is going to speak to us today on the genus *Pyracantha*. Incidentally, if he can straighten out this group of plants so we all know what we are talking about, he should be a candidate for the Colman Award for the next ten years

Without further ado, I present Francis de Vos.

Mr. Francis de Vos presented his paper. (Applause)

CULTIVATED FIRETHORNS

FRANCIS DE VOS
Assistant Director
U.S National Arboretum
Washington, D C

Firethorns are by all odds the most colorful shrubs in the autumn landscape of the southeastern states Briefly challenged by the autumnal foliage of a myriad of deciduous shrubs and trees, they outlast their competitors and remain the cheeriest plant in the drab landscape of early winter. Today, I shall review with you the landscape merits of the various species and varieties and show you color slides of many of them.

The genus *Pyracantha* is closely related to such genera as *Cotoneaster, Crataegus* and *Mespilus*, and has been assigned at different times to one or the other of these genera The genus is also closely related to *Osteomeles,* with which it has been hybridized to produce the monotypic bigeneric genus *Pyracomeles vilmorini* (*Pyracantha crenatoserrata* x *Osteomeles subrotunda*). Despite the closeness of the genus *Pyracantha* to its related genera we have the most difficulty in determining the true identity of specimens at the species and cultivar level.

Let us take a closer look at the six species of *Pyracantha* that are in cultivation in this country to see how the typical forms differ from one another.

Pyracantha angustifolia is native to China and is perhaps the most tender of the species. The tomentose condition of the under surface of its leaves and of its calyces clearly set this species apart from the other species, which are essentially glabrous Typically a broad-spreading shrub reaching a height of 10 to 12 ft, it does, on occasion produce some prostrate branches. Its fruit are orange-yellow and flattened on the ends

Pyracantha atalantioides (*P gibbsi*), also native to China, makes a very strong upright-growing shrub 15 to 20 ft in height. This species is frequently referred to as the Gibbs firethorn (*P. gibbsi*), because it was named after the Hon. Vicary Gibbs, in whose garden in England there was a magnificent specimen Later nomenclatural studies, however, revealed that *P. atalantioides* was the first name to this species and should take precedence over *P gibbsi*. The most distinguishing features of this speies are its leaves which are larger than those of other species, ranging up to 3 in. in length, and the long-lasting quality of its fruits. The bright-red fruits are said to stay in good condition until late winter.

Pyracantha crenato-serrata (*P. yunnanensis*) is closely related to *P. atalantioides* and can best be distinguished from it on the basis of leaf differences. The leaves of *P. crenato-serrata* are widest above the middle, toothed, and green beneath, whereas the leaves of *P. atalantioides* are widest at or below the middle, usually entire, and slightly glaucous beneath. *P. crenato-serrata* is native to Yunnan Province, China, and was introduced into France in 1906. It is said to retain its red fruits well into spring.

Pyracantha crenulata is native to the temperate regions of the Himalayas. Although it is probably more closely allied to *P. coccinea,* from which it differs by its glabrous instead of pubescent corymbs, it may more frequently be confused with *P. crenato-serrata* It differs from the latter in that its leaves are less rounded at the apex. The fruit of this species range from orange-red in the species to yellow in the variety *P. crenulata flava.*

Pyracantha coccinea, especially the hardy upright form *P. coccinea lalandi,* is the most widely grown of the species. It is native to southern Europe and Asia Minor and makes a typically broad-spreading shrub up to about 20 ft. in height. It can be distinguished from *P. angustifolia* in that its leaves are only slightly pubescent beneath. The fruits of the species are bright red and those of the more popular *P. coccinea lalandi* are orange-red.

Pyracantha koidzumii (*P. formosana*) is the most widely grown species in the southeastern states. Since this Formosan species is precariously hardy in Washington, D.C., it is not usually found in northern gardens. The bright-red fruits of this species are borne in great profusion and last until early spring if left unmolested by birds. It can be distinguished from *P. crenato-serrata* by its entire leaves and from *P. atalantioides* by its smaller leaves which are green beneath

Although the species seem to be reasonably distinct, it is difficult and frequently impossible to determine the true identity of specimens growing in our gardens. There are three reasons for this: (1) Plants raised from seeds of open-pollinated flowers are variable in foliage and habit, and seeds from red-fruiting varieties often give rise to yellow-or orange-fruiting forms; (2) since the chromosome number is probably the same for all species, seeds collected from plants growing in collections containing more than one species are likely to give rise to interspecific hybