twelve feet long. This plant is now in Durand Eastman Park, Rochester, N. Y.

In 1954 Bernard Harkness of Rochester Parks, N. Y., found an old and large witches'-broom on a branch of Amur Maple, Acer ginnala. This form was immediately propagated, but the grafter plants have grown more rapidly than the original mutation, although the globe shape is retained in the new plants.

In 1950 a witches'-broom was found on a Scots Pine in Riverside Cemetery, Rochester, N. Y. In 1954 Bernard Harkness grafted this form, which he named Pinus sylvestris "Riverside Gem'. For the first few years the grafts made slow growth, but after five years, growth was very strong; the dwarf form was lost, and the grafts were destroyed. A new lot was grafted from the original witches'-broom, and they followed the same manner of growth as the first lot, and they have now been discarded.

Plant pathologists in studying the diseases that cause witches'-brooms have been successful in transmitting the disease to healthy stock through grafting. Those proved to be transmissible by grafting are usually virus-caused. This work is described in a German publication. (1) Transmission studies of alfalfa witches'-broom virus in Utah are described in AGRONOMY JOURNAL 52, pages 63-65, February, 1960 by Glover and McAllister.

We have tried grafting a number of witches'-brooms. The first one was from Black Walnut, Juglans nigra. In two attempts, one by grafting and later by budding, no scions grew. The second attempt was a broom from a Soft Maple, Acer saccharinum. Only a few grafts were made, on potted standards in the greenhouse, and most grafts were successful. For the first two years growth was very slow and the buds very close together. The third year the grafts returned to nearly normal growth for the species. The fourth spring they were moved to the Collections, where normal rapid growth was made. During mid-summer the various plants began dying; each plant would wilt and die within the space of two or three days. On examination, the stem and roots of the standard were found to be dead.

We have made two attempts to graft a witches'-broom of Concolor Fir, Abies concolor. In the first attempt of 20 grafts, only a few were successful, but all were dead by the end of the first summer. On the second attempt over 30 grafts were made. Nine are alive at the end of the second growing season; three died during this summer. Growth this year was short but averaged 3 or 4 times longer growth than on original branches. Buds on the new growth are very close together, as they are on the original broom.

We have also made grafts of Acer ginnala "Durand Dwarf", the witches'-broom from Durand Eastman Park, Rochester, N. Y. Only a few grafts were made in February, 1956, on potted understocks of Acer ginnala, and all grafts were successful. Growth the first two years was slow but in the third year it increased. In 1960 growth averaged 2-4"; this year, the sixth season of growth, terminal length increased to 6-9". One plant is now barely 3 feet high and 3-1/2 feet wide, but the plant has retained a fine globe shape.

In March, 1960, we made a few grafts from a broom on a Colorado Blue Spruce, Picea pungens glauca. Half are still alive, and growth this year has increased slightly over the growth on the original broom. Buds are very close together, but a little farther apart than on the original broom.

Most witches'-brooms contain a great amount of dead twigs, which is probably caused by the disease causing the broom to form. This disease is then transferred to the new grafts and is responsible for the continued mortality. Other brooms which are healthy, and where grafting results are satisfactory, may be bud sports.

(1) HANDBUCH DER PFLANZENKRANKHEITEN, Bank II, 1. Lieferung, Viruskrankheiten, by Kohler & Klinkowski; Paul Parey, Berlin & Hamburg, 1954.

MODERATOR MARCH: I am sure you would like me to thank all the speakers who have participated in today's program for their very fine papers.

PRESIDENT VAN HOF: For the assembly I want to thank Mr. March for conducting the meeting. We have stayed right on time. With a program like we have had, I thought we would have to forego our lunch.

The session recessed at 12:00 o'clock.

SATURDAY MORNING SESSION

December 9, 1961

The session convened at 9:30 o'clock, President Van Hof presiding.

PRESIDENT VAN HOF: Good morning, gentlemen.

Now, I see that our panel is anxious to get started and so without further ado it is a great pleasure to turn the meeting over to Roger Coggeshall.

MODERATOR COGGESHALL: This morning the meeting has to do with the Propagation Panel, and the first speaker on the panel will speak to us on the Propagation of Clematis - Mr. William E. Cunningham, Cunningham Gardens, Waldron, Indiana.

CLEMATIS

William E. Cunningham
Cunningham Gardens
Waldron, Indiana

To give you an idea of the procedure we follow in producing clematis, first some comment should be made on the way in which the stock plants are managed. Soon after the first of the year, one-year old plants are brought out of refrigerated storage and potted in 4" and 5" pots in a soil mix which is high in humus content, a mix in which drainage is good and wherein there is adequate texture to permit a free exchange of oxygen. Our potting mix is made up of fertile field soil and peat moss at a 2 to 1 ratio, plus about 10% sand or perlite.

The dormant one-year old stock plants are potted over a period of several weeks to spread out the work load to alleviate the demand for growing space, and ease somewhat the demand for rooting space during the early spring season. We try to time the production of cuttings so that only about 20% of the total production occupies heated space in the early spring, with the greater proportion of the clematis production scheduled for the early and mid-summer propagation period.

The stock plants awaken from dormancy very rapidly, and they produce cuttings just a few weeks after potting - usually in 5 to 6 weeks.

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The stock plants awaken from dormancy very rapidly, and they produce cuttings just a few weeks after potting - usually in 5 to 6 weeks.

At least three flushes of cuttings are available during the season, each flush taken just as the blocks begin to flower. The stock plants are grown in cool, plastic house areas, poly covered and temperature controlled during the winter months, but open and saran-shaded in summer. The plastic house environment seems very satisfactory for growing this crop, certainly better than in greenhouses where temperatures are too warm for stock, though ideal for rooting.

The first cuttings are stuck in the rooting houses in February, March and April and, as rooted, are grown on in 2-1/2" clay pots. These are known as our 1st flush lots.

The second flush of cuttings, are the lots which are stuck in May, June, July and in early August. These cuttings go into 2-1/4" round peat pots, and are grown in flats. The summer production of clematis cuttings is the main production period, and it is timed to fit in our schedule of a year-round propagation program. Plants developed from cuttings rooted during the long days of summer ultimately develop into plants just as nice as the earlier 1st flush lots.

The third flush of cuttings, the last of the season, are those taken in late August and in September, cuttings of varieties in which shortages still exist at this date and for which greater numbers apparently will be needed the next season for stock production. The rooted cuttings of this 3rd flush are potted in small clay pots and carried in plastic house storage through the winter months, then shifted the following spring to larger containers and grown on for another season.

To repeat, the propagation of clematis entails an average of three flushes of cuttings, the first potted in 2-1/2" clay; the second, and main crop, in 2-1/4" peat pots and grown in flats; the third - and usually the last flush, into small clay pots.

All propagation is own-root, that of leaf-stem cuttings - lightly pruned, hormone treated, using No. 1 Hormodin, and rooted under clock-controlled intermittent fog-mist. The rooting media is comprised of concrete sand and peat, on a half and half basis, and of course steam sterilized. No appreciable time is lost between taking cuttings and placing under highly humid greenhouse conditions. All rooting is on raised benches with 5 weeks the approximate time required to root.

A particularly critical period in managing this crop comes in the transition of the rooted cuttings from the humid greenhouse propagation space to the cooler, drier atmosphere in which plants must be grown - though under the gentle protection of 46% saran. Handling must be such to make sure the plants do not dry-out, to desiccate, in this change. It is at this period the initiating buds at the leaf axil can be lost, and if so, plants ultimately die, though some root action may take place.

The ability of a clematis cutting to root, to root rapidly and well, we believe is directly connected with the plant food stored in the cutting - and this fact is apparent in the rooting of clematis. We know this is a factor, too, in rooting chrysanthemums. We prefer soft cuttings, not cuttings that have become hard through lack of nutrition, so one key to success with clematis is that of making sure good levels of nutrition are kept. In addition, though complete research information is still unavailable, we're now realizing clematis is subject to day-length response, and if we are to succeed best - then supplementary light requirements should be met during the short days of the production season. It is certain that long days, preferably interrupted night lighting, definitely accentuates vegetative growth.

As to our feeding program, we let the appearance of the crop guide us in determining the rate of fertilizer application and the interval between feedings. This crop, both the stock and the new, young progeny, to point out again, is grown in the open during the summer months, though under saran, so if heavy rains have occurred, or if it has been excessively hot and therefore necessary to irrigate heavily, then the interval between feedings is adjusted accordingly. The crop appearance and the weather is our guide, plus an occasional soil test to double-check. On the average, soluble plant food is applied weekly, usually preceding the spray operation. The 3-1-1 soluble nutrient is applied at the rate of 1 pound per 100 gallons to the stock plants as well as to the new crop.

We use the "pinch" method in managing the young clematis and in using this "pinch method", we try to keep a semblance of balance between the vegetative top growth and the root system. We do not want the new growth to extend beyond a point for which there is root development sufficient to sustain it. To accomplish this "pinch method" in preference to the conventional staking and tying system, we begin to pinch out young, soft tips just as soon as they develop on the young potted plants. This pinching is very similar to the pinch on chrysanthemums to induce more branching, and subsequently more wood upon which more flowers are produced. On clematis, wherever possible, we pinch out this terminal growth when it is soft and before any vine extension occurs, but if through delay we fail to do it at the preferred time, we don't hesitate to prune long vines which have grown beyond the soft-pinch stage.

Cane stakes are not used, therefore, either in the management of the stock plants nor in growing the new crop, and this may seem unorthodox to you but we feel the cooler environment nearer ground level is more conducive to better growing than if the vines are trained upward and exposed to conditions which dry out and lead to maturity. The cutting wood taken from vines growing in horizontal position is softer, more succulent, and is definitely preferred during the hot summer months. In letting clematis vines sprawl, instead of using the customary staking and tying system, we don't under any circumstances let vines pile up too heavily, lest there is trouble. There must be some air circulation, otherwise there's foliage breakdown and a possible loss among the young, fragile plants.

In the late fall when the foliage begins to take on hues indicative of maturity, as dormant eyes become evident, - say in November when short days and soil temperatures have changed to a point inducing dormancy, the packaging operation begins. Plants become dormant and store very nicely on the ground beds in the plastic houses - though refrigerated storage is a definite asset, a facility we could not do without in the management of the clematis crop. Foil and poly are used in wrapping plants individually, and small wire-bound crates are used as storage and shipping containers. Clematis retains dormancy beautifully at 32^{o} - 33^{o} F and stays perfectly dormant until needed for orders or for propagation stock - whichever the case may be. On occasion, we have potted stock from refrigeration as late as August 1st with marvelous success.

In conclusion, our general recommendations are as follows:

1. Use a soil mix - well drained, well aerated and fertile.
2. Feed lightly and often; keep a high nutrient level.
3. Spray thoroughly and religiously; maintain a good sanitation and spray program.
4. Take soft cuttings and keep turgid while rooting.
5. Grow plants in sunny but cool location, on sterilized ground beds.

MODERATOR COGGESHALL: We have time for several questions.

MR. CASE HOOGENDOORN: What do you spray with, Captan?

MR. CUNNINGHAM: This can be rather involved, but we spray with a mixture of half Captan and half Parzate, with an occasional spray of Bordeaux mix. We have to rely on the coppers occasionally, maybe once a month, and of course, the insecticides run the gamut, depending on what we think we need. A thorough job of spraying is necessary. It should be regular. We feel once a week or after each heavy rain.

MR. KLAUS VAN HOF (Newport, R. I.): What is the pH level?

MR. CUNNINGHAM: We try to keep the pH level in the middle range. We don't have too much trouble doing it because our sand is calcareous and water is from a limestone source, so we don't have to add lime to our potting soil. I think the middle range would be the ideal.

MR. LOWENFELS: I may have missed this. I came in a little late. Where do you take the cutting - at the nodes?

MR. CUNNINGHAM: You perhaps recall the illustration of the cutting that was rooted. We sever the cutting about two inches below the node and about half of that is stuck in the sand.

MR. CASE HOOGENDOORN: What happens if you don't cut them below the node?

MR. CUNNINGHAM: We cut about two inches below the node. You might be interested in this system that Henry Tusher, of Montreal

Botanical Gardens, spoke of recently in the American Nurseryman of the leaf bud system. That might have real merit. We expect to try it. In the case, the bud would be stuck under the sand and would be more or less protected during the rooting period, and I think that could be real important. We use the leaf stem system, a two inch stem with a four inch.

MODERATOR COGGESHALL: Richard Fillmore?

MR. RICHARD FILLMORE: I would like to ask about varietal differences with respect to ease of rooting. Mr. Cunningham, could you name an easy one and a very difficult one, and one which he would regard as intermediate with respect to ease of rooting?

MR. CUNNINGHAM: This might not be true with a competitor. He might have ones that root easily and they would be difficult for us. For us, Montana rubens, Madam Baron Veillard, Elsa Spath and Romona are easy ones. Of course this usually happens - the difficult ones are those that sell the best. Jackmanii is one we have the most trouble with. (Laughter)

MODERATOR COGGESHALL: I am sorry, that is all the time we have for questions now. Thank you very much.

Our next speaker on the program will speak to us on the propagation of Chaenomeles, and he is certainly no stranger to us. Mr. Wells, of Red Bank, New Jersey.

CHAENOMELES

James S. Wells
Red Bank, New Jersey

The propagation of Chaenomeles does not apparently present any unsurmountable problems and the tests which I am about to describe will simply illustrate some of the finer points which can raise propagation results from a mediocre to an excellent level. The tests were carried out during 1954 while I was with the D. Hill Nursery Company in Dundee, Illinois, and they therefore apply to plants and conditions as they exist in the Midwest. The tests were made on numbered varieties of Chaenomeles raised by Dr. Colby at the University of Illinois, Urbana. These plants had been growing for many years in a stock block on the Hill Nursery and were well established. They normally grew quite vigorously and produced ample supplies of good shoots from which cuttings could be taken.

Equipment

As usual, we were trying to test a number of things at the same time - a mistake, I believe, because one can become so confused in the multiplicity of tests that it is difficult to sort things out - but basically, we were rooting these cuttings in an open-air mist bed.

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The bed was set up in a concrete frame with a central mist line. One section was covered with shades and one section was covered with plastic, more or less following the Templeton method. In general, cuttings rooted best in the open with a 50% lath shade covering, but this should not be taken to indicate that the plastic covering could not work. I am quite sure from the results we had that if we had accurately followed the Templeton method the results would have been just as good.

Medium

The medium used was plain, sharp sand and as the mist was applied for 24 seconds every six minutes, excellent drainage had to be provided beneath the bed. Some side protection to prevent drift of the mist was given by the concrete frame and the lath shade, which was desirable to insure complete coverage of the cuttings with the mist.

Timing

Our tests were made on June 23, 1954, and the cuttings were lifted on August 4, a period of exactly six weeks. This was obviously quite sufficient for proper rooting under optimum conditions but no doubt cuttings could have been taken a week or two earlier, which would have been of value in the subsequent reestablishment of the rooted material.

Type of Cuttings

This appeared to be important in terms of size of cuttings. Cuttings were taken from vigorous shoots of current season's growth which had been made following flowering. The shoots were from 6-10" in length, depending upon habit of growth of the variety, but the larger the cutting and the stronger and the more vigorous the stem, the better would the cuttings root. This was noted time after time in the tests on this range of 12 varieties and seems to be important. Some varieties would not naturally produce large cuttings and were more difficult to root.

Hormone Treatments

These were of clear value and should be considered essential. The actual treatment to use depended upon the variety and varied to some degree, but not very widely. A range of tests was applied to almost all of the varieties being grown and although one or two responded to indole butyric acid at 4 mg/g (Hormodin #2) most of them required something a little stronger. Hormodin #3 was good on a number, but time after time, the results showed the clear superiority of 1% (10 mg/g) of the Potassium Salt of IBA. Let me give a typical example.

Variety #5 - High Noon	% Rooted
No Treatment	0%
Hormodin #2	40%
Hormodin #3	50%
1% K Salt IBA	100%

Now I would like to quote my notes at the time these cuttings were lifted. On Hormodin #3 I said, "Treatment not really strong enough. Rooting light, and undeveloped." And then on the 1% K Salt IBA, "large cuttings, excellent rooting, well developed and mature. Size of cutting is obviously important." Some varieties responded to a lesser treatment and variety #2 was one of these. Here, Hormodin #2 gave 100% rooting; Hormodin #3 gave 90%; and 1% K Salt IBA gave 50% rooting. But, this was only one from the many and it seems clear that for most varieties either Hormodin #3 (IBA 8 mg/g) or 1% K Salt IBA should be used. The choice of which to use from these two will also depend somewhat upon the size of cutting available. If the cuttings are sturdy and strong they will respond to the stronger treatment. All cuttings were wounded with a single heavy wound immediately before dipping in the hormone powder.

Hardening up and Subsequent Handling

Cuttings rooted under intermittent mist out-of-doors require care in the return to more normal conditions. A time clock is advantageous in reducing the interval of misting and this, coupled with heavy shading for a week or two, will allow the cuttings to be prepared for moving. It is desirable to move the cuttings, if you can, as early as possible in August, and either pot them or flat them so that they can become re-established before the end of the growing season. Alternatively they could no doubt be allowed to develop a root system in the soil beneath the propagation bed and protected in situ (Templeton method) with equal success. In these tests we lifted the cuttings and potted them and then carried them through the winter in a deep frame. It is interesting to record that there was a distinct difference in the percentage of survival of cuttings dependent upon the quality and vigor of the root system. For instance, with somewhat lightly rooted cuttings, rooted with Hormodin #2, three out of eight died, while the much more strongly rooted cuttings treated with the 1% K Salt IBA only one out of ten died. The following spring this young material was canned and grew successfully into young, salable plants.

Propagation from Root Cuttings

I recently had a visit from John Verkade of Wayne, New Jersey, and as we were discussing the qualities of these Chaenomeles, he casually mentioned a method of propagation used by him in Holland which sounds extremely efficient and simple. I have not tried it, but I intend to do so. He said that an established plant should be carefully lifted in early spring and the large roots removed. The plant can then be set back to re-establish itself. The roots are cut up into 3/4-1" pieces, simply cutting them with a pair of shears. It is unnecessary to differentiate between the top and the bottom of the root. These pieces are then sowed in rows in a bed, not broadcast, because he suggests that by keeping them in rows they have more room to develop and produce better plants. The pieces of roots are covered with about 1" of a 50-50 mixture of sand and peat and he says all you have to do then is watch them come up like seed. He pointed out the importance of not letting the roots become dry while they are being removed and handled. It is vital that there be no delay during this process and certainly the roots must never be left lying around. In talking about this with John, he said that the quality of the plants produced in this manner was excellent. The plants had a full year to grow, which in a well prepared bed they did with vigor, and the stock could be lifted for sale as lining-out material or for planting or canning, as desired, at the end of the first year. This sounds such an easy and efficient method that I think we should all try it next spring.

I cannot close this discussion without very briefly commenting on the excellent quality of the varieties raised by the University of Illinois. I have watched these now for some years and I believe that they are all of exceptional quality, but if one could be selected, then I would have "High Noon (#5). This is a strong and vigorous plant with excellent large, semi-double flowers produced in massed profusion. The color is shown as porcelain rose on the color chart but these words are quite inadequate to describe the brilliancy of the color. The sound quality of this group of plants, coupled with their extreme hardiness, recommends them without reserve as first-class horticultural material.

MODERATOR COGGESHALL: Are there any questions?

MR. WELLS: I shouldn't bring in this subject, I am sure. Truthfully, I haven't grown Chaenomeles commercially, produced any large quantity for the very simple reason they don't produce a good income. Why these plants, and one or two others, should always sell for such a low price, I don't know. We have to go through essentially the same procedures to produce them as many others which will command a much higher figure. There doesn't seem to be any rhyme or reason why one plant should be priced so low and this is one of them.

MR. ROLAND DeWILDE: Have you tried heel cuttings at all? I find heel cuttings yield close to 100 percent if you put Hormodin #3 on. In fact, in some cases, #2 is strong enough. What I try to get is the spurs that come on these things, that grow anywhere from three to six inches long, and cut right off on the side of the branch. I guess I am old-fashioned but I always carry on the experiments of Boyce Thompson, where they found the natural auxins are close to the base of the heel cutting. Maybe that is one reason I make out alright with a lower concentration of Hormodin.

MR. WELLS: I think that is probably true, Roland. Like you, I was brought up that a cutting without a heel was no cutting at all, but I recall making tests on Juniper pfitzer in which it was clearly shown heel cuttings were less satisfactory. Now I don't want to get off on another plant, but I don't think that we can slavishly accept on all plants these rules of thumb which we did accept twenty years ago without question. Now I think it might well be on this plant, that you are right.

MR. DeWILDE: It works out about the same with holly. Sometimes you get more roots on cuttings which most have an older piece of wood on them than the softer flush of growth.

MR. WELLS: We noticed a very great difference in the rooting ability between varieties. This is shown in Figure 2. No. 13 callused with great big gobs of callus, but rooted very indifferently at any concentration of Hormone, whereas, the other varieties rooted very easily indeed.

In talking with Harvey Templeton about this, he said he has a couple of varieties which he can't root at all. It would be interesting to work on some of these. There is a wide varietal difference.

MR. DeWILDE: I worked on them in France. This was back in 1926 in a propagating department of a nursery under the so-called glass bells. The same thing turned out. This would be before hormones or anything of the kind. They usually make very short heel tipped cuttings and so you would get a solid stand and some maybe only 20%, and some practically didn't root, but they raised about 35 or 40 varieties, as I remember, and there was a definite difference between each variety as far as rooting is concerned.

MODERATOR COGGESHALL: I am sorry, gentlemen, we must call a halt to these questions.

The next speaker will speak on a plant which is not too commonly grown or propagated, at least to my knowledge - Helleborus. Mr. Case Hoogendoorn, Hoogendoorn Nurseries, Newport, Rhode Island.

PROPAGATION OF HELLEBORUS

Case Hoogendoorn
Hoogendoorn Nurseries
Newport, Rhode Island

Before I go into this subject I would like you to understand that I am no authority on Helleborus and I am going to tell you only my experiences with the limited variety we grow.

For the benefit of those members and guests who don't know Helleborus (also called Christmas Rose), I would like to tell you a little about this particular plant regarding its likes and dislikes so that you will understand more readily how we try to apply its proper environments to the propagation of this particular plant in order to grow it successfully.

To begin with, I would like you to understand that Helleborus is a perennial and because it is called Christmas Rose, it is not a rosebush as some people think.

We all know that Helleborus is a rather tempermental plant, but it is not too bad once you understand the plant. Helleborus is perfectly hardy as it originated from the Alps in Europe. It will never get winterkilled as it does not mind low temperatures at all but it might get summer-killed, as it resents heat and drought. Furthermore on them than the softer flush of growth.

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We all know that Helleborus is a rather tempermental plant, but it is not too bad once you understand the plant. Helleborus is perfectly hardy as it originated from the Alps in Europe. It will never get winterkilled as it does not mind low temperatures at all but it might get summer-killed, as it resents heat and drought. Furthermore it likes shade or partial shade and a well-drained, humus soil, which will retain moisture. A neutral to moderately alkaline soil is recommended although they will also grow well in a slightly acid soil.

Helleborus also likes to grow in a sheltered position, which will help to retain its foliage. So you see the best place to plant them is on the east side or north side of a building amongst other plants or on the north side of a shrub border, but never in the full hot sun with south or west exposure.

Being acquainted now with the likes and dislikes of Helleborus, I will go on and explain the propagation of it. We generally pick our own seed of Helleborus niger in June just before it pops open and we dry it in the greenhouse.

After a couple of weeks we clean it and put it in sand for stratification in clay pots or a box and keep it moist. Seed has to be handled promptly as it loses its germination power quickly.

In October or November we sow it in a well prepared frame with plenty of cow manure worked into the soil to provide humus. We cover the seed with a mixture of 50% peat moss and 50% sand, which we mix with a soil shredder and roll it down with a roller. After that we cover the seed-bed with burlap right on top of the soil to keep the peat and sand from blowing and washing, and to keep the seed from heaving out during freezing and thawing weather. Then we cover the frame with lath shades, which provide 50% shading. The following spring the seed will start to germinate sometime during April.

As soon as we notice germination, we remove the burlap. In case of a dry spell we help out by giving the seed bed a good watering. After the seedlings are up and well started, we raise the shades to about 18 inches to get more air circulation. The shades remain on the seed-bed all summer.

When the weather gets cooler during October, we pick up the seedlings and transplant them in heavy manured beds about 6 inches by 6 inches, which give them enough room to develop properly into saleable plants.

After the beds are planted we mulch them with sugar cane (also called servall) and cover the beds with lath shading on runners about 18 inches high. In case of dry weather we put on irrigation to water the seedlings in thoroughly. The sugar cane helps to maintain moisture and also prevents heaving during the winter. The lath shades stay on these beds winter and summer until the plants are dug and sold. If we should have a dry and hot spell during the summer we irrigate.

This concludes growing Helleborus from seed.

Now I will go into named varieties of Helleborus, which all originated by seedling selection, such as Buis, Keessen, etc.

In order to keep these true to name they have to be propagated by divisions. These plants can be divided either in the fall or early spring. Planting out these divisions and caring for them requires the same treatment as the seedlings I have just described.

Now we come to Helleborus Orientalis varieties. I have not had much experience with them. Some of them seem to come true from seed while others need to be grown from divisions.

About twenty five years ago I imported seed of Helleborus niger for the first time. I sowed it and it turned out to be Helleborus Virides. It has clusters of green flowers, which is the reason they call it St. Patrick's Rose. I noticed they all came true to name.

On the other hand we grow Helleborus Orientalis Atrorubens, so called Red Christmas Rose, and I have never seen that set seed yet, therefore we grow that from divisions.

As I mentioned before, once you plant out your divisions, the treatment of shading, watering, mulching, etc., is the same as that of seedlings.

This concludes my experiences with the propagation of Helleborus.

MODERATOR COGGESHALL: Roland DeWilde.

MR. ROLAND DeWILDE: Case, don't you have any disease problems with them? It seems to me when I used to play around with these things we had leaf troubles.

MR. HOOGENDOORN: You do, but that depends a good deal on the weather. There is a fungus and we used to spray during the summer with Captan and the fellow at the college said, "You are wasting your time." I said, "Why? If I keep spraying I would have control." He said, "No, these are spores and they only explode when the weather gets cold and wet. That is the time they get it." You look at these leaves, we had a beautiful fall. You don't see anything on these leaves. They haven't been sprayed at all. If you get a wet fall you will have more trouble with that.

MR. HUGH STEAVENSON: Sometimes they bloom at Christmas. Two years ago we were over at Bosley's on one of those tours and we were looking at the big hollies and all of a sudden I spotted a couple of clumps that big. First, they will turn white and after that when the flower gets older it has a pinkish cast and this was already pink and that was the beginning of December. I said, "What variety is that?" He said, "I don't know. It is Helleborus." I said, "but it is already through blooming". He said, "That is the first time it happened this year. It never happened before."

That is why I say it is a tempermental plant. No doubt all these things have a lot to do with it. Maybe they have a dry summer and set quicker, or it might have been a weather condition. The weather plays a big part. The reason I started this, when I was a youngster, my father had them and that thing has stuck in the back of my mind. I never could understand how he could have in December these white flowers and the next day you would have the pink, and the flowers don't freeze. That is what fascinated me. That is the reason I am growing them, not because you get 500 blooms.

MODERATOR COGGESHALL: Thank you very much, Case.

We will now have a ten minute recess.

PRESIDENT VAN HOF: May I have your attention, please? Mr. John Vermeulen wishes to make an announcement at this time.

MR. JOHN VERMEULEN: One of our old charter members, Mr. Anderson, of Erie, had a very bad accident last spring. He is recuperating and I think it would be nice if anyone here would sign the card so he would know we are thinking of him.

MODERATOR COGGESHALL: The next speaker on the program is also a man who has traveled a considerable distance. He is going to speak to us on his experiences in plant propagation - Dr. Seymour Shapiro, University of Oregon, Eugene, Oregon. Dr. Shapiro.

EXPERIENCES IN PLANT PROPAGATION

Seymour Shapiro
University of Oregon
Eugene, Oregon

I think I should probably start out by saying the title which reads, "Experiences in Plant Propagation", is really very misleading. I think it is probably put in this way as a trap to make sure that you came back after the recess before lunch.

What I would like to do is discuss with you some of the experiments that you have been continuing along the same lines that I was working on in 1958. I have been concerned with working on some of the factors that control rooting. A plant very easy to root is Lombardy Poplar. The first question to ask is, why is the Lombardy Poplar so easy to root? The answer is a very simple one - it is very easy to root because the roots are already present in the tree at the time that you go out to take your cuttings. The root primordia in the poplars and in many of the willows are laid down as a normal feature of development of these particular plants and so they are already in the tree. All we have to do, then, is concern ourselves with what regulates the growth of these new primordia.

What are the factors which control their emergence? A number of the speakers at this meeting talked about rooting in 4 to 6 weeks. This is, of course, the sort of thing you have to face if you are initiating primordia from cuttings. If you are starting from the cells they have to reorganize to form roots. In the poplars, all we have to do is make them grow. If we can make them grow, they will come out in 4 to 6 days instead of that many weeks.

I would like to review some of the things I talked about last time, to set the stage for some of the more recent experiments we have done since that time.

The roots of the Lombardy Poplar are formed in the phloem of the stem and they are arranged in rather systematic fashion, about one every centimeter along the line. You can't tell precisely where they are from the outside of the stem, but if you peel the bark you can see there are tiny dimples in the bark itself, and these mark the positions of the root primordia. They are generally laid down toward the end of the first year of growth and in all of the experiments that I will describe we worked therefore with cuttings that were at least two years old.

Apparently there are some varietal differences here. We had some material sent to us from Canada with the root primordia apparently formed very early in the first year and you don't have to wait to be able to study this.

The big question that attracted me to this problem was, if the root primordia are present in the poplars, why don't they grow out right on the tree? Why aren't poplars covered with roots all the time? There seemed to be a pretty obvious answer to this because if you take a cutting and stick it in the ground, it is the portion in the dark which roots and the portion which remains in the light does not root. So we put some containers around the branches, and wherever we darkened the stem, roots would emerge and they would emerge in 5 or 6 days. It certainly seemed as though light was a factor which normally keeps the roots from growing out on the poplar stems.

We wanted to find out something about the sensitivity of these roots to light and so we made some cuttings and gave them daily periods of light, low intensity light, the sort of light Dr. Waxman talked about with the photoperiod studies yesterday, and intermittent light experiments, and I will have something to say on how it relates to the Lombardy Poplar, in a few minutes.

We take ten centimeter cuttings, put them in a small fish tank, a little water in the bottom, and this very quickly becomes a saturated atmosphere with 100% relative humidity. A tank cutting of this sort will root in five or six days. If we keep them in the light, the roots will not come out.

The next slide shows what happens if we put them in the dark. You can see that the distribution of roots along the cuttings is rather uniform. The roots which emerge from the preformed primordia are peculiar in several respects. Notice the direction in which they are growing. They don't really grow down; they sort of grow out horizontally with a slight inclination toward growing down.

Here we have cuttings that have been given light on a daily schedule. We have plotted the number of roots that form per cutting on the different days. For example, in the dark, the first roots to appear, appeared on the fifth day. We got about 2-1/2 roots per cutting. On the sixth day we added another three roots. On the seventh day we had another two roots. By this time we had something like seven roots per cutting and it falls off on about the eighth day, and perhaps a small amount after that, but most of the roots emerged between day five and day eight.

If we give these cuttings one minute of light per day, of about 300 foot-candles, we inhibit root development by about 50%. If we give them four minutes of light per day we inhibit them almost completely. With fifteen minutes of light per day of one hundred foot-candle intensity, we cut our number of roots by about 50%, and with four hours of light we cut it down to practically zero.

We continued this kind of regime for 14 days and then we put all of the cuttings in complete darkness. We stopped the light-dark cycle. We expected the cuttings would recover from this once they were in complete darkness.

We found that green and blue gave us very, very little inhibition. But if we gave 30 minutes of red light we got just about complete inhibition. So red light apparently is the offender here, and the reports in the literature have indicated if you have a particular responseof a plant to red light you can reverse this effect by subsequent exposure to this far red light. This is a well known system.

If we supply far red light we find its effect can vary slightly and this may be a leakage effect. If we give 30 minutes of red light, which gives us almost complete inhibition, and follow it by 30 minutes of far red light, we have reversed the effect of the red light. So apparently in the poplar roots we are dealing with the same system that other people have worked out. They are stopped at this level of development and will not recover.

As far as commercial practice here, I really don't think it has any real importance, but certainly I would not leave poplar and willow cuttings around in the light before putting them in the ground.

This slide shows some experiments on the quality of the light. We wanted to know what part of light, which of course is made up of a mixture of all parts of the spectrum, is bringing about the inhibition. So we gave them darkness, green light, blue light, standard red light and far red light. We used these because of what people had published in the literature before on visible light effect.

Next we wanted to know how efficiently the stem is able to absorb and use this light. It is coming into it as light energy. Is it going to do anything with it? It has to convert to some sort of chemical energy, so we took our light cycle and broke it up as follows: We had what we called a long cycle in which we gave 24 minutes of light in 24 hours. We took the same 24 minutes of light per 24 hours, but broke it up into a series of very short bursts. We gave our short cycle - 6 seconds of light every 6 minutes. In 24 hours the cuttings received the same amount of light on the short cycle as on the long. What we find is when we interrupt light by darkness, our short cycle is a much more effective inhibitor. This is much the same kind of thing, I believe, that Dr. Waxman and others have found.

What this tells us is that during the light exposure this energy is trapped by some pigment present in the stem and this is the primary light reaction. Then this energy which is trapped is passed on to other chemical systems during the dark period which follows, and this light trapping system can obviously handle only so much light at a time. It is much more effective than when you give one long burst of energy.

Next we tried to find out something more particularly about this pre-emergence period. What happens during the five days before the roots come out? So we gave them 24 hours of light, but scattered it through this five day pre-emergence period. In other words, light on the first day followed by complete darkness.

With another set of cuttings we gave darkness on the first day and light on the second, followed by darkness.

If we give them light on the first day, it doesn't really recognize it. The same number of roots are the same as for total darkness. If you give them light on the second day, after one day of darkness, we have significant inhibition, but when the light is administered on the third day after two full days of darkness, it is most potent. If we give that light on the fourth day, after three days of darkness, it is less effective, and progressively less effective as this light period comes later and later in the pre-emergence period.

We used 1, 2, 3, 4, and 5 days of light and followed by complete darkness. When we had a solid block of light followed by darkness, it takes 5 days approximately of complete darkness from the time we shut off the light, before the roots appear. Then we gave them different numbers of days of darkness and then followed it by light, because if what I said before is true, ie., that something is happening in the dark, which promotes root emergence, which starts these roots to grow, then how much of this darkness is really required?

So, again, this supports the idea I mentioned before, that something happens very slowly in the dark and this something can be very rapidly destroyed by light, and once it is destroyed by light in the cutting, it is apparently not replaced. When we returned our cuttings to the complete darkness after different amounts of light, they were frozen at the level of roots they had. They do not recover from this.

So we have built up an idea which says this: That something forms very slowly in the dark, is inactivated very rapidly in the light, and this material is present in rather short supply in the cutting. Now if it is present in short supply in the cutting, how does it get into the cutting in the first place? And also, when the tree is growing in the field as an intact tree, why isn't this material destroyed by the light that the tree gets?

This puzzled us for quite a while and we set up the following experiment. After all, a cutting is not an intact plant, although I didn't mention earlier that we debud all our cuttings before we set them out; remove all the lateral buds to conserve the food supply in the cutting, and we began to wonder whether the source of this substance which is depleted in the dark period, is converted to something which is required for re-growth, whether perhaps this isn't supplied by the buds. We ran the same experiments with active buds on the cuttings with active growing leaves and it makes no difference.

Then it occurred that perhaps the root system of the plant itself was supplying this material, and so we did the following experiment to check this out: We took a tree and severed it at ground level and brought the whole tree into the laboratory, and set it in a bucket of water for about 10 days, so we illuminated the whole tree rather than the cutting, but it was rootless and we made cuttings of these and left them in the dark and the cuttings only saw darkness. But cuttings made in the dark and kept in the dark will form no roots.

So we began to suspect that whatever this substance is, it is coming from the roots. So we went out and made some large marks on some of our trees, about two feet in diameter. We wounded our stem and wrapped this whole thing in plastic and covered with black cloth and developed an aerial system of roots, a second system. We left this on the trees for almost a year. We now had a tree which had a root system about three feet off the ground and also a system of roots in the ground. The following year we cut such trees off, brought them into the laboratory, put them in a bucket of water in a light room; so now you see it had lost its original system but it had a second one.

We compared these with other trees that were in the water and in the light, but had no roots again. What we found again when we made the cuttings from these two; the ones with the aerial root system, the second system, could tolerate the exposure to light, and cuttings from them would root.

So we believe now that there is some substance in the poplar which is required for rooting, not for initiation, but to trigger these roots into growth which comes from and is constantly being replenished from the natural root system of the tree. We have tried to find out what this substance might be, but all we have is a long list of things that it is not. (Laughter) It is not auxin, for example. It does not behave that way.

Well, there is another natural step, and that is about where we stand with this. I hope that we will learn more about it in the next couple of years.

There is another natural phenomenon which controls rooting in the Lombardy Poplar, and this is seasonal. We ran into this unexpectedly, and if we could have the next slide (slide), I will show you something about this system. For many of our experiments we keep our cuttings only in the dark, and this shows you the number of roots which we got on experiments over, I think, a 1-1/2 year period, with all cuttings being in the dark. In November, December, January and February, we had high numbers of roots, between eight, and what some experimentors counted in March, April, June and July, in which the number was very low, and then it rose again in the fall and dropped again the following spring. We didn't quite know what this was due to, but it was very apparent that whereas the roots emerge on the cuttings during the winter months when the tree is dormant, all along the length of the cutting, as you would expect because they are from pre-formed root initials, that when we have our low number of roots in the summer months only, those roots at the base of the cutting will emerge. So the roots are polarized at a basal end at the number where they are distributed throughout the length of the cutting during the winter dormant months.

This is not a simple relationship with activity in dormancy on the part of the plant. At least, not so far as cambial activity or the setting of its terminal bud is concerned.

The next slide will show the way these polarized cuttings look. There are roots just at the base, no roots up above. Whenever you get a polarized condition like this in plants, especially if you get it with something that is involved in auxin, and we know auxin accumulates at the basal end of the cutting, we began to suspect this might be related to auxin and changes in auxin between the two seasons. If we invert such a cutting, the roots still know which end is up or down and the roots will emerge at the basal end with regard to its position with respect to gravitation. So it is not gravitation.

We followed a devious line of thinking and decided these cuttings which are polarized must have an auxin deficit. At first we were reluctant to accept this. We felt these were cuttings from trees in active growth when trees are forming auxins and it should have an abundance of these materials, but everything else led us to believe they must have a shortage. So we applied artificial auxin, indoleacetic or indolebutyric acid, and you see it in the controls.

Here we got the typical peeling that you get very often on callus formation, very pronounced here and completely removing this polarization of the roots. So it turns out that the indoleacetic acid is probably present in the cuttings from these active trees in insufficient quantity to meet the needs of the primordial that is buried in the bark. We can change summer cuttings that are polarized in the winter, and non-polarize cuttings by adding additional auxin. We know roots are very, very sensitive to auxin. Probably of all the parts of the plant, the root is most sensitive to auxins and low concentrations of auxin, usually inhibitive. The same concentration which will stimulate shoot growth will almost invariably inhibit root growth.

The next slide (slide) will show you some numbers. We weren't low at all of these. Let's take this series here in which we have auxin concentration in parts per million. The number of roots that develop, the number of roots in the apical half and the number of roots in the apical. With no auxin we have only three roots, only 10% of these were in the apical half, in other words, a strongly polarized, and were 2.6" in length. We went all the way up to 800 parts per million which is an enormous amount of auxin. All these concentrations broke the polarization - 47 to 48% of the roots in the upper half. The root length is inhibited only very slightly. We were never able to inhibit these by any amount of auxin we applied at the apical end, and we have an explanation for it, which is based upon the fact that we believe that once the root starts to grow it immediately precludes the possibility of an excessive auxin reaching the tip of that root. It has a mechanism which says the auxin in it will not go from the base to its apex. If the auxin has to reach it from the inside of the cutting, it has to move down to the root from the basal part to the apical part. We believe the root has ability in this mechanism which prevents it from happening once it starts to grow.

To test this, we took the roots once they emerged from the cutting, and dipped them in auxin solution, so now the auxin is bathing the bare tip of the root. When we do this we find concentrations not of this order but concentrations of one hundredths or one thousandths of a part per million, will stop their growth completely. So they are sensitive to auxin, but they have some kind of ability in this protection mechanism against being inhibited by the very high concentrations of auxin that might possibly reach it through the cutting itself.

I think that is the last slide for this. There is only one other thing I want to say. We wonder what happens to these roots as the tree gets older. After all, these root primordia are deposited at the end of the first year of growth, in a five or six year old tree - are these roots buried in the bark, or can you root a five or six year old poplar branch as easily as a two year old poplar branch? If the roots actually remain behind and are buried in the root, it should be much harder to root this material. It turns out that six year old or eight year old, or ten year old root not only as easily but as quickly as two year old material. The root primordia are still in the bark and we tested this idea in a number of ways and, for example, if we put a little black patch on just one section of the cutting, the root which is under that patch will emerge, but all other roots on the cutting will be inhibited.

MODERATOR COGGESHALL: Are there any questions in relation to that talk?

MR. RICHARD FILLMORE: I would like to ask if this system might not be used in relation to the appropriate time for taking such cuttings as grape and currant and gooseberry and so on; the grape being one of the very few plants, together with poplar and possibly the willow, which I know about, which will actually come better from dormant cuttings.

DR. SHAPIRO: I think it might be used where you have the root primordia present in grape.

MR. WALTER GRAHAM: Is there any study going on with a series of plants that have root primordia?

DR. SHAPIRO: We are not doing it. The Lombardy Poplar will take very, very small amounts of light. Some of the willows can tolerate quite a bit of light. I think most of you know pussy willow branches which have these primordia rooting will root in a clear glass vase at home, one time or another.

MR. JAMES WELLS: I would just like to clarify something and repeat something I think you said. That was that red light tended to inhibit rooting, and far light tended to reverse that effect. Now I seem to recall the data we were given at Beltsville, that red light triggered it and far red reversed. How do you explain that?

DR. SHAPIRO: I should have said something about this. Remember, whenever you have a light reaction, this light is only the first of many, many steps before the energy which is absorbed, whatever it is that it does, the light has to be captured. This is a physical thing. You have to have a pigment. The pigment picks up this light. It then puts it into any one of a number of different chemical pathways. In some plants it will turn out that the end result of this will be inhibition, and in other plants it will turn out that the end result will be stimulation, but the initial light trapping is so far removed from the final result, what the plant does with this energy, that it is very easy to see that this can happen. It isn't a direct action, by any means.

MR. HUROV (Cornell): Your experiments with the large cuttings are very interesting, but I see no reason why large cuttings should root where more difficult ones don't.

DR. SHAPIRO: My only feeling is that here the roots are formed at the end of the first year and if the subsequent growth of the plant buried these root primordia, they obviously could not grow through five years of wood deposited around. If that happens, they should root very poorly. When I found they rooted very easily, it gave me the clue that the roots must be in the bark and therefore must be keeping pace with the addition of wood.

MR. HUROV: There is another thing I want to ask you. Bare rooted liners - is there any reason to believe that if the roots on bare rooted liners are exposed to light they won't root?

DR. SHAPIRO: No, I have gone through a lot of literature on the effect of light on roots in general. It is impossible to generalize. There are plants which are inhibited by light, there are plants which are stimulated by light, as far as root growth is concerned. There are other plants which are totally indifferent to light. The only way you can find out whether something of that sort is happening is to try it with each individual species. You can't relate this even to members of the same family; some will be stimulated, some will be inhibited, and some indifferent.

DR. CHARLES HESS (Purdue): Seymour, do you ever guide advantitious root formation in poplar?

DR. SHAPIRO: Today, you can get new roots formed as a consequence of auxin applications in three and a half.

DR. HESS: Even though the pre-formed initials are growing, so there is no inhibition from roots being present?

DR. SHAPIRO: No. It is interesting when you get new roots formed as a result of auxin applications, anatomically they are identical but physically they are not. They are insensitive to light and they do not ignore gravity the way these do.

DR. HESS: A second question was - you felt the polarity effect was due to a lack of auxin which you could replace by an exogenous application. Have you measured the auxin to see if this would be correlated?

DR. SHAPIRO: Yes, we did some auxin extractions to find as far as the extractable auxins are concerned we can get as much out of polarized cuttings as depolarized cuttings, and this is a very perplexing thing. If we extract the auxins from these polarized ones that we say are auxin starved, from a single auxin starved cutting, we can extract enough auxin to break the polarity on five other cuttings, so obviously if the auxin is there, it is there in a form which is not available to the roots or else our extraction procedure is converting something else into auxin.

DR. HESS: There was a paper at AIBS where a chap was correlating extractable auxin with disfusible auxin and here he found in many systems he could extract a lot of auxin but there was no physiological response, but to correlate the physiological with the fusible.

DR. SHAPIRO: We have tried to do the fusible auxin study. We have run into a lot of technical difficulties with this, but we will be doing more of it.

MODERATOR COGGESHALL: Dr. Snyder, of Rutgers.

DR. SNYDER: Going over the question Charlie raised, he said if we have pre-formed initials and they grow, you can still get the other type of adventitious roots forming. Have you found the opposite situation where the presence of inactive pre-formed root primordia will have any effect on the primordial root growth?

DR. SHAPIRO: I don't know. I have no information.

MODERATOR COGGESHALL: Someone in the back of the room.

MR. WILLIAM FLEMER, III (Princeton): Have you a list of those poplars which do not have root primordia already there?

DR. SHAPIRO: I can't list them now. I just don't remember them, but I will see that the list is put into the proceedings.

MR. FLEMER: One other question - have you ever worked with very rare poplinonce seocarba, great big leaves, like catalpa?

DR. SHAPIRO: No. I worked with all the poplars you have at Princeton because you sent some of them, but I don't think that was one of them.

PRESIDENT VAN HOF: There is a question from a dirt farmer here. Did you ever try the hard-to-root plants like crabapple or beeches? Would that work the same way?

DR. SHAPIRO: No, I don't think it would.

PRESIDENT VAN HOF: Two years ago I set some crabapples during the summer with intermittent mist, too. There was a variety that had a root here and there but not of any significance.

DR. SHAPIRO: It would be very hard to say whether this was involved or not, but if there are pre-formed primordia you might well expect this kind of a thing.

QUESTION: What variety?

PRESIDENT VAN HOF: Red Silver.

MR. ROLAND DeWILDE: I have experimented with crabapples for three years and the results aren't always the same every year, but one variety roots rather easily, but none of them as fast as you say, in five or six days.

DR. SHAPIRO: I should certainly not leave you with the impression that I was the one that discovered these plants had primordial roots. This is something that has been in the literature probably for years and years, probably one hundred years. People have known that poplars and willows had these primordial. Their anatomy had been studied. We started at this point with this information.

MR. JAMES WELLS: Is the source of energy important? In other words, have you tried any other source of energy to effect these roots?

DR. SHAPIRO: We know that ionizing radiation, X-ray will inhibit these roots much the same way that visible light does. We know also that if we combine visible light with ionizing radiation there is a synergizing between them. If we select an intensity of light to give us 20% inhibition of root emergence and select those X-rays which will give us 20% inhibition, we would expect with no interaction between the two, that we would get no more than 40% inhibition, possibly less than 40%. When we do the experiments we get somewhat better than 80% inhibition. So the two can act together and by some means that we don't understand yet, give much more than the simple sum of the two alone.

DR. ANDREW T. LEISER (Clarksville, Md.): Dr. Shapiro, would Metcalfe and Chalk perhaps have a listing? That would be a source that people could go to to get listings of species that would have the pre-formed?

DR. SHAPIRO: I think if you really worked your way through you might find it there. We got some of our information from them but not a complete picture. We still don't have a really complete picture.

DR. L. C. CHADWICK (Ohio State): I wonder if you have done any work, or know of any work that has been done on the time of initiation of flower bud on the poplar?

DR. SHAPIRO: No.

DR. CHADWICK: Any correlation between flower bud formation and the development of roots?

DR. SHAPIRO: In our material we have, I have been growing Lombardies now for more than 10 years, probably closer to 15, what we do, we have a small thicket of these and we cut them back about every two or three years to use in experiments, so none of our stems generally are more than three years old. Our root system is quite old and we never get flowers on 3 or 4 year old material. We have seen a little bit of it. Some of our trees have gotten some, but I can't relate the two.

DR. STEVE O'ROURKE (Michigan State): I presume then that these shoots are epiformus, arising from the basis of plants. My question concerns the position of the cutting on the plant and if there is a difference in degree of rooting between those taken near the base and those further up?

DR. SHAPIRO: As long as it is two years or older, there is no difference. You cannot work with one year old material because the root initials are not well established. You can see them in some one year old material as a small maristomatic mask, but it is not formed into a root yet, and this has given some people interested in poplar breeding, a lot of trouble. They have been trying to get more easily rooting lines and talking with someone from Canada, for example, I learned that he screened some 500 or 600 selections for root-ability, and found they all rooted with very great difficulty, but he was only working with one year old material and this was his mistake. But once the material is two years old or older we get no difference with age.

MODERATOR COGGESHALL: Any other questions?

MR. CASE HOOGENDOORN: In other words, you are trying to imply two year old wood poplar will root easier than one year. Is that it?

DR. SHAPIRO: Exactly, and in Lombardy Poplar this is true.

MR. HOOGENDOORN: Would that hold true for other trees or shrubs?

DR. SHAPIRO: I will only say Lombardy Poplars. (Laughter) I think if you are to compare them not on the basis of when do you get your first roots, but if you were to say when do new roots form, truly new roots, it may well be that they will form earlier on one year than on two year old wood, but that will take at least three and a half weeks. I am talking only about these roots that come out in five or six days. Those roots will not come out on one year old cuttings, and from the experience of this man in Canada, he doesn't get very many of the other kind of roots even after six or seven or eight weeks, and everything I say is based upon this.

MR. HOOGENDOORN: One more question. As to tolerance to light and pussy willows, if they can't stand the light and root, why do they root in the house?

DR. SHAPIRO: They will root with the amount of light they find in a house, but they will not root with a much stronger sunlight.

MR. HOOGENDOORN: You mean in the house it is diffused light?

DR. SHAPIRO: The intensity is much lower and they will tolerate that and they will not if you give them strong light. I would certainly appreciate suggestions of plants you people know.

DR. CHADWICK: Are these root primordia always in the formed tissue?

DR. SHAPIRO: Yes.

DR. CHADWICK: Near the pericycle of the cortex?

DR. SHAPIRO: I have never seen them in all the anatomical work done.

DR. CHADWICK: Apparently they are not tissue cut off from proformus.

DR. WAXMAN: I was wondering, Seymour, if you had worked with photoperiod and initiation of these root initials since they root at the end of the season. Is it lack of daylight response or not?

DR. SHAPIRO: There is a long story. We have done photoperiodic work particularly with regard to the polarization and depolarization. We haven't done enough for me to be able to say with real confidence, but if you can imagine working a photoperiod with these trees, it is hard. They built a number of very attractive buildings, all brick and shaped like out-houses, and the size of the shape they had, and they moved them over the trees every night to control the period, because I thought we had a case of two different photoperiodic mechanisms operating in the same plant. In other words, the fact that the cuttings of poplar rise so late in the spring compared to when growth starts, made me feel it was not directly related to the onset of vegetative growth. Buds break. It followed this by too large a gap. Similarly, the fact that it followed the setting with terminal bud in the fall by such a long period. What we found was this: That if we kept the photoperiod in the spring from getting to be long, and I think it was 11 hours, that we did not interfere with vegetative growth but the roots did not polarize and I think it takes a photoperiod of about 12-1/2 hours before the roots will polarize, so I think it is photoperiodically controlled but it has a different photoperiod threshhold than the initial growth. We have to do a lot more with this.

DR. HESS: In relation to Dick's statement last year, Paul Wilms working with Steve O'Rourke gave a paper on the bubble cuttings. I think this is in the proceedings, and there I think he had some reference to the types of plants with which he worked in particular that you could select with these apparently pre-formed initials in the conifers. I think it was the thujas and junipers.

I would also like to make a comment. I feel on Seymour's very significant finding on a substance in the root system which apparently moves to the upper portion of the plant and affects its subsequent capacity to form or stimulate the growth of the roots, the reason I say this is that working with juvenility, and this is particularly in the ivy, we have always noticed that it seems as though the plant which is closest to the root system was the most juvenile, and you have all heard the relationship of the epicormics, the shoots that rise from the base of the near juvenile. Take cuttings from the base of the plant and you get juvenile material. We feel that there is a relationship between the capacity of a plant to be juvenile and its proximity to a root system. It is quite far out, perhaps a guess, and we are trying to establish it experimentally, but the fact that now you have found a substance which definitely does influence this response, I think is very significant.

One other comment along this line - where you can observe, if you have ivy in a transitional state and you can get in where you have juvenile, have high lobed leaves and have rapid rate of growth and you can get a source of quasi-mature where the leaves are more tired and the growth rate is slower, if this vine hits the ground and forms roots, then all the growth subsequent to that point will be very highly juvenile as the rejuvenated. I repeat once again I think this is really great that you have found the substance.

DR. SHAPIRO: Incidentally, I should say it is probably too late now. When I spoke last time I also showed you some pictures of the results of some of the radiation induced mutation work we were doing at Brookhaven. Some of you seemed interested in that at the time. I brought some pictures along to show a few of the mutations we obtained with radiation since that time. I suspect we probably haven't time to do this. We can slip through them in order in 5 or 6 minutes.

MR. CASE HOOGENDOORN: I have one question, rather one more puzzle. Does Euonymus vegetatus also have this root?

DR. SHAPIRO: I have often thought to look at it because in looking at the plant you see bumps around the node which I may well suspect may be root primordia.

MR. HOOGENDOORN: This is my biggest trouble - to take it beyond. You take the vegetatus cutting in sand under the fog line and in a week you have a wonderful root system and you pull the cutting up and you have nothing.

DR. SHAPIRO: They are at the node. Make sure your basal cut is right at the node. I will look into this.

MR. HUROV (Cornell): You studied the effect of light on cuttings which already have root initiation. What is the effect on the cuttings that haven't root initiation?

DR. SHAPIRO: It varies.

MR. HUROV: Correlation has been shown where you put a part of a tissue like marked cuttings, you form these.

DR. SHAPIRO: According to the literature you get very variable results depending upon species on the initiation of the roots, but there are reports of stimulation, also reports of inhibition.

(Slide) In summary, what happens when we radiate something? We damage the chromosomes in the cells and as they rearrange themselves we pick up this effect at the cellular level in a change of shape. These are normal chromosomes separating as the cell and here is the irradiated cell. You can see the orderliness of the process disrupted. Some of the chromosomes are sticky chromosomes, little pieces actually break off. They get lost. They don't go with either of the two daughter cells. This is the basic thing that happens with a lot of these changes.

The next slide will show what happens in a single cell. This is a petal showing a mutated cell which is changed from white to red. What happens here is very, very important. The time at which the mutation takes place in the development of the stem or flower is very important in whether you can get a coverable mutation or not, so here the mutation obviously took place too late in development of the flower that only a single cell shows mutation. If it took place earlier and this cell had a chance to divide one or more times, you would see what we have in the next slide.

(Slide) Here is mutation. You have a streak on the petal for color.

Now the next slide will show what happens if it takes place still earlier. Half the flower is now of a different color. This is the mutated area and this is the original. The distinction between mutated tissues and unmutated is very sharp. You can see down in this petal - half is darker than the other half and slightly longer. The darker mutated area of the petals are a little longer than the sharper demarcation part.

(Slide) This is Bericans rose. We have been able to get more support for both darker and lighter color. There is a graduation between the better types color and this very pale and this very velvety. We have about four integrates between this and we have all these propagated as separate plants and they continue to show the new color. Some of these, and this will be true for many of the things I show you, are things which have been seen and have been found in nature. In many regards we duplicate the sports which occur spontaneously. It is possible all the sports we get by radiation are only duplicates of what we get in nature. This point can be debated. One thing is certain, that we can bring out all the sports in better types of two years of research in the plant, that people pick up spontaneously in periods of 30 or 40 years. We accelerate the process.

Now we get this as a sport from one of the better types. (Slide) It maintains the completely speckled appearance, sometimes a little more white and sometimes not quite so much flecking. This is a variegated sport as far as I have been able to determine as not being picked up spontaneously, by not asking enough people.

QUESTION: When you revert back, are the chromosomes rearranged?

DR. SHAPIRO: What it means, you are selecting stems that were not damaged originally. They outgrow the other cells that were damaged. There is a competition between the cells changed by radiation and the cells which are not changed. If these things grow together, in fact have the same ratio, we have a perfectly stable situation. If one grows a little faster, it will in time outstrip the other. These are things you can control by propagation, knowing which buds to force can give you this or this or the variegated type.

MR. WILLIAM FLEMER: Variegated flowers always seem to be unstable. In azaleas they are always reverting back to the solid colors one way, or also in camellias.

DR. SHAPIRO: I certainly can't explain it on the basis of any simple chimera. I believe there are genes which control the maturation.

Now we come to the geraniums. We charted out Enchantress fiat at the suggestion of Professor Nelson of Connecticut. He supplied us with our earliest plant. This is what fiat would look like, and this is what the Enchantress would look like. We found we could change Enchantress to fiat very easily. It arose originally as a spontaneous mutate. It is probably a chimera. I also got a very pale color type and we got one the same size but which is much more pale in color than the original and as far as I can tell the geranium people have never seen these before. The small type can revert to it. We started with it being reverted to fiat. Whenever it is reverting to fiat it takes place with the petal increase in size.

Here is toning of reddish tissue on one petal. It overgrows. This is due to a difference in cell size. The mutant we have here is smaller cell size. If you incorporate the original tissue, the cells are larger.

You can put fringes on some of this Enchantress. This is stable. This (Slide) shows the pale pink mutant we got and in this case with a fringe on it associated with some of the fiat type petals which are not fringed.

Coming to Mungus we did a good deal with the Shoesmiths, starting with the white. From this we picked up on Schwartz which appeared to be identical with yellow Shoesmith, and also one you see here which is variegated, single petal, has some yellow streaks on it. This is perfectly stable. We propagated this any number of times.

We come now to the Masterpiece, this bronze master. There is a sector for bronze master and a Shoesmith sector, which is unknown to the people who have grown this. It is white.

Here is our Masterpiece - half of it has been changed to bronze Masterpiece. If you propagate from bud on this we can get all Masterpiece. If we propagate in the middle we will get some kind of thing.

(Slide) This was grown at too high a temperature for Masterpiece color to show up well. This is a larger sector from the white color that you saw earlier.

We also get a clear yellow out of a bronze master. People at Yoder Brothers tell me they have never seen a clear yellow, have tried to get it, and it holds up very well at higher temperatures, and also shows that we get streaked in the Masterpiece series also. This is one that came from the original Masterpiece. The yellow is streaked and the yellow runs and there are occasional small streaks of the white.

(Slide) There is a change in petal form. We also pick up spider tips from the Masterpiece series, and I think one from the shasta group. Some of these, Bill Duffy of Yoder Brothers, says he has never seen in his experience. It may be radiation can give not only an acceleration of what will take place in nature, but also some types which are distinctly new. (Applause)

PLASTIC HOUSES FOR WINTER STORAGE AND PROPAGATION

Andrew T. Leiser
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Clarksville, Maryland

The old adage "there is nothing new under the sun" must, to quote another old adage, be "taken with a grain of salt". The fabulous fifties have had their impact on the nursery industry through the advent of plastic films. These are new. But it appears that many of the uses to which they have been put are refinements of old, old ideas. With the "old" as background we might review some of the uses of plastic houses, some of the problems and successes in the nursery field in order that it may stimulate a wider adoption of them for both propagation and winter storage.

L. H. Bailey (1) makes some interesting observations on the etymology of the word greenhouse and on the history of greenhouse construction and use. Dr. Bailey notes that the original meaning of the word was simply "a house in which to keep plants green during the winter." The plants were not expected to grow in these original "greenhouses" which may have started as a glass-walled portion of a dwelling. Ultimately separate structures evolved, made entirely of glass. European terminology referred to a house used for forcing or growing plants as "stove" houses, hot houses etc. In America common usage has come to limit the word "greenhouse" to a "glasshouse used for forcing plants, propagation, etc."

We have, however, come full circle and I should like to discuss the use of plastic houses as "greenhouses" in the original sense as well as consider some of their special attributes in the propagation program. The industry never got away from the use of cold frames, pits and other devices as means of preventing winter injury. And in recent years above-ground "cold frames" constructed of plastic have been tested extensively as winter protection for container-grown nursery stock. Concurrently the use of plastic houses for various phases of propagation has increased and some parties have used both heated and unheated plastic houses solely for winter storage.

Let us first consider the design, construction and some costs of suitable structures. The same factors apply whether the house is used for storage or propagation. Then we might discuss some specific uses of plastic houses, successes and failures and finally summarize with a series of slides.

Plastic houses had very early acceptance in climates such as exist in California. Heating is not the problem there that it is in more northerly latitudes. The concentration of industry there also favored widespread adoption of these relatively economical structures. The styles and variations have only been exceeded by the new models of automobiles, gable houses, shed-roofed houses, sawtoothed ranges and many other variations. Where snow was a problem the design was limited to a gable house. But in all these designs we have an illustration of the straight-jacket in which we restrict our minds when attempting something new. They are all "glasshouses" glazed with plastic, perhaps a little wider rafter spacing, but not much different. None really utilized one unique feature of plastic, the fact that it is available in large dimensions - 24' X 100', 28' X 100', 32' X 100'.

W. E. Cunningham of Cunningham Gardens capitalized on this attribute in the structure design that is now so familiar - the quonset shaped plastic house - available in various forms from most major greenhouse suppliers. This structure is simply a smooth metal frame with end-gables upon which a single sheet of plastic is spread. The plastic is fastened only at the perimeter to sideboards and the end gable. The design is particularly adaptable to covering with Saran screen at a minimum cost. The cost is less than for comparable area in cold frames and under current tax laws need not be capitalized.

Cost of materials for a typical 16' X 96' house of this style will probably not vary much from location to location, although used lumber, pipe or other parts may lower them somewhat. Labor costs will not be estimated for two reasons: first, pay scales vary widely, and second, labor efficiency (output per man per hour and slack seasons) will also vary.

Foundation pipes of 1" X 36" galvanized iron water pipe are driven in the ground or set in concrete at appropriate spacing (3') in two rows 16 feet apart and 96 feet long. These are driven to a level about 8 inches above grade and sideboards are attached with pipe strap. 24-foot bows made of 3/4 inch galvanized thin-wall electrical conduit are placed in these foundation pipes and fastened with bolts or cap screws. The conduit is joined with screw or clamp couplings and joints may be reinforced with 3/4 inch o.d. soft iron rod.

Early designs used 6 X 6 inch concrete reinforcing mesh to tie the bows into a unit and support the plastic. A later refinement at Cunninghams was the use of longitudinal members (purlins) of 3/4 inch conduit for this purpose. Fourteen-gauge galvanized wire is used for supporting the plastic between purlins.

The gable ends are constructed to fit and may be varied in details such as door location, ventilator openings, etc. Cunningham Gardens now glaze theirs to save on covering labor each year.

The final step is to install the plastic on a nearly windless day. The plastic must be rolled at least one turn around the furring strips to prevent tearing. W. E. Cunningham comments that "the secret of success is to have the plastic drum tight".

The materials cost for this house is about $400 and is broken down as follows:

1.	33 bows 25' long plus 7 purlins 96' long	$183.60
2.	Couplings, 129 at 18¢	23.22
3.	Galvanized pipe, 1", 10 lengths	56.00
4.	Soft iron rod	15.00
5.	Pipe strap, hardware, wire	18.00
6.	Filament tape	13.35
7.	Lumber at $200/M	80.00
	Sub total	$389.17
	Plastic, 2 layers and end gables	64.43
	Saran cover	125.00
		$578.60
	Options:	
	Heaters - 2 LP Gas + controls	400.00
	Ventilation, 36" fan + shutters, etc.	157.90
		$557.90

The job of a propagator begins with the starting of a new plant but doesn't end until the liner is sold or planted out. In many operations the propagator may also be concerned with growing. For the sake of simplicity in cost comparisons we will start with considerations of the unheated plastic house for storage of container-grown stock or liners and work backward to the young liner in a heated plastic house and finally to propagation in these structures.

If we take the construction figures just given and make certain assumptions we may arrive at some cost estimates for storage. Assuming $300 for labor plus $400 for materials, a total cost of $700 plus plastic is obtained. Amortizing this over five years the annual structural cost is $140 plus $64.50 for plastic; $204.50. Allowing a 2-foot aisle, 3,000 gallon cans may be stored in this structure at a cost of under 7¢ per can plus handling. Experience at Purdue University indicated that any conifers or broad-leaved evergreens could be decked two deep with good results and deciduous material could be stored three and four deep with safety. This practice would cut costs to less than 3.5% and 2.3¢ per can.

Comparisons of storage in a plastic house and storage under closed plastic frames as mentioned previously indicated a decided advantage of the former. The ability to inspect the stock, water and ventilate are probably responsible for lack of losses in the plastic house. Comparable species under frames suffered various degrees of damage in these tests. Items successfully stored at Lafayette included Junipers, Yews, Viburnum, Pyracantha, Abelia, Clematis, False Cypress, Kalmia, Azaleas, Leucothoe, Holly, and many more.

The largest storage operation in heated plastic houses with which I am familiar is at Cunningham Gardens. Here materials from summer and late propagation are stored with moderate heat; 50° at 5 feet, about 40° at plant levels. The plants attain dormancy but begin to grow in late winter and produce excellent stock for spring sales. We are indebted to Bill Cunningham for some cost figures in this operation. Two 75,000 BTU LP unit heaters supply this heat for about 16.9¢ per square foot per season. Comparable glasshouse heating costs for an oil-fired hot water system at 55° F cost 19.1¢ per sq.ft.

Plants stored successfully include Holly, Azalea, Baby's Breath (Bristol Fairy), Clematis, English Ivy, Vince "Bowles" and any late season propagations for which frame storage might be dangerous.

Bill calls attention to the versatility of these houses. In the summer they become shade houses.

Plastic houses are in widespread use in California in the propagation schedules for many crops. Some growers use them to grow their stock plants under greater environmental control than can be attained out-of-doors. With the use of mist propagation the author has been very successful in rooting many herbaceous and woody crops in an unheated plastic house in Los Angeles. Rooting was slower in the winter months but with 60 bottom heat a wide spectrum of crops could be handled: Azaleas, Hydrangeas, Euonymous, Carnation, Chrysanthemums, etc. Subtropical items did not root well in these conditions in winter but required heat.

In the midwest, nurserymen have used the Cunningham house for winter propagation of evergreen cuttings. In these instances some heat has been applied to maintain air temperatures of 40° - 50°. In a typical operation evergreen cuttings, Yew, Juniper, etc. are stuck in ground beds in late fall or early winter. If rooting is delayed until hot weather desiccation becomes a problem, Dr. Hess advised one grower to close his house tightly. This was done and although temperatures of over 110° F were attained a good take resulted. Charlie informed me that this same grower had good results with a number of varieties of hardwood cuttings this past year.

Plants grown from seed may be started in such houses with advantages. A summer or fall seeded crop will overwinter without the losses often encountered out-of-doors. A spring crop may be seeded earlier, germinated earlier and then carried through the summer under Saran shade. If necessary the plants may be protected during first winter.

The propagator who is on a year-round program with cuttings coming off at all months of the year will find these structures invaluable in giving a balance to his operation as well as a means of rapid expansion. Faced with potential sales beyond current capacity these structures offer a means of answering the door when opportunity knocks. The plastic house may be used to harden-off the newly rooted plants, hold them in dormant storage and finally give the added bonus of extra root growth and better condition at market time in the spring.

If I may quote Bill Cunningham again, "Plastic houses are an adjunct to greenhouse use, not necessarily perfect in themselves. We feel any propagating nursery must have both glass and plastic to balance operating costs within a structure which will permit some profit".

(1) Bailey, L. H., Standard Cyclopedia of Horticulture, MacMillan, New York.

PRESIDENT VAN HOF: Are there any questions?

MR. KLAS VAN HOF: How high is your wind velocity in the winter? To me that is rather important.

DR. LEISER: It is important. There have been some bad lots of plastic that split on the seam. We lost a plastic cover last spring at Purdue. We presume it was during a 60 mile an hour gust.

MR. KLAS VAN HOF: What plastic do you recommend?

DR. LEISER: All I have used has been polyethylene.

MR. KLAS VAN HOF: There are several companies making poly.

DR. LEISER: I would go to the name brands. Beyond that, I don't want to recommend one over another. I have always used Vis-Queen. It is a name brand. If the seam splits, they will replace it. The inner liner tightly applied will give you some insurance against splitting and losing a crop. You may also use some sort of a hold-down. Bill Cunningham has gone to just plastic covered wire every 15 feet or so, the length of the house, to prevent some of the flapping, and this I understand has been a big help. It is similar to the Lord and Burnham idea of the hold downs at each rafter.

MR. JAMES WELLS: I have three questions. What gauge plastic?

DR. LEISER: We have used four mill, I believe. Bill Cunningham I believe has been using four mill all the time. Some people go to six.

QUESTION: What is the minimum?

DR. LEISER: Bill has used four and I have four on the outside and two on the inside. It depends - well, your insurance will be a lot more with the four mill on the outside.

MR. WELLS: Question No. 2. You use furring strips just to tack the plastic on the two gable ends only?

DR. LEISER: And the sides down at ground level.

MR. WELLS: At the bottom, so you have a wood board?

DR. LEISER: Wood board across the full length.

MR. WELLS: Attached to the pipes?

DR. LEISER: Attached to the pipes in the ground with the pipe straps. That is part of the lumber cost.

MR. WELLS: The third question. In your original method of fixing it, you indicated bolts with washers. Doesn't the plastic pull over those?

DR. LEISER: Bill cut out little fiberboard washers about an inch in diameter.

MR. CUNNINGHAM: About two inches square.

DR. LEISER: And it did not. This wire method of fastening I like because of its quickness.

MR. HANS HESS: You had the heater for your house. You said it was now placed in the middle. In other words, one diverting air to the one end and the other to the other. Are these both together or spaced how much?

DR. LEISER: I will refer that to Bill. Side to side or back to back?

MR. CUNNINGHAM: In the middle side by side, one directed toward each end. I want to say that the installation in the middle of the house is far more efficient than where the heaters are put on each end and directed toward the middle.

MR. HANS HESS: The reason I asked that is this process of investigating heating in a plastic house - I was advised by a heating engineer that in a 100 foot house you would have to have them equally spaced so that they could divert the heat in different directions. In other words, if we place them on each end there would not be sufficient drive to bring the air to the middle, and if you placed them in the middle and diverted toward the end, the ends would be cold and the middle would be warmer. That is what I was wondering about. I would like further information.

MR. CUNNINGHAM: In theory that might be right, but in practice it isn't true.

MR. HANS HESS: The reason I bring this up is that many times the fellow who is a heating engineer, who has not had experience with something of this sort, his theory may be correct and yet in actual practice it isn't right. You say it definitely does give you good heat distribution.

MR. CUNNINGHAM: Yes.

MR. PETER VERMEULEN: I have two questions. I am interested primarily in light. Have you made any study on light transmission, if we know red and far red is necessary?

DR. LEISER: I have seen spectral curves on poly and there are no cutouts in the areas we feel are important.

MR. PETER VERMEULEN: This is poly?

DR. LEISER: I have seen it on a number of other kinds. Fiberglas, for example. There is no cutoff in the red and far red and the blue regions that are important.

MR. PETER VERMEULEN: Have you made any comparative studies on the cost as compared with the semi-permanent type of plastic, like Mylar? We have repetitious costs in applying polyethylene every year.

DR. LEISER: No, I haven't at all. One reason I guess is that I have known half a dozen different people who have been very unhappy with Mylar. They have known it to split in two or three years. Apparently this has been a bad application. These problems have seemed to rule it out, and I haven't particularly considered it for this reason.

PRESIDENT VAN HOF: Two more.

DR. FRED J. NISBET (Asheville, N. C.): I have invested in Mylar. I had looked over Mylar houses from Mentor to Mobile and I have found too many that failed. The main cause of failure was using poor lumber, so that we stress when putting on Mylar to get it drum tight.

MR. ARIE JAN RADDER: (Conn.): We built a plastic house this fall and we inquired about a heater. We got a propane gas heater. It throws out 138,000 BTU for $175. This is a check type heater. It is ignited by a spark plug, electrically ignited. It has a fan behind it and by pulling a switch you can use the fan for cooling. I felt I should mention it since yours throws 75,000 BTU.

DR. LEISER: This is a unit heater?

MR. RADDER: It is portable. We place it in the center of the house.

DR. LEISER: Like used for corn drying.

MR. RADDER: I don't know what they use it for. We also put air conditioning pipes on it and heat wherever we want. The only thing, there might be some dead spots and I might have to put fans in it.

DR. LEISER: I inquired somewhat of this and the man selling them was afraid it wouldn't be too suitable for propagation houses because of the high heat, spot heat effect. He felt it would be too hot in some areas. If you have good luck with it, this is good news.

PRESIDENT VAN HOF: Thank you, Dr. Leiser.

Next in order is "Dwarfing of Ornamental Plants by Grafting." We tried to get it last year but something else came up. We have a capable man doing this, John P. Mahlstede. Dr. Mahlstede is from Iowa State University.

DWARFING OF ORNAMENTAL PLANTS BY GRAFTING

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Iowa State University

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DWARFING OF ORNAMENTAL PLANTS BY GRAFTING

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Several months ago, without giving it much thought I accepted Dr. Synders' invitation to discuss the topic of the Dwarfing of Ornamental Plants By Grafting. When the time came to survey the literature associated with this subject, I found that he had restricted me to ornamentals. This means that we can come as close as the ornamental crabs, but not fruits, an area in which most of the dwarfing work has been reported. The title also restricted dwarfing to that resulting from grafting, which in turn eliminates a discussion of Bonsi, and the techniques associated with this ancient culture. To further complicate the preparation of this paper, I find that Dr. Karl Saxs' scholarly talk to this Society in 1957 summarizes the literature connected with this subject most admirably.

I would propose that we discuss the topic of Dwarfing In Ornamental Plants under the general headings of:

1. History of Dwarfs
2. The advantages and disadvantages of dwarf ornamentals
3. Sources for dwarfing components
4. Methods of producing dwarfs by grafting
5. Theoretical causes for dwarfing, and
6. The future outlook for dwarf ornamentals.

HISTORY OF DWARFS

Early history associated with dwarf plant materials is essentially The History of Dwarf Fruit Culture. The existence of plant parts used as the rootstock or scion was known to the greeks over 2000 years ago. When the emphasis shifted from that of food production on the continent, the ornamental phases of Horticulture began to take form. The use of special or selected rootstocks to dwarf a few of the more choice ornamentals, popular in the renaissance period has been reported. Such plant materials were adapted to methods of training for both utilitarian and aesthetic purposes. Of course, in the gardens of Early Europe records tell us of plants selected specifically because of their dwarf or low growing habit. Jardinieres and urns represent a type of culture which actually represent the forerunner of modern container culture. It was in this connection that many of these dwarf plant materials were utilized.

There has been this continual shifting of emphasis between food and ornamental crops, as influenced by the economy of the nations of the world. This shift of emphasis has been directly related to the wars, periods of recession, and the so called periods of good times.

As the utilization and availability of the principle crop land became a problem in Europe, China and Japan, as well as in other countries, the need for more varieties and species that could be grown in a limited area, the need for dwarf ornamental and fruit plants has increased.

The use of interstems for the purpose of dwarfing is a technique of relatively recent origin, dating back only some 300 years or so. It is virtually an untried and untested entity in the production of dwarf ornamental trees, shrubs and vines. One reason for this is the lack of information, which can be attributed to the fact that only recently has there been a need for this type of plant material. Coupled with the increased cost of production, and comparatively high price that a nurseryman must receive for this product, as well as the customer, who is not yet willing to pay this premium, dwarf ornamentals have not received the attention they deserve. Still another factor that has complicated the selection and introduction of dwarf plant materials is that of interest. It has been only recently with the popularity of the 80' X 100' lot that a real need has existed. It did not much matter if a three story house on a one or two acre plot was planted to the 8-10' Bridalwreath, or 10' Privet, or the 120' Silver Maple. With our single story ranch, these plants soon look out of place if a regular maintenance program is not practiced; and practiced it is not by most people.

Because there has not been this need, only the stirringly different, the odd, the unusual dwarf has been picked up by the nursery industry. The large seedling growers have looked for the most vigorous, the best adapted stock, and used these to vegatatively propagate clones. The dwarfs, or so-called runts have either been rouged out or discarded. I would guess that many select, dwarf forms have been discarded long before introduction, because of their slowness to makeup, and the reluctance of nurserymen to risk an investment in an item which had a questionable market.

ADVANTAGES and DISADVANTAGES of DWARFS

There are a number of advantages and disadvantages associated with the use of dwarf plant materials. The lower maintenance costs of dwarf, usually slower growing plants, heads the list of dwarf attributes. Reduction in the frequency of pruning and the ease of spraying, and ultimate removal of the plant are included on the positive side of the ledger. Utility companies spend some $125 million dollars a year on line clearance. City and State governments also spend sizable sums each year on building, sidewalk, street and sewer repair brought about by the activity of wind and ice storm effects on trees, and the action of tree roots.

The advantage of dwarfs to contemporary architecture, inclusive of public building sites, industrial locations, recreational areas and homes has already been mentioned. The production of small pop plants, for mass market sales, the production of more compact plants, with shorter internodes, earlier maturity, the delay in pot binding, the control or elimination of tall, straggly plants, are also attributes of dwarf plant materials.

Disadvantages include the higher cost of production, brought about by the longer period of time required to obtain a salable plant, the greater number of plants required for planting, especially if immediate effect is desired, are also disadvantages for the nurseryman and customer alike. Since dwarfing may involve grafting, the factor of incompatibility and resultant problems of poor anchorage, brittle graft unions, and overgrowth are problems which suggest the need for more research. Hardiness, disease and insect problems may be aggravated by dwarf plant materials, resulting from the more compact, dense growth produced. Suckering, delay of flowering may also be aggravated by incompatibility problems. The limited number of plant materials of desirable color, foliage type, texture, and stature are also problems associated with our dwarf inventory.

SOURCES OF DWARFING COMPONENTS

At the present time there are some fifty or more of the most important genera of trees and shrubs that have known dwarf forms. Of these genera, 16 are broadleaved evergreens, 6 are narrow leaved evergreens, and the remainder gerera of deciduous trees and shrubs. The possible sources for future dwarf components, that is scion varieties, interstems, and rootstocks, include: (1) Specialized breeding programs in some of our most important genera, (2) Natural selection and the propagation of these selections by nurserymen, (3) Sports or mutations of now vigorous species, (4) Induction of chimeras incorporating a now vigorous variety and one of its closely related dwarf forms, and (5) Introduction or selection of virus carrying components which impart stunting, or slow growth, but which do not impair the aesthetic qualities of the plant when used as an ornamental.

The success of the entire venture of selection and introduction of new dwarf forms lies with our botanical gardens, arboreta, the ornamental breeding programs at our land grant institutions, and with the nursery industry. Those plants produced as dwarfs through grafting will require still another step in the development program, ie., research and testing on compatibility of various dwarfing combinations. This can only be solved through time.

METHODS OF PRODUCING DWARFS BY GRAFTING

The techniques of grafting, or joining two components of a graft combination together are well known to members of this Society. The type of graft, that is the veneer, side, whip and tongue, speed or splice grafts, to mention a few, will have little influence on the success of a scion if it has been properly handled, is mechanically sound, and the components are compatible.

The methods of producing or arranging components of a graft combination in such a way as to result in the production of a dwarf plant fall into seven groups. These include:

1. Use of dwarfing rootstocks grafted to an otherwise vigorous scion variety.
2. Dwarfing scions grafted on otherwise vigorous rootstocks.
3. Dwarfing interstems inserted between two vigorous components.
4. Dwarfing resulting from an interaction between otherwise vigorous components. This would occur after union.
5. Girling or interruption of food transfer to the rootstock.
6. Bark, ring, spiral, inverted bark, and phloem blocks.
7. Two other techniques, which deserve further attention as possible methods of producing dwarf ornamentals have been described

by Garner and Nicolin. Nicolins' method of double shield budding as adapted by Dr. D. B. White who described it at this meeting two years ago, bears further investigation by researchers interested in compatibility bridges and dwarfing interstems. The length of interstem, overgrowth, and other possible effects from this thin shield should be studied.

THEORETICAL CAUSES FOR DWARFING

From observation we know that there are degrees of dwarfing, brought about by the use of specific rootstocks, interstems and/or scions as well as the union of certain of these elements in a prescribed manner. With some dwarfing rootstocks or combinations of rootstocks and specific scion varieties, there result plants which are too dwarf to be of any use commercially. The question in point now, is why do certain plant materials, when used alone, or in combination with other, closely related plants, cause dwarfing? The theoretical causes may be separated on the basis of plant physiology, plant morphology, and plant pathology.

Thomas Andrew Knight, the first president of the Royal Horticulture Society of London, postulated in the year 1822 that dwarfing and early flowering (and fruiting) were the result of the checking of flow of nutrient supply to the roots in combinations utilizing a dwarfing interstem piece.

This check in the flow of nutrients results in the accumulation of food in the tops, which subsequently stimulates flowering, fruiting and hastens maturity and differentiation. The interstem, if defined literally, is a living, well controlled phloem block or girdle.

In reviewing the literature on stock-scion influences, Tukey and Brase have concluded that when considering vigorous wood, no one part dominates the growth of the entire plant, since all have, at one time or another, a marked influence on the growth pattern of the combination. Where dwarfing wood is used, the dwarfing character predominates, regardless of its position in the combination.

The cyclic suberization of the roots of dwarf trees, as well as a differential water relationship of the particular dwarfing rootstock or interstem has been suggested as a possible cause or effect of dwarfing (Colby, Pao & Berry). Beakbane and his co-workers discovered that dwarfing stocks generally have smaller cross-sectional areas of vessels, smaller volume of Xylem fibers, and greater volume of Xylem Parenchyma and Meduallary Rays. They suggest that the smaller vessel area of dwarfing stocks may reduce water uptake, and that the increase in the volume of living cells, such as Parenchyma and Ray tissue may serve as a carbohydrate reservoir. Both of these factors may lend to the throwing of the balance to differentiation, early flowering, and fruiting.

Always associated with grafting and a discussion of dwarfing are the attendant problems and complexities of incompatibility. We know, for example, that incompatible unions are characterized by:

1. Limited and contorted elements of the union
2. Structural weaknesses
3. Inward curving of the layers of cells or crevices in the bark and xylem.
4. Others rosetting bud death.

Toxic secretions have been held responsible for certain stock, scion, and stock, interstem scion combinations reactions.

Viruses too have been credited with causing degrees of incompatability in plants. The action of growth substances has also been credited for causing dwarfing. It is also known that dwarfing interstems result in a tree that has wider branch angles, in other words results in the production of a spreading tree. These trees may produce as much total growth as standard trees, but the distribution of this growth over the periphery of the plant is different. This characteristic of branching can be shown to be a growth response derived from auxin relationships in plants. In fact, more recently, experiments with certain types of dwarf corn, have demonstrated that dwarfing is caused by auxin destruction during translocation from the point of manufacture in the foliage downstem. Short internodes result from the lack of auxin.

Scholz has explained dwarfing, induced in interstem trees on the basis of reduced water conduction caused by the reduced xylem area in dwarfs and reduced nitrogen translocation through the phloem. This results in reduced shoot growth. Such slowing or cessation of shoot growth, concludes Scholz results in a carbohydrate build up and attendant induction of flowering. It is further suggested that antiauxins may be related to dwarfing as they are linked to carbohydrate accumulation and floral induction.

FUTURE OUTLOOK FOR DWARF ORNAMENTALS

The great majority of the research work on dwarfing, has been done on fruit. This work, principally concerned with the apple, has been brought about by the availability of stocks of known performance. Research on dwarf pears and the quince A, B, and C series is another example of the recent emphasis and interest in this trend to finding out more about the phenomenon of dwarfing and the commercial use of dwarf plant materials. Think now, about the inventory of ornamentals that are available for study. Not only do we have to find dwarfing components for many of our more important plant genera, but we have to find specific rootstock-scion, and rootstock-interstem-scion combinations for specified soil types, climatic ranges, and growth characteristics. These in the ornamental phase of Horticulture have much to look forward to in the future; helping to develop a dwarf inventory of ornamentals.

PRESIDENT VAN HOF: We will go right into the talk by Dr. Henry M. Cathey, Department of Horticulture, Plant Introduction Station, Beltsville, Maryland.

DR. HENRY M. CATHEY: I would like to tell you a different experience in dwarfing. This consists of not using switch blades, which was apparently what we were seeing, but to use your talents in mixing. This is the other side of growth control. This is maintaining your plants and using chemicals to dwarf the plant.

CHEMICAL DWARFING OF NURSERY PLANTS

Henry M. Cathey
Horticulturist
Crops Research Division, Agricultural Research Service
U. S. Dept. of Agriculture
Beltsville, Maryland

Recently developed growth-retarding chemicals provide means for restricting the growth of many plants. They are useful in production and maintenance of plants of smaller size than those typical of the species or the cultivar. They also make it possible to use some species not now suitable for pot use and allow all plants to be fertilized and watered as frequently as necessary.

The leaves of all plants treated with growth-retarding chemicals are much darker green than those of untreated plants. This color is related more to the action of the growth regulator than to mineral nutrition.

Three chemicals have been extensively tested on many kinds of plants (2). These are Amo-1618 (4-hydroxy-5-isopropyl-2-methylphenyl trimethyl ammonium chloride, 1-piperidine carboxylate), phosfon (tributyl,2,4-dichlorobenzyl phosphonium chloride), and CCC (2-chloroethyltrimethyl ammonium chloride). The growth of most plants may be controlled by the proper selection of one of these chemicals. None of the three is active on all plants. Few plants respond to applications of Amo-1618; details are available elsewhere (2). The dosages for phosfon were 0.16 to 4 gm of the technical material and for CCC, 4 to 20 gm/cu ft. of potting soil.

The list* which follows shows the growth-retarding activity of two chemicals on potentially useful plants.

Common and Latin Name	Response to Applications of Phosfon	CCC
Apple, <u>Malus sylvestris</u> Mill.	Inactive	Active
Azalea, <u>Rhododendron</u> sp.	Active	"
Camellia, <u>Camellia japonica</u> L.	Active	"
Chrysanthemum, <u>Chrysanthemum morifolium</u> ramat.	Active	"
Dogwood, <u>Cornus florida</u> L.	Active	"
Elm, American, <u>Ulmus americana</u> L.	Inactive	"
<u>Euonymus japonicus</u> L.	Active	"
<u>Fatshedera lizei</u> (Cocket) Guillaum	Stimulates	"
Holly, <u>Ilex crenata</u> Thunb. (Rotundifolia)	Active	"

DR. HENRY M. CATHEY: I would like to tell you a different experience in dwarfing. This consists of not using switch blades, which was apparently what we were seeing, but to use your talents in mixing. This is the other side of growth control. This is maintaining your plants and using chemicals to dwarf the plant.

CHEMICAL DWARFING OF NURSERY PLANTS

Henry M. Cathey
Horticulturist
Crops Research Division, Agricultural Research Service
U. S. Dept. of Agriculture
Beltsville, Maryland

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Dogwood, _Cornus florida_ L.	Active	"
Elm, American, _Ulmus americana_ L.	Inactive	"
Euonymus japonicus L.	Active	"
Fatshedera lizei (Cocket) Guillaum	Stimulates	"
Holly, _Ilex crenata_ Thunb. (Rotundifolia)	Active	"

Continued:

Common and Latin Name	Response to Applications of Phosfon	CCC
Hydrangea macrophylla Thunb.	Inactive	Active
Lily, Easter, Lilium longiflorum Thunb.	Active	"
Mimosa, Albizzia julibrissin Durazz.	Active	"
Maple, Red, Acer rubrum L.	Active	"
Oak, Red, Quercus borealis Michx.	Active	"
Pear, Pyrus cummunis L.	Inactive	"
Petunia hybrida Vilm.	Active	Inactive
Poinsettia, Euphorbia pulcherrima Willd.	Stunts	Active
Privet, Ligustrum japonicum Thunb.	Inactive	"
Rhododendron, Rhododendron maximum L.	Active	"
Sycamore, Platanus orientalis L.	Stimulates	"

* Mention of commercial products herein does not constitute their endorsement. Phosfon is registered for use on chrysanthemums by commercial florists. CCC is still in the experimental stage of development, and is not generally available, and is not recommended for commercial use. Results reported herein for phosfon and CCC are given as research results only and do not constitute official clearance or recommended use.

The basic concept of using growth-retarding chemicals is being extensively tried on many kinds of plants. Most foliage plants, such as Dieffenbachia, Peperomia, and Philodendron, grow without apparent responses to applications of phosfon and CCC. High dosages (100 to 500 times the dosages used on chrysanthemums) frequently stunt growth and result in a reduction of leaf size, drying of the margin of the leaves, and the development of few or no lateral shoots. Plants of chrysanthemums, coleus, and Schefflera actinophylla (Endl.) Horms respond to applications of both chemicals by continuing to form leaves at the same rate as untreated plants but the distance between leaves decreases with increasing dosages.

Woody plants as a group are not particularly adapted to the immediate utilization of growth-retarding chemicals because they grow for only a few weeks during the year and the root system tends to be extensive. Preliminary testing is being conducted with plants growing in clay pots on long days. Plants of several holly species, Euonymus, Ligustrum, Rhododendron, and oak respond to applications of phosfon and CCC. Plants which grow in flushes such as oak and holly respond only to much higher dosages than does chrysanthemum. The time from period of growth (flush) to another is delayed slightly and the number of nodes per flush is smaller than on untreated plants. The actual internode distance on these plants may be unaltered, but the number of nodes is smaller than on untreated plants.

Plants from many different families such as chrysanthemum, Rhododendron, Hydrangea, and Mimosa, respond to applications of CCC at dosages of 10 gm/cu. ft. of composted soil. In contrast, the optimum concentration for growth retardation by phosfon varies from 0.16 gm/cu. ft. of potting soil for chrysanthemum, to 4 gm/cu. ft. for Rhododendron.

The application of growth retardants to monocots has generally been disappointing. Although wheat responds markedly to CCC, the other grains have responded only at fairly high dosages or not at all. (4) Tillering was promoted on treated plants and occurred earlier than on untreated plants. The tendency of the plants to node was also reduced.

These points are vital in the use of growth-retarding chemicals: Prepare soil plant regulator mixtures of varying dosages by dissolving the required amount of chemical in water, pouring it on a known volume of composted soil, and mixing thoroughly to distribute the chemical throughout.

Plants already established in soil may be drenched with the chemical at rates similar to those used in the soil-amendment procedure. The latter procedure is preferred for treating at a specific stage of growth. Plants sprayed with aqueous solutions of phosfon develop yellow spots on the leaves. At high dosages, the veins are cleared of chlorophyll and the leaves develop marginal browning which persists throughout the life of the plant. Other plants sprayed with aqueous solutions of CCC develop yellow tips. Eventually the leaves regain their green color. The margin of safety between retardation without injury and with injury from growth retardants is very small and should not be considered for general use as a method of applying them at the present time.

Amo-1618 and phosfon persist in the soil for more than one crop of plants, whereas CCC did not persist for the growth of one crop. Amo-1618 was slightly more active in summer than in winter in retarding growth of plants, phosfon much more active in summer, and CCC much less active in summer.

All varieties of a given plant species are not equally sensitive to growth-retarding substances (2).

All plants treated with growth retardants appear more resistant to heat and drought stresses (1).

Plants of Enonymus (Figure 1), Fatshedera and Platanus are stimulated to grow more rapidly following application of certain dosages of phosfon. Higher levels of application result in browning of the leaf margins and stunted growth of Fatshedera while plants of Enonymus were retarded in growth in relation to dosage. Application of CCC retards the growth of these plants.

The photoperiod in which holly, petunia, and chrysanthemum plants grow determines their flowering and growth habits (1). Treating the soil with growth retardants does not alter the response to photoperiod, light quality, or night temperature. Therefore, the action of the retarding substances is different from that imposed by short days. Short days continue to be essential for flowering chrysanthemums and long days for stem elongation of holly and petunia. Primarily, internode extension of responsive species is retarded by a wide range of concentrations of phosfon. The action of growth retardants to shorten internodes is independent of the other environmental factors, and is specific in activity on internodes since the other parts of the plant are not noticeably affected. Few formative effects on leaves, stems, and flowers are observed.

In most instances, the growth retardants exert relatively little influence on flower initiation of herbaceous plants. Treatment beyond that necessary for moderate reduction of stem length usually delays flowering. Treatment of vegetative azalea, camellia, and Rhododendron with phosfon and CCC, however, results in less stem elongation and earlier flower-bud initiation (2,3).

The search for effective and economical chemicals that can retard the growth of plants will continue. At present their use is limited to container-grown plants. In the future, it is hoped that more chemicals which can be used as foliar sprays will be found. Applying growth retardants directly to the growing point of plants appears to be the only way to use them in field plantings. The dosages or the extended persistence in the soil of the chemicals now available limits them to a few special purposes. The concept of dwarfing plants out-of-doors through the use of chemicals ultimately will depend upon finding ones that are active, safe, and persistent on a wide range of plant materials.

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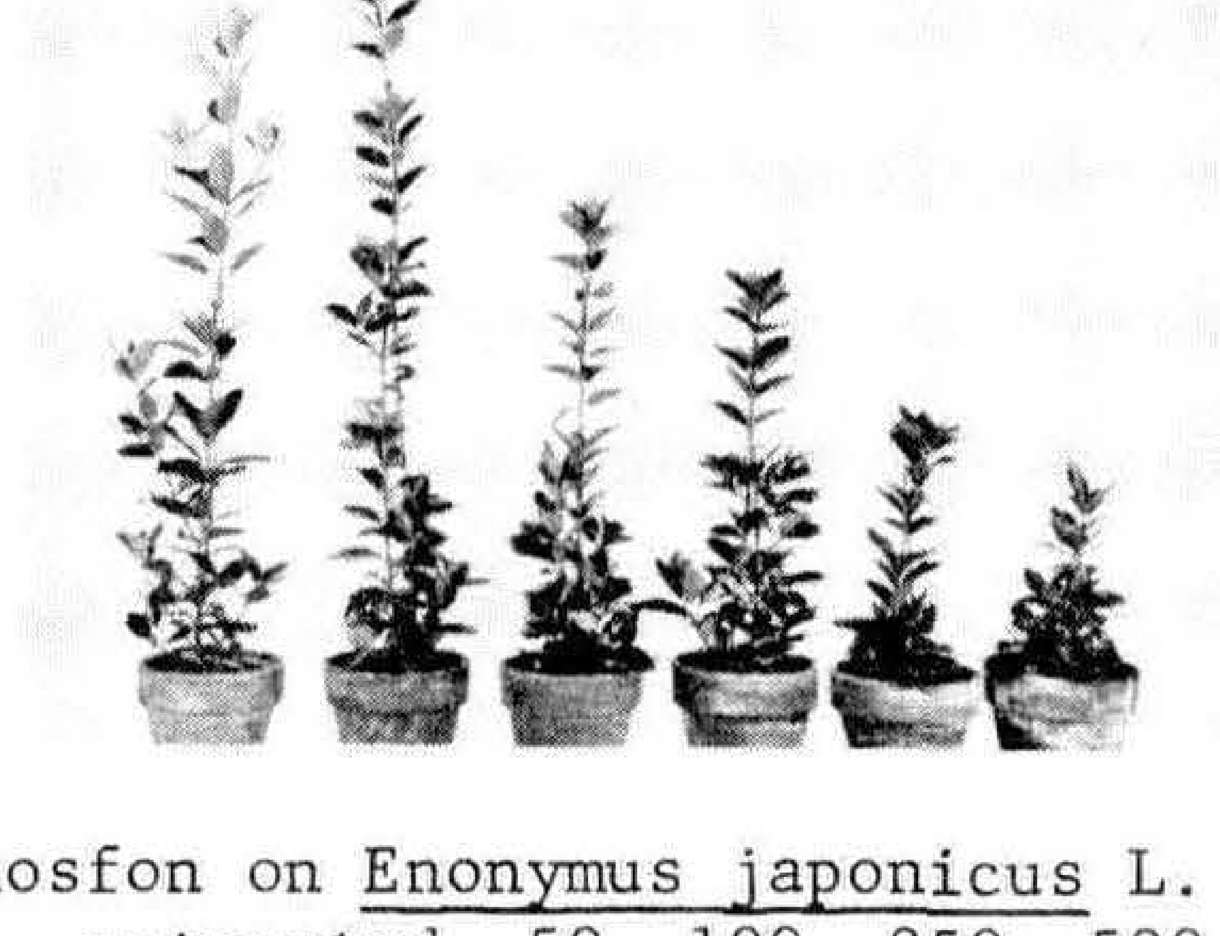

Figure I

Activity of phosfon on Enonymus japonicus L. differs with dosage. Left to right: untreated, 50, 100, 250, 500 and 1000 pounds per acre of phosfon amended in the soil at planting.

PRESIDENT VAN HOF: Gentlemen, there is a little time left for questions. Address your questions to Dr. Mahlstede or Dr. Cathey.

MR. JOHN B. WIGHT (Cairo, Ga.): Out at Beltsville the other day we saw azaleas that were not only retarded in growth but the blooming time was retarded. How much have you retarded azaleas time-wise by CCC?

DR. CATHEY: If I may, would Dr. Stuart answer that? He is doing the work on azaleas?

DR. STUART: The delay in flowering depends upon the strength of the CCC applied. Now if the amount is not excessive, as you saw in one of the slides, there was very little delay. But if in your enthusiasm you overtreat, then there is a delay in flowering just as there is a delay or reduction in the amount. I would have to say that it depends upon the variety to some extent, the time of the year, but mainly depends upon the amount of CCC or phosfon you use.

MR. GRAY: Is there a temperature correlation in this application?

DR. STUART: You mean can the material be applied in the spring or fall?

MR. GRAY: Let's say in a greenhouse with a low temperature, would it be actuated as well as at somewhat higher temperature? Say a temperature of 45 versus 65^{o} F.

DR. STUART: We have no application at 45^{o}. We have observed that applications made say at 60^{o} were very effective or at any time in the spring or summer. In other words, you do not have to have a high temperature.

DR. KENNETH REISCH (Ohio State): Just one comment on this dwarfing. Some years ago we reported on dwarfing permanently, crabapples and catoneaster. It was in 1954, and they are only four feet high and rather scrawny, too. They are dwarfed but not particularly good quality.

MR. PAUL KERN (Cincinnati): I want to ask Dr. Cathey, has there ever been made further use of the growth retarding Maleic hydrazide.

DR. CATHEY: Maleic hydrazide is used, for instance, on the Merritt Parkway to cut down the mowings, but unfortunately, the side effect from Maleic hydrazide on some plants is undesirable. The leaves can be malformed, the growing point can be killed. We have two chemicals that I talked about here which when applied properly will in no way cause a malformation of the plant. It will look just like it is a dwarfed plant. For instance, to see an untreated dogwood growing with nodes three or four or five inches long and you can see the inner nodes come right down so the plant is not disturbed. It looks like an ornament. Unfortunately, maleic hydrazide on most plants make it look like a plow has been through.

MR. HOOGENDOORN: How would you go about producing Bonsi plants?

DR. MAHLSTEDE: Jack Hill has a very nice brochure, that you can obtain and put your name on and put out to your customers. Pot binding is one method, root pruning and meticulous care of the top is another. Whenever it grows, cut it off.

MR. WILLIAM FLEMER: I would like to ask Dr. Mahlstede what he thinks of Malus sargenti as understock for fruiting and apples.

DR. MAHLSTEDE: I can't answer that, Bill, we haven't worked with it.

MR. JOHN E. TANKARD (Exmore, Va.): I would like to ask Dr. Cathey if he has had any experience with CO_{11} and if so, would he comment on it?

DR. CATHEY: CO_{11} is extremely new growth retardant chemical and it is primarily active as a foliar spray. That is my talk next year. It is way too new. The strange thing about it, all we have said about phosfon being active to the roots with a perfectly normal, the CO_{11} in our experience is just the opposite. You put it on the roots in the soil and you get a very depressed looking plant for Washington, very depressed, whereas a foliar application in some of the rates it looks quite good. You are shrinking them down, you are getting a rosette. The trees I showed you did not have true rosettes, which is one leaf right on top of the other. This, we feel, is true dwarfing, the scaling of height is past stunting but still perfectly safe insofar as the appearance is concerned. But CO_{11} is extremely new and we don't know a great deal about it, but the little we do know it looks like it is one way of approaching foliar application.

DR. KENNETH REISCH: Do these retardants work on monocots?

DR. CATHEY: Monocots do not respond as easily as the dicots. CCC does work on a pure stand of one kind of grass of some variety but the problem is that seldom do you have a pure stand of crab grass that you can get the right dosage for. On the one that got the CCC it apparently is working but the rates on a mass population of different kinds of plants makes it extremely difficult to get, because some of them will be dwarfed and the others will not be responding at all. I think that is the major problem. You still have to keep your lawnmower, so far.

PRESIDENT VAN HOF: We have to close our meeting on the educational phase. It has, of course, been very enlightening. Everybody contributed. Even if it wasn't by speech it was by their presence. We say thank you to Dr. Mahlstede and Dr. Cathey and with this we will stretch our legs for a while and at 3:30 you will start on a business session. As Harvey Templeton said last year, our guests are invited to stay with us, but please keep mum - no voting. Thank you. At 3:30 we will start the business session.

(The technical session was adjourned.)

TECHNICAL SESSIONS

WEDNESDAY EVENING SESSION

October 25, 1961

The Second Meeting of the Plant Propagators Society - Western Region, convened at 7:30 P.M., October 25, 1961, at the Asilomar Conference Grounds, Pacific Grove, California. Mr. Don Hartman, Leonard Coates Nurseries, Inc., San Jose, California, opened the meeting as President of the Western Region with some remarks of welcome. He then introduced Program Chairman Herman Sandkuhle, Jr., Sunset Nurseries, Oakland, California, who in turn introduced Mr. Harry B. Lagerstedt, Assistant Horticulturist, Oregon State University, Corvallis, as Moderator for the evening program.

MODERATOR LAGERSTEDT:

Growth Regulators in Relation to Plant Propagation

H. B. Lagerstedt

Department of Horticulture

Oregon State University

Corvallis, Oregon

I would first of all like to commend our program committee on their excellent choice for this evening's topic, Growth Regulators in Relation to Plant Propagation.

This subject, growth regulators, is a very timely one. It was, in fact, a timely subject 25 years ago when IAA was isolated from urine and found to be useful in rooting cuttings. It was even a timely subject long before that when sugar and oxidizing agents were being investigated as rooting aids. It will no doubt be a timely subject 50 years from now, even though plants will have yielded up more secrets about themselves than we presently know. Perhaps, thinking of it in this way, Growth Regulators in Relation to Plant Propagation should better be described as a timeless subject.

At the present time we are probably on the threshold of propagation discoveries nearly equalling the period of the mid-thirties. Perhaps this evening we will catch a glimpse of what is currently going on in propagation as well as what the future may hold for us.

I have been asked to introduce this evening's subject and an excellent place to begin is with a definition. It so happens that in 1954 Dr. van Overbeek, one of our panel members, headed a committee of the American Society of Plant Physiologists on nomenclature of chemical plant regulators. From what better source could we draw a definition? His committee defined plant regulators as, "organic compounds, other than nutrients, which in small amounts promote, inhibit, or otherwise modify any physiological process in plants". He also mentioned that compared to auxins or hormones, the term regulator had the widest of boundaries and could be applied to materials that modify any physiological process in plants.

Personally, I prefer the broadest interpretation of the term "growth regulator" as it applies to plant propagation. Under this heading, we can then discuss everything from florigen to kinetin, from 2,4,5-T to vitamin B, from traumatic acid to "accelerator A", and from Chloromone to co-factors. And, should boron be found to aid rooting, it too could be included in the list, perhaps not as a nutrient, but as a regulator playing a far different physiological role.

Who knows what substances will serve to answer some propagation questions we have at present? For example, why do etiolated stems root better than normal stems; why does juvenile wood root more readily than the adult type; who do pendant branches root better than erect ones; why does a light interruption during the night have an influence on rooting; and lastly, why does Bartlett pear, which normally doesn't root at all, produce a fair stand when the source of cutting wood comes from trees grafted on quince? When these questions, and many others are answered, we may have some surprising new growth regulators on the books.

An excellent example of what lies in the future can be drawn for the work of Dr. Hess at Purdue University. He has isolated four substances he calls co-factors, since they do not function alone, but only in the presence of IAA. Co-factor #4 appears in the largest quantity in juvenile or easy-to-root cuttings. This is the co-factor Dr. Hess is presently trying to identify. He has located a very similar compound, a reducing agent commonly used in photography. While this substance is not identical to co-factor #4, it still is very active in promoting rooting when combined with IAA. It is the ultimate aim of Dr. Hess to identify all four co-factors. Once this is done, a difficult-to-root variety need merely be analyzed to determine which co-factors are missing or in low supply. The right co-factor could be supplied and rooting would be achieved.

Now that the future and the past have been briefly investigated, let us see what the present holds in respect to Growth Regulators in Relation to Plant Propagation. Our first speaker will be Dr. J. van Overbeek, Chief Plant Physiologist, Shell Development Co., Modesto, California. Dr. van Overbeek --

Plant Hormones

J. van Overbeek

Shell Development Company, Agricultural Research Division

Modesto, California

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Plant Hormones

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Shell Development Company, Agricultural Research Division

Modesto, California

In the plant, as well as in the animal, minute amounts of chemicals regulate the growth process. These compounds are called growth regulators, and if they are naturally-occurring, they are spoken of as plant hormones. At present we recognize three major classes of plant regulators:

The Auxins.
The Gibberellins.
The Kinins.

We will discuss what they are, how they regulate the plant's physiology, and to what practical uses they have been put.

The Auxins

The prototype of the naturally occurring auxins is indoleacetic acid (IA). It is formed from tryptophan via indoleacetaldehyde in young growing tips. If these courses of IA are cut off, the remainder of the plant ceases to grow. However, growth is resumed when IA or another synthetic auxin is applied to the cut stump.

Plant cells grow by taking up water osmotically. Auxins promote this process by softening the cell walls. This leads to cell enlargement.

A general characteristic of hormones is that they affect a multitude of processes. Thus, auxins not only promote growth of stems and fruits, but they promote the formation of roots on cuttings and the formation of flowers on pineapple plants. Not only do auxins promote growth, but sometimes they inhibit it. Lateral buds, for instance, are prevented from growing out of the leaf axils because of the auxin produced by the terminal bud. When we cut the terminal bud off, as in clipping a hedge, these lateral buds then grow out.

The major practical use of auxins is as selective weed killers. A synthetic auxin, principally 2,4-dichlorophenoxyacetic acid (2,4-D), is sprayed on plants in such relatively large amounts (yet only one pound per acre!) that it "drowns" the natural regulating system, and the plant dies a slow death. Cereals, such as wheat, can inactivate the synthetic regulator, while broad-leaved plants, such as wild mustard cannot. Thus, 2,4-D sprays have effectively removed broad-leaved weeds out of wheat, thereby making grain production more efficient.

Synthetic auxins are also universally used for plant propagation. Most modern nurseries treat the base of cuttings with indolebutyric acid before these are placed in the propagating frame. Root formation is accelerated in this way and, in addition, a "bottle-brush" type of root system develops which facilitates transplanting.

In boysenberry culture "king-sized" fruits are produced by application of synthetic auxins; and in the citrus industry 2,4-D in small amounts is a standard ingredient to increase the size of oranges.

The Gibberellins

The structure of these plant regulators is far more complicated than that of the auxins. Man has not yet synthesized them. Their existence was known in Japan long before the western world became aware of them. The gibberellins promote shoot growth dramatically. These chemicals can give dwarf plants the appearance of normal, tall plants. They promote flower formation in many species. Growth of lateral buds is promoted by gibberellins, but curiously the presence of auxins prevents the gibberellins from exercising this power.

Gibberellins are beginning to find practical uses. In the culture of table grapes of the Thompson Seedless variety, gibberellin is used to make larger bunches with larger berries. Celery is made larger after gibberellin application. Gibberellins speed up malting in beer brewing. In the seed industry, gibberellin is used to make head lettuce produce seed stalks.

The Kinins

These are the most recent discovery. Structurally they are related to the nucleic acids, but man has made synthetic kinins. In nature they are found in tissues that nourish the plant embryo. It was first discovered in coconut milk. Kinins promote cell division in very low concentrations; a few parts per billion is enough.

Adenine is the essential ingredient which gives a kinin molecule its biological activity. Adenine is an essential ingredient of nucleic acids. Nucleic acids control important processes such as protein synthesis. It is not surprising, therefore, that kinins promote both nucleic acid and protein synthesis. Kinins appear to do this especially well in leaves, even in the dark and in leaves which have been removed from the plant. Kinins, therefore, may be called maintenance hormones. Kinins maintain normal biochemistry in the leaf. Kinins, therefore, keep green produce healthy after harvest, a feature which is being exploited commercially at present.

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MODERATOR LAGERSTEDT: Thank you, Dr. van Overbeek. Our next speaker on this evening's program will be Dr. Hudson T. Hartmann Professor of Pomology, University of California at Davis. Dr. Hartmann --

The Use of Growth Regulators in Propagating Clonal Rootstocks for Several Tree Fruit Species

H. T. Hartmann

Dept. of Pomology, University of California

Davis, California

Clonal rootstocks are becoming more important each year in propagating many kinds of fruit trees. Such stocks have the advantages of uniformity, perpetuation of specific, desired characteristics without change, and often result in more rapid propagation time than when seedling stocks are used. They have the disadvantage, however, of perpetuating diseases -- so the use of initially clean stock is very important.

During the past few years in California, a definite need for clonal rootstocks, and rapid methods of propagating them, has arisen in several tree fruit species.

As a rootstock for the English walnut, Paradox walnut seedlings (*Juglans hindsii* x *J. regia*), resulting from natural crossing, have

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During the past few years in California, a definite need for clonal rootstocks, and rapid methods of propagating them, has arisen in several tree fruit species.

As a rootstock for the English walnut, Paradox walnut seedlings (*Juglans hindsii* x *J. regia*), resulting from natural crossing, have proved to be excellent, better in many instances than the usual *J. hindsii* seedlings. However, certain Paradox seedlings are far superior to others in vigor, resistance to nematodes, and to oak-root fungus. A method of developing clonal rootstocks from these certain seedlings would be of great value.

Studies have been going on in the Department of Pomology, University of California, for about ten years in efforts to develop satisfactory methods of rooting Paradox walnut clones. The problem has proven to be quite difficult. Both leafy, soft-wood cuttings under mist and woody hardwood cuttings have been used. In each case, treatment with a growth regulator - indolebutyric acid - was essential for rooting. Without such treatments not a single instance of root formation occurred. Table 1 shows typical results obtained in rooting tests with soft-wood cuttings under intermittent mist (2). Paradox walnut softwood cuttings, while rooting readily under mist, do not survive easily after rooting. Any disturbance of the root system seems fatal. Tests in 1961 indicate that rooting in mist beds which permit root growth on down into soil under the bed, with removal only after the rooted cuttings go dormant in the fall, may prove to be a feasible means of obtaining survival.

Table 2 shows results of a test with hardwood Paradox walnut cuttings (1). To obtain rooting, the cuttings were set upright in boxes of damp peat moss. A pronounced temperature effect was noted; raising the temperature about 10 degrees during the 60-day rooting period greatly stimulated rooting. This method, while producing rooted cuttings, has its drawbacks, since large losses occur in moving the rooted cuttings to the nursery. Rooting does not take place if the cuttings are just planted in the nursery row due, no doubt, to the low soil temperatures occurring in the spring.

The pear decline disaster in California, Oregon, and Washington may possibly be overcome by the use of a particular decline-resistant clonal rootstock - the Old Home pear. Means of rapid propagation of this clonal stock was urgently needed to permit its large-scale use.

Tests in rooting Old Home pear hardwood cuttings have been very rewarding. By following certain procedures, good rooting and survival has been obtained. Treatments and results are shown in Table 3. Collection of the cuttings in the fall, treating with IBA, then storing in damp peat moss at warm temperatures (65£ to 70°F.) for about four weeks before planting resulted in good survival percentages (3,5). No rooting was ever experienced when the IBA treatment was omitted. Direct planting in the nursery in the fall was not successful even with IBA treatment due, no doubt, to the lack of warm temperatures at the base of the cuttings, needed to stimulate adventitious root formation. The four-week storage period at a 70° temperature did not force the buds into growth since they were still in the rest period. Cold weather the remainder of the winter, after planting in the nursery, served to break the rest period of the buds. Bud growth as well as root growth then started with the onset of warm weather in the spring.

The Stockton Morello cherry has long been known in California as an excellent clonal rootstock for the sweet cherry, being adaptable to heavy, poorly-drained soils and, at the same time, imparting a much-needed, semi-dwarfing effect to the tall-growing sweet cherry. The Stockton Morello, however, could only be propagated by using the few suckers arising around the trunks of older trees. In addition, this stock was heavily infected with viruses, (necrotic rusty mottle, ring spot, and sour cherry yellows). Work is underway by the Dept. of Plant Pathology, University of California, to eliminate these viruses by heat treatments. A rapid method of clonal propagation from these limited virus-free sources was urgently needed.

Stockton Morello leafy cuttings taken from very young shoots in the spring root readily under intermittent mist - but only if they are treated with IBA (4). Rooting can be obtained as long as the new shoots are in active growth, but as soon as shoot elongation stops and a terminal bud forms, rooting of cuttings taken from such shoots is very difficult. Possibly a naturally-occurring auxin is being produced in the actively-growing bud which stimulates root formation.

Hardening off the rooted cuttings is a problem. Attempts to move them into pots or into the nursery row generally are failures. Best results are obtained when the cuttings are left in the flats in which they were rooted, then moved gradually from the mist into the greenhouse, then into a lath house and left there with occasional treatment with a nutrient solution until they become dormant in the winter. The following spring they are lined out in the nursery row and develop into good nursery trees by the end of the summer. This may prove to be the best practice for handling cuttings of deciduous species rooted under mist since, to produce good nursery trees, two years probably would be required in any event with most species.

The Marianna 2624 plum, a vigorous seedling selection of the parent Marianna plum (Prunus cerasifera x P. Munsoniana), is widely used in California as a rootstock for plums, prunes, and apricots. This is commonly propagated by hardwood cuttings but sometimes, especially in heavy clay soils, good stands are difficult to obtain. As shown in Table 4, tests conducted with this clonal stock showed marked benefits from treatments with indolebutyric acid (3).

In the instances described here, the use of a growth regulator, particularly indolebutyric acid, was found to be essential in obtaining satisfactory rooting. The statement is often made that growth regulators are of no benefit unless the cuttings will root to some extent without them. This is certainly not the case with Paradox walnut or the Old Home pear hardwood cuttings. We have never had an instance of their rooting when IBA was not used. The statement is also heard sometimes that root-promoting substances are of no value for hardwood cuttings - only for leafy cuttings. This again has not proven true with the species used in these tests.

Of course, other factors must be considered in rooting cuttings aside from the use of growth regulators. Timing is often of the utmost importance. In the work described here, in rooting Old Home pear hardwood cuttings, excellent results are obtained under California conditions if the material is taken and planted in the fall. Spring planting gives almost 100% failure. In rooting soft-wood cuttings of cherries under mist, only the time between beginning of shoot development in the spring and the cessation of terminal growth in mid-summer is suitable for taking the cuttings. Many other cases of "timing" effects could, of course, be cited.

Temperature relationships are extremely important in rooting cuttings. The application of growth regulators to a cutting to stimulate root formation is of no value if the base of the cutting is plunged into cold soil where the temperature is so low that there is no cell activity.

Failure to obtain rooting of hardwood cuttings of difficult species when planted in the spring can often be attributed to temperature effects. The uppermost buds, exposed to the heat of the sun, soon become warm and open, followed by leaves which quickly withdraw the water from the cutting. The base of the cutting, several inches deep in the soil, at lower temperatures, is inactive - no roots develop, no water is absorbed to offset that removed by leaves, and the cutting soon dies. The age-old practice of callusing hardwood cuttings by storing upside down in out-of-door pits with the base of the cuttings several inches below the soil surface is based on sound physiological principles. Adventitious roots are stimulated by the higher temperatures of the warmer surface soil, while the buds are retarded by the lower temperatures of the deeper soil layers.

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TABLE 1. EFFECT OF INDOLEBUTYRIC ACID ON THE ROOTING OF PARADOX WALNUT SOFTWOOD CUTTINGS UNDER MIST. CUTTINGS TAKEN JUNE 16, 1956. 30 CUTTINGS PER TREATMENT.

CONCENTRATION OF IBA[1]	PERCENT OF CUTTINGS ROOTED	AVERAGE NUMBER OF ROOTS PER ROOTED CUTTING
0 PPM	0	--
2000	13	2.5
4000	23	5.0
6000	53	8.3
8000	60	7.3

[1] Applied by concentrated-solution-dip method.

TABLE 2. EFFECT OF INDOLEBUTYRIC ACID, BUD REMOVAL, AND WOUNDING ON THE PERCENT ROOTING OF HARDWOOD PARADOX WALNUT CUTTINGS. AFTER STORAGE IN PEAT MOSS FOR 60 DAYS.

CONCENTRATION OF IBA - 24 HR. SOAKING METHOD	BUDS REMOVED		BUDS NOT REMOVED	
	WOUNDED	NOT WOUNDED	WOUNDED	NOT WOUNDED
STORAGE AT 60°F				
0 PPM	0	0	0	0
100	0	0	0	0
200	0	0	0	0
300	13	13	13	7
STORAGE AT 70°F				
0 PPM	0	0	0	0
100	0	0	0	0
200	13	26	20	13
300	40	33	26	33
400	13	20	20	20

TABLE 3. PERCENTAGE OF OLD HOME PEAR HARDWOOD CUTTINGS WHICH PRODUCED VIGOROUS NURSERY TREES. 1959-1960.

TREATMENT	CUTTINGS MADE	ROOTED CUTTINGS		
		100*	200*	300*
TREATED WITH IBA AND PLANTED AT ONCE	NOV. 16	1.3%	2.6%	2.6%
	DEC. 15	1.3	0.0	0.0
	JAN. 15	0.0	0.0	0.0
TREATED WITH IBA, HELD IN WARM (65°F) STORAGE 3 WEEKS, THEN PLANTED	NOV. 16	37.3	53.3	42.7
	DEC. 15	24.3	35.1	24.3
	JAN. 15	0.0	13.5	8.1

*Base of cuttings soaked in IBA solutions - 100, 200, and 300 ppm for 24 hrs.

TABLE 4. EFFECT OF TIME OF COLLECTION, STORAGE, AND AUXIN TREATMENTS ON SURVIVAL AND GROWTH OF MARIANNA 2624 PLUM HARDWOOD CUTTINGS. THREE REPLICATES OF 45 CUTTINGS EACH PER TREATMENT, 1956-57.

DATE COLLECTED	HANDLING METHOD	TREATMENT IBA	% SURVIVAL	AV.TREE HEIGHT JULY 26, 1957
Oct. 2, 1956	Planted immediately	45 ppm*	56	83 cm
		Control	28	63
Oct. 2	Stored for 6 weeks at 60°F. Planted Nov. 13	45 ppm*	53	73
		Control	23	70
Nov. 13	Planted immediately	45 ppm*	79	96
		Control	29	73
Nov. 15	Stored for 6 weeks at 60°F. Moved to 36°F until planted Feb. 19	45 ppm*	95	100
Feb.12,1957	Planted immediately	45 ppm*	50	60
		Control	8	48
Feb. 12	Stored for 3 1/2 weeks at 60°F. Planted Mar. 8	45 ppm*	65	67
		Control	0	--
Feb. 12	Stored as shoots for 4 weeks at 32°F. Planted Mar. 13	45 ppm*	69	60
		Control	2	40
Difference required for significance at 1% level			32	17

*Base of cuttings soaked for 24 hours in indolebutyric acid, 45 ppm.

MODERATOR LAGERSTEDT: Thank you, Dr. Hartmann. We will now hear from Dr. George Oki, Oki Nursery Co., located at Perkins, near Sacramento, California. Mr. Oki --

Growth Regulators, The U. C. System, and the Oki Nursery

George Oki

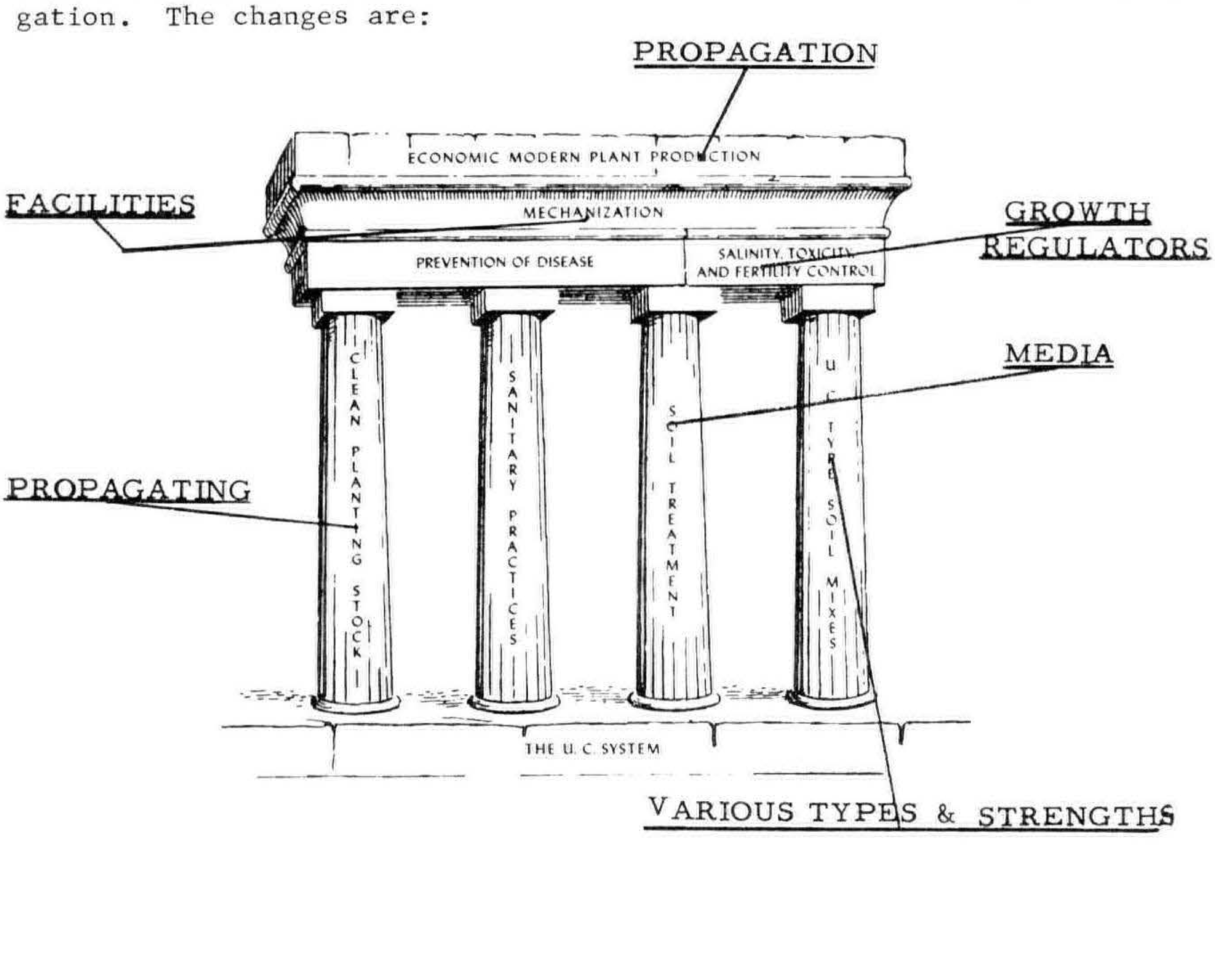
Oki Nursery Company

Perkins, Sacramento County, California

A great deal of emphasis has been placed on rooting hormones since 1935. This, however, did not mark the beginning of the use of hormones. It has been said that Dutch propagators inserted a wheat grain into the split basal ends of cuttings over a century ago.

The wheat grain in germinating, releases an auxin, thus stimulating root growth. Auxin is another term for natural hormone produced by plants. Growth regulators as we know them today are synthetic auxins, with a purpose in mind, "to stimulate root growth".

Although auxins, or hormones, play a very important role in propagation today, there are many other factors equally, if not more important. In the preface of the University of California Manual 23, edited by Dr. Ken Baker, is a symbol of the U. C. System. Within this symbol, with a few minor changes, lies the identical basic rules of plant propagation. The changes are:



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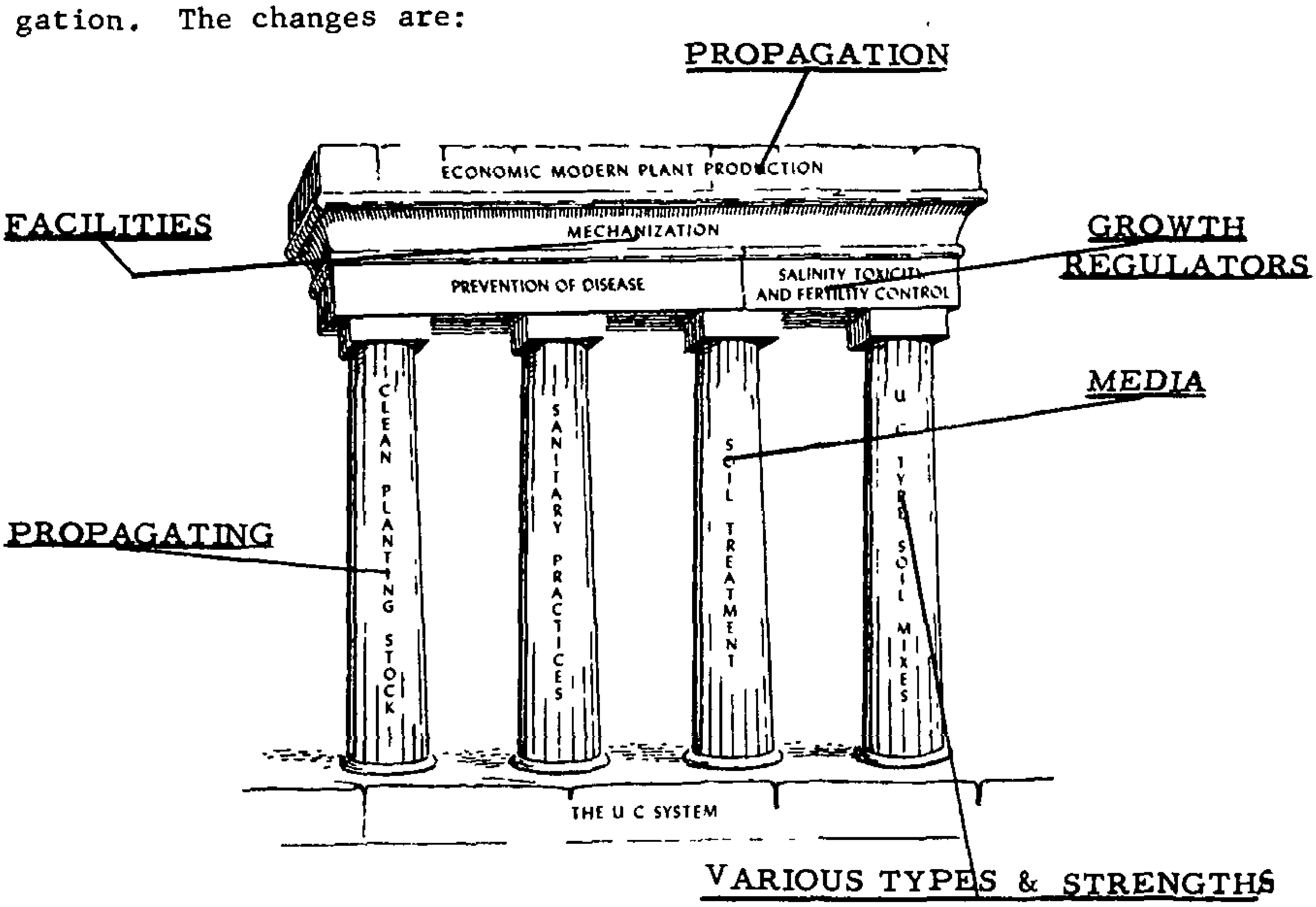

The furious pace of today's competitive business world focuses our attention on the economics of plant propagation. The use of growth regulators is primarily an economic factor; thus any supporting facilities that may be built or devised to expedite this operation will directly influence our cost of production.

In the quest of this goal, Oki Nursery has installed in the past four years, in chronological order, greenhouses, heating facilities, mist and, in 1960, a propagation building complete with refrigeration facilities. Primary emphasis was placed on sanitary control and the ease of sanitation maintenance during its entire construction program.

In support of a preventative sanitation program a mother block was established in 1960. All prostrate Junipers and other prostrate type plants were trained and staked to grow upright as standards. The soil being one of the prime sources of pathogens, this area is being turfed since irrigation is of the overhead sprinkler type.

If natural auxins are better produced in vigorous growing plants, then cuttings made from this type stock will root more easily and more quickly with the aid of growth regulators. Heeding this rule of thumb, a great deal of emphasis has been placed on roguing, replacing, and general maintenance in the production of a vigorous growing "mother block".

Sanitary practices in the propagation department is not an impossibility. Ordinary household cleanliness and practices are expected throughout the entire department. Analagous to a housewife washing pots and pans and her kitchen, a propagator cleanses and sterilizes his media and general working tools. (For further information on this subject see page 22 of University of California Manual 23.)

The cutting material brought in is washed thoroughly on portable steel racks. After the cuttings are made, the cuttings are dipped in a solution of Morton's Soil Drench C. (1 oz. per 35 gallons of water). The cuttings are drip-dried and the basal ends are treated with hormones. Both the powder form and the quick-dip method have been used. Thus far our records are inconclusive in making a definite statement as to which is preferable, but indolebutyric acid in the liquid form is much more flexible and easier to use in formulating different concentrations.

To obtain a 1000 part per million IBA solution dissolve 1 gm of IBA crystals in 500 cc's of Quakersol (95% ethyl alcohol). Stir vigorously to assure solvency and then add 500 cc of water and shake again. If stronger solutions are required just dissolve more IBA crystals, keeping in mind that each gram of IBA increases the strength of the solution by 1000 ppm.

Since our entire program is based on soft-wood cuttings, the usual IBA strength is 1, 3 or 5 thousand ppm. Keeping in mind that the greatest cost involved is the actual gathering and preparation of the cuttings we use a lesser concentrate than may be recommended. An extra week into the greenhouses becomes incidental if the loss should become greater due to hormone burn.

These hormone-treated cuttings are then stuck into a steam sterilized perlite media. It may be interesting to note that we use a flat of perlite 3 to 4 times before dumping. Sterilizing each cycle and reuse does not seem to affect the rooting percentages or quality. As a general rule, most soft-wood leafy cuttings are ready for the hardening-off house in 3 to 4 weeks, more or less. This ends the initial phase of production.

To summarize then, although growth regulators or hormones are very important, we now see the contribution of each segment of the U. C. symbol and we should never lose sight of the gift of natural auxin that nature has provided us. Facilities and its limits are endless. Prevention of disease by clean propagating stock, common sense sanitary practices, and sterilized media are vitally important. How useless a growth regulator can be rendered is often seen in a pathogen-infested crop failure. Here, then, is the true and actual beginning of the U. C. System.

MODERATOR LAGERSTEDT: We will now have questions from the audience. The first two questions are to Mr. Oki. What strength do you generally use in your nursery to strike roots on cuttings and what sequence do you use in your intermittent mist?

MR. OKI: 5000 parts per million, as an alcohol-water quick-dip solution. The sequence used for our mist varies with the season, but specifically in the summer when soft-wood cuttings are taken, the sequence is 10 to 15 seconds of mist every 5 minutes.

MODERATOR LAGERSTEDT: Some questions for Dr. Hartmann - where can concentrated IBA be obtained on the West Coast and what commercial preparations are available?

DR. HARTMANN: Braun-Knecht-Heimann at 1400 16th Street, San Francisco 19, California, handles pure IBA crystals. Hormodin powder, in three strengths, contains indolebutyric acid as the active ingredient and is sold by many garden supply companies. It is manufactured by Merck Chemical Co.

MODERATOR LAGERSTEDT: One further question for Dr. Hartmann. In rooting cuttings of the Old Home pear rootstock, why do you hold them at 70°F for 3 weeks before planting?

DR. HARTMANN: Treatment with IBA stimulates development of root initials but only if temperatures are high enough to permit cell activity. If the cuttings are inserted into the cold soil at - say 50° - after treatment, nothing happens. Holding the cuttings at 70° after treatment gets root initials actually started. Planting in the cold soil then may temporarily retard further development, but as soon as the soil becomes warm in the spring the already-formed root initials begin growing - right along with the opening buds above ground.

MODERATOR LAGERSTEDT: Now some questions for Dr. van Overbeek. Are there any commercial brands of kinins available?

DR. VAN OVERBEEK: As far as I know all materials are experimental. One is Shell Verdan R Senescence Inhibitor. It is also still experimental.

MODERATOR LAGERSTEDT: Will kinins stimulate shoot development on root cuttings?

DR. VAN OVERBEEK: Kinins are known to stimulate bud development, so it is logical that they can stimulate the buds on root cuttings.

MODERATOR LAGERSTEDT: Another question from someone in the audience. We ship broad-leaved evergreen plants bare root to the East and defoliation is a problem. Do you think a kinin dip would be helpful to retain leaves?

DR. VAN OVERBEEK: Kinins maintain green foliage in healthier, greener condition so one might expect less deterioration. Perhaps a mixture with a small amount of auxin should be tried, as the latter does retard abscission.

MODERATOR LAGERSTEDT: Would kinins sprayed on cuttings aid in root initiation?

DR. VAN OVERBEEK: They retard it, except perhaps in very low dosages. I may point out here again that this is the first time that the subject of kinins has been brought up in connection with possible uses in the plant propagation business. It is a broad field, full of opportunities for those willing to experiment.

MODERATOR LAGERSTEDT: Does kinin have any fungistatic action which may make leafy tissue resistant to fungus invasions?

DR. VAN OVERBEEK: Not directly - it is not a fungicide. However, due to its effect on the mainteance of leaves, kinins decidely prevent fungi from attacking the leaves. It is a question of a healthier leaf being more capable of beating off an attack.

MODERATOR LAGERSTEDT: This concludes our questions as well as the program for this evening. I wish to thank our speakers for participating in the program tonight.

THURSDAY MORNING SESSION

October 26, 1961

The session convened at 8:45 a.m. with Mr. Jack Spring, Chief Nurseryman, Golden Gate Park, San Francisco, presiding. The subject of this Symposium was Selection of Vegetative Propagative Materials.

MODERATOR SPRING. Mr. Maunsell Van Rensselaer was originally scheduled to be the Moderator for this section of the program, but he became ill shortly before the meeting. It is too bad that he could not be here because, as we all know, in his work at the Saratoga Horticultural Foundation he is particularly interested in selecting clonal forms of trees for plant propagation. As he finds a worthwhile specimen he is, of course, interested in registering and patenting it and making sure that the ultimate purchaser gets stock of the named clone that he is requesting. And, more or less, this is the type of program we are presenting to you this morning. Our first participant in this session is Dr. Curtis J. Alley who is an Associate Specialist with the Agricultural Experiment Station at the University of California, Davis.

Progress in the Production and Distribution of Registered Stocks

Curtis J. Alley

University of California

Davis, California

Certification programs are not new. G. H. Berkeley, speaking at the 14th International Horticultural Congress in 1955, reported that Canada probably had one of the first certification programs. It was inaugurated in 1915 in Ontario for the certification of seed potatoes. Previous to this (1910) Ontario attempted to control certain stone fruit viruses, such as those which cause peach yellows, little peach, and "X" disease of peach by requiring annual inspections of orchards. In 1924-25, certification of virus-free red raspberry planting stock was initiated. In 1947 a certification program was started for virus-free cherry budwood based on an indexing procedure. The States of Washington and Oregon have informal certification programs for virus-free cherry trees. J. A. Milbrath reported on such a program at the Oregon State Horticultural Society meeting in 1947. At first the program was very successful, but it gradually deteriorated because of lack of proper maintenance for virus-free trees. In 1957 the program was started again, with improved facilities for the maintenance of virus-free stocks. The State of Washington also has a successful cherry certification program. It is based on visual inspections as well as indexing to test trees for freedom from virus diseases.

In California there are at present certification programs for strawberry, cherry, citrus, avocado, grape, and garlic. Most of this report will be restricted to the cherry and grape programs (the two programs currently underway at Davis.) Consideration also will be given to future stone fruit programs.

Prior to 1950, pathologists and pomologists of the University of California had been visually selecting cherry trees for virus freedom as well as for quality and production. These included also any virus-free stocks that were available from other experiment stations. In 1950 a program was started by the California Department of Agriculture to develop a method for certifying that fruit, nut trees and vine nursery stocks were virus-free. Previously published knowledge of cherry virus diseases was utilized to index selected trees in order to determine their freedom from viruses. Budwood was taken from selected trees. A portion of the buds from a few budsticks was placed on 5 host trees: Bing, Montmorency, and Shirofugen cherry, Elberta peach, and Italian prune to test for known virus diseases. The remainder of the buds from the same budsticks were placed into Mahaleb seedlings which had been grown from seed taken from trees that had been given the same indexing and found to be virus-free. These budded trees on Mahaleb root were maintained in isolation until indexing was completed. If no virus disease was found after two years indexing, the budded trees were then designated as registered trees. While the trees were being indexed, personnel of the University of California, United States Department of Agriculture, and California Department of Agriculture worked closely to establish regulations for a registration program. The regulations were adopted in September, 1956. In order to maintain freedom from virus disease, the budded trees are grown inside a plastic, insect-proof, 32x32 mesh screenhouse, located 1/4 mile from the nearest peach tree. An area adjacent to the screenhouse is set aside for growing limited quantities of registered Mahaleb and Mazzard liners, and registered budded trees of the varieties in the program. The registered Mahaleb and Mazzard trees from which seed is obtained are grown in the orchard. Each seed tree is visually inspected twice each year and given an indexing on Shirofugen flowering cherry. Each registered tree that is grown inside the cherry screenhouse receives this same inspection and indexing. Nurseries or growers who wish to participate in the program must notify the California Department of Agriculture of their intention. Isolation is one of the main requirements for participation. A certified planting must be at least 300 feet from the nearest tree of Prunus, or at least 1/2 mile from any such commercial planting. Following an inspection of a proposed planting site, the state nursery service notifies the University of those growers who qualify. Active participants are given preference in the distribution of registered plant materials. Each year registered Mahaleb seed and liners are distributed, primarily to such participants. When registered Mazzard seed and liners are available, the same procedure is followed. In the spring of 1961 approximately 10,000 registered Mahaleb liners and 800 registered Mazzard liners were distributed. This fall approximately 100 lb. of Mahaleb seed and 10 lb. of Mazzard seed from registered trees, and 85 lb. of Mazzard from nonregistered (ringspot negative) trees were distributed. There are 15 registered Mahaleb trees, 11 registered Mazzard (Saylor), and 1 registered Silverbark Mazzard tree from which seed is obtained. There are 6 varieties and 2 rootstocks in the cherry registration program. Registered budded trees of commercial varieties are distributed primarily to nurseries or growers for developing mother and increase blocks. It is from these sources that commercial quantities of buds and scions are obtained. There are now two nursery-growers who provide certified budwood of different fruiting cherry varieties in commercial quantities primarily to nurseries in the certification program. There are two commercial nurseries who maintain their own registered trees for collecting budwood. Each lot of seed from a registered tree, bundle of liners grown from seed from a single registered tree, or registered budded tree bears an appropriate orange registration stock tag issued by the California Department of Agriculture.

In the spring of 1959 an addition to the screenhouse was built so that the program could be expanded to include other stone fruits. In the winter of 1959 the California Department of Agriculture made cuttings from selected trees of 17 peach varieties, 2 peach rootstocks, and 1 nectarine variety. Part of the cuttings from each tree was used for indexing. The remainder was used for propagation of progeny trees which are in their second year's growth in the screenhouse. After two years' observations on indexing, those trees that are found to be virus-free will become registered and permanently established in the screenhouse.

Work is started on a second addition to the screenhouse, intended primarily to house the remainder of the stone fruit trees. This fall the California Department of Agriculture made cuttings for indexing from selected trees of 22 plum and prune, 5 almond, 5 apricot, and 1 Mahaleb cherry. Following two years' indexing it is planned to establish a registration and certification program for the remainder of these stone fruit varieties and rootstocks.

As previously indicated, the development of registered and certified cherry varieties and rootstocks has been accomplished by indexing on five indicator hosts. With the addition of other stone fruits into the program this indexing procedure is being enlarged to include Shiro plum, Peerless almond, and Tilton apricot, making a total of 8 hosts. In this manner, after all stone fruits have passed the indexing tests, it will be possible to maintain trees of all types of stone fruits within the same screenhouse if necessity should arise, since all will have equivalent indexing.

Prior to the time that the cherry program was started, grape growers began to complain of the degeneration problems with grapevines. Already Pierce's Disease had been recognized, and more was becoming known of the White Emperor disease, Fanleaf, Yellow Mosaic, and Yellowvein. In July of 1951, Dr. H. P. Olmo made a report to the Technical Advisory Committee of the Wine Institute outlining a proposed program for the introduction, improvement, and certification of healthy grape varieties. This gave growers an idea of a way to overcome some of their very serious vineyard troubles. In July, 1952, through the combined efforts of the Wine Advisory Board and the University of California, The California Grape Certification Association (a nonprofit corporation) was formed. This association was an organization composed of industry and the University of California, particularly the departments of Viticulture and Enology and Plant Pathology. Under the guidance of Dr. W. B. Hewitt of the Department of Plant Pathology work was begun in the spring of 1953 to index the commercially important table, raisin, and wine varieties. A year or so later assistance was obtained from the California Department of Agriculture and the United States Department of Agriculture. At the same time personnel of the various State and Federal agencies worked closely together to formulate and establish regulations for the registration of grape vines. Nurserymen and interested growers assisted in the refining and adoption of these regulations in September, 1956. The known troublesome virus diseases at that time were Fanleaf, Yellow Mosaic, White Emperor, and Yellowvein. The indicator plants used were French Colombard, Thompson Seedless, Ribier, and Emperor. In the spring of 1956 a Foundation Vineyard was established at Davis. It consisted of 4 rootstocks, 7 table and raisin varieties, and 15 wine varieties. New planting sites on which to establish mother blocks and increase blocks for nurseries and growers were carefully examined by the State inspectors. Commercial plantings were started in the spring of 1956. The main isolation requirements were: 1) no grapevines had been grown on the land for at least 10 years; 2) certified plantings must be at least 150 feet from any noncertified grape planting; and 3) the land must not be subject to flooding or injury by herbicides. The vines that were grown in a foundation vineyard received two visual inspections annually. Every four years each vine in this vineyard had to be given a complete re-indexing. Nurserymen and growers participating in the program had the choice of establishing either a mother block or an increase block. A mother block received two visual inspections annually. An increase block received one visual inspection annually. No reindexing was necessary. Fees were established by the California Department of Agriculture to cover the inspection costs. About 15 nurseries and growers presently are participating in the Grape Registration and Certification Program.

In 1958 the University of California combined the cherry and grapevine programs into one organization called the Foundation Plant Materials Service. The cherry program has continued on to date as outlined. As more information has become known of the grape viruses, it has been necessary to modify the grape registration and certification program. The last change in regulations occurred in May, 1961. There are better indicator varieties than used previously. These are St. George, Mission, Carignane, and Baco 22-A. What was originally the foundation vineyard at the University has now become a mother block. A new foundation vineyard was established at Davis this Spring. The isolation distance from a noncertified grapevine has been reduced to 100 feet. To date there are 3 rootstocks, 8 table and raisin varieties, and 27 wine varieties in this new foundation vineyard. The distribution of registered grape material from this vineyard is expected to start in the spring of 1962 in very limited quantities. Each bundle of cuttings or rootings of registered grapestock will have attached to it an appropriate tag issued by the California Department of Agriculture. In addition the ends of the twine or wire used to tie the bundles are sealed with a yellow metal seal issued by the California Department of Agriculture.

Besides the established programs for cherries and grapes, and those which are underway for other stone fruits, a program for the maintenance and distribution of registered garlic is in the initial phase at Davis. At present such a program is maintained by industry in the northern part of the state. A small planting of garlic was made on Foundation Plant Materials Service premises this year. Another year's testing will be needed to determine if registered garlic can be grown here. The garlic program is one that certifies to the freedom from the stem and bulb nematode, Ditylenchus dipsaci. Virus diseases are not involved.

Information concerning the strawberry, citrus, and avocado certification programs may be obtained from the Bureau of Nursery Service, California Department of Agriculture, 1220 N Street, Sacramento 14, California.

MODERATOR SPRING: Thank you, Dr. Alley. Along with Dr. Alley's field, we have this morning to speak to us Mr. Walter Krause on the progress of production and distribution of certified nursery stock. Walter has been active in his field for over 20 years. He is a sales and field representative for Stribling's Nursery for the five southern counties of the San Joaquin Valley of California. His duties, in addition to this, are as Director of the research program for Stribling Nursery, which carries on research in plant breeding, variety selections, "bud-line" selections, indexing and virus control and also work in specialized propagation methods for the production of fruit trees and grape vines. I would like to call now on Walter Krause to cover his section.

The Commercial Nurserymen's View of Certification

Walter D. Kraus

Stribling's Nurseries, Inc.

Merced, California

It has been our privilege and opportunity to work very closely with Dr. Curtis Alley and his associates and the State Bureau of Plant Pathology in the establishment of Certified Increase Blocks of cherry varieties, grape varieties and rootstocks. We were inexperienced in how to convert and apply these new phases of science to a commercial and practical enterprise, integrating them into our production of nursery stock. The University of California, and the Bureau of Plant Pathology, and the Nursery Service, California State Department of Agriculture, have given their undivided support and assistance, for which we are very grateful.

Dr. Alley has informed us of the development and importance of registration and certification of plant material, and I would like to review with you what we are doing with this material, how we maintain such plants, and the inspection of these Increase Blocks and last of all, the very important point, the acceptance of such nursery stock by the commercial grower.

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Registered plant material purchased from the Foundation is planted on our property, isolated from related plants by a given distance ranging from one hundred yards to one-half mile, depending upon the variety. The soil history also must comply with the requirement of a defined number of years during which time related plants have not infested the soil. The Increase and Mother Blocks are under our supervision, directed by the Foundation. Budwood or cutting stock is removed from this propagation area only under the direction of the Foundation. Repeated inspection of each plant to determine continued cleanliness and variety identity is carried on by the Foundation. Every effort is exploited to maintain these Increase Blocks in perfect condition to ascertain maximum production of budwood and cutting stock.

This year we are growing for the commercial trade, three grape varieties, three grape rootstock varieties, and three cherry varieties. These are all grown under the Certification Program.

Production of nursery stock under these conditions, complying with regulations and procedures not common to nursery production have at times proved a burden and we have at times reviewed the possibilities and the advantages of this program. We are, however, delighted with the progress and advances and are anticipating an active participation in the Certification of stone fruits. We are hoping for this to become active and a reality very soon. In the meantime we have designed and built our own chamber for heat treatment of stone fruit varieties, having completed the indexing of all varieties we are growing and having initiated periodical re-indexing of all varieties. We have already "tasted" of the advantages of growing clean nursery stock. Indexed bud-lines on seedlings from indexed trees have resulted in twenty per cent increases in bud stand, plus additional caliper sizes and tree uniformity. At this time we are participating in several test plots to determine the effects of viruses on fruit quality and production.

We are interested in the advancement of superior nursery stock to supply a better informed, better equipped and qualified commercial grower than we have known in the past decades. Thus we are continuing with enthusiasm to co-operate with the Registration and Certification of nursery stock.

My personal experience in the cherry producing area is very limited, therefore it is difficult for me to enlarge on the Certification of cherries and their rootstocks. However, the Certification of grape varieties and their rootstocks in the southern half of the state has been very enlightening and rewarding. Growers in the table grape and valley wine producing areas are reporting yield increases of twenty and twenty-five per cent, better plant uniformity, and increased vigor, resulting in vineyards which withstand the attacks of insects and diseases. But the most gratifying and encouraging are the reports of superior quality of their product.

In our agricultural production of surpluses the "quality factor" becomes of ultimate importance. Increased production alone only leads to more controls and government controlled marketing orders. These I presume, are necessary, but often prove to be necessary evils.

The all-important question, and with this I conclude, what can the commercial grower expect from his certified nursery stock? What does he say about certification and what is his attitude toward premium prices for certified nursery stock? Commercial growers planting certified nursery stock in their orchards and vineyards at present are growers that look ahead and very carefully plan and evaluate every phase of the future. These people recognize the value of superior merchandise; they not only expect increases in production, but much more than this they expect to deliver a product to their market and their consumer that is of superior quality - superior in appearance, uniformity, flavor and - in grape production - higher sugar content. These "extras" are the factors that will make Certified Nursery Stock the best buy in spite of established increased prices for such stock. The production of superior merchandise leads to greater and proper utilization of our product. The results are satisfaction, pride with accomplishment, and desire to build an industry with which to be affiliated.

These are points of interest to us, and with this scope and anticipation we feel the Certification of grapes, citrus, fruit and nut trees and other nursery stock will induce similar rewards of accomplishment, satisfaction and monetary gain for those who look ahead.

MODERATOR SPRING: Thank you, Walter. The importance of selected plant materials is more and more evident every day as we look around our industry, whether it be for the production of fruit, as we have discussed this morning, or in my field - ornamental horticulture. We are very grateful to you gentlemen for your discussion on the certification of nursery stock and how it is maintained.

I rather doubt that our next speaker needs to be introduced to most of you. Mr. Wray Hildabrand has given many years to agriculture in California, having served some 15 years as the Chief of the Bureau of Nursery Services, California State Department of Agriculture. Since 1961 he has been assigned additional duties - as often happens in these Divisions - and also received a new title, Assistant to the Chief, Division of Plant Industry. This morning I'd like to call on Wray to discuss with you the progress in bringing the nomenclature of western ornamentals into conformity with the International Code of Nomenclature for Cultivated Plants. Wray --

Progress in Bringing Nomenclature of Western Ornamentals Into Conformity with the International Code of Nomenclature for Cultivated Plants

Wray F. Hildabrand
California Department of Agriculture

Sacramento, California

The California Department of Agriculture and the County Agricultural Commissioners are interested in this subject for several reasons. (1) One of our objectives, which is shared with the nursery industry, is the production of high quality nursery stock in California. (2) We have a law to enforce which requires that plants be labeled correctly when sold. (3) We have some good friends in the business of growing and selling plants and we would like to see them get ahead. Good merchandising practices such as adequate labeling should help.

The International Code provides the guide lines for the correct naming of plants and sets a standard for the industry, as well as for regulatory agencies in enforcing laws pertaining to plant names.

Through need and experience, most industries have established standards for the products they handle. These standards may be voluntary on the part of industry members or may be established by law. When legalized it helps eliminate unfair competition. A standardized product increases the respect and faith of the customer in the product and in the firm from which it is purchased.

Horticultural standards for nursery stock were adopted by the American Association of Nurserymen in 1923. The original standards have been revised from time to time and are still in effect as "The American Standards for Nursery Stock". The California Association of Nurserymen first adopted grades and standards for nursery stock in 1930. In 1937 the Association sponsored legislation to include the standards in the law. Major revisions in the law occurred in 1939 and again in 1957. The law was first enacted for the purpose of preventing deception or misrepresentation in the handling and sale of nursery stock. That is still its primary purpose.

Provisions covering deceptive practices are a part of most grades and standards laws that have been enacted by the different states. In the trade practice rules for the nursery industry adopted by the Federal Trade Commission, there is a separate rule covering deception through use of names. The first paragraph of this rule states: "In the sale, offering for sale, or distribution of an industry product, it is an unfair trade practice for any industry member to use a name for such product which has the capacity and tendency and effect of deceiving purchasers or prospective purchasers as to its true identity".

California's law states in part. "Whenever nursery stock is sold it shall be labeled plainly and legibly as to the correct name".

"Ornamentals, except roses and annual or herbaceous perennial plants, shall be labeled with the botanical name".

Labeling plants correctly with the botanical name is not always as simple as it sounds. It is true that the International Code of Nomenclature provides guide lines. In addition there is a need for a list, based on the rules of the Code, which would provide a single reference for ornamental shrubs and trees handled in the California trade. Such a list has been prepared by Dr. Elizabeth McClintock, California Academy of Sciences, and Dr. Mildred Mathias, Department of Botany, University of California, Los Angeles. It will be published soon. These ladies, who are recognized authorities, graciously agreed to prepare such a list when the need for such a reference was pointed out to them. The list will not only be of value to propagators, nurserymen, landscapers and enforcing agencies, but also to botanists, research workers and teachers. It is not expected that it will settle all the differences of opinion of botanists nor is that its purpose. It will be a valuable reference.

Since the present law was revised in 1957, there have been a few serious problems in enforcement. That was to be expected. The law was something the nursery industry wanted. The co-operation in complying with the labeling requirements has been very good. The trouble spots have been where it was necessary to tell a nurseryman he had to label his plants. Nurserymen don't like to be told they have to do something. But usually after the stock was re-arranged into blocks of the same species, the inferior stock had been dumped, and the signs or labels were in place, the nursery had a much more orderly appearance. The labels help both the customers and the salesmen. Many times inspectors have been thanked for bringing about such a change.

The nursery industry in sponsoring the legislation asked that if it was passed, it should be given strict enforcement. Provision for covering the field adequately was made by including County Agricultural Commissioners with the Department of Agriculture as co-enforcing officers. Since this was a new job for commissioners and they already have a wide range of duties, it took some time for them to adjust their work, train their men, and acquaint nurserymen with the requirements of the law. Progress in uniform compliance with the law throughout the state has been slow but steady. Work started at the wholesale level and progressed to the retailers. The job of coordinating inspection throughout the state for the sake of uniformity was assigned to the Nursery Service in the Department of Agriculture.

At present, compliance with the labeling provisions of the law at the wholesale level is very good. At the retail level, enforcement in the northern coastal area is somewhat ahead of the rest of the state. Progress is being made each month.

County Agricultural Commissioners report monthly to the Department the violations of the grades and standards law found in incoming shipments of nursery stock. In 1959, 1,386 violations were found; in 1960, 818, and in 1961 to October 1st, 646. These figures include violations because of defective roots of deciduous fruit and nut trees, dead and dying plants and improper labeling. Lots found improperly labeled during those years totaled 275 in 1959, 171 in 1960, and 86 to October 1st in 1961. This shows an improvement trend each year, though it must be remembered that the bulk of the shipments moving in California move under "pinto" tags and are not held for inspection at destination.

There is a plan which is progressing rapidly to get away from the need for inspection at destination of nursery stock shipments moving within the state. Enforcement of both pest cleanliness and grades and standards laws at origin is being stressed. Shippers, by using care in proper labeling can speed up this elimination of inspection at destination. It will be easier to accomplish if agricultural commissioners can be assured that an adequate job of labeling is being done at origin.

There are always problems when things are changed and when progress is sought. There are still questions when some authorities differ as to the correct naming of plants. The list that is being prepared should help answer some of these questions. It is difficult to keep away from the promotional and advertising aspects when a plant is named. Terms such as "new", "improved", "dwarf", "giant", "ever-blooming" are used frequently and while they may not be a part of the plant name they may be deceptive unless the terms are factual.

The responsibility for correct naming starts with the propagator. If he follows the rules of the International Code of Nomenclature for Cultivated Plants, the stock he propagates may move through the nursery trade to the customer with the correct name attached. The list prepared by Drs. McClintock and Mathias is certain to be of great assistance in accomplishing the objective of the production of high quality nursery stock that is labeled correctly when sold.

MODERATOR SPRING: Thank you, Wray. Dr. Elizabeth McClintock, of the California Academy of Sciences at San Francisco, is going to carry on the discussion; that is, the part on correct nomenclature of plants. As you have heard from Mr. Hildebrand, Dr. McClintock and Dr. Mildred Mathias of the University of California at Los Angeles have been working on a project for some time now, compiling a list of plant names and synonyms. The pleasure to call on Dr. McClintock is rather great for me, because I have had the good fortune to be in the general vicinity of the California Academy of Sciences throughout my career in horticulture and I have found that any time there was a problem that dealt with the botany or the naming of plants that all I had to do was to call upon Dr. McClintock for assistance.

The Naming of Horticultural Plants

by Elizabeth McClintock

California Academy of Sciences

Golden Gate Park, San Francisco 18, California

Plants have names for the same reason that persons and objects are named, simply as a means of referring to them. Long before our present civilization came into being, people who lived in a particular area or region of the world had their own names for the plants they knew and used. The Aztecs, for instance, had medicinal uses for many of the plants in their area and they had their own names for them.

The naming of a few plants in a local region, however, is quite different from the situation which exists today when we are dealing with many thousands of plants on a world-wide basis. There are probably between 200,000 and 300,000 species of ferns and seed plants known today. These are contained within about 10,000 genera and 300 families. Of these 200,000 to 300,000 known species, about one-tenth or 20,000 to 30,000 species, are cultivated. I have not located exact figures but Hortus II, published in 1941, lists over 18,000 species cultivated in North America.

The naming of cultivated plants has been a problem for many years for those who sell, buy, and use them. I would like to touch on some of the problems involved in the nomenclature of plants (that is the system of names which is based on the botanical classification of plants), and how these problems are being solved by the application of two codes of nomenclature: the International Code of Botanical Nomenclature and the International Code of Nomenclature for Cultivated Plants.

Plants are not named haphazardly. For the past two hundred years the naming of plants has followed certain procedures. Carl Linnaeus, the Swedish botanist, in 1737 laid down the first of our modern rules of nomenclature and in 1753 he published his account of all the plants of the world known at that time. It was in this work, the Species Plantarum or the "Species of Plants, " that he gave to all plants a combination of two names, which we call a binomial (the Latinized name of a species, composed of two words -- the generic name and the specific epithet -- Eucalyptus globulus). Before Linnaeus published this work the name of a plant might consist of one, two, or three or more words, which might be compared to using the definition of a word instead of the word itself. Linnaeus was a systematic organizer who could see the advantage of having uniformity in the naming of plants and soon other botanists began to follow his system of binomial nomenclature.

In the hundred years following Linnaeus, vast areas of the world were explored and colonized. Think of the exploration which went on across our own continent from the end of the Revolutionary War until the Civil War. Wherever these exploring expeditions went there were usually plant collectors along, who sent back their plants to centers of research where they were looked over (sometimes too hastily!) and identified and named. With this activity all over the world, in discovering and naming old and new plants, there resulted a considerable amount of confusion; some plants had more than one name and so would be known in one country by one name and in another country by another name. It soon became obvious to botanists that there ought to be set up a system of rules of nomenclature which would be international, thereby providing a basis for all botanists to follow.

In 1867 the First International Botanical Congress was held in Paris. At this meeting there was presented for discussion a set of rules for botanical nomenclature written by a Swiss botanist, Alphonse de Candolle. From the time of this Congress until the Fifth International Botanical Congress in 1930 at Cambridge, England, there were certain disagreements among botanists regarding these rules. However, at the Congress in 1930 many of these differences became reconciled and for the first time the rules of botanical nomenclature became truly international.

The International Code of Botanical Nomenclature states the principles for naming plants and the specific rules for carrying these out. It deals with the categories of plant classification and the names assigned to these categories.

There has been worked out a system of classification by which those plants whose similarities are greater than their differences are brought together into taxonomic groups. These similarities are a combination of some of the characters of the flower and its various parts, the fruit and its seeds, leaf structures and the arrangement of the leaves, and the habit of the plant. Every plant belongs to several taxonomic groups which form a series with a fixed, hierarchical sequence. These are family, genus, species, botanical variety.

Family. This is an assemblage of smaller groups called genera which resemble each other in general appearance and technical characters. Some well-known families are the *Rosaceae*, the Rose Family; the *Liliaceae*, the Lily Family; the *Leguminosae*, the Pea Family; the *Myrtaceae*, the Myrtle Family; and the *Ranunculaceae*, the Buttercup Family. Most names of families end in *aceae*, with a few exceptions, of which *Leguminosae* is one.

Genus. This is a group subordinate to the family and often recognized from other genera in the same family by one or more characters. *Eucalyptus* and *Leptospermum* are genera of the *Myrtaceae*. Each genus consists of one or more species.

Species. This is a kind of plant distinct from other kinds in marked or essential features which provide good characters for its identification, and which may be assumed to represent in nature a continuing succession of individuals from generation to generation, and which ranges over a certain geographical area. The name of a species was referred to earlier as a combination of two words, called a binomial, consisting of the generic name and the specific epithet, as Eucalyptus globulus or Leptospermum scoparium. It is important to realize that species are variable and that a species may be composed of subordinate groups, one of which is the following.

Botanical variety. Species may be composed of two or more variants which have originated and maintain themselves as natural populations in the wild and which generally have their own geographical distribution. For instance, Ceanothus papillosus consists of two varieties which may be distinguished from each other by the shape and size of the leaves. C. papillosus var. papillosus has leaves which are oblong-elliptical to elliptical, rounded to truncate at apex, 1/2 to 1 inch broad, while C. papillosus var. roweanus has narrow leaves which are linear to oblong, more or less retuse to truncate at apex, and less then 1/2 inch broad. When a species consists of two or more varieties the one which was recognized first and to which the specific epithet was first given is named by repeating the specific epithet and thereby using it also as the varietal epithet for that particular part of the species. Thus we have the above mentioned C. papillosus var. papillosus. When brought into cultivation a botanical variety is known by the same name given to it as a plant growing in the wild.

The International Code of Botanical Nomenclature deals with the botanical categories which have just been mentioned. Without going into the details of this Code, I would like to mention a few points of importance.

The principle of priority is the cornerstone of the Code. It provides that each group from family to species has only one correct name, the earliest one published within the same rank. Publication of names is governed by the Code; the place and scope of publication is covered in some detail. One condition of publication, observed since 1935, is a Latin diagnosis for each new species. Another very important rule is the homonym rule; a name cannot be used if it is a later homonym, that is, if it duplicates a name previously and validly published for another and different plant.

In cultivation there are two kinds of plants:

1. Those introduced directly from the wild, without any noticeable change in appearance or characters from those growing in their native habitat. Many of our ornamentals fall into this category, but others fall into the following one.

2. Those plants which are of horticultural origin. These have originated in cultivation and differ in various ways from their wild prototypes. We are always trying to find plants which are more suited to our needs and so through selection and hybridization many new plants with qualities superior for our uses than those of their wild progenitors have been developed by man. These cultivated plants are named at

three main levels: genus, species, and cultivar. We shall now answer the question of what is a cultivar, and at the same time consider the use of the second code of nomenclature mentioned above, the International Code of Nomenclature for Cultivated Plants.

Species, mentioned previously as often being variable, when brought into cultivation may produce seedling plants which differ among themselves. Some of these may have qualities such as flower color or habit of plant which are desirable for a particular purpose. A species with normally colored flowers may produce seedlings with white flowers, or a normally erect species may produce seedlings which are dwarf, prostrate, or fastigiate in habit. Such horticultural variants, which have arisen and are maintained in cultivation, have been called "varieties" but these variants differ from botanical varieties by reason of their origin and maintenance in cultivation and should not be confused with them. The term cultivar has been proposed as an international term for such variants and replaces the English language term of variety and also such terms as the Italian razza, Dutch ras, German Sorte, and Scandinavian sort. A cultivar may have originated as a selection from a single species or from a group of hybrids between two or more species. It may be a single plant or several plants seen first in cultivation and recognized by horticulturists, agriculturists, or foresters and which is distinguished by any characters (morphological, physiological, genetical, or chemical) that are different for the purposes of horticulture, agriculture, or forestry. It is a unit which is intentionally maintained as uniform as possible.

Because of the desirability of uniformity in horticultural material certain uniform groups of cultivars have been developed and are maintained by the particular mode of reproduction and propagation best suited to them. Two such groups are clones and lines. These two differ in their modes of reproduction and propagation.

Clone. A clone is a kind of cultivar. It is a collective name for all plants asexually reproduced (that is, by vegetative means, as, for instance, cuttings, divisions, grafts, or others), from a common ancestor. Plants which are members of a clone are all alike and identical with their common ancestor.

Line. A line is a kind of cultivar. It is a group of individuals of uniform appearance reproducing sexually, propagated by seeds, its stability maintained by selection to a standard.

Cultivar may be defined as a general term for an assemblage of individuals propagated either by seeds or some vegetative means and having one or more characters by which it can be differentiated from other cultivars within the same genus or species. The naming of cultivars is governed by the International Code of Nomenclature for Cultivated Plants. Let us now consider the relationship of this code to the International Code of Botanical Nomenclature and the difference in purpose of the two codes.

The International Code of Botanical Nomenclature governs the use of botanical names in Latin form for both cultivated and wild plants. The International Code of Nomenclature for Cultivated Plants aims to promote uniformity, accuracy, and fixity in the naming of cultivars, that is, for cultivated plants below the rank of species, and which are normally given fancy names. It does not regulate nor attempt to standardize common names. The two codes supplement each other. The International Code of Nomenclature for Cultivated Plants carries on for horticultural, agricultural, and sylvicultural plants where the International Code of Botanical Nomenclature stops.

The International Code of Nomenclature for Cultivated Plants, after defining the term cultivar and naming kinds of units which the inclusive term cultivar may embrace, provides for the formation, use, publication, priority, and rejection of cultivar names. These may be summarized as follows:

1. New cultivar names published on or after January 1, 1959, are to be fancy names, that is, different from botanical names in Latin form. This does not affect the use of botanical epithets published previous to this date being used as cultivar names.

2. New cultivar names may be written in any language. The code provides for their translation and transliteration.

3. Cultivar names may follow either the botanical name or the common name of the plant.

4. Cultivar names should be written in such a way as to be distinguished from the plant names which they follow, either by use of different type face and preceding the cultivar name by the abbreviation cv., or by enclosing the cultivar name in single quotes. (Double quotation marks must not be used to distinguish cultivar names). Examples: Magnolia campbellii 'Strybing White'. Magnolia campbellii cv. Stark White. Rosa 'Peace'. Rose 'Peace'.

5. Cultivar names must not be repeated within a genus.

The Agricultural Code of California requires that wood ornamentals, except roses, whenever sold shall be labeled with the botanical name (Agricultural Code of California, Sect. 1148.2. See also Directory of Nurserymen and Others Licensed to Sell Nursery Stock in California and Summary of Laws and Regulations. As of September 30, 1960. State Publication No. 281, p. 237.) Because it is necessary to go to many different sources for the names of plants in the California nursery trade it was decided that Dr. Mildred Mathias and the present writer would collaborate in the preparation of a list of the woody ornamentals in the California nursery trade. These plants have come to California chiefly from those regions of the world having a Mediterranean climate, as California has, such as the Mediterranean region, certain parts of South Africa, South America, Australia, New Zealand, and in addition, from the milder parts of western Europe and eastern Asia. Thus, we are dealing with many plants from a large portion of the temperate regions of the world.

The sources of names for the list which Dr. Mathias and I have prepared were the printed or mimeographed price lists for wholesale nurseries. We divided California into two parts, (1) southern, and (2) northern and central. Dr. Mathias took the southern part and I took the remainder. We each made a card file of the items in our respective areas. There are enough differences in materials used in these two regions so that each of us had a considerable number of items not in the other's region. We listed both botanical and common names and when our two regional lists were put together we had about 6,000 items. Each item is cross-filed, common names to botanical names, and synonyms to the botanical names which we have chosen to use, and under our chosen botanical names are given the common names and synonyms. The list is alphabetical in one sequence and does not include several specialty items, such as ferns, bamboos, roses, fuchsias, rhododendrons, and camellias.

The sources for checking and verifying these names are considerable and too numerous to mention here, except for the following: Index Kewensis, Index Londonensis, Bibliography of Cultivated Trees and Shrubs and Manual of Cultivated Trees and Shrubs by Alfred Rehder, Hortus Second, Manual of Cultivated Plants, and Standard Cyclopedia of Horticulture by L. H. Bailey, Trees and Shrubs Hardy in the British Isles by W. J. Bean, Handbook der Laubgeholze by Gerd Krussmann, Nederlandse Dendrologie by B. K. Boom, The Royal Horticultural Society Dictionary of Gardening edited by Fred J. Chittenden, The Royal Horticultural Society Supplement to the Dictionary of Gardening edited by Patrick M. Synge, and the following periodicals: Curtiss Botanical Magazine, Edwards' Botanical Register, Revue Horticole, Baileya, Journal of the Arnold Arboretum, Gentes Herbarum, Gardener's Chronicle, Journal of the Royal Horticultural Society, and the National Horticultural Magazine. Regional floras of various parts of the world were used and also those works dealing with particular genera.

The plant names in the proposed list are written in accordance with the two codes of nomenclature just discussed.

It is hoped that the list will do the following:

1. Serve as a guide in labeling nursery stock.
2. Eliminate mislabeling.
3. Aid the customer in knowing what he is buying.
4. Promote uniformity in the names of ornamentals in the nursery trade.

It is expected that after the list is published problems will arise, since the list is only a guide to labeling of plants in the trade. In questions of doubt, the authors should be consulted for their interpretations of special problems.

MODERATOR SPRING: Thank you, Dr. McClintock. To present the first part of the next section - on the Selection and Production of Nursery

Stock, Mr. Van Rensselaer invited Mr. Fred Petersen, who is with the Soil and Plant Laboratory, Inc. of Orange, California, to present a talk on the methods used in producing standardized quality nursery stock and procedures, with the various methods at our disposal now, to keep these registered and certified clonal selections healthy and disease-free for our customers.

I would like to introduce to you Mr. Fred Petersen, who is a graduate from the University of Utah, having specialized in plant physiology, chemistry, and experimental biology. He has been with the Soil and Plant Laboratory since 1958. When recently it was decided to open a Central California office, Mr. Petersen was selected as the man to manage that office. I now call on Mr. Fred Petersen.

Current Methods in the Selection and Production of Nursery Stock

Fred H. Petersen

Central California Office
Soil and Plant Laboratory, Inc.

Without prescribed systemetized methods, the production of any item of commerce, be it an intercontinental ballistic missile or Juniper Tam, could be a chaotic unpredictable, uneconomic and unrewarding procedure. The pressing need of a guide for the systematic production of nursery stock was seen several years ago by Dr. Kenneth F. Baker in the Department of Plant Pathology at the University of California in Los Angeles. The outgrowth of this awareness was the UC Manual 23, The UC System for Producing Healthy Container Grown Plants. This Manual, edited by Dr. Baker, provides practical guides and a realistic basic philosophy upon which many present-day successes in the California Nursery Industry are based. The authors, both explicity and implicity, convey the thought that systemetized growing and the adoption of standardized methods and procedures can lead to the production of nursery stock with a higher degree of standardization than some thought ever possible. The successes of the system in the production of standardized plant material are largely the result of the fact that plant material grown under this system is provided with as near optimal conditions for growth and development as are possible. These conditions primarily depend upon freedom from plant disease caused by pathogenic fungi, nematodes and/or chemical damage.

The philosophy and methods suggested by our Organization are founded in the UC System. In extending this system into the nursery industry, our Organization would make the following suggestions as far as methods and procedures are concerned, particularly as they affect the propagation aspect within the industry. If we acknowledge that systemetized growing is pre-requisite to success, we must accept principles and follow plans. The procedures in propagation and production within the nursery should be detailed in writing by highly trained personnel, particularly in view of the fact that many simple procedures can be carried out by inexpensive and not highly skilled labor. These

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1. Source of Material.

   We suggest that cuttings be taken from healthy, vigorous growing stock plants. This is not always possible and in many instances, the propagator is obliged to depend upon field grown material of questionable background.

2. Degree of Maturity.

   This information would presumably be observations as to the softness, hardness and the general vigor of the plant material being propagated.

3. The Propagation Treatment.

   To be included, should be the type of cutting, the method of cutting, the specific fungicides, bacteriacides and insecticides which were used in this particular cycle of propagation.

4. The Propagation Medium.

   Which of the several generally successful materials were used? A peat-perlite mix, a sand mix, a vermiculite mix or combinations of these or other materials? We have seen high degress of success with each of these materials.

5. Pretreatment of Propagation Medium.

   Was the medium steamed, methyl bromide treated, or untreated? We suggest that all propagation media be steamed within the propagation flat. Treatment here provides a measure of protection against possible re-contamination in filling the flats. Where steam is lacking, methyl bromide should be used. We do not suggest that any propagating medium be used without treatment.

6. The Number of Cuttings Stuck.

7. The Rooting Environment.

8. The Time to Root.

9. The Percentage of Take.

10. The Time that Rooting Cuttings were Potted On.

11. The Production in the Liner Stage.

    Here, should be included notes as to any fungicides, insecticides used as well as the fertility levels maintained in Liner production.

12. Production Achieved.

    Precisely, what per cent of cuttings initially made actually resulted in a healthy, vigorous growing Liners?

13. And most importantly, Review Notes by the propagator suggesting changes in procedure or possible explanations of losses incurred. Here the dynamic aspect of propagation enters. We should never be so tied to a system that we are not willing to accept change, but only by careful review through thorough record keeping can we have a logical basis upon which to make conclusions.

A mainstay of propagation depends upon the physical facilities and procedures followed. We encourage nursery management not to negate the propagation facility. The facility should not be a spare room, a multi-purpose room or a storage area. It should, rather, be a specific entity within the nursery. It should be dust-tight, be well-lighted and have hot and cold water facilities for personal and mechanical hygiene. We prefer cement floors with drains so that the entire facility can be cleaned daily with a disinfectant such as dilute Purex or Chlorox. This requires that all bench tops and working surfaces be constructed of a material inert to these materials. Daily practices should include a thorough cleaning of all tools and equipment, presumably by dipping in dilute Chlorox or Purex and storage in plastic bags injected with a fumigant such as propylene oxide. Periodically the entire propagation facility should be cleaned from top to bottom with dilute formaldehyde. Such a treatment, of course, requires that all plant material be removed from the facility.

The design of the facility should be such that materials flow in only one direction. A long rather narrow structure would seem ideal. The flow pattern should then be like the production line in a factory. The idea here is to prevent re-contamination at various steps within the propagation facility. Certain areas within the facility should be designated.

1. The Admission Area. Overhead misting should be provided with a drain facility. Here, all plant material should be washed free of outside contamination and debris. Continuous overhead mist will prevent dessication.

2. The Preparation Area. Work should be done on clean, pretreated and routinely cleaned benches. We prefer the use of sharp knives for preparation of cuttings, but shears are used successfully by many of our clients, though a worn pair of shears can, by crushing tissue, inflict serious damage. Whatever choice of tool is made, the tools should be cleaned repeatedly throughout the working day by dips in dilute Chlorox or Purex.

3. The Cutting Area. The cuttings, once prepared, should be placed in a slotted poly-ethylene basket or some other container which will drain well, then washed in clear running water in a deep sink. An adjoining deep sink can then be used for dipping the cuttings. The so-called "Triple-Dip" of 2 cups Captan, 1/4 cup Terraclor, and 1/4 cup Agrimycin 100, per 5 gallons is acknowledged as an excellent method of disinfecting the cuttings of disease organisms. Many propagators, particularly recently, have successfuly used a solution of Morton Soil Drench C diluted 1 to 10,000, for the general clean-up dip. This material is a mercury fungicide of broad spectrum activity. Included in the dip might be an insecticide, depending upon local immediate problems.

   After draining, the material is considered "clean", and is then treated with hormone if required. In this regard, we suggest using the very minimum amount of hormone solution or dust suspension in disposable containers -- this to preclude the re-contamination of cuttings if perchance some disease organism entered the hormone material.

4. The Sticking Area. This is considered a scrupulously clean area. Here, flats of pre-treated media enter the facility, ideally, on rollers which can be cleaned daily. Here, the actual sticking of cuttings takes place and rigid standards of personal hygiene are required. Overhead misting is ideal to prevent dessication.

5. The Shipment or Transfer Area. This area is considered "clean" and meticulous cleanliness is necessary. This is probably the easiest place to re-contaminate propagation material as the material is transferred from one building to another. The flats should be placed only on copper naphthenated treated surfaces or other clean surfaces, and should never be allowed to come in contact with the floor.

The flats, once prepared, are then transferred to the rooting facility which should be an area of absolute isolation with no through traffic allowed. Here, of course, rigid cleanliness standards must be observed. All wood surfaces should be coated with copper naphthenate. The floors should be kept meticulously clean. A cement floor with center drain is ideal. The construction of the rooting facility should be tight enough to prevent dust as a re-contaminate. As soon as material arrives in the rooting facility, it should be drenched with a fungicide such as Morton Soil Drench C as a final clean-up precaution.

Upon rooting and hardening, the material is transferred to the Liner facility. Cleanliness, here again, is paramount. Two systems of potting on are generally used successfully:

1. With a Head House Unit at the Liner House, potting is conducted on scrupulously clean benches ideally equipped with an overhead hopper containing the steamed pre-treated soil mix. This would prevent the accumulation of a soil pile in the bench. The soil mix we suggest would be patterned after the UC type mixes. These mixes provide optimum physical characteristics and fertility for the rooted cutting. We suggest that potting be done in peat transplanter pots, these to be preferred over either clay or plastic. We find that more normal root development takes place in the peat pots, there is no re-cycling of clay pots in the nursery and there are no leftover pots. The re-use and/or storage of clay pots, we feel, serve as sources of re-contamination. We suggest that the peat pots be placed into copper naphthenated treated flats for transfer to the growing area. The flats should be placed on raised benches of treated wood in the Liner House.

2. With no Head House System, the pre-treated soil mix is brought in unitized boxes directly to the Liner Benches and potting is conducted into the peat pots which are lined out on the surface of the bench. This system has the advantage of reducing labor by less handling of the material, and also tends to preclude a possible source of re-contamination in the Head House.

The Liner facility should be equipped with suitable fertility management equipments. We find that Liner production generally requires a slightly different fertilizer program than container growing, and for this reason, where possible, we suggest the installation of a separate fertilizer injector for the Liner facility. Without hesitation, we suggest the Smith Measuremix Injector, as, in our experience, this has proved to be the superior injector available. We maintain fertility according to methods of interpretation based on our Laboratory experience. Best results are obtained when fertilizer is applied in dilute quantity on a "constant feed" basis. The finished Liners are then cycled into the container growing area.

In conclusion, production of nursery stock would seem to be dependant upon two things: system and facilities. The system should be such that it is reproducible yet alterable for improvements, and records should be kept at every stage in propagation. The facilities should be such that they are complete and are specifically designed for the use of the propagator.

The relative success of production, by and large, will depend upon the degree of care taken in selection of the system for propagation and of proper propagation facilities and equipments.

MODERATOR SPRING: So we strive on for our ideals. While Mr. Petersen has described a very ideal facility, I know that it will be a long while before many of us can attain this ideal, but it certainly has proven itself, I understand, in the profits returned on assured methods of plant propagation.

Our next speaker will be Mr. Paul W. Moore, who is Director of Research and Development for Willits and Newcomb Citrus Nursery, Thermal, California. In preparation for this position Mr. Moore obtained a degree, specializing in sub-tropical horticulture, at the University of California. From there he worked for a while at the University of California at Los Angeles as a Technician in Sub-tropical Horticulture. He was a Farm Advisor, both in San Bernardino County and in Los Angeles County. For seven years he was chairman for the Citrus Grove Rejuvenation Research Group at the University of California Citrus Experiment Station, Riverside. Since 1960 he has been with Willits and Newcomb in his present capacity. This is one of the larger citrus nurseries in California, specializing in the propagation and distribution of virus-free budwood -- Mr. Paul Moore --

CURRENT METHODS IN THE SELECTION AND PRODUCTION OF CITRUS NURSERY STOCK

Paul W. Moore

Willets and Newcomb Citrus Nursery
Thermal, California

The objective of the reliable citrus nurseryman is to produce trees which are typical of the variety, have a high yield potential, and which will be long lived. To accomplish this requires a thorough knowledge of variety and strain characteristics, careful scrutiny of budwood sources for mutations, acquaintance with the known virus diseases which affect production and longevity, and a knowledge of rootstock-scion interactions and adaptations.

The prosperity and success of the citrus industry, and the financial solvency of individual growers, depends in no small measure upon the integrity, the knowledge, and the sound judgement of the nurseryman.

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The prosperity and success of the citrus industry, and the financial solvency of individual growers, depends in no small measure upon the integrity, the knowledge, and the sound judgement of the nurseryman.

During the last three years over 5 1/2 million citrus trees have been grown for planting in the commercial orchards of California. Every one of these nursery trees consisted of two parts, scion and rootstock. The scion variety was chosen first for the variety - such as orange, lemon, tangerine, or grapefruit, and secondly, as a particular strain of the variety, selected for some outstanding trait or adaptation to a specific climatic zone, and freedom from virus diseases. The rootstocks were selected for their tolerance to certain virus and fungus disease, their cold hardiness, and their influence on productiveness, and fruit quality.

BUDWOOD SELECTION

Budwood selection is extremely important in our industry. There are three reasons for this: First, many of our citrus clones and cultivars are infected with bud-transmissable virus diseases. These should not be propagated. Secondly, citrus species, especially oranges, have an unusual capacity to mutate. It is necessary to constantly examine "mother trees" for mutations or sports in order to assure the customer that his trees will be true to type. The third reason is that many new, superior strains have been developed in recent years which are more vigorous and productive than the old ones.

The citrus nurseryman must select the best of these for the areas in which they will be planted. It is no longer a matter of growing Valencia oranges. One must choose between Frost Nucellar Valencia, Campbell Valencia, Campbell Nucellar Valencia, Wood's Valencia, Cutter Valencia, Olinda Valencia, etc. The lemon picture is even more complicated. We maintain a scion orchard of 14 lemon strains and should have at least 5 more if we want to satisfy the requirements of all areas.

SELECTION OF DISEASE-FREE BUD SOURCES

The recognition of the importance of selecting virus-free propagating material is a rather recent development. In 1933 Dr. H. S. Fawcett of the University of California Citrus Experiment Station, first proved the virus nature of sorosis. Since then at least 10 virus diseases of citrus have been described. Four of these are known to cause serious economic loss when present in the wrong scion-rootstock combinations.

The most spectacular of these is Quick Decline or Tristeza. In 1937 the disease was first reported in the state of Sao Paulo, Brazil. Twelve years leter it had spread to all citrus areas, destroying 6,000,000 trees, or 75% of all the citrus in that state. In 1944 Tristeza made its California debut near Covina. Ten years later most of the oranges on sour orange rootstock in the San Gabriel Valley were dead. It is currently completing its destruction in Orange County and is ravaging the Redlands-Riverside area.

Fortunately, it is not present in any of the orchards in the Coachella Valley and is still rare in the San Joaquin Valley. Nurserymen in both areas are required by law to use only Quick Decline-free bud sources in order to preclude its introduction into these areas.

In California, serious economic losses from the disease can occur when sweet orange varieties are grown on sour orange, Citrus aurantium, rootstock. In areas where the disease is now indigenous, losses can be avoided by propagating oranges on tolerant rootstocks. The nurseryman has a wide choice of such stocks, including sweet orange, Rough lemon, Trifoliate orange, Cleopatra mandarin and Troyer citrange. A few new hybrid rootstocks such as Citrumelo 1974, Citremon 1449, and the Carrizo citrange look very promising and will undoubtedly be used in the future.

Psorosis, the first recognized virus disease of citrus, causes a slower decline but takes its toll from among trees that should be in their prime producing years. A survey of the orange industry in California made by the author in 1954, revealed that approximately 10% of the mature trees were exhibiting various degrees of deterioration due to this virus. All oranges, lemons, grapefruit, and tangerine varieties are affected by psorosis.

A third disease, exocortis, causes early death or severe stunting of all infected citrus varieties grown on Trifoliate orange or Rangpur lime rootstock. It will also stunt and reduce yields of trees grown on Troyer citrange rootstock. Exocortis-free sources of propagating materials are available for most of the commercial citrus varieties. Nurserymen should take advantage of them when propagating any varieties grown on Trifoliate, Troyer, Rangpur lime, and Trifoliate-hybrid rootstocks. If he is uncertain of the exocortis status of his bud source he should grow them only on tolerant rootstocks such as Cleopatra mandarin, Rough lemon or sweet orange.

Xyloporosis (cachexia) is a fourth virus which limits the production and causes the death of certain orange varieties on susceptible rootstocks such as Sweet lime and of many mandarine and tangelo varieties.

The task of obtaining virus-free budwood would have been many times greater if investigations of a phenomenon called "nucellar embryony" had not been made by Dr. H. B. Frost starting in 1913. It is largely from his nucellar seedlings of the important commercial varieties that we have been able to find virus-free propagating material.

The mechanics of this process may be described briefly. Many citrus varieties produce more than one seedling per seed. One of these may be a seedling resulting from the normal process of pollination, and would be a hybrid of doubtful value. All of the others arise in the seed tissue called the nucellus and are called nucellar seedlings. Nucellar seedlings might be described, in an over-simplified way, as arising from buds within the seed. Just as other plants propagated from buds are genetically like their parent, so are nucellar seedlings genetically like their seed parent. The pay-off in nucellar seedlings is that apparently viruses do not move from the tree into the seed. Nucellar seedlings are, with few exceptions, virus-free. Thus it is possible to get clean sources of propagating material, true to the parent type, by using nucellar seedlings.

Within the last 6 to 8 years the citrus nursery industry has almost completely switched from the old strains to propagating the nucellar lines.

A few varieties do not produce nucellar seedlings and so the search must be made for disease-free sources and other techniques must be used to detect them.

Fortunately, as the result of research on the part of citrus virologists, it is possible to detect the presence of any of the above viruses by inoculating seedlings of citrus species which develop well-recognized symptoms, either as foliage patterns, bark shelling, stem pitting, or gum deposits in bark. These are called "index" plants.

It is, therefore, possible for the commercial nurseryman to take advantage of these techniques to screen his budwood sources. Since the W-N Nursery is engaged in the sale of budwood to other nurseries, we have established what we call a permanent indexing block. In the block are 50 commercial varieties, each on 5 indicator rootstocks, sour orange, Trifoliate orange, Rangpur lime, Orlando tangelo, and Morton citrange.

Any varieties on sour orange rootstock which have Tristeza will die within 2 to 3 years and cause stem-pitting on Morton citrange. Any having exocortis will cause typical bark scaling and stunting on Trifoliate orange, Morton citrange and Rangpur lime. Those having xyloporosis will be identified by its reaction on Orlando tangelo.

Our primary sources of budwood have been entered in the State Department of Agriculture's psorosis registration program and have been certified psorosis-free after indexing on Mexican lime indicator plants. Any nurseryman desiring to locate psorosis-free parent trees may obtain a list of registered trees from the State Department of Agriculture, Bureau of Nursery Service, Sacramento, California

There are a few varieties that are known to carry viruses and for which there are no known clean sources. The Temple orange is an example of this. Since it is infected with exocortis and xyloporosis it must be grown on tolerant rootstocks such as Rough lemon or Cleopatra mandarin.

Currently the University of California has undertaken a citrus variety improvement project. The goal of the program is to develop a bud bank of high-yielding, true-to-type, virus-free citrus varieties This collection will become the source of propagating material for foundation blocks to be established by the citrus nurserymen of the State as sources of certified, virus-free nursery stock. The program is to be supervised and administrated by the State Nursery Service. Availability of certified buds from these sources for the nursery industry is still about 5 years away, pending the completion of the indexing terms for exocortis and xyloporosis. When this certified budwood becomes available a great stride forward will have been made in citrus nursery stock production.

SELECTION OF TRUE-TO-TYPE BUD SOURCES

The possibility of inadvertently propagating inferior bud sports or mutations is an ever-present danger. An illustration of this is found in the work of Dr. A. D. Shamel, "Citrus Fruit Improvement-A Study of Bud Variation in the Washington Navel Orange". Dr. Shamel started a study of individual trees in several Washington Navel orchards in 1909. He eventually found and described at least 13 strains possessing very distinct characteristics. Trees bearing ribbed fruit, pale yellow fruit, brown stained fruit and juiceless fruit were common. Others had long fruit, pear-shaped fruit, or flat fruit. High-producing and low-producing strains were also found. Each one was a distinct genetic mutation. The lowest percentage of off-type trees found in the commercial orchards which he studied was 10% and the highest about 75% of the total trees in the orchard.

The first two Washington Navel trees, from which the entire Navel Orange industry of California has been established, were planted at Riverside in 1873. The first propagations were made in 1875. Thirty years later, roughly 15% to 30% of the Navel trees of the State were inferior, mutant, progeny.

This phenomenon is not a thing of the past. This spring one of the owners of our company examined what was reputed to be one of the best young, true-to-type, Navel orchards in Central California before cutting budwood. He found 10% of the trees to be obviously off-type.

These illustrations emphasize the necessity of careful selection of budwood from bearing trees. Ideally, the trees should be examined annually while in fruit for the purpose of discovering and eliminating any bud sports or mutations from one's "bud bank" or "mother trees". Although this practice is as old as plant propagation it is as modern as tomorrow.

SELECTION OF ROOTSTOCKS

A third essential in the production of citrus nursery trees is the proper choice of rootstocks. This a choice of life or death, success or failure.

Rootstocks are chosen for their tolerance of virus diseases, their resistance to root diseases, their influence on productivity and fruit quality, their adaptability to adverse soil or water conditions such as high salinity, high boron, or high lime, and for their ability to impart some frost tolerance to their scions.

A few examples of climate-soil-rootstock-scion interactions will illustrate the process of rootstock selections for a specific orchard site:

For our first example, let us assume that John Jones wants to plant Navel oranges on a piece of land that has a relatively high frost hazard. He would like to market his fruit as early in the season as possible to avoid holding fruit on the trees during the cold winter days of December, January, and February. The soil has a neutral reaction and is low in free lime but is heavy and has a tendency to remain wet for long periods following rains or irrigations.

His first choice of a rootstock would probably be Trifoliate orange. It is the most frost-tolerant of citrus rootstocks. It matures fruit earlier than any other stock and is nearly immune to the common root-rots which are associated with wet soils. It will not stand soil containing high amounts of lime or which have a high pH. But, since this soil has neither limitation, Trifoliate can still be used.

His choice of scion variety would normally be an early-maturing strain of Navel. This is found in the Atwood Early Navel. However, most, but not all, Atwood Early Navels are infected with the exocortis virus. Trees having this virus are a complete failure on Trifoliate rootstock. Since there are some exocortis-free trees of Atwood Early, his nurseryman must seek them out. One safe procedure would be to take buds from vigorous, healthy trees already growing on Trifoliate rootstock and which are at least 10 years of age. In the above case, the nurseryman has had to consider certain factors of microclimate, soil conditions and disease, and tailor trees to fit the situation.

A second case will illustrate a choice with another set of factors. Lester Smith has just lost a Navel orchard from Quick Decline in the East Highlands area. Soil, water, and climate are ideal for citrus growing. He has a low frost hazard and can hold fruit on his trees several months after they reach maturity.

A study of some of the factors show that the acreage of summer Valencias has declined 48% in the last 13 years. The areas suitable for growing late Valencias is limited to Southern California counties and much of this has become urbanized. Subdivision prospects are still many years in the future in Smith's area.

Smith's first choice of rootstock would be the Troyer citrange, a hybrid of the Navel orange and the Trifoliate orange. It is resistant to root-rots and is one of the few stocks that perform well on old citrus soil. Most of the standard rootstocks perform very poorly when planted to soils previously occupied by citrus. Trees on Troyer produce high quality fruit and are above average in production. Most important, trees on Troyer root are immune to Quick Decline. However, they are stunted by the exocortis virus.

This grower's first choice of scion variety should be the Valencia orange. But, there are several strains of Valencias, some of which are known to be infected with exocortis and psorosis. For a highly productive orchard he must be sure of having virus-free trees. Fortunately, there are new strains of Valencias which are free of the known viruses and have proven records of high yield potential and good quality fruit. One of these is the Frost Valencia, named after its originator, Dr. H. B. Frost of the Citrus Experiment Station.

In this case, the over-riding considerations in choice of scion and rootstock were: the market picture as related to variety, tolerance to "old citrus soil" conditions, immunity to Quick Decline, freedom from virus diseases, and yield performance.

A grower in Ventura County will need a rootstock tolerant to high boron levels in irrigation water and one that is not subject to micronutrient problems such as iron chlorosis. His choice of rootstock will be one which has recently been proven in experimental orchard trials, Citrus macrophylla.

Our current practice of selecting disease-free varieties, and good performing rootstocks would have been impossible without the tremendous amount of research conducted by the Citrus Experiment Station and Crops Research stations of the USDA. It has been through the efforts of their staffs that we can now identify obscure but dangerous virus diseases and that we have virus-free sources of budwood. It is also through their efforts that we will soon have rootstocks to fill almost every production requirement. By utilizing this relatively new knowledge, citrus nurserymen are growing trees today which are distinctly superior to those produced in yesteryear. Research work now in progress promises that the time is not far distant when every citrus grower can have trees tailored from specific strains of scions and rootstocks for his own climate, soil, water, disease and pest conditions.

MODERATOR SPRING: The meeting is now open for questions on this section of the program.

The first question is one directed to Dr. McClintock.

Rather than try to force the artificial term "cultivar" on the nursery industry might it not be more appropriate for the taxonomic community to strive for consistency and leave the English term "variety" as indicating the cultivated sorts of plants, retaining the Latin term "varieties" as an expression exclusively for botanical varieties?

DR. McCLINTOCK: Well, we're talking about two different things when we use the term "variety". We're talking about botanical varieties and we're talking about cultivated varieties. Actually the term "cultivar" is not really an artificial term. It's a term which has a good meaning. It simply is taken from the two words "cultivated variety" and has been shortened to "cultivar". It is an international term and has been so accepted, although it may not be accepted by horticulturists at a local level.

MODERATOR SPRING: Another question: Why do you believe "cultivar" will never be accepted as a term in ornamental horticulture?

DR. McCLINTOCK: I would not go so far as to say that it will never be accepted but its acceptance will be slow, perhaps because some people sort of rebel against accepting a new term, but it is accepted on an international basis.

MODERATOR SPRING: Another question: How would you name a hybrid other than assigning a cultivar name?

DR. McCLINTOCK: Well, hybrids can actually be named by giving them a Latin name and describing them in the same way that you describe a new species. That is acceptable, but because so many hybrids, once they have been established, go into the nursery trade as vegetatively propagated plants which are really clones; it is, I think, a good idea to establish as a clone the plant selected from the particular hybrid and to give the selected plant a clonal name. As an example, I would like to cite *Photinia* x *fraseri*, a hybrid between *P. serrulata* and *P. glabra*. In order to distinguish the plant introduced by the Fraser Nurseries, Auburn, Alabama, from other plants originating from the same hybrid group, the cultivar name, 'Birmingham', has been given to this plant. A clone is simply material vegetatively propagated which has originated from one particular plant and which maintains itself because it is vegetatively propagated - so you are always dealing with the same plant. It's just the same as nucellar seedlings. You are dealing with a part of a single plant actually which has been divided up again and again, but all the new young plants have the same genetical constitution as the original plant which was the beginning of the clone.

MODERATOR SPRING: Next question: Is there a good book or reference work to establish identification and correct nomenclature for bamboo, inasmuch as this has been omitted from your list?

DR. McCLINTOCK: There is one man in the United States who knows more about bamboos than anyone else. He's the one to whom bamboo questions can be referred; we left bamboos out of our list because we felt they were a specialized sort of a group and that, even though they are woody plants, their nomenclature is very involved. I hope that maybe sometime we can make up a list for bamboos alone or have bamboos treated separately.

QUESTION: Who is the gentleman to whom you referred?

DR. McCLINTOCK: He is Dr. McClure; he can be reached at the United States National Herbarium, Smithsonian Institution, Washington, D. C. He has published a paper recently on all the species of *Phyllostachys*, but he hasn't studied all the genera of bamboos which we cultivate. There is a recent publication - a USDA bulletin on the bamboos cultivated in the U. S. It contains a key, but it's based on very technical characters. I've just received the bulletin; Dr. McClure is one of the co-authors. It costs about 35 cents and is available from the U. S. Govt. Printing Office, Washington 25, D. C. It lists all the genera of bamboos, I believe, that are cultivated in the U. S. but it doesn't give the species nor the cultivated forms.

QUESTION: There is an air of uncertainty as to the validity of the names in the forthcoming list. Will we be correct in using it as a "Bible" for labeling our plants?

DR. McCLINTOCK: Well, you can use the names in this list and then if we ever should find, sometime in the future, that some other name should replace a particular name, then we will use that other name; but I think for the time being we should certainly be able to use what is in the list until we find out the list is in error. We've drawn up this list to the best of our present knowledge and it is the best that we can do at this time.

MODERATOR SPRING: And the last question directed to you, Dr. McClintock - We are asked repeatedly to identify plants. How do we address inquiries to your attention?

DR. McCLINTOCK: You just send them to me at the California Academy of Sciences, San Francisco 18, and I'll be glad to answer them. If you send the plant, try to send as complete a representation of the plant as you can. Don't pick off one leaflet of a compound leaf, but send a branch so that I can see the plant not only has compound leaves, but the plant has opposite or alternate leaves. If you have flowers, or if you have fruits, or if you have something else that will be helpful in the identification of the plant, that's fine.

MODERATOR SPRING: Thank you very much, Dr. McClintock. I'd like next to call on Dr. Alley. How are grapes indexed for virus?

DR. ALLEY: Indexing for grape virus diseases is done at Davis by the Department of Plant Pathology of the University of California. For instance, there are certain varieties that are very susceptible to certain diseases. Let's take the variety, Mission. When it becomes infected with leaf roll, the basal leaves of this variety will tend to curve downward in the fall of the year. They will also develop a reddening color which will progress upwards along the shoot or the cane as the season advances. These symptoms generally start showing from the middle of September onward. I'm speaking just now about indexing for the leaf roll virus. The plant pathologist will take about four or five buds from the variety that he wants to test. Let's say we have the variety, Zinfandel, that we want to test to determine if it is virus diseased. We select a vine that looks very healthy as far as we can tell visually. We will take five buds and bud it into five young growing cuttings of Mission. This bud will be placed below the young shoot. It will be grown in the greenhouse for about 6 weeks. Then it will be planted in the nursery or into the vineyard. It is grown here for two years. If the original Zinfandel vine is healthy, no symptoms will show on the leaves of Mission. Probably our chief indication is the way the leaves "turn". If this Zinfandel should be infected, let us say, with leaf roll and if it's a mild strain, it may not have shown on the original vine. But the basal leaves of the Mission will start to curve slightly downward - a convex curving - also the leaves start to become discolored. First it will be a light red, turning a darker red as the season advances. If the virus is very severe, symptoms will show the first year. If it's not severe, generally by the second year one can observe these symptoms in the leaves of Mission. Now if you want to index, let's say, for the virus disease - fan leaf, the St. George rootstock which is commonly used in California, is considered one of our best indicators. We will take cuttings of St. George and root them in the greenhouse until the shoots get about six inches long. Then we will take buds from selected vines that we believe are healthy, and put a bud into each of five or six young growing vines of St. George. If the Zinfandel has fan leaf, the symptoms would be expressed in the leaves of St. George. In the shoot, or in the young leaves, symptoms appear like a vein-clearing or even a slight mottle. Now this same technique is used on other indicators, for example with Emperor. Another good indicator, which is not in the program, but is considered very good, is Baco 22 A - for the leaf roll virus disease. It gives a shock symptom. Healthy Baco 22 A will grow very vigorously but if we bud from a variety that has leaf roll in it, it goes into a shock - it refuses to grow. Where the healthy vine might be 2 feet high, the Baco vine infected with leaf roll will be stunted. We can pick it out immediately. It is this type of indexing that is being used on grape vines to test the vines to make sure they are virus-free. Now there are many varieties that will show symptoms of these virus diseases at certain times of the year. When it is very severe in a variety, fan leaf will show in the early spring of the year, in May and June, and then as the temperature gets warm, the vine appears to grow out of this symptom. With many of the degeneration viruses like fan leaf, yellow vein, or yellow mosaic there is a noticeable reduction in crop and a shot berry condition. With leaf roll you generally have a delayed maturity of fruit and a reduction in sugar. In other words, there are symptoms to look for on the vines, but to make sure, if you can't catch them at the right stage and in case some of the vines don't show these symptoms, the plant pathologist will also use an indexing system as I have outlined using this budding technique.

MODERATOR SPRING: Mr. Petersen, there is one question for you - That very simply is, first where is Morton's Soil Drench C available, and secondly, what fertilizer do you generally recommend to be used in propagation feeder lines?

MR. PETERSEN: The answer to the first question - Morton's Soil Drench C is now available from any Niagara distributor. In the San Jose, California area: Moyer Chemical, or Garden Valley Fertilizer.

The second question is more difficult to answer. What is the best fertilizer? Two things we have to consider, three things actually, the type of medium the liners are growing in, the facilities that are available, and the type of transplanter pot. If we are using peat pots, for example, we can generally get by with something less in the terms of concentration of fertilizer because they do not appear to have the drainage characteristics that we see in other pots. We prefer that a fertilizer be applied at every irrigation, and a typical formula would be in the order of 3 to 5 pounds of ammonium nitrate, 1 to 2 pounds Di-ammonium phosphate, and 1 to 2 pounds muriate of potash per 1000 gallons of water as applied. However, these are very broad directions - it would depend, for example, upon: how much fertilizer was incorporated in the original mix, when the mix was prepared, and the age of the material. Often times we can manage quite nicely on only nitrogen and potassium, providing sufficient phosphorus was incorporated in the original mix.

MODERATOR SPRING: Thank you very much, Fred. Now I'd just very simply like to say: remember again the work Mr. Van Rensselaer did in organizing this part of the program. I feel that the quality of the talks presented certainly proves the wisdom of his choices and I for one thank him very deeply. I will now turn the meeting back to our Program Chairman, Herman Sandkuhle.

CHAIRMAN SANDKUHLE: Jack, thanks a lot. Ladies and gentlemen, these are, in my estimation, real basic subjects. If we are going to propagate, we must start correctly. We must know what we are propagating because there is no use propagating something unless it is true to variety, because we are mixed up today on some things and we are doing our best in the industry to correct this; as was stated earlier this morning, when we order something or start writing about something we must all know that we are talking about the same thing.

This is an organization that will lead to no commercialism. But, in future meetings, we like to have you people - if you have some new innovation that we don't know about, and you think it is of some importance - bring it along with you; we would like to take a short time to demonstrate it. Now I'm going to call on Carl Schmidt from Pt. Reyes, who built a Connecticut light integrator to control a mist unit, to give us a few minute dissertation. You people who are more interested in the details can see Carl after lunch and he will put it out in the sun where it actually performs.

MR. CARL SCHMIDT: Well, this is actually an unscheduled demonstration. I was simply asked by some who have seen this instrument working in my greenhouse to give other people who are using a mist system the opportunity to see it. I'm not really prepared to give any formal lecture. I will just simply give a brief description of it and show it to you. Later on if someone should be interested in seeing it working, I will take it out in the sunlight because there is not enough light in here to operate it fast enough. In the misting of cuttings in a greenhouse the requirement for water usually varies according to the brightness of the sun. On bright days the evaporation would be fairly rapid. On dark cloudy days when the rate of evaporation is extremely low, there is little or no need for mist. The basic mechanism that operates this mist controller is a photoelectric tube that responds according to the brightness of the sunlight falling upon it. The original idea for such a controller was conceived by Dr. Hans Petersen of Denmark while a visiting professor at Cornell University. The Agricultural Engineering Department of the University of Connecticut has modified the unit making it more flexible, and therefore more adaptable for propagation purposes. I simply have obtained the blueprints[a] from these people and put one together;

(a) Whitaker, J. H. and S. Waxman, Instructions for a light-operated interval switch for controlling a propagating bench mist system. Univ. of Conn. Mimeo. Leaflet. 1960.

that is, the only part I had in it. Now within the unit there's a phototube that responds to the energy from the sun, and through several steps, causes a magnetic counter to rotate. After 100 clicks - in my case, I have modified this to 90 counts - to get a more stabilized period - the mist is automatically turned on for a short, predetermined period. The frequency of the rotation of the counter is determined by the level of light intensity falling on the phototube. There are two dials - a coarse and a fine adjustment. By adjustment of the dials the frequency of misting can be increased or decreased. This feature permits the rooting of a wide range of materials, from plants requiring frequent misting to those requiring only occasional mist. There are differences in rates of water loss among various species of plants. By an adjustment of the sensitive dial the particular needs of a cutting can be satisfied. In other words, on the fine rate there is a great variability which you can use to determine the number of times that your predetermined "on" period will come on. I will make this a little clearer when I actually demonstrate the device. Now, once the cuttings have initiated roots, the frequency or misting should be gradually decreased to harden off the cuttings and this can be accomplished by turning down the sensitivity dial a little each day. You simply keep on decreasing it as you go along. This will cause a more delayed misting and will permit the foliage gradually to become firmer. Another feature is the third dial which can change the slope of sensitivity to sunlight. For example, if the dial is set on number 2, there will be frequent misting on bright days and little on dark cloudy days. That's the normal setting here (2). If, however, a little more mist is desired on those dark days, then the dial may be turned to the No. 3 position. There is no need to have a 24 hour clock to turn the controller off at night or on during the day because it automatically slows down and stops as darkness approaches and will start itself with the rising of the sun. If, however, some mist application at night is desirable, then the dial can be turned to the No. 1 position, that's on the slope calibration, and in this position the controller acts as a time clock and provides a steady frequency of mist. These are the basic features without going into the more theoretical details; what it actually amounts to, to make it very simple, is that the photoelectric tube triggers a discharge from a gas tube, which in turn operates a magnetic counter. The frequency of triggering, of course, being proportionate to the light intensity falling on the photoelectric cell, and while the current flowing in the gas tube is not sufficient to operate the counter directly, a relay in the circuit allows each discharge from the gas tube to be counted or accumulated by the counter, and with each 100 counts - and in my case, 90 - a micro switch on the counter activates a program timer which subsequently turns the mist system on and off. An adjustment on the timer can be made to provide whatever length of misting period is desired. This device can be extended to operate outlets for any number of solenoid valves. I have used it since January; it has never failed me and it is doing a real good job. The ordinary time clock is more or less a semi-manual operation because it does not react to the weather. We have to make frequent adjustments. In this case, the light is doing it for you. Now, as I say, I've built this myself but you people would not have to go to this trouble because, in the meantime, I have received brochures stating that a very similar instrument is now available commercially, using basically the same idea.

CHAIRMAN HERMAN SANDKUHLE: Thank you very much, Carl. I'm sorry that we had to rush you through.

THURSDAY AFTERNOON SESSION

October 26, 1961

q The session convened at 1:30 p.m. with Dr. Vernon T. Stoutemyer, Department of Floriculture and Ornamental Horticulture, University of California at Los Angeles, presiding. The subject of this Symposium was: Light in Relation to Plant Propagation.

MODERATOR STOUTEMYER: The amazing thing about light effects is that many people who almost made the important discoveries, didn't. The men who should have made these, I think, were the Germans who dominated plant physiology from 1850 into the beginning of this century. The one who probably should have discovered photoperiodism was a man named Klebs. He almost had it; but two men in the U. S. Department of Agriculture, Garner and Allard, were unquestionably the first to present proof of this phenomenon of photoperiodism.

We are covering many subjects related to light in this discussion, not only photoperiodism, but many other things. I'm sure there are things that we will be doing with light some day in propagation that we're not doing now. For instance, by exposing stock plants to an unbalanced spectrum, you can change completely the type of roots formed, the amount of callus in the relation to the roots, and the ease of rooting.

LIGHT AND PROPAGATION

V. T. Stoutemyer

Department of Floriculture and Ornamental Horticulture
University of California, Los Angeles

The subject of light in propagation is an example of a badly integrated field of knowledge with a conspicuous lack of communication between the workers in basic science and those who represent the applied side of agricultural science and technology. It is also an example of a rather haphazardly worked basic field with many conspicuous gaps in our knowledge. It is difficult to explain why researchers have given so little attention to some of these problems. One example is that almost no information is available on the effects of different light qualities and intensities on the stock plants for cuttings. The voluminous literature on the influence of light on seed germination is somewhat confusing for reasons which will be discussed later, although the rapid progress of recent research is clarifying the situation.

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We shall treat four main subjects in our discussion of light. These are:

1. Light and seed germination.
2. Effects of light on stockplants for cuttings.
3. Light and the rooting of cuttings.
4. Etiolation and root formation in stems.

Light and Seed Germination

Around the turn of the century, the great German plant physiologists and botanists accumulated many interesting facts on the effects of light on seeds. Seed testing laboratories have also had to take the effects of light into consideration with their seed testing and germination procedures. For instance they commonly expose grass seeds to light for about four hours a day for best germination. Many light-sensitive seeds will germinate in the dark if given a weak solution of potassium nitrate or a complete mineral nutrient solution. Foresters have known that light is beneficial to the germination of seeds of some pines. According to Burkholder (4) about 1200 different kinds of seeds, many of them important economic plants, have been reported to be light-sensitive. There are many contradictions in the literature. Some of these variations, as with tobacco or *Lobelia*, are due to the genetic differences of various varieties and species. The results are also influenced by the temperatures used for germination and by the age and condition of the seeds. Light can be inhibitory as well as stimulating.

The investigations of Axenthev (3) aid in explaining the nature of the mechanism of light stimulation of seeds and also the inhibition of another group. He found that both stimulation and inhibition were dependent on the seed coats in some species but not in others.

In seeds which are inhibited by light, this effect depended upon an intact seed coat in *Amaranthus retroflexus*, *Phacelia tanacetifolia*, *Bromus squarrosus* and *Androsace maxima*. However, in *Nigella arvensis*, *Cucumis melo*, *C. sativus* and *Cucurbita pepo* the effect did not depend entirely on seed coats.

Among the seeds which are stimulated by light, the effect was due to the intact seed coats in *Rumex crispus* and *Epilobium hirsutum*, but the coats played little part in the stimulation of seeds of *Oenothera biennis* and *Silene densiflora*.

In all seeds in which the seed coat played an important part, increasing the oxygen in the atmosphere improved germination and reducing it, decreased it. In some of these seeds the effect of the coat was eliminated by pricking a hole in it. These facts suggest that the seed coats act in some cases by reducing the supply of oxygen and that the light changes the permeability. Apparently light increases oxidative processes in some seeds and decreases it in others.

Although light promotes the germination of some seeds, in others it has an inhibiting effect. Thus the seeds of Lallemantia iberica normally germinate well in the dark, but were thrown into secondary dormancy by exposure to light in experiments by Vakulin (18). The seeds germinated when placed in the dark again, but with increasing difficulty as the exposure to light was increased.

With seeds of tomato, a subject which has also been recognized to be inhibited by the action of light, the seeds were illuminated by Aneli (2) through a filter vessel 2 cm. thick containing a 0.01 per cent aqueous solution of methylene blue. This passed the whole blue spectrum and one-third of the violet end and the usual depression of the germination occurred, and percentages ranging from 0 to 28.5, depending on the variety, were obtained from samples of seed which normally germinated about 96 per cent in darkness. Biochemical studies which were made on these seeds showed that respiration was reduced under blue irradiation, and disaccharides decreased in amount at first but afterwards increased. On the contrary, in seeds germinated in darkness, the increase was in the monosaccharides as the starch decreased.

Some other examples of seeds inhibited by light are Nigella, Celosia and certain species of Amaranthus, although light is helpful to some of the latter if dormant.

The experiments of Flint and McAlister (6) at the Smithsonian Institution of Washington, D. C., demonstrated that the wavelengths between 5,200 and 7,000 angstroms were effective with light-sensitive lettuce seed in promoting germination. The critical wavelength within the most effective range was about 6,700 A. The light which appeared to be most effective was the same as that which is absorbed most abundantly by chlorophyll and the authors were able to demonstrate the presence of chlorophyll in the seed. It is now known that red light promotes germination of some seeds but the far red inhibits it.

This work was later continued brilliantly by a group of scientists at the USDA Plant Industry Station at Beltsville, Maryland, who separated the influence of red and far red light and were able to develop an action spectrum for the effects which seemed to relate these effects to the same action spectrum for the control of flowering in plants. An unstable pigment, phytochrome, was discovered and partially characterized, although much work may be needed before its chemical structure will be known completely.

At the U. S. Plant Introduction Garden at Glenn Dale, Maryland, the head propagator, Mr. Albert Close, handled thousands of seeds of little known plants from all over the world. Seeds were usually sown on shredded and sifted sphagnum moss, either living or dead, and the seeds were covered very lightly, or not at all, so that a little light would be available for the seeds which would benefit by it. The seed flats were covered with glass or with plastic in wooden frames and were covered with newspapers so that the light was quite subdued.

The 1961 Yearbook of the U. S. Department of Agriculture is devoted to the subject of seeds. On page 93 an instance is cited of birch seeds which will not germinate on a forest floor beneath a leafy canopy, but will germinate in an opening which receives direct sunlight. This is interpreted as a response to the filtering out of the red light, but not the far-red by the leaves of the trees.

Effects of Light on Stock Plants

The modification of the quality or quantity of light on stock plants has a profound effect on stock plant behavior and also on the rooting of cuttings taken from them. Abbot (1) found that a plant of *Pandanus* grown under light rich in the red end of the spectrum and poor in the blue proliferated buds and produced an exceptional number of offshoots.

Stoutemyer and Close (15) illuminated stock plants of *Gordonia oxillaris* and *Cinchona* with various qualities of light from fluorescent tubes and compared the callus and root formation with that produced on cuttings from greenhouse grown stock plants. With the latter and with stock plants grown under daylight tubes, callus formation was excessive and roots were light. Plants grown under blue fluorescent tubes produced the heaviest rooting and lightest callus. In this experiment, the results were clear cut and striking, but unfortunately this line of work has never been continued either by the speaker or by others.

A moderate reduction of light on stock plants may increase the ease of rooting of cuttings. Thus cuttings of certain varieties of roses grown outdoors in sun root poorly, but may root better when the stock plants are grown in partial shade, according to a famous nurseryman of a past generation, Thomas Meehan (9). This rule is not invariable. L. B. Stewart, the famous propagator of the Botanical Garden at Edinburgh, took cuttings from plants in both sun or shade according to the requirements of the individual plant. Thus cuttings of *Escallonia* were taken from plants in full sun, but cuttings of *Clematis montana* were taken from plants in shade.

The reason why plants which are grown under low light intensities often supply cuttings which are rooted more easily than those from plants grown in full sun may be related to the established fact that solar radiation tends to inactivate auxin. This is particularly true of the short wave lengths of the spectrum.

Since environmental factors about the parent plant influence greatly the internal condition of the part of the plant which is to be made into a cutting, they are among the most important considerations in the rooting of cuttings. This is the reason why cuttings of a plant may be difficult to root in one country, but easy in another. Altitude may also be a factor in rooting, and sometimes cuttings from plants grown near sea level are hard to root, although those grown a short distance away near the top of a high mountain may be rooted easily. Probably this is not directly related to light quality.

Cuttings taken from stock plants grown under glass usually root much more freely than those taken from plants of the same species grown outdoors. The causes may include the greater humidity under glass or the screening out of ultra-violet rays by the glass or possibly the higher temperatures. At any rate, cuttings of many woody plants which are exceedingly difficult to root may strike easily when taken from stock plants which have been forced under glass. This is almost always one of the most useful procedures for the rooting of difficult plants.

Light and the Rooting of Cuttings

Not long ago the noted plant physiologist, Frits Went, suggested that a blue or purpled glass or plastic would be more efficient in plant growing structures than clear glass. It is interesting to note that as far as propagation is concerned this idea was prevalent in some circles both in Europe and in America. In 1845, Neumann, the propagator of the famous botanic garden at Paris, reported that bell jars of blue glass were often preferred to those of the ordinary clear greenish glass for covering cuttings during the process of rooting. (11) Grape cuttings were reported by "Thoth" (16) to root more quickly when covered by blue or violet tinted glass than when under clear glass.

The addition of supplementary artificial light over cutting beds has occasionally been demonstrated to increase root production in cuttings under certain circumstances. Chouard (5) found that supplementary lighting increased root production in cuttings of pea. Under orange glass the roots were numerous and little branched, but under blue glass the roots were longer, fewer and more branched. Leaf cuttings of Brimeura (Hyacinthus amethystina) produced the best bulbs under neon lights but mazda bulbs likewise increased rooting.

Since the light intensity is a highly important factor in the rooting of greenwood cuttings it is not unlikely that in the future an increasing use will be made of objective measurements of the light intensity within propagating structures by means of various types of illuminometers.

When the speaker was working at Glenn Dale, Maryland, measurements were made at noon of the light intensity within outdoor propagating frames, in which cuttings of azaleas were rooting with excellent uniformity and ease. The light intensity within the frame at noon as measured by a Weston illumination meter was never much over 250 to 300 foot candles. Measurements made within propagating cases in a north lean-to greenhouse used for summer propagation gave similar readings. The normal intensity of noonday sun in this locality is over 10,000 foot candles.

Although these conditions were not proved to be entirely optimal they certainly approached this condition, which shows the desirability of a considerable reduction of the light over cuttings in frames. Traub and Marshall (17) found an even lower light intensity to be beneficial in rooting cuttings of payaya, and only 100 to 200 foot candles of light were maintained over the cuttings in the propagating frame. On the other hand, the introduction of mist propagation has given an entirely new impetus toward the use of high light intensities, even to the use of unscreened or unshaded sunlight. The rooting of cuttings with full sun under mist is now quite common and many cuttings do quite well with such a treatment.

Since length of day has a considerable effect on both the vegetative and reproductive processes of plants, it would indeed be surprising if photoperiodism did not also influence the rooting of cuttings of plants in some degree. In some experiments with southern species of woody plants transported to more northerly latitudes, the rooting of cuttings was improved when the day length for the parent plants was decreased to that normal in their native habitats. Nevertheless, the cuttings of most species rooted better when the propagating bed which Moshkov and Kocherzhenko (10) used was illuminated continuously.

Etiolation and Root Formation in Stems

The etiolation of shoots, which is accomplished by growing them in darkness, is a particularly effective treatment for the rooting of cuttings of plants which are otherwise difficult or impossible to root. The etiolation of the stems is undoubtedly one of the chief factors responsible for the exceptional success of layers with recalcitrant plants. The effectiveness of etiolation can be enhanced by applying ringing or notching treatments at the same time.

Since most methods of etiolating stems also change other growth factors such as temperature and humidity, the exact part played by the exclusion of light is not always easy to measure. However, there can be no doubt of the inhibitory action of light on the rooting of cuttings of certain plants. The chemical and anatomical changes produced by etiolation are not clearly understood at present. However, some important observations have been made by Smith (14) which aid in the comprehension of the process. As tissues increased in age, the proportion which is highly lignified became greater. Etiolation changed some of the tissues back to a condition resembling that of the younger and more active portions. The tissues were softened, especially the pith and fibers, and meristematic activity was promoted, particularly in vascular rays, which often play an important part in rooting.

Kuster (8) has reviewed the literature on the changes produced in stems by etiolation. He concluded that the etiolation of stems depresses the development of mechanical strengthening tissues and also the vascular conducting elements. Parenchyma was less differentiated and the development of highly specialized units such as hairs, was suppressed. The large amount of undifferentiated tissue in etiolated stems favors root formation, and although large, vacuolated cells can divide, undoubtedly the advantage of having as many cells as possible in an undifferentiated condition is great.

Etiolation has been considered by Priestley (13) to delay lignification of pericyclic cells and to keep them more actively meristematic. One significant difference following etiolation was observed in shoots of broad bean, pea or potato which, when grown in darkness produced a functional endodermis with Casparian strips, although shoots produced in the light formed a simple starch sheath.

One other change noticed by Priestley and Ewing (12) in apical shoot meristems after etiolation which also suggests root structure is that the growth of the superficial meristem is diminished and fewer folds occur resulting in a decreased development of lateral leaf initials.

Priestley (13) made some observations which have an important bearing on the greater ability of etiolated stems to form roots. In darkness the fatty substances released from the dividing meristem cells tended to remain in these cells instead of going to build up the cuticle, thus resulting in a thinner cuticle. The free passage of food was hindered and the meristem did not form the folds which ordinarily differentiate into leaves. Thus the meristem of the shoot, because of a change in nutrition, resembled that of the normal root more closely.

In the root, the fatty substances do not reach the cuticle and air passed in freely. These substances were oxidized and formed a relatively impervious layer in the endodermis, which kept much of the passage of nutritive materials within this layer. Priestley and his associates have laid much emphasis upon the existence of endodermal leaks which determine the regions of root formation.

The effects of etiolation on the food reserves of tissues have been studied, but the interpretations placed on the results do not always agree. In studies on Clematis by Smith (14), starch practically disappeared from the pith, xylem parenchyma and vascular rays and was also reduced in the cortex of stems of clematis defoliated and wrapped with black paper for 10 days to three weeks. A starch sheath was present but without Casparian strips, thus indicating that this was not a true functional endodermis. Walls of fiber cells were reduced in thickness. In these experiments, the reduction of the carbohydrates changing the carbohydrate-nitrogen ratio was considered to be an important factor in changing a resting cell into an actively meristematic cell. Shading of the entire cutting does not accomplish this, since the carbohydrate is reduced without increasing nitrogen and the cutting is therefore weakened.

On the other hand, according to Hicks (7) etiolation did not reduce starch in stems of willow, Salix viminalis, but the reducing sugars were diminished. Cells were more elongated in etiolated tissue and sometimes were thicker.

From a biochemical standpoint, the available information is certainly inadequate and out of date. A modern approach, using more advanced methods of the subject, studying the metabolic changes which the treatment produces might throw much new light on the subject.

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MODERATOR STOUTEMYER: Our next speaker in this symposium is a man in the USDA Beltsville group working on light, at the Plant Industry Station. I would say there's no group in the world that is as far advanced in work on light and on this strange pigment, phytochrome. We don't know what it is yet, but we know it's there; it's a pigment, but it's very unstable, it shifts back and forth from the exposure to the light. It is part of the mechanism of a built-in time clock.

Our first speaker got his Master's Degree at the University of Minnesota, and later his Ph. D. at the University of Maryland. He was in pomology for a while at Minnesota after he got his doctor's degree, and then went to the USDA at Beltsville about a decade ago where he has participated in some of the work on photoperiodism. He has worked especially with woody plant mechanisms as regulated by light, and will lead us in this discussion today - Dr. Albert A. Piringer, Jr.:

PHOTOPERIOD, SUPPLEMENTAL LIGHT, AND ROOTING OF CUTTINGS

A. A. Piringer

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Plant scientists have known for over 40 years that the length of day controls many phases of plant growth and development and this control has been called photoperiodism. Since the phenomenon was discovered in 1920, they have learned through systematic experimentation which plants flower or grow best on long days and conversely which like short days best (1,2,3,4,5,6). Later, they learned that the response depends on the daily duration of darkness. If the middle of a long night was interrupted with some white light, the plant responded as though it had received short nights, hence long days. Since white light is a mixture of many colors, one wondered whether any color controlled plant growth and flowering more effectively than another. When plant physiologists tested the responses of plants to the various pure colors, they learned that red was most effective. Subsequently, they also found that many kinds of plant responses other than flowering were controlled in much the same manner by red light. More recently, studies in the U. S. Department of Agriculture showed that the action of red light could be nullified by far red given immediately after the red (1). Far red is the name given to part of the infrared just at the red end of the visible spectrum. If you were in the dark and saw this kind of light, it would appear as a rosy glow.

During the 1940's, when fluorescent lamps became generally available, plant physiologists noted that plants grew differently in fluorescent light than in incandescent. For example, sugar beets produced flowering stems on 16-hour days if the supplemental light was obtained from incandescent-filament lamps, but not if it was from fluorescent ones. Since then we have seen many plants differentiate between the two light sources in similar fashion and we know the different response is due to the relative amounts of red and far-red light emitted by the two kinds of lamps. The fluorescent lamp emits a very small amount of far red compared with red, whereas the incandescent lamp emits a high proportion of far-red light. In general, far-red light results in elongation of internodes and red light does not. Hence, with an incandescent source, stems would be longer and flowering would be earlier if flowering is associated with stem elongation.

All this information indicated to the plant physiologist and biochemist something about the nature of a substance involved in the light control. He knows that the controlling substance is a pigment because it absorbs red light; that very little of the pigment occurs in plants because even albino, or colorless, plants respond to red light; that because the pigment absorbs red light so strongly it must be blue when it is seen; and that the pigment has two interchangeable forms because of its characteristic reversible reaction with red and far-red light. In short, the plant physiologist knows many of the characteristics of the controlling pigment without ever actually seeing it.

During 1959 very precise and sensitive spectrophotometers enabled U. S. Department of Agriculture scientists to detect the operative pigment in intact plants. The pigment was not destroyed by grinding the tissue and subjecting it to precipitation, centrifugation, and other procedures designed to aid in separation and purification.

A mixture containing the pigment has been extracted from certain plants and held in the test tube for several months without loss of its character. It is a large molecule: a protein. The form that absorbs the far-red light is believed to be the active one and the red-absorbing form is blue, as predicted by results of earlier physiological experiments. The pigment has been detected in many plants and its purification and identification are expected. For the present, this pigment is called phytochrome. Although we do not yet know its specific action, phytochrome is obviously involved in a basic reaction controlling many features of growth and development of plants.

A rather recent development in plant-growth control with supplemental light is the use of intermittent lighting during the night to regulate flowering of chrysanthemums. The light procedure generally used to provide the long-day effect depends upon application of light continuously for a 3- to 4-hour period near the middle of the night. Light given intermittently is as effective as light given continuously during the interruption period in causing long-day responses of plants and was suggested by Waxman (7) as a horticultural procedure. More recently, this lighting procedure has been used by U. S. Department of Agriculture scientists to study the mechanism of growth control by light. Although the early experiments of Waxman and the others were done with chrysanthemum, various woody plant materials also are apparently responsive (7). The use of intermittent lighting as a substitute for a continuous light break is based on the knowledge that the controlling action of light continues for a time after the light goes out and the control can be directly related to the phytochrome system.

Most of the classical photoperiod studies involved plants of the Temperate Zone, where natural day lengths vary greatly through the seasons. One might wonder about the response of plants growing at or near the Equator, where a natural 12-hour daylength is more or less constant.

Physiologists have known for many years that tropical and subtropical plants are highly sensitive to photoperiod control. Such plants tend to be short-day with respect to flowering. Some, however, are long-day or indeterminate and some have highly specialized photoperiod requirements. At Beltsville, studies of *Cacao*, *Rauvolfia*, *Coffea*, *Hevea*, *Psidium*, and several kinds of *Citrus* showed that the longer the photoperiod the more the total growth in a given time. Tropical plants respond to a light break in the middle of the dark period the same as plants on very long photoperiods and in this respect they are like plants from latitudes higher than the tropics. Tropical plants are thus controlled by the same pigment system as other plants.

Plant propagators now know that the duration of light influences the rooting of cuttings. The daylength to which the stock plant is exposed also exerts a marked effect on the ability of the cuttings to root. The woody plant Weigela is a good example. If grown continuously on long days, Weigela continues to grow and flower. Softwood cuttings can be taken anytime and these root readily in the greenhouse on the same long days. If grown on short days, less than 12 hours, the plants become quiescent and their cuttings are more difficult to root. In general, too, long days provided as artificial light to extend the natural day during the rooting period cause an increase in the speed and the extent of rooting as measured by the number and length of roots produced (4).

At Beltsville we recently conducted experiments indicating that rooting of holly and boxwood is favorably influenced when the short natural days of winter are lengthened with incandescent light. In our experiments with holly we studied the response of cuttings taken in the fall and rooted on short and long days during a 4-month period from mid-November to mid-March. For the short photoperiods, cuttings were given natural days, which ranged from 9-1/2 to 12 hours during the experiment. Long-photoperiod conditions were provided by interrupting the middle of the natural night with 3 hours of incandescent light. The light was given from 11 p.m. to 2 a.m. nightly. The supplemental light source was 100-watt incandescent lamps with reflectors spaced at 4-foot intervals 4 feet above the plants. One-hundred-fifty uniform terminal cuttings were taken from a single stock plant clone of each of the following holly (Ilex) taxa: I. aquifolium L., I. altaclarensis (Loud.) Dallimore, I. cornuta Lindle. & Paxt. (male) I. cornuta (female), I. cornuta 'Rotunda', I. crenata Thunb., I. crenata f. microphylla (Maxim. ex Matsum.) Rehd., I. opaca Ait. (male), I. opaca (female), I. pedunculosa Miq. (male), I. pedunculosa (female), and I. pernyi Franch. Seventy-five cuttings were placed on each photoperiod.

Intermittent mist was used and the temperature of the propagating medium (Perlite) was kept at 70°F by thermostatically controlled heating cable. The air temperature was never below 70°. Root-inducing chemicals were not used.

In general, in these conditions the light interruption of the long night caused earlier and heavier rooting. The heavier rooting was due to fibrous roots rather than to more main roots. The light interruption also stimulated bud break and growth of some clones. Clones of I. crenata were the most responsibe and those of I. opaca and aquifolium the least. No consistent differences in rooting were associated with sex of a given holly species.

With boxwood we studied the rooting response of nine clones of the following species: Buxus harlandii Hance, B. sempervirens 'Handsworthii' Boom, B. sempervirens f. pyramidalis (Simon-Louis) Rehd., and B. sempervirens L. The boxwood experiment was conducted more recently than the holly one but during the same season with the same facilities and in the manner previously described for holly except that temperatures of the rooting medium were 70 and 80°F.

In general, more than 95 percent of the cuttings of all clones rooted on all treatments except on the interrupted night at 80°F, where the rooting was slightly below 90 percent. More main roots tended to form at 70° than at 80° regardless of daylength. The longest main roots were produced at 70° and the shortest ones formed at 80° on the interrupted night. Roots produced at 80° in the interrupted night were thick and heavily branched or fibrous.

Cuttings of holly and boxwood formed characteristic fibrous roots when grown in interrupted night: holly at 70° and boxwood at 80°F. One now suspects that the fibrous-root character of the two plant materials is controlled by a temperature-photoperiod interaction in which the temperature requirement varies with the plant. Boxwood requires a warmer rooting medium for production of fibrous roots than does holly. Studies must now be made to re-examine the response of holly at different rooting temperatures in interrupted nights.

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MODERATOR STOUTEMYER: Thank you, Dr. Piringer. I think that we can resolve some points now by questions.

MR. HERMAN SANDKUHLE: Al, what type of light was used?

DR. PIRINGER: Incandescent light was used.

MR. HERMAN SANDKUHLE: And how far away was it from the plants?

DR. PIRINGER: The light intensity was 20 foot candles at plant level. Incandescent lamps were hung 4 feet above the plants at 4 foot intervals. We give a 3 hour light interruption of the long dark period and we don't know how much less than that is required.

MR. HERMAN SANDKUHLE: But did you use a "hormone" treatment?

DR. PIRINGER: No, we did not use any chemicals. We were interested in studying the effects of light, per se. There is no question, in the case of Ilex aquifolium and I. opaca, that had we used rooting chemicals, we'd have had better rooting responses. However, we were interested only in the effect of light itself. I might make another point, if I may. There are reports in the literature that a light interruption has done no good, but no place has it done any harm, unless you call accelerated growth in the propagating bench harmful. If you consider accelerated growth as detrimental, then this light interruption will have a detrimental effect.

QUESTION: Has this light been used on any seedlings - such as right after they germinated?

DR. PIRINGER: Yes - and seedling growth will be stimulated. I might say that many years ago when Dr. Stoutemyer was still with the USDA Dept. of Agriculture, he wrote a publication called "Propagation Under Fluorescent Lights" and it is still one of our most popular items. What he said 20 years ago about the use of fluorescent lights in plant propagation is still true today. There is a great merit in the use of fluorescent lights to lengthen the day or give supplemental light. Fluorescent lights cause short internodes and compact plants. Far-red light in the incandescent source causes long internodes. So where you are going to start seedlings and use supplemental light it would be best to use a fluorescent rather than incandescent source because of difference in the quality of the two light sources.

MODERATOR STOUTEMYER: Our next speaker will present some ideas that I think may mean some money in your pocket. Most doctoral dissertations should not be published at all, but occasionally somebody "rings the bell". Well, this man from his thesis obtained a couple of landmark papers on an entirely different type from the usual long-day or short-day plants. He made the first laboratory proof of the existence of a combination long-day, short-day plant. Our next speaker attended the Massachusetts Institute of Technology to get his degree in plant science and then came out to the California Institute of Technology where he took his doctorate. Later he went to Italy on a post doctorate, and did some work on gibberellin. He's much like Dr. van Overbeek - a "hormone" physiologist. He's quite a plant anatomist and is also interested in morpho-genesis. It gives me great pleasure to introduce Dr. Roy Sachs, now of the Dept. of Landscape Horticulture, University of California, at Davis.

THE USES AND LIMITATIONS OF SUPPLEMENTARY LIGHT IN CALIFORNIA NURSERIES

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Piringer (6) has reviewed the main discoveries showing that growth and development in woody plants are greatly dependent upon day length. We have been particularly interested in commercial application of these findings.

Some parts of coastal Southern California are noted for relatively mild spring and autumn temperatures, perhaps suitable for optimum plant growth and generally considered to have a growing season of 250-300 days (9). Optimum day lengths[1], however, prevail for no more than 90-120 days of that period; indeed, most species make the major portion of growth during late May to early September. Thus, it might be expected that supplemental lighting that creates summertime (greater than 14 hours) day lengths throughout the "growing season" might have great value in promoting the growth of nursery plants--perhaps to the extent of doubling the growth per year of many species.

In our initial experiments at and around the University of California at Los Angeles, these exciting possibilities were seldom realized. The reason is probably an over-optimistic estimate of the spring and fall temperatures. In other words, the "growing season", as presently defined, is by no means a broadly applicable term, and does not mean that the prevailing fall through spring temperatures will support growth of all plants, particularly the growth of leaves and stems.

As our greenhouse work progressed, however, some useful information has been collected. This paper presents the results and conclusions.

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1 Optimum day length must be defined for each species; however, in this paper we assume that for most plants day lengths in excess of 14 hours fall into the "optimum" category. Some support for this figure appears in the literature (5). In the Los Angeles area (at the 34th parallel), greater than 14 hour day lengths occur from April 21 to August 21. This includes the sunrise to sunset hours plus 1/2 hour twilight at dawn and again at dusk.

MATERIALS AND METHODS

The plants used were mostly obtained from nurseries as "liner stock"[2], a few were propagated from cuttings available on the UCLA campus, and a few were from seeds collected locally. In all cases the plants were introduced into experimental conditions when they were in the liner-stock category, no more than 6-10 inches (15-25 cm.) above the containers. The potting mixture was a standard peat-enriched sandy loam supplemented with fertilizers, and throughout the experiment all plants received periodic applications of liquid fertilizer (according to standard procedures described elsewhere).

To create long day (LD) conditions in the greenhouses and outdoors, the plants were lighted between 10:00 p.m. and 2:00 a.m. by incandescent lamps yielding 10 foot candles, 18 inches above the bench or ground surface (4,7). In some cases (cited in Table I) 16 hours of supplementary light was used to establish LD conditions. Short day (SD) conditions in the greenhouses were obtained by covering benches with black cloth at 4:00 p.m. and uncovering at 8:00 a.m. daily. Circulating air under the black cloth kept temperatures there almost equivalent to those on the uncovered benches. Minimum temperatures in the greenhouses were 15 to 18° C. (60 to 65° F.); outdoors, temperatures were the same in natural day length (ND) areas.

Plant height was recorded as the distance between the container and terminal cluster of leaves. Measurements were made monthly.

RESULTS AND DISCUSSION

Although our main interest was in vegetative growth, reproductive development (in the greenhouses) was also observed. The results are presented in separate sections according to the type of observation and conditions.

Vegetative growth. Of the more than 40 species tested, only a few warrant special attention. Table I gives a complete list of the plants tested and an evaluation of the effects of supplemental lighting. The "outdoor"[3] results, of course, pertain only to climates resembling that at UCLA.

2
We thank the Four Winds Growers for donating several varieties of dwarf citrus, and the Select Nurseries, Inc. for the Bougainvillea plants. Mr. Richard Maire and Mr. Wesley Humphrey of the Agricultural Extension Service have been extremely cooperative in locating materials and suggesting application of this research.

3
Marston Kimball, of the Agriculture Extension Service, is preparing a plant-climate zoned map of California that should be particularly useful for extending information such as contained in Table I to other areas of the state.

OUTDOOR LIGHTING

Pinus radiata (Monterey pine) was far and away the most responsive plant. With regard to height alone, supplemental lighting increased the growth rate more than twofold during the February-April period (Fig. I). Increased growth was also reflected in greater stem diameter and lateral bud development. In all respects the lighted plants were more valuable than the untreated specimens, and ready for transplanting to 5-gallon containers several months sooner. As the treatment continued, however, the growth rate of the lighted plants fell below that of the controls. The reasons are not clear, though growth cycles during continuous LD treatment are well known for other species of the pine family (5).

Subsequent short-term experiments with P. radiata and other plants revealed still another feature of outdoor (OD) supplemental lighting: that spring lighting did not speed growth every year. Variable temperatures were presumably responsible, and the data in Table II support the view that low spring temperatures completely nullify the response to supplemental light. OD treatments were much less effective than those in the greenhouse, and the principal difference between the two was the lower temperatures prevailing outdoors. (Juniperus keteleeri was the only species that grew as well outdoors as in the greenhouse). In this respect it is of great interest that supplemental lighting has been more successful in the fall than in the spring. (Fig. II). This can be attributed to the warmer weather in September, October, and part of November than in March, April, and May.

Under lights, Erythrina and Albizzia retained their leaves several months longer than unlighted plants, and showed the greatest promise for increased growth through supplementary lighting in the fall (Fig. II). Moreover, stem "die-back" was considerably less on the lighted Erythrina plants. "Die-back" is surely one of the most undesirable features of E. cristogalli, and supplemental lighting may be of value for this use alone.

Several investigations have shown that below a certain minimum temperature--21° C. (70° F.) is commonly quoted--the response of woody plants to supplemental light is greatly reduced, and in some cases may disappear entirely (3,5). The question of temperature is so important that, before OD supplemental lighting can be recommended as a standard nursery practice, steps must be taken to maintain temperatures higher than that of the surrounding environment (in certain areas and times of the year in California, as much as 15 to 20° F. higher). Do the increased costs for lights and cover (for example, that provided by a polyethylene greenhouse) justify the benefits? The economic bases upon which nurseries operate are not widely published, and it is not possible to estimate the value of increased growth rates (which are eventually reflected as increased productivity or faster turnover on reduced acreages). It is really from the economists rather than the physiologists that we require the greatest amount of data.

GREENHOUSE LIGHTING

Except for Cycas revoluta, Macadamia ternifolia (which grew poorly under all conditions), Acer paxi, Bougainvillea brasiliensis, and Viburnum japonicum, every species tested responded to LD treatments in the greenhouses. In some cases the differences between long and short days were truly spectacular: Jacaranda, Magnolia, Acer palmatum, Quercus borealis, Thuja bakeri, Libocedrus decorrens, Juniperus keteleeri, and Pinus halepensis more than doubled their growth rate with LD, at least for the first four months of treatment. Some trees showed the typical SD dormancy response: Betula alba, Acer palmatum, and Quercus borealis were in this category, although after several weeks the buds opened even under SD conditions. Chilling requirements to break dormancy were not tested although, in every case, the plants had already been exposed to low temperatures in December and January in the Azusa-Monrovia, California area.

Reproductive Development. Supplementary lighting was also directed toward the problem of hastening flowering in woody plants. For example, if the generation time could be decreased by day length controls, breeding programs could be accelerated in this otherwise difficult group of plants.

OUTDOOR

Regardless of the day length, several plants were observed to flower during the first year of cultivation: Jacaranda, Bauhinia, and Magnolia were the most surprising cases, since they are generally vegetative for several years under ordinary nursery and landscape conditions. The forced feeding and soil conditions presumably reduced the time to reach maturation, and these studies should be extended to check for fertility and fruit set wherever breeding programs are in progress.

With supplementary lighting, camellias and azaleas were delayed about one month in bud development, and there were many "by-pass" shoots. That is, the flowers were confined to the lower axillary buds, with the terminal buds generally vegetative. This characteristic is highly undesirable commercially where masses of terminal flowers are required for showiness. However, the lighted plants showed faster growth, and during the first year of propagation, when flowering behavior is not very important, some value may be derived by supplemental lighting.[4]

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[4] Dr. Harry Kohl, of UCLA, has shown similar effects of day length upon azaleas in much more detailed experiments, studying both temperature and day length simultaneously. He has found that all varieties do not respond equally and some do not respond at all to supplemental lighting.

GREENHOUSE LIGHTING

A by-product of our screening program was the discovery that many varieties of Fuchsia hybrida are very good LD plants with respect to flower initiation (8). Full-blooming fuchsias have been produced in mid-winter by the use of supplemental lighting in the greenhouse and, for display purposes, nurserymen should find day length-controlled flowering of some value. Bougainvillea, as reported by Allard (1), is an SD plant, and in our greenhouses three varieties behaved in this manner. Under black cloth, flowering plants were obtained in mid-summer whereas lighted plants remained completely vegetative. Since these plants bloom profusely outdoors in late spring and early summer, it is clear that other important contributing factors affect flower initiation and development in Bougainvillea.

CONCLUSIONS

Long days promote vegetative growth in a wide variety of plants commonly grown in California, but the temperature requirement of the plants is too high to obtain consistently increased growth rates in outdoor nursery plots by the simple expedient of supplementary lighting. If economical methods can be developed to maintain 60 to 70° F. minimum night temperatures throughout the year, however, supplementary lighting might well become standard practice in nurseries. In some areas autumn temperatures are high enough for lighting on an experimental basis, and OD lighting should be given extensive field trials in more genuinely tropical climates (such as Southern Florida, Gulf of Mexico, areas, and Hawaii). We believe that with supplemental lighting, average temperatures between 65-70° F. will support nearly optimum stem growth and leaf initiation.

Our experience outdoors has shown that this kind of average is most easily met if the night temperatures do not fall below 60° F. for any prolonged period. It is no coincidence that maximum response to supplemental lighting occurs in September and October when the above mentioned temperature conditions prevail at UCLA (10).

A major application of day length control in nurseries, regardless of area, may be to induce permanent (overwintering) or temporary (7-14 days) dormancy during the summer by creating SD conditions. Temporary dormancy, or hardening, in plants may be of great value for summer landscaping jobs, where water stress is probably the greatest factor contributing to the loss of plants. Although this idea has not been field tested, it is clear from our greenhouse experiments (Table II) that many plants grow slowly if at all under SD conditions.

FUTURE RESEARCH

One long-term goal of our research is in the area of defining the minimum and optimum temperatures required for response of plants to supplementary light. Environment-controlled facilities such as that available at UCLA are well-suited to this type of problem.

Another critical problem is that of growth cycles in woody plants, which seems to be the case in Pinus radiata. It may not be possible to force prolonged rapid growth in many species, owing to little understood internal growth requirements.

From the standpoint of commercial application of supplementary lighting, research is required on means of heating (by plastic covers to use re-radiation of solar energy or other methods) large areas of plants, and on the most efficient use of artificial lights for extending the natural day length. Several recent studies suggest that intermittent (or cyclic) lighting is considerably more efficient than a 4-hour interruption of the night, as done in most of our experiments (2).

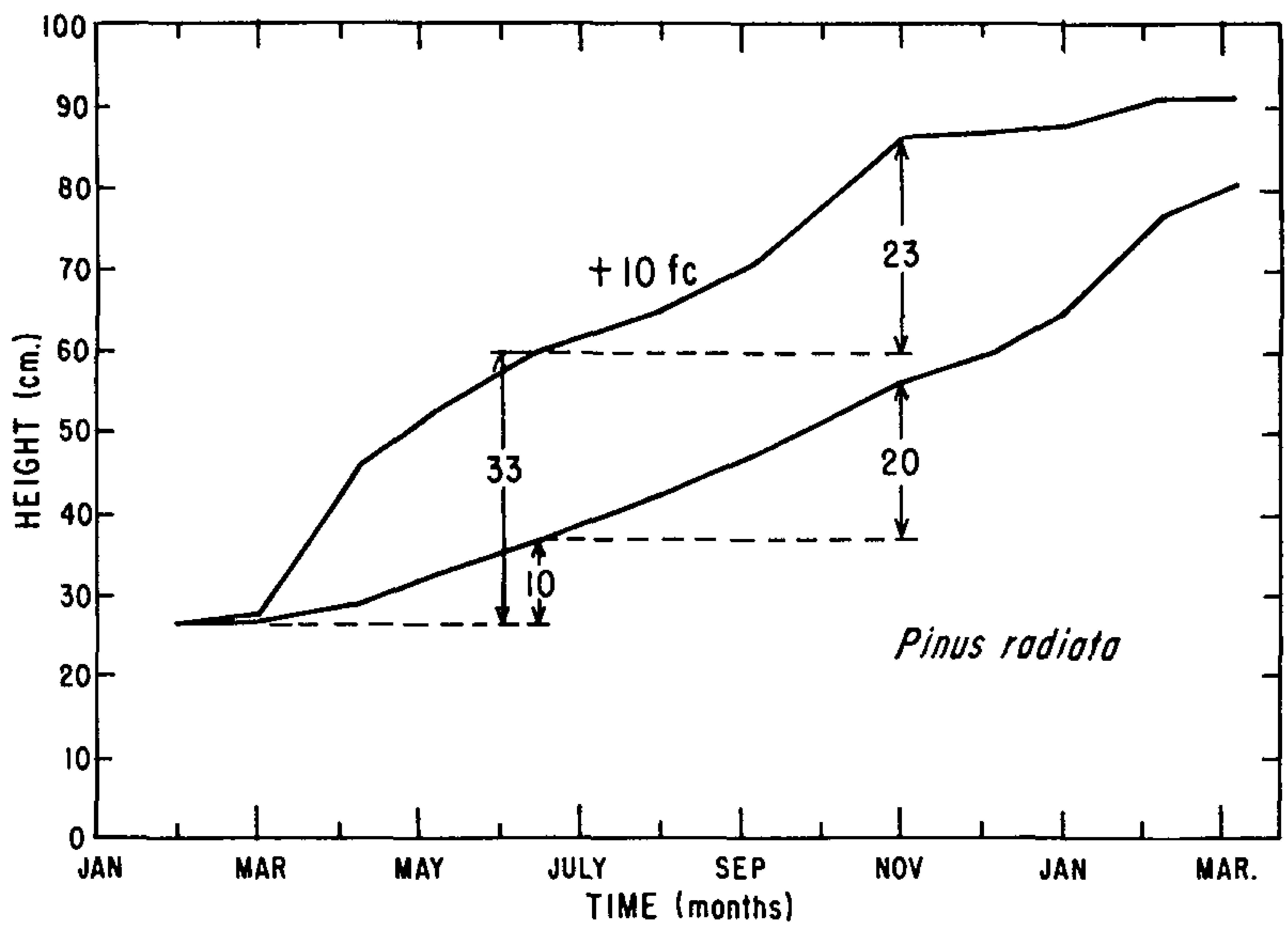

Fig. I.

Stem growth of Pinus radiata outdoors. Upper curve - 10 ft. c. light daily for four hours; 10:00 p.m. - 2:00 a.m. Lower curve - natural day length.

Note 1). that the maximum response to supplemental light occured in the first 3-4 months, and 2). that the growth rate of the lighted plants was less than that of the natural day length controls in the November through March period.

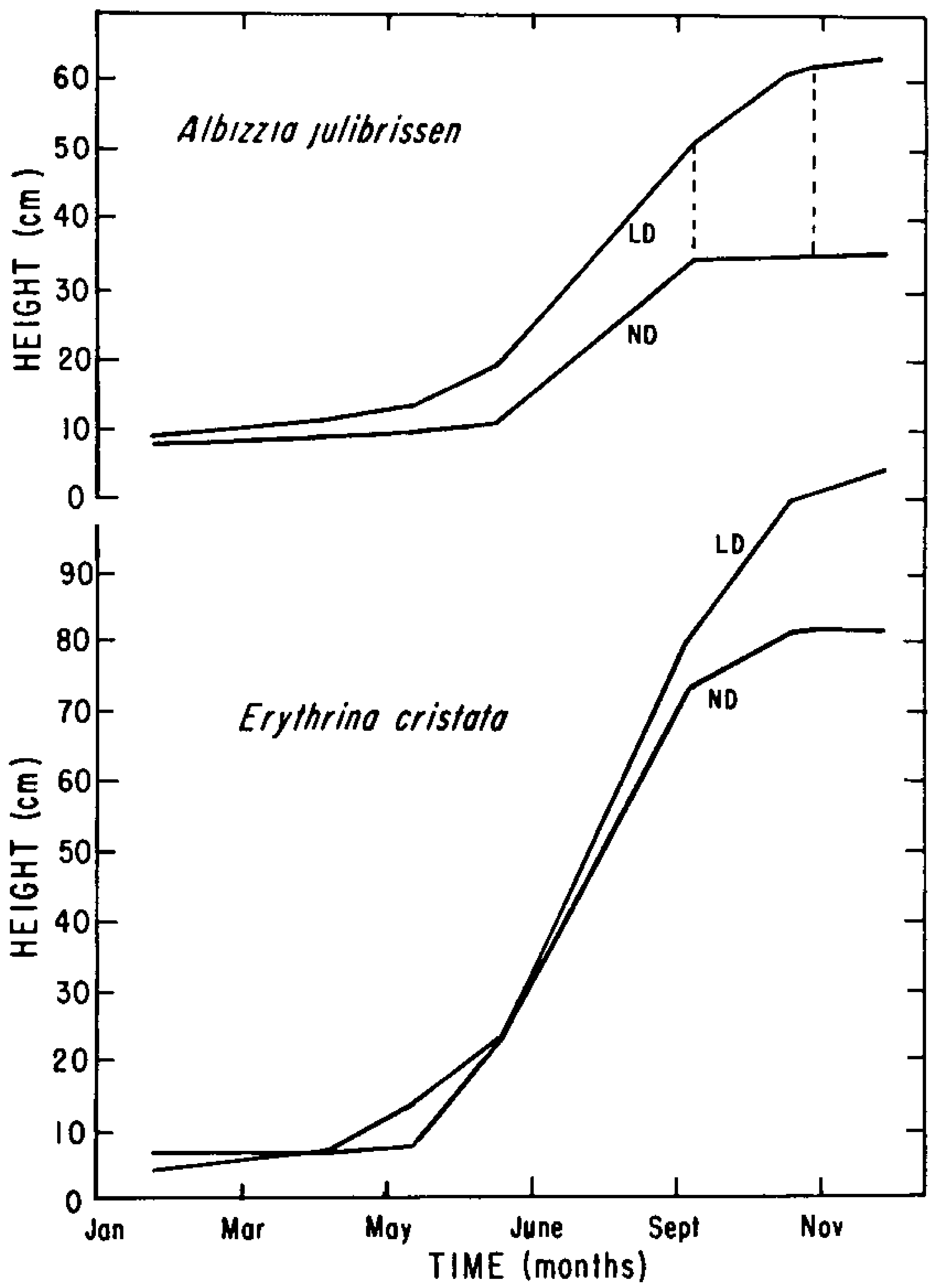

Fig. II.

Stem growth of Albizzia julibrissen and Erythrina cristata outdoors. Upper curves - 10 ft. c. light daily for four hours, 10:00 p.m. - 2:00 a.m. Lower curves - natural daylength. Note that response to supplemental light was greatest in the September - October period.

TABLE I

Evaluation of Supplementary Lighting on Vegetative Growth. UCLA, 1959, 60, 61.

Plants tested	Outdoors[1]	Greenhouse[1]
Gymnospermae		
(Cycas revoluta)..................	0	0
Pinus radiata.....................	+,(+)	+,-
P. halepensis.....................	0	+,-
P. canariensis....................	0	+,-
Juniperus chinensis "Keteleeri"....	+	+,-
" " "pfitzeriana"..	0	
Thuja orientalis "Bakeri"..........	0	+,-
Cupressus sempervirens glauca......	0	+,-
Libocedrus decurrens..............	0	+,-
Cedrus deodara....................	0	
Angiospermae - deciduous		
Acer palmatum atropurepureum.......	0*	+,*,-
Albizzia julibrissen..............	+,(+)	
Betula alba.......................	0	+,-
Erythrina crista-galli............	+,(+)	
Liquidambar styraciflua...........	0	
Quercus borealis..................	0	+,-
- evergreen		
Acer paxi.........................	0,*	0,*
Azalea............................	+	
Bauhinia..........................	0	
Bougainvillea "Barbara Karst"......		+
" "San Diego Red"......		+,*
" "Brasiliensis".......		0
Buxus harlandi....................	0	
Camellia..........................	+	
Camphora officinalis..............	0	
Ceratonia siliqua.................	+,(+)	
Citrus (dwarf): Robertson navel orange, Eureka lemon, Owari Stasuma mandarin, Kinnow mandarin, Nagami Kumquat.	0	

Plants tested		
Anigiospermae - evergreen		
Daphne odora......................	0	0
Ilex crenata convexa..............	0	
Leptospermum flore pleno..........	0,*	+,*
Jacaranda mimosaefolia............	0	+,-

TABLE I, (Continued)

Plants tested	Outdoors	Greenhouse
Anigiospermae - evergreen (continued)		
Macadamia ternifolia...............	0	0
Magnolia grandiflora..............	+, (+)	
Pyracantha gregeri.................	0	+
Schinus molle......................	0	
Viburnum japonicum.................	0	0
Xylosma senticosa..................	0	

Evaluation Code:

+, promotion with supplementary light
0, no response to supplementary light
(+), promotion in spring months not observed regularly
-, reduction of growth in short day below that of plants in natural day lengths
*, continuous low intensity light promotes growth above the standard, 4 hour interrupted night treatment

1. 5 plants per treatment.

Supplementary light and short day conditions are described in the text.

TABLE II*

Supplementary lighting effects in Greenhouse and Outdoors[1]

		Pinus halepensis L(cm) 75 days	Pinus halepensis L(cm) 135 days	Juniperus chinensis Keteleeri L(cm) 75 days	Juniperus chinensis Keteleeri L(cm) 135 days
GH	SD	4	7	3	4
	LD	13	27	11	24
OD	ND	6	13	7	20
	LD	8	15	8	32

		Thuja orientalis Bakeri 75 days	Thuja orientalis Bakeri 135 days	Acer palmatum 75 days	Acer palmatum 135 days
GH	SD	2	3	1	2
	LD	10	22	34	105
OD	ND	5	8	6	25
	LD	6	11	9	36

---

* L - growth in height after 75 and 135 days of treatment

GH - greenhouse

OD - outdoors

SD - short day

LD - long day

ND - natural day

[1] 5 plants per treatment

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MODERATOR STOUTEMYER: Our next speaker is a native Californian and has been at UCLA quite a long time. He's a "green thumb" man, a natural propagator; but I think he should have been a professor, because if you have ever had a chance to talk to him for a while, you find he is just brim full of ideas. He should be directing experiments in propagation as well as carrying them out. It gives me great pleasure to introduce Mr. Edward F. Frolich -- all of us at UCLA know him as "Ted" --

Etiolation and the Rooting of Cuttings

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Webster defines the term, etiolation, as "to blanch by the exclusion of sunlight". This is hardly an adequate definition when applied to this particular discussion. A better title might be "the inhibiting effect of light on the production of root initials". This effect differs somewhat from those in the preceding discussions in that here we are interested only in the light falling on the actual tissue that is to produce the root initials. This, in ordinary nursery practice, would be the tissue at or near the base of the cutting.

There are statements in the literature that mention was made of the beneficial effects of darkness on rooting of apples as early as 1537 (2). Since that time there have been several papers describing the use of this technique for rooting cuttings of several different kinds of plants. Plants vary widely as to their ability to produce root initials when exposed to light. Many plants, of course, must be not at all, or only slightly, inhibited by light in the rooting process. We have all seen aerial roots on such things as ivy, *Philodendron*, *Ficus*, and tomatoes. Many plants can be rooted in a jar of water or in a humid atmosphere with the entire cutting exposed to light. The production of root initials in many other plants, however, is inhibited unless light is excluded from the tissue involved.

Sachs in 1865 (9) reported on an experiment with *Cactus speciosus*. He found that cuttings of this cactus kept in the dark for several weeks formed adventitious roots, while cuttings kept in the light for the same length of time did not. Cuttings of *Tropaelum majus* and *Veronica speciosa* behaved in a similar manner. In 1931 Mevius (4) worked with species of *Tradescantia*. He found rooting of *T. fluminensis* and *T. purpusi* was inhibited when the bases were exposed to light. Mevius pointed out that there are genetic differences involved. *T. fluminensis* var. *myrtifolia* was much less inhibited by light than was *T. fluminensis*. Once roots formed in these materials, however, they grew perfectly well in the light.

The simplest example of this practice is what we all do in our everyday work. We place the cuttings in a more or less opaque rooting medium which excludes light from the tissue where we wish roots to form. This undoubtedly would not be necessary with all materials but it is one of the factors contributing to successful rooting with many of them. I do not know of any extensive survey to determine which materials root better with light excluded from the base of the cutting.

A slightly more involved application of the same thing is illustrated by the process of mounding soil around the bases of shoots before the cuttings are taken. This is one of the effects of stooling. Regel (7) in 1853 reported better rooting of rose cuttings by this practice. A modification of the same thing is wrapping a section of the stem with black paper for a period of time before taking the cutting. Reed (6) in 1922 and Blackie, Graham, and Stewart (1) in 1926 found this method effective for rooting a difficult clone of Camphor. Smith (10) in 1924 reported that rooting was improved in a species of Clematis by this same method. In general it was the opinion of these workers that some growth of the tissue must take place either in length or thickness in the darkened area before the cuttings are detached.

The root formation of some other plants is even more strongly inhibited by light than those mentioned above. With these more difficult subjects we have to actually grow what is to be the base of the cutting in the dark. This generally is what is referred to as etiolation. Many of you have, no doubt, seen or read about the method employed with certain plums in England. They plant their stock out in such a way that it is possible to lay the branches down flat on the ground so they can cover them with soil before growth starts in the spring. The shoots grow up through the soil and into the light where they form normal leaves. By the end of the season most of these shoots develop roots in the soil and can be detached for planting in the nursery row. Gardner (3) in 1937 rooted cuttings of commercial apple varieties by a modification of this method. He covered his trees with an opaque box before growth started in the spring. When the trees had made about an inch of growth he removed the box and wrapped black tape around the base of the shoots. These shoots were allowed to grow naturally and the next winter they were detached and used as hardwood cuttings. Roots grew out from the area which had been covered by the tape.

Some years ago workers in avocado rootstock research at UCLA needed rooted cuttings of avocado (Persea americana) for certain experiments. We could always root cuttings of very young avocado seedlings and we had a very few old varieties that could be rooted from normal green cuttings, but with the great majority of varieties we could get absolutely no rooting. These cuttings would survive for two to three years with prolific callus formation but regardless of any "hormone" treatment used we could not initiate roots. A trial with the etiolation technique proved to be quite successful for producing experimental material although it requires too much labor for a commercial operation.

We first grow an avocado seedling in a small container and graft it with the variety we wish to root. For some unknown reason the rooting of shoots from plants in small containers is much better than shoots from larger containers so we have to assume that etiolation is not the only factor involved. The plants are cut back to near the original scion and when the buds show signs of pushing the plants are placed in a dark room maintained at 70° - 75°F. At higher temperatures the new shoots are affected with what seems to be a physiological breakdown. Tissues in the dark will not stand as high a temperature as the same tissues in the light. At lower temperatures growth is slower and we also get water condensing on the shoots which favors fungal attack. The etiolated shoots do not form a true epidermis and are far more subject to invasion by fungi than are normal green shoots. The plants are left in the dark room until the shoots are about 3" long at which time they are brought out into the light (Fig. 1). A paper cylinder is placed around the shoots and filled with vermiculite or some other material to exclude the light. The tips of the shoots are left exposed and in a few weeks normal leaves develop (Fig. 2). At this time the shoots can be girdled near the base (Fig. 3) and the collar and vermiculite replaced or the shoots can be detached and rooted as cuttings in a propagating case. Girdling weakens the stock plants more than detaching the shoots and does not allow using them over again as many times. The plants are put back in the dark room to grow new shoots again. After two or three times the stock plants get so weak they have to be discarded. It is interesting that the weaker growing shoots root more readily than do stronger shoots but if they become too weak they will not elongate in the dark. For satisfactory rooting it is necessary to work in the area between the two extremes.

Rooted cuttings of the avocado are difficult to handle in the initial stage. They apparently have a higher soil oxygen requirement than do avocado seedlings. However, once they reach a certain size they grow well and develop into satisfactory trees (Fig. 4).

Some attempts were made to find out more about what etiolation is doing. If a collar is placed around a cut-back plant and filled with vermiculite as the buds grow so that just the tip of the shoot is visible but no stem area is exposed to light the shoot will root as well as if the shoot were grown entirely in the dark for the same period.

There seems to be no transmission either up or down from an etiolated section of stem. It is possible to grow a shoot with a ring of tissue from which light has been excluded and when such a shoot is put in to root the initials form only in the area which has had the dark treatment.

Ryan (8) ran some trials at UCLA with both Hass avocado shoots and mung bean seedlings. The Hass was used because it is one that will not root without etiolation and the mung bean because it has been used as a test plant in other rooting work. Ryan showed with both avocado and mung bean that reduction in rooting was dependent on the total light period for a given intensity (Tables 1 and 2). He also showed that with the avocado, inhibition of rooting was not limited to light of a certain color (Table 3). The earlier in the development of a shoot a certain quantity of light is applied, the greater is the inhibition of subsequent rooting (Table 4).

Priestly and his co-workers (5) showed in their anatomical studies of etiolated shoots of broad bean that an endodermis and starch sheath formed which they associated with increased root production. Ryan, however, could find no endodermis in etiolated avocado shoots and no striking anatomical difference between shoots that would root and those that would not. In the etiolated mung bean shoots he did find an endodermis but the endodermis was still present in tissues that had been exposed to light for a sufficient length of time to reduce root formation.

There has been little progress on the basic reason for light inhibition of rooting in the past few centuries. Perhaps with some of the new techniques and equipment Dr. Piringer has described someone may be able to discover the mechanism involved.

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Table I

Effect of light exposure on subsequent rooting of layers of etiolated Hass Avocado shoots, 1958. Shoots grown in dark to height of 3" then exposed to light for period indicated after which they were handled as illustrated in Figures 1, 2, 3.

Light exposure 12 hr. days 600-700 f.c.	No. of Shoots	Percent rooted	Mean number of roots
0	12	92	7.1
1	11	64	4.3
3	11	45	4.4
5	12	42	4.4
7	12	33	1.0

Table II

Effect of duration of light exposure on rooting of etiolated mung bean (Phaseolus aureus) hypocotyls. Seedlings grown in dark for five days, then exposed to light for the period indicated, after which they were detached and rooted in darkness.

Hours of Light	Number of Roots	Percent of dark controls
0	31.6	-
1.5	23.9	75
3	22.4	70
6	16.4	52
12	14.4	46
24	7.7	24
36	5.5	17
48	2.8	9

Table III

Hass Avocado etiolated shoots, 14 12-hour days, 300-350 f.c. Shoots grown in dark to height of 3" then exposed to colored light as indicated, after which they were handled as illustrated in Figures 1, 2, 3.

Color of light	No. of Shoots	No. rooted	No. of roots per cutting
Green	4	0	0
Blue	5	0	0
Red	3	0	0
White	3	0	0
No light	4	3	7

Table IV

Effect of time of interruption of etiolation by light exposure on subsequent rooting of layers of Hass avocado shoots. Shoots were grown in darkness to a height of 3", then treated as illustrated in Figure 1. The collars were removed at times indicated and the bases of the shoots were exposed to 600-700 f. c. of light for 7 12-hour days. The plants were then handled as illustrated in Figures 1, 2, 3.

Light exposure	Percent rooted	Mean number of roots per shoot	Mean number of roots per rooted shoot
Before layering	22	0.4	2.0
After start of layering			
1 week	38	1.7	3.0
2 weeks	67	2.0	3.0
3 weeks	67	2.7	4.0
4 weeks	88	1.8	2.0
5 weeks	86	1.7	2.0
No light	100	7.0	7.0

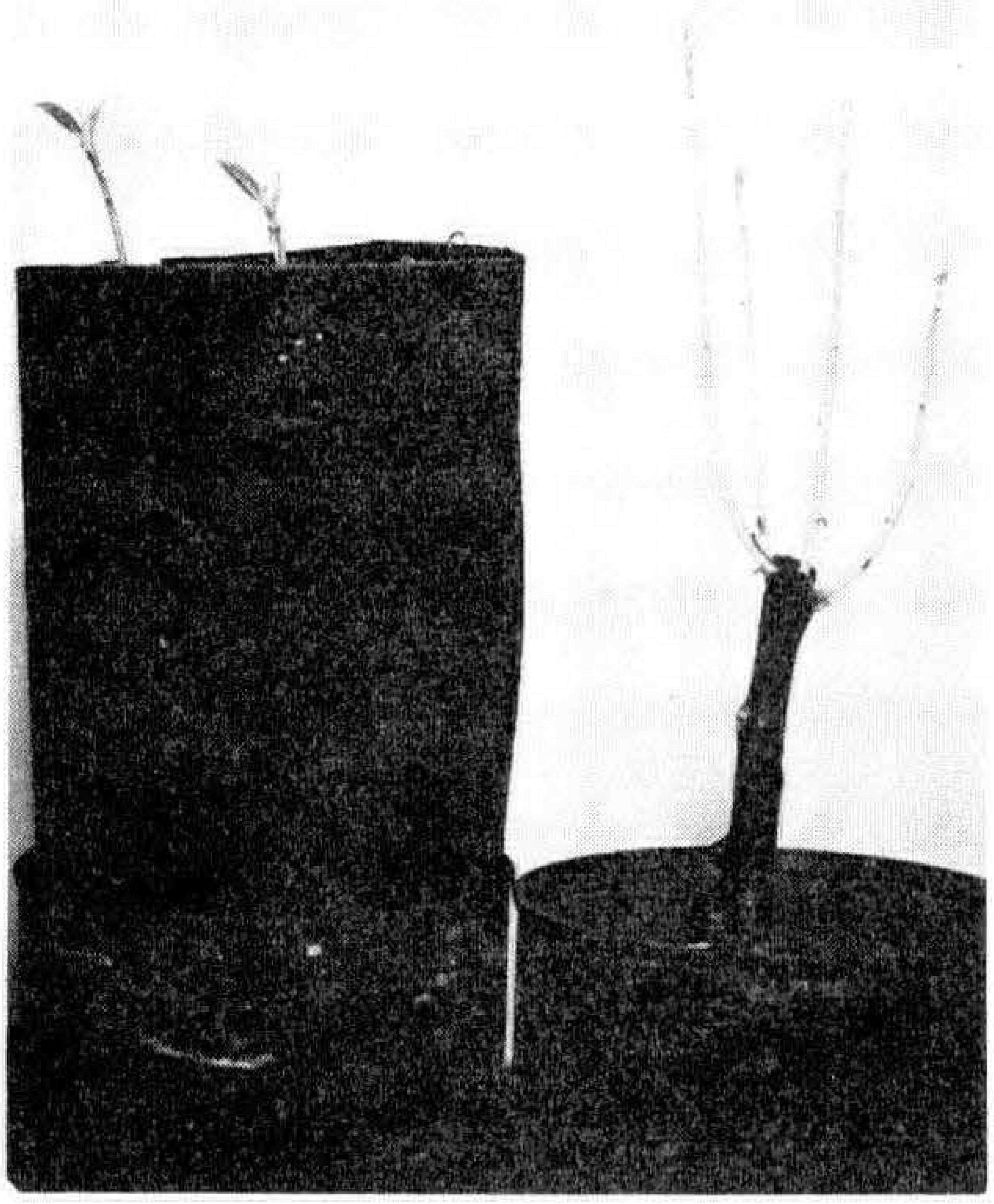
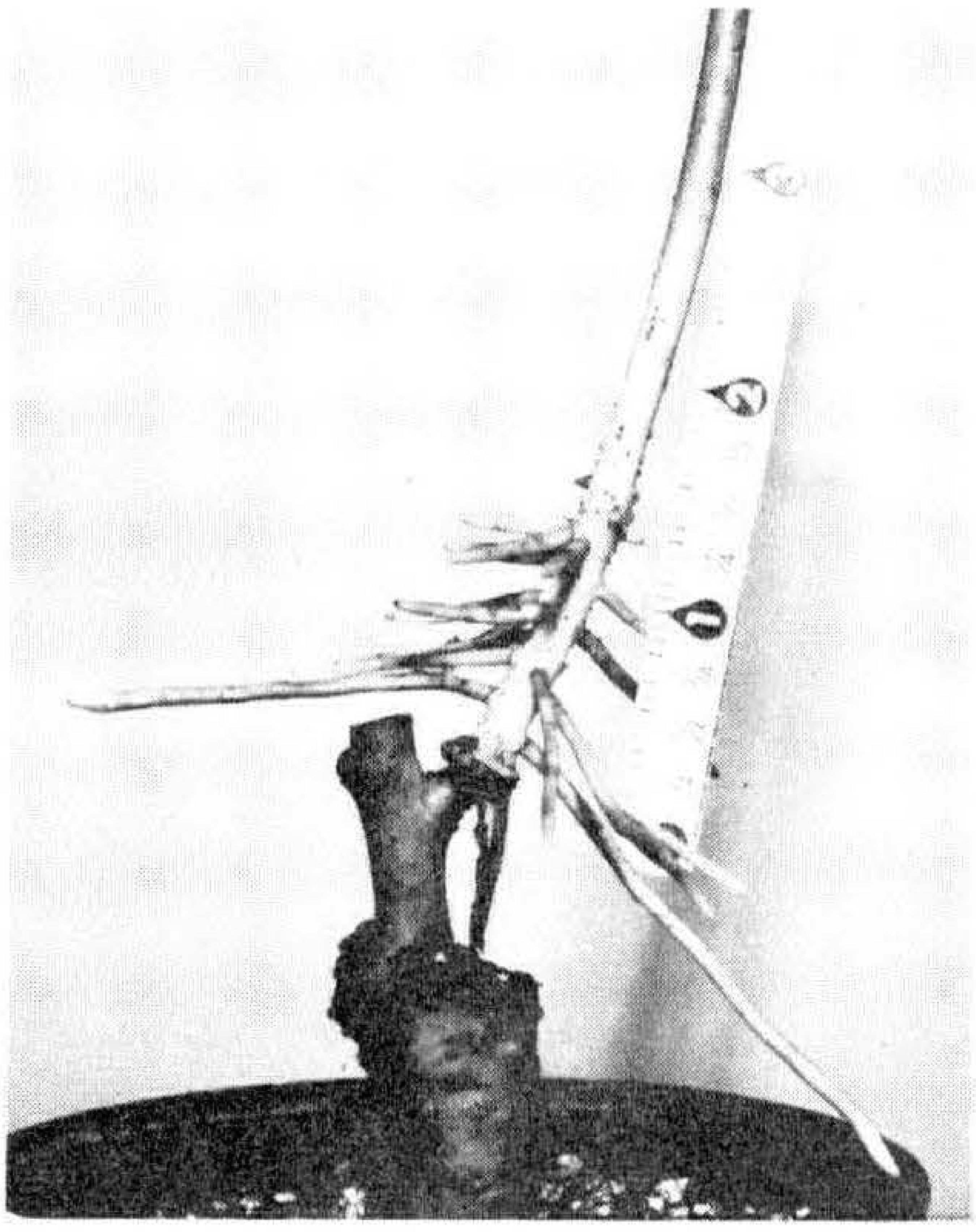


Figure 1. Right -- Hass avocado at time of removal from dark chamber. Left -- Vermiculite-filled collar placed around base of etiolated shoots.

Figure 2. Left -- Shoot ready to detach. Middle -- Detached shoot showing etiolated base. Right -- Detached shoot after 6 weeks in propagating case.



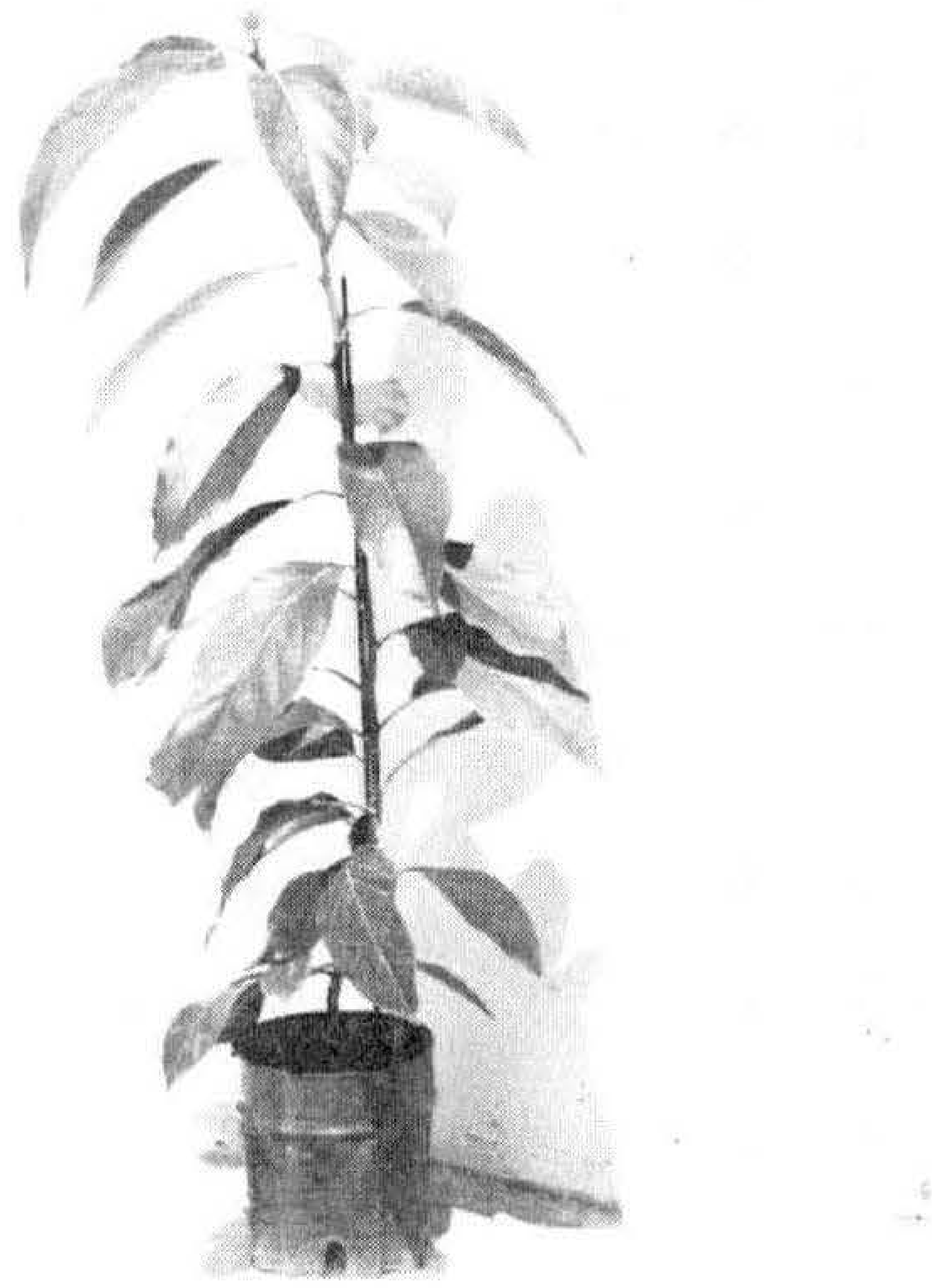


Figure 3. Etiolated shoot girdled near base and rooted while still attached to stock plant.

Figure 4. Established rooted cutting in gallon can.

MODERATOR STOUTEMYER: I would say from this symposium thus far, you can see that we have here what the extension people and communication experts call "resource" people. If we don't have time this afternoon, you come primed for the Question Box period tonight, because I think you can pick their brains and go back home wiser by doing so.

We have one additional presentation on this program which will be short. We're fortunate in having a member of the Staff of the Plant Pathology Department of UCLA who participated in the developmental work on the UC System of soil mixes; in fact, he was, I understand, brought there specifically to participate in that work. He's going to tell us something about "cleaning up" stock of Hibbertia. I've been used to seeing Hibbertias around the coastal area where I live, and usually they're rather sick looking things. I've always blamed it on thrips, but now I think I was mistaken - more than thrips was wrong with them. Now we'll hear this very interesting story from Mr. Phil Chandler of Plant Pathology at UCLA.

The Cucumber Mosaic Disease in Hibbertia Volubilis

R. M. Endo (Presented by Philip A. Chandler)

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In California, the Guinea Gold Vine, Hibbertia volubilis, is affected with mosaic symptoms so commonly that not a single healthy plant has been observed either in home plantings or nurseries. The Guinea Gold Vine is native to Queensland and New South Wales, Australia, where it grows as a prostrate or twining shrub with solitary yellow flowers. In California it is grown primarily in the cool, coastal areas where it fails to produce seeds; thus vegetative propagation is necessary and is suspected as the major factor responsible for the high incidence of mosaic-affected plants.

Recent studies at UCLA indicate that the disease is caused by strains of the cucumber mosaic virus (CMV), and that the widespread occurence of the disease is probably due to propagation of diseased cuttings from infected plants. Shoots free of CMV were rather readily produced by growing diseased plants at temperatures averaging 90°F for 3 to 12 weeks. Symptom-free shoots were removed from diseased plants, and were proved free of CMV.

Symptoms. Mosaic-affected Hibbertia plants develop mild to severe leaf mosaic, leaf deformation, stunting, and usually, considerable leaf chlorosis or yellowing. Some strains of the virus cause a mild, greenish-yellow mosaic, some a bright yellow mosaic, and still others a strong mosaic mottle consisting of islands of dark green tissue, and large areas of greenish-yellow. All strains occasionally produce oak leaf and ring patterns on old leaves. Leaf deformations occur as a change in shape, margins, and in the surface, which usually became rough and irregular due to raised veins and sunken interveinal tissue. Flower set and flower size also are reduced. Symptoms are severe, persistent, and completely systemic during the cooler months of the year; during the warmer months, symptoms tend to be mild and usually incompletely systemic, particularly following periods of rapid growth. Field infected plants also commonly suffer from mineral deficiency resulting in a marked chlorosis and yellowing of the areas between the veins.

Control. Since CMV is transmitted by aphids, and occurs commonly in numerous plants in the field, it is not likely that healthy plants will remain permanently healthy in outside plantings. These studies indicate, however, that disease-free shoots can be readily produced by growing diseased plants at high temperatures, thereby enabling growers to propagate from disease-free mother-stocks, and to produce and sell disease-free plants. Since the appearance, vigor, and growth rate of healthy plants is much greater than diseased plants, customer appeal and salability is greatly increased.

Mother stock plants should be grown in a greenhouse section free of aphids or under aphid-proof cages. If infection re-occurs virus-free plants may be obtained by growing mosaic-affected plants in the greenhouse at an average air temperature of 90°F. After 4 to 6 weeks, symptom-free tip-cuttings may be taken and the cuttings rooted under mist. Plants that are free of mosaic symptoms at 55-75°F may be retained as mother stock plants.

THURSDAY EVENING SESSION

October 26, 1961

This session - the Plant Propagation Question Box - convened at 7:30 p.m. with Mr. Percy Everett, Rancho Santa Ana Botanic Garden, Claremont, California, as the moderator.

MR. DON HARTMAN: Before we get started with the Question Box, I would like to introduce a visitor with us who is a distinguished individual. He has been introduced once already, but I'd like to re-introduce him and ask a few words from the gentleman - Mr. Louie Vanderbrook from Hartford, Connecticut, who is the representative from the Eastern group. Louie was born and raised in Hartford and operated a nursery that he took over from his father and enlarged it, if my memory doesn't fail me, from around 35 or 40 acres up to around 120 acres. Louie, would you like to say a few words, please.

MR. LOUIS VANDERBROOK: Ladies and gentlemen. I can't say that I'm not forewarned. Your President, Don Hartman, asked me yesterday if I would say a few words before this meeting. I have been very much impressed with the group here, the size of the group of people with your keen and intense interest in this subject. You are only a year and a half or two years old. I've seen ten years of this in the East because produce oak leaf and ring patterns on old leaves. Leaf deformations occur as a change in shape, margins, and in the surface, which usually became rough and irregular due to raised veins and sunken interveinal tissue. Flower set and flower size also are reduced. Symptoms are severe, persistent, and completely systemic during the cooler months of the year; during the warmer months, symptoms tend to be mild and usually incompletely systemic, particularly following periods of rapid growth. Field infected plants also commonly suffer from mineral deficiency resulting in a marked chlorosis and yellowing of the areas between the veins.

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October 26, 1961

This session - the Plant Propagation Question Box - convened at 7:30 p.m. with Mr. Percy Everett, Rancho Santa Ana Botanic Garden, Claremont, California, as the moderator.

MR. DON HARTMAN: Before we get started with the Question Box, I would like to introduce a visitor with us who is a distinguished individual. He has been introduced once already, but I'd like to re-introduce him and ask a few words from the gentleman - Mr. Louie Vanderbrook from Hartford, Connecticut, who is the representative from the Eastern group. Louie was born and raised in Hartford and operated a nursery that he took over from his father and enlarged it, if my memory doesn't fail me, from around 35 or 40 acres up to around 120 acres. Louie, would you like to say a few words, please.

MR. LOUIS VANDERBROOK: Ladies and gentlemen. I can't say that I'm not forewarned. Your President, Don Hartman, asked me yesterday if I would say a few words before this meeting. I have been very much impressed with the group here, the size of the group of people with your keen and intense interest in this subject. You are only a year and a half or two years old. I've seen ten years of this in the East because

I went in as a charter member. I know the intense interest we have there. I have watched your program develop under your able chairman, Herman Sandkuhle - he's done a wonderful job. He has arranged some very interesting subjects. Thinking back beyond the ten year history of our Plant Propagators Society - back 15 or 20 years ago - we common "green thumbers", as Herman calls them, didn't have the contacts with the academic men. We didn't know what they were doing. They didn't know what we wanted. Today we've gotten together and, boy, we are really going places. We have had real accomplishments in the last 10 years in the field of plant production.

I bring to you the felicitations, the good will, and a hope for a rosy future from the officers and members of the Eastern region. I had the very pleasing privilege of sitting in with your Board of Directors the first day that I came here and - gentlemen of the rank and file - you have an able group of men that are representing yourselves and, as long as the affairs of your Society are in their hands, you can rest assured that you are going to have the best. Your officers are very capable. Your president conducts his meetings with dispatch and is a brilliant man. I think his successor is going to be equally as good. With that I will ask your pardon and sit down.

MR. HERMAN SANDKUHLE: The gentlemen who is going to run the program and be the moderator this evening has been your Membership Chairman and he's had a real tough time; he's gone through a lot of papers and what have you, but I will say he's been doing a very capable job, and there is just no question about anyone not getting the right treatment when it comes up before our good friend, Percy Everett. Percy, would you please take over and moderate the Question Box.

MODERATOR EVERETT: Thank you, Herman, for those kind words. Ever since I have had anything to do with plants and their growth and have watched all the variety of places where we have attempted to grow plants and the variety of conditions under which plants are grown, I'm constantly amazed at the extreme diversification of all of the factors that a plant has in it. I was equally amazed about the light effects that Dr. Piringer told us about this afternoon, and to know that plants have a built-in "IBM computer", one that memorizes. I didn't know that plants had that ability, but I thought to myself then, here is another amazing fact about plants. The more you work with them, the more of these things are discovered. It's quite amazing what goes into the make-up and internal structure of plants, all of these chemical compounds that we find, all of the genes, etc.

I'm going to direct the first question from our Question Box to Dr. McClintock: Elizabeth, someone wants to know when and where your publication on the nomenclature of plants will be available.

DR. McCLINTOCK: I still don't know where it's going to be published. Mildred Mathias and I hope that it will be published sometime very soon. We have discussed the matter with the University of California, Agricultural Extension Service. We hope that it will be published, if not by them, by some other agency. So I really can't say when, but we hope it will be soon and certainly, when it is published, it will be available to everyone.

MR. MARTIN USREY: I would like to ask Dr. McClintock how are you going to convert the public over from a name that has been in general use over 15 or 20 years and has been accepted as that, to a proper name when the proper, or correct, name is something no one has ever heard of?

DR. McCLINTOCK: Well, I don't know. That's pretty hard to answer. I hope that if you people find out that a plant should have a certain name, and that it's recommended that the plant should be known by that name, that you will do all that you can to accept that recommendation. All we can do is to suggest or to recommend.

MR. MARTIN USREY: But if we advertise it under the new name, no one will know what we are talking about.

DR. McCLINTOCK: Well, you can always say that the plant has been known by such and such a name or list a synonym following that name. It is unfortunate that there has been confusion in certain names that have been used. I think that the only way that we can resolve the thing is to try to use the names which are the correct names for the plants - just try to use them.

MODERATOR EVERETT: This business of naming plants is quite something. I know I've been disturbed many times by the fact that plant names I've gotten to know real well - plants which have become well known - then all of a sudden the name is changed - but there are basic reasons for this. It's unfortunate that these things do get mixed up, particularly in the trade, because I know it's quite a job to get them untangled, and those are just some of the things that we will probably have to work out among ourselves. I do know something of the work that has been entailed in the preparation of the list that Dr. McClintock has told you about, and it has taken a tremendous amount of time - in fact, well over two or three years. They have given unstintedly of their time and energy and I'm sure that the time spent is all going to be for the good.

Now, Dr. Hartmann, the question is directed to you. Will you give instructions for putting indolebutyric acid into solution?

DR. H. T. HARTMANN: It's really not too difficult to do. It depends upon whether you want to prepare a dilute solution for, let us say, a 24-hour soaking treatment, or a concentrated solution for a quick-dip treatment. Taking the first one, the 24-hour dilute soaking method, you should weigh out the proper amount and add just enough alcohol to the indolebutyric acid to dissolve it and then just add that to the volume of water that's required. If you're making a concentrated dip solution, 50 per cent alcohol ordinarily is used as the solvent, so the proper proportions of 50% alcohol and the IBA are prepared and just mixed together. This concentrated material will keep almost indefinitely if it's sealed. It's a good idea to use a small part at a time, then discard that and then keep the main amount of the solution to use again. The diluted solution should just be used once and then discarded. It can't be expected to keep very long. The actual preparation of the correct proportions is something that would have to be figured out. The strength is usually expressed in parts per million. The University of California has a bulletin entitled "Propagation of Temperate Zone Fruit Plants". The proper measurements are given in teaspoons per gallon of water, so that the IBA would not have to be weighed out on an analytical balance.

MODERATOR EVERETT: You might explain the type of alcohol used and the difficulty of obtaining a small amount.

DR. HARTMANN: Ethyl alcohol is ordinarily used, but isopropyl alcohol will work quite well. You can ordinarily buy that in a drug store. It's a type of alcohol that's used for sterilizing needles, etc., and they will sell it in small quantities without a prescription. We have used this alcohol quite successfully.

DR. STOUTEMYER: I have used ordinary wood alcohol (methyl alcohol). You can get that without a prescription and it works just as well as ethyl alcohol.

MR. DENNISON MOREY: Another material in this connection which I don't think has been widely tried is making the ammonium salt of the indolebutyric acid. In Arizona last year we treated approximately two million cuttings with this particular solution and it seemed to work as well as the alcohol solution did, but you have to remember that in this case you are dealing with completely soluble hormones and something the ground water may leach away. In quick dip applications, all the hormone you put on the cutting stays there pretty much until it is taken up by the plant.

MR. GEORGE OKI: You can get IBA crystals in one gram bottles. It's more expensive this way than in the larger sizes, but using the rule of thumb that to get 1,000 parts per million, dissolve one gram per 500 cc of alcohol, and then adding 500 cc of water gives you 1,000 parts per million, so if you need any multiple of this, like 5,000 parts per million, then all you have to do is add 5 grams, which is already measured up for you, especially if you don't have the delicate balance that's needed.

MODERATOR EVERETT: Dr. Alley, a question for you: How is equitable distribution made of a limited supply of foundation stock?

DR. CURTIS ALLEY: Let me give you an example of what we have done in the past on distribution of registered Mahaleb cherry seed. We send out notices about the end of August to the nurseries that are participating in the registration and certification program, stating the approximate quantities of the registered Mahaleb seed that we have available. We state on the accompanying order blank that the deadline is, say September 20th to order any quantities of registered seed they wish to obtain. That gives them about 3 weeks to a month to submit their order. After the 20th of September we take all the orders that we have received from these participating nurseries and divide up our quantities of seed which, up until this year, was always in smaller amounts than what the nurseries have ordered. If some of the nurseries have ordered only one or two pounds of seed, of course, we would fill such an order immediately. Then if we had say, about 20 pounds of seed left over, and there were three nurseries which each wanted about 15 pounds, we divide it as equally as possible.

The same goes for the distribution of registered Mahaleb liners. There might be two or three nurseries that want 200 liners each. We will have a total of somewhere between 7 and 9,000 liners. For those few nurseries that want small quantities, we will make up their orders immediately. Then for the large orders we divide those up as equally as possible depending upon what the nurseries want.

On distribution of grape materials it works very much the same way - not a matter of first come, first served. We generally set a deadline about January 20th or 25th in which orders for registered stock have to be in. After that time we make our distribution of the materials as equally as possible. The non-registered material is also worked the same way. We generally wait fairly late in the season and then divide it. For those growers and nurseries that want small quantities, the orders are made up rather quickly. On the large amounts it's generally allocated as equally as possible.

MR. HERMAN SANDKUHLE: Curtis, I'd like just to ask a question while you're here. It doesn't pertain to this particular subject, but you were talking about screen houses. Would you give us a quick run down on what a screen house is, and what is the usual size?

DR. ALLEY: We have two screenhouses at Davis. The first is approximately 25 feet wide, 35 feet long and 12 feet high. Dr. George Nyland designed the screenhouse with the idea that the trees would be placed in a container in the ground, and right now I'm very thankful that it is that high because those trees that are growing in the large wooden boxes buried in the ground just about reach the top of the screenhouse. The second unit that we built was 25 feet wide, about 35 feet long, and only 8 feet high. We have peach trees in this one, growing in three gallon cans. These are surrounded by a large box containing sawdust to keep the cans from getting hot in the summer time. This has worked very successfully. Otherwise one would have to bury the can. The screen used is a 32 X 32 mesh - 32 horizontal and 32 vertical threads to the inch. The actual screenhouse is a frame structure. About every four feet is a vertical upright. We have a series of posts placed in the center for support. There's a double entrance. The first door opens into a small hallway. Then you close the door. You open the second door which leads into the screenhouse proper.

MODERATOR EVERETT: The next several questions are directed to

Dr. Piringer. The first question is: (1) Would the use of red light be beneficial to ornamentals, specifically azaleas, and (2) will these light rays penetrate glass?

DR. PIRINGER: The light rays involved - red - will, indeed, penetrate glass. Photoperiod definitely controls growth of azaleas and the most recent work along this line is - I believe out of Oregon; a report that with continuous light, or very long day lengths, one gets very rapid growth. We are also doing work with cyclic lighting on azaleas and getting some response. I might call attention along the same line to work being done now by Dr. Neil Stuart at Beltsville. By using certain growth retardents, he can stop the vegetative growth of azaleas and induce flower-bud formation over a wide range of photoperiods. However, the plants still require cold temperatures for normal flower development.

DR. ROY SACHS: Dr. Kohl of UCLA has recently found several variables in the day length response of azaleas - temperature is one and the other is the variety. Not all varieties will respond, and it will depend upon the temperature to which these plants are subjected.

MODERATOR EVERETT: The next question is: Has any work been done on light responses with bulbous plants in respect to increasing vegetative growth or flower promotion?

DR. PIRINGER: Flower initiation in bulbs is primarily due to thermoperiodicity; that is, primarily a temperature control.

MODERATOR EVERETT: Another question: Have you or your colleagues of the USDA worked with phytochrome reds - far reds - in regard to citrus? If so, has this been published? If not, has any such investigation been scheduled in the near future?

DR. PIRINGER: We have not looked for phytochrome specifically in citrus. Phytochrome itself is a regulating pigment and has been found in avocado fruits. It has been located in plant materials that are free of chlorophyll. Any time that we look for it in plant materials that has chlorophyll we have difficulty because of the masking influence of the chlorophyll. We know that phytochrome is operative in citrus because citrus is responding to photoperiod as far as growth is concerned, and citrus will recognize the difference between fluorescent and incandescent light, and again I say that photoperiod is involved but in this case it's guilt by association.

MODERATOR EVERETT: Mr. Dillon, does that answer your question?

MR. FLOYD DILLON: We would like to see more specific work done, sir.

DR. PIRINGER: I am interested in the photoperiodic responses of tropical plants. We have studied the responses of over three dozen kinds. We try to interest workers in the tropical or sub-tropical areas to study them in their natural environment.

We grow our material in the greenhouse in photoperiod chambers. As soon as our plants get to the order of four or five feet tall at most, they've grown beyond our facility, we can no longer get them into our chamber, and then we have to rely on natural day length or interrupted nights. The point is very simple, we just have no business studying tropical woody plants where we are located, and as soon as we can convince someone else to do it, fine.

VOICE: At what temperatures do you get photoperiodic response?

DR. PIRINGER: We use a 70^{o} minimum. In mid-summer maximum temperature will go as high as 115^{o} in the greenhouse, but about ten and one half months of the year we have no trouble getting a 70^{o} night minimum.

MR. DON DILLON: Dr. Piringer, when you say that citrus will recognize the difference between fluorescent and incandescent lights, what are these differences?

DR. PIRINGER: The difference is in the stem internode length, and it's the same for Cacao and Rauwolfia. When we grow these plants in incandescent light, they get long internodes.

MR. DON DILLON: If the internodes are short, would you get more -

DR. PIRINGER: You would get the same number. In the case of -

MR. DON DILLON: I mean with supplemental light you would get more than you would with normal day -

DR. PIRINGER: Yes, and you would get them faster. In the tropical plants we've studied, there was essentially the same number of parts - under both light sources.

MR. DON HARTMAN: I was wondering if there are publications that have been printed from Beltsville on the subject you have discussed here today.

DR. PIRINGER: We have a wide variety of publications and these are generally available. There is one entitled from "Photoperiodism to Phytochrome", which will pretty much summarize and give in a little more detail some of the things to which I have alluded this afternoon. Also, there is a publication called "Light and Plants" (ARS 34-19) and this one again is a general summary. There are also technical papers on woody and tropical plants. The address to obtain these publications is: The Plant Physiology Laboratory, Agricultural Research Service, Crops Research Division, USDA Plant Industry Station, Beltsville, Maryland.

MODERATOR EVERETT: Do we have additional questions of Dr. Piringer? This is an excellent time to tap a wonderful source of information. As you know he works on the other side of the country. We don't have a man like this every day. Here we are, we've got him captured. Dennison, I knew you'd have a question.

MR. DENNISON MOREY: Dr. Piringer, do you get a photoperiodic effect with far red as well as with ordinary light?

DR. PIRINGER: If I understand you correctly, you are asking if far red substitutes for darkness? Yes, you'll remember that I said if you give a short day plant an interruption in the middle of the night with a minute of red, you prevent flowering and if you follow that with far red you do not get flowering. In other words, the plants see the far red as darkness. However, if you will give that far red for thirty minutes instead of a minute or two, you get a red effect.

MR. DENNISON MOREY: Is your photoperiod an energy proposition rather than a color quality?

DR. PIRINGER: Yes, it's an energy proposition, but it's an energy proposition that's triggered by the red. Photoperiodism is just one of the responses that's triggered by this photomorphogenic system. Other responses controlled by this photo-reaction are seed germination, stem internode elongation, anthocyanin formation in certain plants, and skin coloration in tomato fruits.

MR. DENNISON MOREY: But your photoperiod also depends on the red - far red?

DR. PIRINGER: Yes indeed, but the point I'm making is that photoperiod is only one of the photomorphogenic effects that is controlled by the red-far reaction.

MR. DENNISON MOREY: One last question. Is it presently possible to generalize about this red-far red reaction to any extent, that is in terms of flowering, in terms of cell elongation, or length of internodes, in terms of anthocyanin development, etc.?

DR. PIRINGER: Yes. We know that the controlling substance is a pigment because light is involved. We know that the pigment has two interchangeable forms because of its characteristic reversible reaction with red and far-red light. Although we do not yet know the precise chemical nature of the pigment or its specific action in plants, the pigment is obviously involved in a basic reaction controlling the many features of plants' growth and development discussed here today.

VOICE: This is on the holly discussion. After potting the cuttings when you took them away from the light, wouldn't it affect the plant adversely?

DR. PIRINGER: That depends on what you mean by adversely. If we removed the plants from the light and put them on short natural days, their growth would be stopped. The plants would respond to whatever day length you provided, whether it were natural or artificial day length. If it were an 8 hour day, you would get no more plant growth. If it were a 16 hour day, the plants would grow very rapidly.

MR. MARTIN USREY: Normally where we are in Southern California we make our holly cuttings in November and they are potted up in January and so they would come under short days but they would be lengthening.

DR. PIRINGER: In Washington, D. C., I make my cuttings in November, because before this time the plants have gone into a rest and they presumably have not yet had enough cold to break the rest. In your area perhaps it is warm enough that they never go dormant.

MR. MARTIN USREY: Well, they're as dormant as they ever will be in November.

DR. PIRINGER: Well, if you would take them then, and if you would give them light, I'm sure they would respond accordingly. I would be very surprised if they did not.

MODERATOR EVERETT: Well, we've had quite a session here with theory. Let's get down to earth on some specific problems. Someone says he needs some help with propagating Clematis Armandi.

MR. BILL CURTIS: Well, I have found this. By taking cuttings from young plants you get a much better strike; they root more easily and they break better. We're potting our cuttings now (October) that we stuck last August. Next May they'll be 18 inches to three feet tall, depending upon the vigor and how soon the plant took off. We cut these back to two eyes and take cuttings from these plants. These will root very readily and they break right away. You don't have a bunch of plants sitting around for two years in pots that don't break. We don't put them under mist. They do not need it in our area of Oregon.

Quite frequently we will take our first rooted cuttings and will grade them out and put some of them in 2-1/2" pots, some in 3" and some in 4" pots, depending upon the size of the root system. The 2-1/2" are put into gallon containers. They will make twice the growth in a gallon than they do in a 3" or 4" pot. By August we have a plant that is 3 or 4 feet tall. These are then cut back giving us quite a few cuttings from a plant out of a gallon container. I might mention that just before I came down we started potting C. Armandi. Some of those that had been delayed in getting potted, had growth of 6 to 8" right in the cutting bench.

MR. LOUIS VANDERBROOK: May I ask, Mr. Curtis, do you take your cuttings in the dormant stage, or in the growth stage?

MR. BILL CURTIS: The plants are growing, but we try to get them just as the terminal stops.

VOICE: How many nodes do you take in your cuttings?

MR. BILL CURTIS: We cut them just above the node. We don't have any node on the part of the cutting that goes in the sand. We have one node out. We take one leaf off, and then cut about half of the leaf off that we retain on the plant. We make them about 2 1/2 to 3 inches long and dip them in Hormodin 3.

MR. LOUIS VANDERBROOK: This particular question has intrigued me because we had a similar question in the Eastern group. We had this question rear its head in the East because evidently the James I. George Company of Freeport, New York, was having some problem in raising Clematis, not necessarily this variety. That intrigued me then, so I went home and did some experiments for two years. If you will look back in some of your Plant Propagator Proceedings, you will find out the reason why I was unfortunate enough to become an official of this organization, made Vice President, and President of it. I submitted a paper at the instigation of Jim Elginfritz on our method of rooting shrubs from hardwood cuttings in the greenhouse in the winter time. I took double node cuttings in the month of February and put them in the greenhouse, with no node on the bottom - in a greenhouse which was filled with evergreens - we applied Chloromone to the base of the cuttings, and I was amazed at the results. Everyone of them rooted and by July we had 3 to 4 foot plants. Now these men have been growing Clematis all the time and producing them even with the stock plants in the greenhouse. So I said to Mr. George, why don't you take cuttings from finished vines, or your young plants outdoors and try this hardwood method?

MR. BILL CURTIS: I have dabbled with Clematis for quite a few years. I found this with armandi - if you let the buds get hard and well matured, they don't break well. If the buds have got a tough, hard scale on them, they'll just set and set and set. When spring comes, a year after you've rooted them, you've got 25 or 30% left that still haven't broken, and you keep them around until fall and you'll get 5% of them that will break and grow.

Now on the deciduous Clematis, I like to use a cutting from a plant that is just starting to bloom. I don't keep them in the greenhouse because that space is too valuable. I have a plastic house and I keep my plants there. We take the small plants that we don't sell and shove them into 4 inch pots. They then go into a cool house or into a plastic house - and from these we take two crops of cuttings. Then we sell the 4 inch potted plant as a by-product of our cuttings.

MODERATOR EVERETT: Now here's one. I'm not sure who to pitch this to. How to make plants set seed and for the seed to mature?

DR. DALE KESTER: This question is very general; you'd almost have to take each plant separately. One point is that if you have a plant that remains vegetative, you may make it flower and produce seed by girdling. But I think your question was if they have flowers on them why do they drop off? Well, first of all, there are plants that set fruit without actual seeds in them but the fruits may grow for a while; the question is whether or not these plants actually have any seeds. Your problem may be lack of pollination or some of the genetic abnormalities that prevent fertilization.

Then there are cases where an embryo may be viable for a period of time, and before the fruit gets ripe the embryo is dead. It is possible to extract these embryos while they are immature and grow them in artificial culture. But this isn't a way to grow plants and make a very big profit. Some growth regulators - such as gibberellic acid - have been placed on the plant at the time they bloom and cause the fruit to remain but the seed may not be there; that is, you could set the fruit, but you can't set the seed. I think this actually boils down to the fact that there isn't a real basic way that you can make these fruits set seed. I think that the basic thing is why the fruit is falling off; it's probably lack of pollination.

MODERATOR EVERETT: Now we come to another more mechanical question. What are the advantages of fine high pressure mist over low pressure mist?

DR. H. T. HARTMANN: I don't think there's any particular advantage in the different types of mist. I think it's just a matter of getting the leaves wet, keeping a film of water on the leaves. Whether it comes on by high pressure or low pressure doesn't make much difference.

MR. MARTIN USREY: Well, I think it's two different types of operation. One of them is under high pressure. It's not actually a mist, it's more like a fog.

MODERATOR EVERETT: We have just installed at Rancho Santa Ana Botanic Garden both a mist and a fogging system - and we're beginning to look very favorably toward the fogging. We get away from certain deposition of salts on the leaves and defoliation of our cuttings that way. We haven't carried it far enough yet to know yet with the growing of our California native plants whether this is going to be satisfactory, but it looks very favorable at the present time.

MR. GEORGE OKI: We put in a high pressure mist for temperature control, thinking that by putting in high pressure mist or high pressure fog that we could lower the temperature. When you first turn it on it cools off the house from 110 down to about 90. When the humidity builds up, then the temperature rises quickly.

MODERATOR EVERETT: One disadvantage we found in the mid-summer was just the same sort of a thing. We have also an evaporative cooler and when the fan came on for the cooler it blew all the fog out. Paul Moore, we have a couple of questions for you. How do you treat large acreages with methyl bromide?

MR. PAUL MOORE: We use injection. Our tractor mounted injection equipment has ten shanks spaced twelve inches apart on a regular tool bar. Two trips across the field fumigates a strip which can be covered with a twenty foot tarp. The fumigant comes in steel pressure cylinders. A tank of nitrogen gas is used to pressurize the tanks of fumigant.

After determining the required dosage, which for us is 175 lbs. of actual methyl bromide per acre, we calculate the proper tractor speed, tank pressure, and discharge orifice size to use at the shanks. The fumigant is injected eight inches deep. The shank openings in the soil are closed by a drag. Immediately following the injection, the treated area is covered for 24 hours with a plastic tarp sealed at the edges by covering with dirt. On the following day we inject another strip and flip the tarp over the newly treated ground. This is repeated, moving across the field until it is completed. We use four tarps 20 feet wide and 800 feet long in fumigating our nursery ground.

VOICE: Do you use straight methyl bromide or methyl bromide - chloropicrin mixture?

MR. PAUL MOORE: We have been using straight methyl bromide, in the form sold under the trade name "Weedfume". The material is 69% methyl bromide - the rest a petroleum solvent. This year we have a condition that we think may be benefited by using a methyl bromide - c chloropicrin mixture. The method of application will be the same.

MODERATOR EVERETT: We have one more for you on the subject of fumigation. What is your impression of Vapam for pre-plant fumigation of citrus sites for the control of Phytophthora and weed seeds?

MR. PAUL MOORE: For replants in old citrus orchards there has been some unfavorable experiences with Vapam. These cases have occurred where small areas - 6' x 6' - have been treated. Under these conditions it is easy to recontaminate the sterilized area. Phytophthora really goes to town once it comes back into fumigated soil. This is less likely to happen where large areas are treated. I have not had any immediate experience with the use of Vapam in treating large acreages except through observation. It is my personal opinion that it is a little more difficult to apply than methyl bromide. It must be applied in water, either in flooded basins or through sprinklers to be effective. I would favor methyl bromide because of the ease of application. I really don't know what the comparative cost is, but considering only the general operations, I prefer the ease with which we can inject and tarp.

MODERATOR EVERETT: We have liked the use of Vapam, not in large areas, but in treating specific spots. We have had a great deal of trouble with plants rotting, a root rot, (Phytophthora), and by applying Vapam to the area after the plants have been cleaned out, we have been able to go back and replant and the plants grow very vigorously and do much better.

Ted Frolich, we have a number of questions for you. First one, does the etiolation technique cause rooting in any other species considered difficult or impossible to root, for instance, eucalyptus or strawberry guava?

MR. TED FROLICH: I've not been able to etiolate eucalyptus. We've tried it. We couldn't get it to grow in the dark - and the strawberry guava, I haven't worked with, but I'd guess it's pretty close to the eucalyptus. Etiolation has been listed as working in apples, pears, I think mulberry, persimmon, camphor, plums - a good many things. I don't know anyone who has rooted eucalyptus very successfully by any method.

MODERATOR EVERETT: You should have read the last Newsletter; I believe it was edited by Mr. Challenger of New Zealand, in which they talk about rooting eucalyptus with abandon.

MR. GEORGE SPAULDING: I believe that Frances Cheng of the Arboretum staff has been able to get callusing but never root formations.

MR. STAN SPAULDING: I recall when I was a student at UCLA under Dr. George Ryan we discussed the subject of juvenility and its effect on the wood that we used for the rooting of stem cuttings, that on some plants the juvenile wood was much superior than wood that was taken from older plants or which possessed an adult leaf form. Now I was a very good friend for many years, and hope I still am, of Walter J. Husband and in my enthusiasm when I discovered this phenomenon of juvenility in plants, right away I discussed this with Mr. Husband and attempted to stimulate him in trying this on eucalyptus. So we proceeded to take stock plants and cut them off close to the ground and induce heavy suckering from the base and in most cases the new foliage was the seedling leaf. Now in the case of Eucalyptus ficifolia he had some success although I wouldn't call his percentages commercially profitable. These little tests that were conducted with Mr. Husband back a number of years ago occurred in small propagation glass houses. The benches were covered with sash, possessed bottom heat, and growth regulators were used. The wood was tips, terminal shoots which were rising in the base of older trees that had been cut back sharply close to the ground.

MR. TED FROLICH: Actually there was a report from the Boyce Thompson Institute in Arizona of eucalyptus rooting. We had not too long ago reports from both New Zealand and Australia that they could root eucalyptus. When anyone asks me about eucalyptus I immediately think of ficifolia because this is the one that everyone is trying to root in our area.

MODERATOR EVERETT: Is there a list of plants on which propagation by etiolation has been successful?

MR. TED FROLICH: It will work on a great many plants if you can get them in to grow in the dark. This is not possible with all. Well, for instance, to grow a plant in the dark we sometimes have to have a very large root system under it and then we can get it to grow in the dark when we couldn't when we had a small root system under it. However, if we get too large a root system, it pushes so fast again that we don't get rooting. You're working in a very narrow range. It's pretty ticklish, Iwouldn't want to make any predictions.

MODERATOR EVERETT: On what kinds of plants has etiolation been used - hardwood, softwood? Does time of year or temperature exert much effect?

MR. TED FROLICH: They have to develop in the dark, so they're plenty soft when they are being processed. Temperature - I wouldn't know. It doesn't seem to be a factor, except that you can get very heavy fungus infections in the dark at certain temperatures that you wouldn't get at the same temperatures in the light. A real epidermal layer does not form on these etiolated shoots. Any fungus that comes along will just work them over good.

MODERATOR EVERETT: Dr. Alley would like to know in your etiolation of avocado shoots with a tar paper collar, would the application of indolebutyric acid at the base of the young succulent shoot assist in rooting?

MR. TED FROLICH: We haven't tried this. We don't know whether an etiolated shoot would respond to hormones or not. We do know that the green shoot in an avocado will not.

MODERATOR EVERETT: Will long-day treatment or light treatment help break dormancy in woody plants?

DR. PIRINGER: We cannot make a generalization. We can base our answer only on specific plant materials that we have. This simply says that it depends on the plant material. In the case of Catalpa, as I mentioned, long days will help break dormancy if we catch it before the plant becomes - I don't like that word "dormancy" - I'll use the word "quiescense" because that covers up a lot of evils. Short days will make the plant quiescent and, in the case of Catalpa, if it becomes quiescent, we see this by the necrosis or the death of the terminal. If we put the plant on long days, within two weeks after we see this, we will get bud break from axillary buds. If we wait more than two days the plant really goes into a deep quiescence and then it requires a cold treatment. In the case of the birchs a short day will make the birch dormant or quiescent. Now if we put it on long days we can break the dormancy or the quiescence of the axillary buds but not of the terminal buds. To break the terminal buds we have to get a cold treatment. Again with the maples, if they are made dormant with short days, we can, in some cases, break that dormancy with long days if we get it early enough. If we wait too long, again it takes cold to break the rest. So it depends upon the plant material with which we are dealing. Again our experience is based only on plants that have been made dormant with short days. We do not have much information on this with plants that would have been made dormant say, for example, with low temperatures. I would say this -- we have had experience with Poncirus trifoliata, a hardy orange, which is used as a barrier plant in the Washington, D. C. area and farther north where it does become dormant over the winter. It is deciduous. It does lose its foliage, and yet we have had plants for about 3 to 3 1/2 years now at 70°, 8 hour days that have not become dormant. They have grown more slowly. They have retained their leaves. They flush very slowly but they still keep going, so in the case of P. trifoliata, it is not day length that makes them dormant but low temperatures. After the low temperatures, if we put them on long days, then we have no trouble. They start growth right away.

VOICE: You're not saying that this photoperiodic response can be accepted by parts of the plants without leaves, are you? In other words, you wouldn't wait until the leaves dropped off; you can't affect the plant then, can you?

DR. PIRINGER: That's right, these are plants that have always had their leaves.

VOICE: It has no effect on the woody plant without leaves?

DR. PIRINGER: No.

MODERATOR EVERETT: Ladies and gentlemen, I think we shall bring this session to a close. It has been very fruitful. I know the clapping is for all the experts who gave of their time this evening. We certainly are most grateful to you people and to you gentlemen who shared so freely with your experiences and your knowledge. That's the very wonderful thing about this society, this give and take, the sharing of our experiences and our knowledge for the betterment of the profession.

FRIDAY MORNING SESSION

October 27, 1961

The session convened at 8:45 a.m. with Mr. Dennison Morey, Director of Research, Jackson & Perkins Co., Pleasanton, California, as Moderator. This session was concerned with the propagation of certain selected plants.

PROPAGATION OF SELECTED PLANTS

Dennison Morey
Jackson and Perkins Co., of California
Pleasanton, California

Last night as I was putting the finishing touches on my introductory remarks I suddenly realized that I had assumed an obligation that was going to be difficult to fulfill. In moderating the final symposium I have accepted, at least in principle, the responsibility for trying to pull things together. Since we are going to deal with practical solutions to difficult problems, my task as I see it, is to try to provide some basis for integrating the vast amount of knowledge which has been presented to us here so far so that it can be evaluated on the basis of experience. This is not an easy thing to do. We have had a unique privilege here. We have stood on the frontiers of science with genuine pioneers, a rather hazardous place for green troops, as the inadequacy of some of my own questions attest.

Fortunately, my prepared remarks seem to be still appropriate. I feel that a tremendous volume of fundamental information has been presented at this Conference. If all of this information is put to work, many of our problems will be solved. Moreover, if we consider what our speakers tell us today in light of what has been said so far, I believe we may discern a few answers to general questions as well as finding practical solutions to specific problems. I also believe that this pragmatic integration can best be made if we employ the convenience of a working hypothesis. It is my own opinion, at the moment, that the recent concept of auxin action proposed by Kefford and Goldacre (1) provides the best available means of making this integration. However, please bear in mind that this idea is not universally accepted. For a detailed rebuttal see Hillman and Purves (2).

Under no circumstances will I enter into the controversy. I don't know enough to do so. However, I do know that the scheme of Kefford and Goldacre best fits my own observations of plants. Consequently I feel that this idea may be useful in thinking about propagation problems, both for myself and, since you are also primarily concerned with application, it may also prove of interest and value to you.

Rooting Difficult Materials

I believe that the auxin concept and the hypotheses proposed by Kefford and Goldacre (1) are of immense practical as well as theoretical importance to the plant propagator. An appreciation of the possible interactions and intricate competition for precursors among auxin (IAA), kinin (kinetin), 6- (furfurylamino) -purine and n, 6- bensyladenine (Shell 4901) and gibberellin, has fundamental significance for all of us.

I believe this even though we cannot exclude the probability that new agents will be discovered which influence growth and development in plants and which will further alter our thinking in these matters. To my mind perhaps the greatest value which these ideas have for us is the stimulation they provide. No discovery in plant science is without practical value. Moreover, progress has invariably been realized first and in greatest degree by those who apply theory to practice to the fullest possible extent. Very often great practical strides have been made by simply appraising theory in the light of current practice. This approach is particularly productive if one makes a well informed effort to understand the way in which an especially difficult practical solution integrates with all known facts and enlightened theory.

This morning, therefore, we have an unprecedented opportunity. We are going to hear about techniques which have proven fruitful in the rooting of especially difficult materials. I think that if this information is carefully considered in the light of auxin theory, and facts obtained empirically (for which see the references at the end of this article) plus our own experiences, we will have assembled the essential tools for impressive progress.

I should not be surprised to see all plant materials that root at all from cuttings, easily rooted in high percentages within ten years time. Certain extremely difficult clones of walnuts, stone fruits, maples and other recalcitrant materials such as *Gymnocladus*, *Eucalyptus*, etc., now budded or grafted or grown from seed, not because of faulty root systems or transplanting factors, but because of rooting problems, will soon become as easy to root as *Chrysanthemums* and *Coleus*.

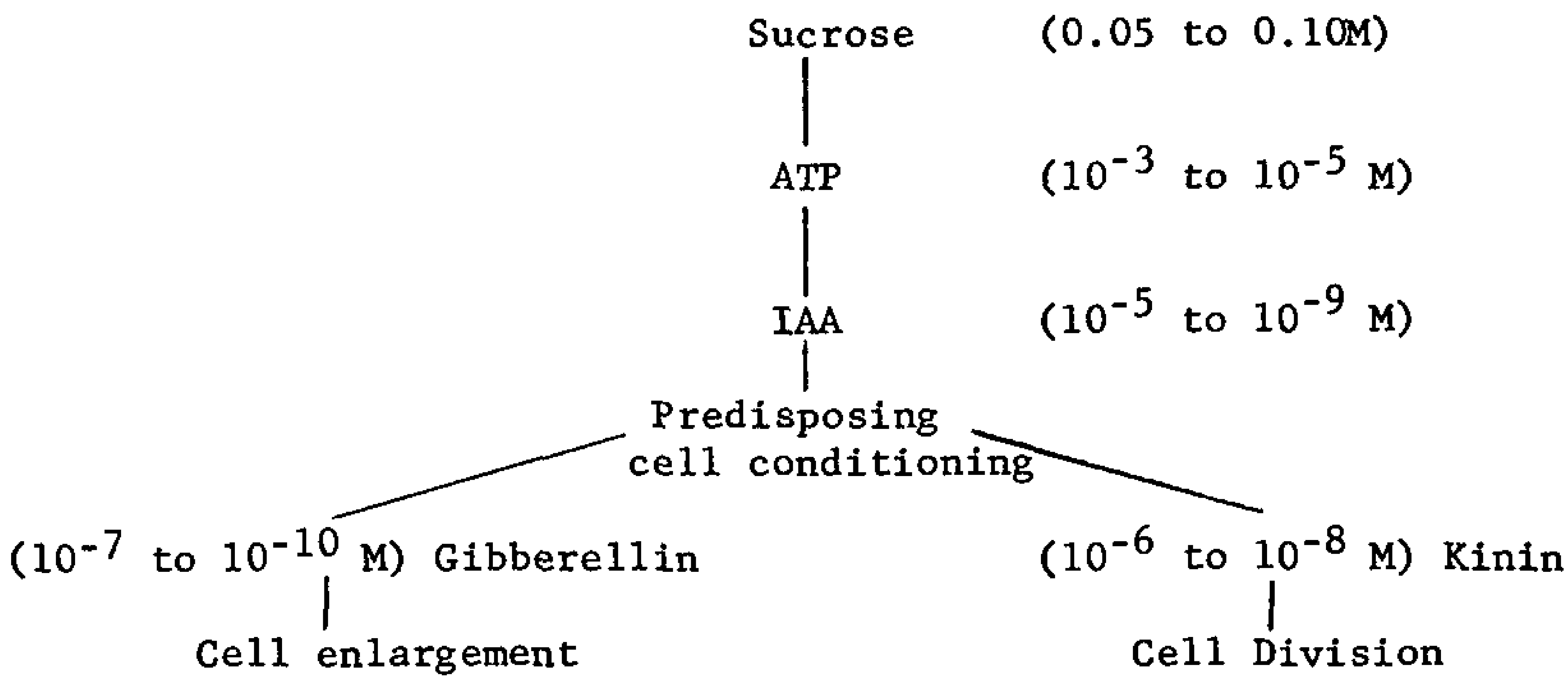
Perhaps it would be well to consider the hypothesis of Kefford and Goldacre for just a moment. They feel that the evidence presently available indicates that IAA and other related auxin-like materials such as NAA and IBA mediate both the action of gibberellin and kinin (kinetin). Since the former is concerned with cell enlargement and elongation and the latter with mitosis and cell division, these authors conclude that there may be, and often is, competition between these two independent systems for IAA and/or the systems involved in its utilization.

Obviously, cell enlargement (gibberellin) can proceed only so far in the absence of cell division (kinin) and vice versa. See Sachs and Lang (3). Neither can function without energy and auxin (IAA). We can conclude that the function of IAA and other similar compounds in rooting is to enable the gibberellin and kinin-mediated processes to proceed.

There appear to be three basic systems that must function before rooting can occur. Perhaps the most troublesome one at the moment, as far as rooting is concerned, is the kinin system. I think practical experience strongly supports this view.

In materials that root poorly, auxins are often of little value, but once rooting has been initiated the roots grow. Well, the problem seems to be one of root initiation; ie., the origination of new root meristems. Basically this must be a problem of cell division and differentiation. If Kefford and Goldacre are correct, a kinin system must be involved.

They propose the following reaction paths:



I feel that it would be a serious error to identify kinin with any specific substance. I feel each morphogenic phenomenon in plants may have its own special kinin. Instead of equating kinetin or bensyladenine as the kinin in question in rooting, until we know for sure, I would prefer to think of it as "Rhizogen".

My final preliminary thought in this connection is induced by the suspicion that the relative efficacy of the several auxin-like materials and the various mixtures of these materials (e.g. IBA with 2, 4, 5-TCPA) may very well depend upon the predisposing of the overall system in such a way that the proper equilibria are achieved.

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PROPAGATION OF JUNIPERUS CHINENSIS TORULOSA

Julius Gorman
Leonard Coates Nurseries, Inc.
San Jose, California

Juniperus chinensis torulosa is an upright juniper. It's common name is Hollywood juniper - it has a very vigorous growth. The plants are hardy and will take considerable cold weather; they like to be grown in a sandy, loamy soil, but are really not particular. They also like a sunny location. They can either be propagated by grafting or cuttings. Grafting is expensive so that's why the Leonard Coates Nurseries started trying to root them from cuttings. We tried them the regular way, just putting them in a greenhouse with bottom heat, but had very poor luck. In October, 1959, we started a couple of flats which were put directly outside, with the idea of stimulating rooting by letting them stay outside for some time. But then we noticed callusing on the cuttings in about three or four months, so we decided we'd do a little experimenting with them. We took them back inside - to the potting shed - and treated them with Hormodin 3 and put them this time in the greenhouse with bottom heat and then they rooted very well. This gave us something to work on. So on October 28, 1960, we started taking cuttings from plants in five gallon cans from stock plants that had nice fresh growth with one year old wood which was growing well; the branches were rather long and we could get three or four cuttings from each one.

Also we would prune the plant and shape them at the same time. We first started from the tip working down the stem, making the cuttings 3 or 4 inches long, putting them in the mixture of two parts very coarse sand and one part peat, but without any kind of hormone. Then we took them directly outside into the lath house and let them stay until they started to callus, which takes about four months. We left ours a little longer than that because we couldn't get around to bringing them back in to give them the other treatment. On May 10, 1960, we brought them back in and started taking them out of the flats, breaking off the calluses. Some of the callus was quite large while some cuttings didn't have any. Anyway we dipped them all in Hormodin 3, then started resetting them into the same flats we'd taken them from. We took them this time to the greenhouse and put them on bottom heat at about 78° to 80° F., letting them stay about 60 days when they were ready to pot. But we don't like to pot directly out of the greenhouse so we took them outside into the lath house again to harden off. It was September 1 before we got around to potting them up. Then we came out with about 60-65% rooting.

Almost all the others that were not rooted were still in good shape, so we again dipped them into the Hormodin 3 (the ones that were not rooted), put them back into the greenhouse on bottom heat again. At this time (October) they are starting to root again, so I'm sure that we'll come out with about 75% rooted. That, for us, is pretty good. Probably everybody else does better. I don't know. Anyway, that's the way we did it this year.

Next year we might do it differently. I know there are several things we'd like to do differently. The tips do not root as well as the secondary cutting underneath the tip, so next year we probably won't make so many of the soft cuttings. The farther down the stem, the better they root, it seems to me. Down the sides we make some almost as big as a pencil and they rooted also. I said in the beginning that coarse sand and peat would work good. There's several other things you could use. We experimented with some granite grits. In peat they do well. Small pea gravel works just as well. The only thing you want is real good drainage when you put them out to stay out through the winter rains. You have to have good drainage.

MR. MARTIN USREY: Julius, did you have them in a cold frame to begin with?

MR. JULIUS GORMAN: No, they were started directly out in the lath house.

VOICE: Where did the roots appear on the cutting after the callus had formed?

MR. JULIUS GORMAN: About a quarter of an inch up the stem, not on the bottom.

MR. HERMAN SANDKUHIE: I know on Juniperus chinensis pfitzeriana we have noted that by scraping the sides of the cuttings we can initiate roots down the side. I think this is brought out by Wells in one of his publications.

MR. JULIUS GORMAN: We tried that on torulosa earlier but it didn't make much difference. We tried wounding.

MR. HERMAN SANDKUHLE: What type of greenhouse or prop house do you operate in - is it a closed house?

MR. JULIUS GORMAN: It's a closed house, yes - with high humidity all the time, but not under mist.

MODERATOR MOREY: I have just one question. Do you feel that the time of year and the conditions prevailing during the time that they're rooting is important, or could you switch the thing around any time that you can get cuttings?

MR. JULIUS GORMAN: I don't think you could. I'd like to try that. I don't think you could change it at all. We tried so many different ways before, that I'm sure that you'd have to stay pretty close to these conditions and this time of the year.

MODERATOR MOREY: Do you feel that the condition of the plant that you're taking cuttings from is important?

MR. JULIUS GORMAN: It is. Anything that's fast growing. Not real fast, but it has to be one year growth.

MODERATOR MOREY: We're back to this juvenile business again.

The next item is another juniper, Juniperus conferta, a prostrate juniper. Mr. William Tomlinson will speak on this subject.

PROPAGATION OF JUNIPERUS CONFERTA

W. M. Tomlinson
Select Nurseries, Inc.
Brea, California

Juniperus conferta, commonly called Shore juniper, was first introduced into the nursery trade in 1915, its native habitat being Japan. The Shore juniper obtains a maximum height of 18 inches and usually has a spread of between four and five feet, making an informal mat of blue-green foliage.

This juniper is one of the best low-growing ground covers for sea shore or dry, sandy situations in the coastal areas. It will withstand salt water spray, and even some submersion, exceedingly well. It also has been used quite extensively the past few years in rock gardens and mound plantings. The Shore juniper grows best in full sun and withstands most coastal and inland weather conditions. Through our past experience, however, we have discovered that it will not grow in the hot desert areas of our state.

In the propagation of Juniperus conferta in Southern California, we have found that cuttings taken from the middle of December to the middle of January root much faster and in higher percentages than those taken at other times of the year.

In our propagation, we use the tip growth from strong, healthy mother plants, making only two cuttings from each tip. Usually the wood is obtained in our nursery from five-gallon container plants which are then sold the following spring. We also have observed that by taking the cuttings from five-gallon container plants which have been properly fertilized, sprayed and watered that our cutting wood is much superior to that which we can usually obtain from outside our nursery. We make our cuttings about two inches long and strip the foliage about half way up the cutting. This causes injury along the stem, which proves to be beneficial in the rooting process, especially if we use a "hormone" powder.

After the cuttings are made, they are submerged into a Fermate dip, then removed, allowing the excess Fermate solution to drip off. The basal ends of the cuttings are then treated with Hormodin #2 powder, with the excess being tapped off. We have found from our past experience that the use of Hormodin #2 powder on Juniperus conferta has consistently given us a better percentage of rooting with the type of wood we use. After the cuttings are dipped into the powder, we put them into 18" X 18" sterilized flats, planting approximately 250 per flat. The flats contain a rooting medium of one-half sterilized peat moss and one-half perlite. We do not, however, sterilize the perlite as it is already a sterile medium. This mixture is first premixed in a large tub containing water so that the peat moss is thoroughly saturated before the flats are filled.

We have conducted numerous experiments using different propagation media (besides the 50% sterilized peat moss and 50% perlite) in the propagation of Shore juniper; however, this mixture has proven to be the best for our conditions, consistently helping us to obtain a higher percentage of rooted cuttings than with other media.

At this time I would like to explain briefly the precautions we take to insure that our cutting wood is kept clean; I feel this is of the upmost importance in the successful propagation of Juniperus conferta as well as any other type of cutting propagation. The propagators working in our propagation department are constantly kept alert to the importance of having a clean propagation area. Their tools, such as knives and shears, are cleaned twice daily in a calcium hypochlorite solution. All our flats are steam-sterilized and, of course, as I have already discussed, our rooting medium is sterile. Everyone is constantly watching that his tools and propagation wood are not in contact with anything that would cause contamination. We also store our cutting wood in wooden boxes on pallets off the floor until the wood is ready to be used; by doing this, the cutting wood is kept as clean as possible until it is used. Each girl works at individual clean, galvanized steel tables where she makes the cuttings and "flats" there herself. Every evening the tools, cement floor, and benches are washed down again with a calcium hypochlorite solution. We have found that by maintaining a clean propagation department, it has given us a considerably higher percentage of rooted cuttings as well as a more over-all efficient propagation department.

After the Juniperus conferta cuttings are "flatted-up" they are moved into intermittent mist fiberglass greenhouses. As these houses are quite different from any of the standard mist greenhouses around, I would like to explain them in more detail. The houses are eight feet wide and 40 feet long. They are constructed by using 2" X 12" redwood. The two by 12's are laid so that the bed is 12" high. This 12" high area is filled with four or five inches of coarse rock, then approximately 2-1/2" of sterilized sand. We next install an Ever-Warm heating cable which is 1100 feet long into the bed. We have found that this type of heating cable will give a more even heat throughout the bed, than other types of heating cables currently available. The cable is spaced approximately three inches apart and then covered with a 1-1/2" layer of sterilized sand. The two ends and roof are then covered with fiberglass panels; the roof having an ultimate height of seven feet. The sides are constructed of polyethylene so that they can be rolled up for ventilation, hardening-off and inspection of the cuttings. The mist system we use in these houses is of the intermittent type. We use two parallel 3/4" galvanized pipe lines, approximately 60" above the flats, for our mist lines. Number 1101 T-Jet nozzles are installed in these lines, being spaced on 40" centers. For the most satisfactory mist pattern, we operate the nozzles at 180 pounds of water pressure. Each of these houses will hold 125 of our standard flats. We have used this type of fiberglass greenhouse and mist system for over three years and have observed that they are as satisfactory as our standard glass propagation greenhouses; however, the construction cost is much less.

After the Shore juniper cuttings are placed under the mist, the automatic time clocks are usually set so that the mist is turned on at 9:00 a.m. and off at 5:00 p.m. This, however, may vary depending on our local weather conditions. The mist is normally on 12 seconds out of every six minutes, however, this again varies according to our weather conditions. With this light misting, a constant temperature of 80° F. at the bottom of the flats, rooting takes place within five or six weeks. From 50,000 cuttings made this year we were able to root 86% by this method.

In hardening-off the rooted cuttings, we gradually decrease the mist and adjust the polyethylene sides to allow for ventilation. After approximately fifteen days, the mist is shut off and hand watering is done as needed. We usually allow 21 days from the time the cuttings are rooted until they are hardened-off.

Our procedure for potting the rooted cuttings is as follows: We use a potting medium of 50% sharp sand and 50% peat moss. To this media, we add hoof and horn fertilizer. The potted Shore junipers are then transferred into a lath house, where they remain approximately six months. They are then sold as finished liners or canned into one-gallon containers.

MODERATOR MOREY: Where do you get hoof and horn fertilizer these days?

MR. HERMAN SANDKUHLE: Northern California Fertilizer in San Jose, California has it.

MODERATOR MOREY: Another question is: Why do people in Southern California think that an 18 X 18 flat is standard? That's something I never could understand. I think 14 X 22 is a little closer to it.

MR. CARL SCHMIDT: The fiber glass on your greenhouses, is it clear or do you use the white type?

MR. WILLIAM TOMLINSON: It is white - not clear. We used to have the houses made out of polyethylene, but it seemed like right in the middle of winter we would get a big rain and the polyethylene would rip; we have also found that with fiber glass, it holds the temperature better. You can adjust the light a little better with it due to its chemical composition and also there's no repair on it at all.

MR. CARL SCHMIDT: What is the brand of the heating cables that you are using?

MR. WILLIAM TOMLINSON: Ever-Warm. It's made in Chicago, and it was originally made for radiant heating of houses. They put it in cement floors and walls. We thought if we could find some type of cable where we could put a thousand feet or so into a bed from one electrical outlet we'd get a more even heat, and this has proven true. It's just the size of a regular wire and covered with plastic. It has a built-up resistance in the copper wire.

MR. MARTIN USREY: Bill, would you go into a little more detail on the hardness of the wood of the cuttings you took?

MR. WILLIAM TOMLINSON: Well, the wood isn't real hard. It's the tip growth. From this tip growth we get two cuttings. We haven't had too much of a problem with Juniper conferta and I think it's this misting that has helped us. With other junipers we have had a problem with misting but the Shore juniper will probably stand more water to begin with than most of them.

VOICE: How do you strip - I know on conferta the needle-type leaves are awfully hard to pull off. How do you strip these?

MR. WILLIAM TOMLINSON: They're stripped, or pulled, by hand. Usually our girls have a rubber protector they can put over their thumb, such as secretaries use for sorting papers and they just strip the leaves off by hand.

VOICE: Bill, there's several varieties of conferta. Which one do you propagate?

MR. WILLIAM TOMLINSON: I was afraid that question would be asked.

VOICE: One variety is much easier to root than the other varieties.

MR. WILLIAM TOMLINSON: I don't know. I think that really in the trade we've got them mixed up. I've seen what I think are two or perhaps three or four different types. They're all clones. We grow one that doesn't burn out in the sun and I think it might be a little easier to root than some of these other clones. I know that there's one clonal type that burns a lot in the sun. I think that's a little harder to root. I don't think it's commercially as good a plant as the one that we are using now.

VOICE: Why do you take the cuttings in the winter time?

MR. WILLIAM TOMLINSON: We've tried to make them in the summer, the spring and different times of the year; it seems that our highest percentage have been obtained in the winter. Also in the winter there isn't too much else we can cut besides the juniper; it's just always worked out as a better time of the year for us.

MODERATOR MOREY: The next material to be discussed will be Ceonthus griseus, var horizontalis 'Yankee Point', by Gerd Schneider, Saratoga Horticultural Foundation, Saratoga, California.

PROPAGATION OF CEANOTHUS GRISEUS HORIZONTALIS 'Yankee Point'

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MODERATOR MOREY: The next material to be discussed will be Ceonthus griseus, var horizontalis 'Yankee Point', by Gerd Schneider, Saratoga Horticultural Foundation, Saratoga, California.

PROPAGATION OF CEANOTHUS GRISEUS HORIZONTALIS 'Yankee Point'

Gerd Schneider
Saratoga Horticultural Foundation
Saratoga, California

Ceanothus griseus horizontalis, 'Yankee Point', originated as a variant in a population of about four thousand seedlings. The seed was collected in the native stand of Ceanothus griseus horizontalis at Yankee Point, south of Carmel, California.

This clone grows about 2-3 feet in height and spreads as much as 8 feet. If planted on level ground, the plant will reach its greatest height at the center, and the side branches gradually slope toward the perimeter of the plant, almost describing a circle. If planted on a slope, the branches will follow the structure of the terrain, often exceeding 10 feet in spread but not more than 12" to 16" in height.

The color of the flower is a deep blue, surpassing by far the flower quality of Ceanothus horizontalis, 'Hurricane Point'. The blooming period extends from March to May. Ceanothus 'Yankee Point' tolerates a wide range of environments. A sandy loam soil with good drainage and, in the inland areas, partial shade provide good garden growing conditions. Five to six applications of a reasonable amount of water during the summer maintain the plant in active growth, and may cause it to bloom a second time in the early autumn.

Ceanothus 'Yankee Point' is propagated most successfully by cuttings. In determining when the cuttings should be taken, we are guided by two main considerations: First, the time necessary to grow a saleable plant with a view toward the best selling season; and second, the condition of the cutting wood.

The time necessary to grow a plant to a one-gallon container size is as follows: From the date the cutting is taken to the time of potting, eight weeks; the liner stage, six to eight weeks; and ten to twelve weeks to grow a saleable plant in a one-gallon can. This adds up to about 25 weeks - the minimum time required to grow a saleable plant. The main sales period is in February, March, and April. A somewhat smaller number of plants should be available from October to January. For the rest of the year a fairly small supply should be sufficient to satisfy the demand of the market.

According to this time schedule, cuttings are taken in early September, in early May and in January. At all three periods we use a terminal soft-wood cutting taken from vigorously growing plants in containers. Cuttings taken from field plants have failed to produce satisfactory rooting results.

The rooting medium in our operation is pure, ungraded Sponge Rok (perlite). However, some of our latest tests give us reason to believe that, at least in September and January, the addition of peat moss in the proportion of 1:4 may improve the average percentage of rooting.

All of our cuttings are rooted in a conventional greenhouse equipped with bottom heat and a mist system. After the cuttings have been prepared for setting, by removing the lower leaves, they are dipped for 5 minutes in a 1:10,000 solution of Morton Soil Drench C. The highest percentage of rooting was obtained with the use of Rootone.

All cuttings are rooted under intermittent mist. It is quite important for us to keep the humidity very high, since the cuttings taken from actively growing plants are soft at all times of the year. We try to adjust the timing apparatus of our mist system to the climate of the season, particularly during the fall propagation period.

The January set of cuttings receives from 200 to 250 seconds of mist a day; the May set receives approximately 2000 seconds a day; and the September set, considering seasonal changes and the relative instability of the weather, from 100 to 650 seconds a day. These quantities are applied when the daily light and temperature supply is at its highest.

The most difficult crop of cuttings to root and to get established as liners is the one taken in May. During this period we usually experience very hot weather. Also, special efforts have to be made to harden-off the rooted cuttings before they can be transplanted.

The average percentage of rooting lies between 60% and 80%. Cuttings taken in January are ready for potting after 8 to 9 weeks. Cuttings taken in May will root much faster. However, potting cannot be done before about 10 weeks, due to the hardening-off period which is extremely important at that time. As a result of this, we arrived at the conclusion that the best single period for the propagation of Ceanothus 'Yankee Point' is in September, and this for several reasons:

(1) The climate at that time is such that a favorable temperature and humidity can be maintained in the greenhouse without too much effort in heating or cooling the propagation house.

(2) Rooting takes place in a very short period, 5-6 weeks, and there is very little need for a hardening-off period.

(3) With the time table as outlined above, plants propagated in September are saleable and in the best condition for planting at the time of the biggest demand.

MODERATOR MOREY: Have you tried supplemental light in your winter cuttings?

MR. GERD SCHNEIDER: No, we have not.

MODERATOR MOREY: Do you think it might be useful?

MR. GERD SCHNEIDER: Yes, I think it might.

MR. MARTIN USREY: Gerd, you said that at times you have poor success with your system. Why?

MR. GERD SCHNEIDER: Since Ceanothus is extremely susceptible to Rhizoctonia we find at times that our cleanliness program has not done a perfect job and a number of cuttings are rotting. This can become very serious because our cutting material is always fairly soft.

MR. MARTIN USREY: Are your methods always the same for all Ceanothus?

MR. GERD SCHNEIDER: Yes, they are.

MR. HERMAN SANDKUHLE: Gerd, is it practical to hold liners at your optimum time of rooting; that is, could you develop enough liners that you could then stagger out for your staging of your crop? Is this possible? Or do you have liner problems?

MR. GERD SCHNEIDER: The fact that we are using peat pots is one reason why we like to keep our liners moving right along. Most Ceanothus show very vigorous root growth and cannot be kept in liners too long.

MR. HERMAN SANDKUHLE: You don't think it is practical. It is better to root and go on, rather than trying to make one batch.

MR. GERD SCHNEIDER: Since we do not grow too many different crops, we would rather stagger them.

VOICE: Are you using a hormone?

MR. GERD SCHNEIDER: We have good success with Rootone.

VOICE: What size cuttings do you take?

MR. GERD SCHNEIDER: We take terminal softwood cuttings, about 5" long and we retain 4 to 5 leaves on top.

VOICE: Do you just take one cutting per branch, say you take them off a gallon can.

MR. GERD SCHNEIDER: We take one cutting from each branch, and as many tips as there are.

VOICE: Do you use a knife for cutting or pruning shears?

MR. GERD SCHNEIDER: We make all our cuttings with pruning shears; 25 cuttings are taken and then cut to one length at one time before they are dipped in the rooting powder.

VOICE: Do you use a fungicide?

MR. GERD SCHNEIDER: All cuttings are dipped for five minutes into a solution of Panogen. (1:10,000) prior to the hormone treatment.

VOICE: How much shade do you use on your greenhouse, do you try to keep it very light or do you shade it quite a bit?

MR. GERD SCHNEIDER: We try to keep it clean from November to March. During the rest of the year we put on a light shade.

VOICE: How do you harden your cuttings off?

MR. GERD SCHNEIDER: Since we usually have more than one crop in the greenhouse which are ready for transplanting at different times, we cannot gradually reduce the amount of water for all cuttings. We therefore have installed a small outdoor mist system, where we move the rooted cuttings for a hardening off period.

MODERATOR MOREY: Thank you, Gerd. We will now hear from Mr. F. S. (Olle) Olsson of Monrovia, California, who will discuss the propagation of Xylosma.

PROPAGATION OF XYLOSMA

F. S. Olsson
Monrovia, California

Cutting Materials: Wood for cuttings should be taken from healthy plants that have attained a spring growth of 6 to 8 inches. Remove the soft tip down to the first mature leaf, then begin taking cuttings down the stem. We cut the leaves in half but that's mainly because we stick 400 to the flat.

Hormone: Hormodin No. 2 - we have had very good results with this. The media is 3 parts Sponge Rok, one part peat moss mixed with water in a tub. The media is packed around the edges of the flat and leveled off. The cuttings are placed in intermittent mist house. Our largest house is 100 feet long, with a capacity of 150,000 to 200,000 cuttings. The house has 50% saran shade on top, a 6 mil. polyethylene on that. One wall is nine feet, the other wall is six feet high. We leave an opening on the highest wall in the summer so the heat can escape. In the winter it is completely covered. The mist is controlled by two 5-minute timers, one for each half of the house. They are connected to a 24 hour timer, which turns them on in the mornings and off at night. We do not have bottom heat. Our first crop of *Xylosma* cuttings was made and placed in the mist about the middle of June. Our rooting percentage of this crop was 60-70%. The second crop was made and placed in the mist approximately five weeks later. The results were very poor and we feel that this was due to a hot spell that we had at that time. We find that the biggest enemy to *Xylosma* is too much heat. Our third crop was put in about the middle of August. We had very good results, probably 80-90% rooting at this time. They are still in the mist house.

We do all of our propagation of *Xylosma* in the summer. The cuttings begin to root in about 3 weeks, but take at least 6 to 8 weeks before you have a high percentage. If you have a big percentage of new growth on your cuttings, you have a better chance of bringing them on. Cuttings that have roots and no leaves will not live. We have found that they will never "break". The hardening off of this variety is trickier than rooting it. We take them out of the mist houses and place them in our cold frames. The sashes are covered with plastic and the frames are shaded with 90% saran shade. We keep them closed for 3 or 4 days, then the sashes are gradually raised to give air. They are hardened off for 3 to 4 weeks. We pot the rooted cuttings in square plastic pots.

Potting media: 1 part plaster sand, 2 parts peat moss and a small amount of hoof and horn. After potting they are placed in the mist house again. In about 3 weeks, about 70% are growing with short roots. We sort them and transfer the ones that are growing to our saran house. In hot weather we hand spray every 45 minutes in the middle of the day. We keep the potted *Xylosma* in flats, on benches, to keep them dry. You stand a good chance of losing them, even as a ready liner, if you get too much rain in the winter. If it is a very wet season, we do not hesitate to move them out of the saran house into the open, so they will dry out faster.

MODERATOR MOREY: Where exactly do you get your cuttings - from your liners, from gallon cans, from stock, or from other plants?

MR. OLSSON: It's a very common item, as you probably know, in southern California. Sometimes we get our cuttings from our own customers because at least 50% of our liners are sold on contract ahead of time, so our customers would be very glad to let us prune their plants in cans, use our labor, and take the material home instead of spending their own time, and then they get the first chance to buy liners.

MODERATOR MOREY: The second question is how much blood meal do you use in your feeding?

MR. OLSSON: Being in wholesale, as we are, I try to make them grow fast; we use a handful to a flat and a half; we go over it very quickly, broadcast it, and then water it down.

VOICE: Do you take tip cuttings or below the tip?

MR. OLSSON: We always cut the tip out because this is during the growing period, so you have a very soft tip with light colored foliage. As I said, when you get to that shiny dark green leaf color - from then on we take cuttings on down the stem.

VOICE: How long should the cuttings be?

MR. OLSSON: They are usually two nodes, sometimes three.

VOICE: Ours always defoliate. What do we do wrong?

MR. OLSSON: I used to have a lot of trouble, even in our regular cold frame; they should be kept at high humidity and still try to keep the temperature down and out of drafts.

VOICE: What pressure do you use in the mist system?

MR. OLSSON: Our pressure there is 80 to 100 pounds. We use the Economy nozzle, which has a 1/32 inch hole, tapped right into the pipe. The pipe is about 2 to 2-1/2 feet above the flats.

VOICE: What light intensity is in the houses?

MR. OLSSON: We have 50% saran shade on the greenhouse. There's no glass, it's plastic with polyethylene on top.

VOICE: How high do your temperatures get?

MR. OLSSON: We try to keep under 95^{o} if we can but we like to have it more than 70^{o} F. We have no bottom heat. All we have is three gas heaters to keep the frost out at night. We are starting to use them now (October) to have a little higher starting temperature in the morning.

VOICE: If there's only one leaf on the cutting, if you lose it, is the cutting lost?

MR. OLSSON: If there is a new shoot starting, then of course it would have other leaves, but without the original leaf and no new shoot, there's no use potting it. It can have beautiful roots, but there's no use to pot it, as far as I can see.

VOICE: How much hoof and horn do you use in the potting media?

MR. OLSSON: We don't know how much you should use. We use very little, approximately 4 lbs. to a mixture of 4 bales of peat moss and 1/3 parts sand.

VOICE: Have you tried redwood sawdust in place of peat?

MR. OLSSON: I haven't personally, but Martin Usrey and I have been through quite a few different mixtures, and I think Monrovia Nursery will also agree that sand isn't bad at all.

MODERATOR MOREY: The next material under discussion is Convolvulus cneorum. Mr. McCabe has a reasonably able substitute in Mr. Martin Usrey of Monrovia Nursery Co., who will give this talk.

PROPAGATION OF CONVOLVULUS CNEORUM

Mr. Martin Usrey
Monrovia Nursery Company
Azusa, California

In the propagation of Convolvulus cneorum (Morning glory bush) we have tried taking cuttings at different times of the year; however, the nature of the plant is such that the wood is always soft. Consequently, the cutting is made a little longer than it would be otherwise in order to get into firmer wood. Cuttings are made about 5" long, with the basal cut made just below the node.

The best times for the propagation of this plant was found to be at two different months in the year - April and September, although cuttings made at these times still gave erratic results; some years very good, but in other years only fairly good. When the cuttings were made at other than the times mentioned, the results were also erratic, but response was usually poor.

The "hormone" we use is Hormodin No. 1 because the condition of the wood necessitates this concentration. Results have been poor where higher concentrations were used.

The cuttings are stuck into a 2 parts Sponge Rok (perlite), 1 part peat moss mix when the flats are to be placed in the coldframes, and into a 3 parts Sponge Rok, 1 part peat moss when they are placed under intermittent mist.

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Mr. Martin Usrey
Monrovia Nursery Company
Azusa, California

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The cuttings are stuck into a 2 parts Sponge Rok (perlite), 1 part peat moss mix when the flats are to be placed in the coldframes, and into a 3 parts Sponge Rok, 1 part peat moss when they are placed under intermittent mist.

We tried propagating cuttings of this plant by two different methods: under intermittent mist and in a coldframe. In both instances we had good results. For intermittent mist our results were 79% rooting compared with 65% for the coldframe method for cuttings taken in September. This was found to be the month for best rooting of Convolvulus in intermittent mist under our conditions. For coldframe propagation, April was the best time and compared favorably with September for intermittent mist. Rooting was 81% for April.

Results are often erratic with this plant. For example, during September we have had as low as 39% rooting when using Wilson's Anti-damp as a cutting dip. We now cut them dry, because results with fungicides were not consistent. Poor results are often due to fungus problems, aggravated by excessive shading. We try to adjust our lighting so that on cloudy days, we reduce the shading by rolling back the muslin shading which we have over our frames.

MODERATOR MOREY: Are there any questions?

VOICE: How many cuttings to a flat?

MR. MARTIN USREY: Oh, with these we'd probably end up with a couple of hundred.

MR. HERMAN SANDKUHLE: I'd just like to add that this plant is one of my favorites, we use it a lot. It takes the place of some of the grey foliage plants that the landscape architects call for today and it's not subject to the water root mold as much as some of the other types. I think nurserymen that are interested in retail sales should promote this particular item. It also puts on a nice blossom, as Martin has pointed out.

VOICE: Are there different varieties of this plant?

MR. MARTIN USREY: There is a more compact type which we have tried to stay away from as it does not bloom, or if it blooms, it's very sparse. The looser growing type blooms very freely - which is this one here. The other one grows quite compact and I do not believe, in this instance, is as desirable as the looser growing one.

VOICE: You didn't say anything about hardening off. Is there any particular way of hardening these off?

MR. MARTIN USREY: We have a greenhouse which we use for hardening off. When you are rooting things under a mist, to take them directly out into a lath house, sometimes it's too sudden, especially if you should have warm weather, which we can get in October or November in our country. We put them in this greenhouse for a week or so and then pot them up.

MODERATOR MOREY: The next topic to be discussed and our final subject is Ilex aquifolium and it will be discussed by Carl Schmidt of Point Reyes Station, California.

PROPAGATION OF ILEX AQUIFOLIUM FROM CUTTINGS

Carl Schmidt
Carl Schmidt Nursery
Point Reyes Station, California

Of the many existing varieties of Ilex aquifolium I have, for the purpose of this discussion, selected the variety commonly referred to as French, English, or Blue Stem English holly. Also, botanically speaking, this is probably not a true variety; this group of hollies produces trees of quite distinct qualities, marked by excellent foliage and berry characteristics. This is the variety most widely planted in the commercial holly orchards of the Pacific Northwest (1) and it is the one that we have used mostly in our own holly orchard at Point Reyes, and from which we are propagating for the nursery trade. Due to the fact that this type of holly produces, at an early age, large amounts of parthenocarpic berries (that is, berries with sterile seeds) it is sometimes referred to in the nursery trade as "self-fertilizing" and thought of as "bi-sexual". However, to the best of my knowledge, all Ilex aquifolium are strictly dioecious plants, which require pollination by male plants for fertile seed production.

As to the various uses of holly for landscaping purposes, its many possibilities are often overlooked in this part of the country, considering the very prominent place it holds in this respect all over the eastern and midwestern part of the United States, where vast numbers of holly are used in the nursery trade. I would suggest one excellent use, that is, as a hedge material. There is nothing more beautiful than a hedge of English holly at any time of the year, particularly around Christmas time.

Holly will grow well over a wide range, temperature and climate-wise, and in many types of soils. For good, lustrous foliage appearance and berry set a deep, well-drained soil, rich in organic matter is very desirable.

Our propagation of holly is carried out by taking cuttings only from a number of our best trees that have established a good record for themselves with regard to foliage appearance, berry production, etc. We take particularly good care of these trees and try to keep them at a high nutritional level. Only terminal growth cuttings are taken from current season's matured wood, beginning in September and continuing until February or Early March. Terminal growth cuttings give better formed young trees. The cuttings are approximately 4" long and stripped of most leaves except for one or two full leaves at the tip. Then, following the sanitary procedures of the U. C. system, they are submerged for ten minutes in a "decontamination solution" prior to hormone treatment. One of these consists of the submersion of the bases of bundled cuttings 1-1/2" deep into a solution of 50 ppm of indolebutyric acid in 10% ethyl alcohol for 24 hours and then rinsed off with water prior to sticking. The other method is to dip the cuttings into a more concentrated solution of 7000 ppm of indolebutyric acid in 50% ethyl alcohol for 10 seconds, followed by sticking immediately into the medium.

As a medium we are using a mixture of either one-half sand and one-half peat moss, or of two-thirds of Sponge Rok (perlite) and one-third peat moss by volume. We put about 250 cuttings into one flat. The flats are placed in a fiberglass-covered greenhouse under intermittent mist with bottom heat at 65° F. The mist system is controlled by a light-energized interval switch which we have built ourselves according to a design obtained from the University of Connecticut(2). We are finding this to be a great improvement over the conventional control by a time clock. When substantial root formation is noticed, normally around 100 days, the flats are moved away from the mist into an unmisted bench in the same house, watered by hand, and given an occasional liquid feeding according to the U. C. system. Approximately 125 days is required for a good, heavy root system ready for potting. The percentage of rooted cuttings is seldom less than 100%. A 90% take we consider low on holly. During the past propagating season we propagated approximately 25,000 cuttings in this manner.

Literature Cited

(1) Roberts, A. N. and C. A. Boller. 1947. Suggestions For Growing English Holly in Western Oregon. Ore. Agr. Exp. Sta. Bul. 409.

(2) Whitaker, I. H. and S. Waxman. 1960. Instructions for a Light-Operated Interval Switch. University of Connecticut. Mimeo. Rpt.

VOICE: Is there a cultivar name for this varigated variety?

MR. CARL SCHMIDT: The varigated variety, Ilex aquifolium, commonly called silver-varigated, is the only one I know, there are many varieties but I don't think any of those varigated ones is a true variety. The holly has a great tendency to sport. You can do almost anything with them, by a little grafting, changing colors and variegation, etc.; they're very easy to change around. For that reason it's very hard to find a real true variety of Ilex aquifolium.

MR. MARTIN USREY: Carl, have you had experience with other hollies outside of Ilex aquifolium?

MR. CARL SCHMIDT: Somewhat limited. We are rooting a lot of I. cornuta.

MR. MARTIN USREY: Those are easy to root, but I mean like I. opaca.

MR. CARL SCHMIDT: Just very little, more or less in a sort of experimental way. We had occasionally a few plants and we fooled around with some oriental hollies in that fashion. I wouldn't be able to report to you.

MR. MARTIN USREY: I. opaca is the American holly.

MR. CARL SCHMIDT: Oh, the Eastern Holly. We have a few of those. We planted them in our own landscaping scheme around our place and propagated them very easily. I would say about the same way - they propagate very easily, but we have never done it for the nursery trade because there's no market for them now, in this area.

MR. GERD SCHNEIDER: Do you think your location at Point Reyes gives you a great advantage in growing Ilex to other places in central California?

MR. CARL SCHMIDT: I think it's an excellent location for the appearance of the holly. Holly will grow almost anywhere. After all, the holly is a native of the near East and you find it all through southern Europe in a rather dry area, and it grows very well in the California valley areas. However, for lush and quick growth and early berry set, I believe that the coastal areas are very desirable. I think that the hollies like to be close to salt water; that is my feeling.

VOICE: Did you ever use Hormodin 3 on holly?

MR. CARL SCHMIDT: Yes, I have, but we find it more convenient to use a liquid than powder, and it works very well with us, so we never changed back to the powder, but we do use Hormodin on other materials.

VOICE: What is the potting compost you use?

MR. CARL SCHMIDT: Our potting compost is 2/3 of silty sand and 1/3 fir bark; we add some chemicals to it under the U.C. system, such as phosphate and potassium.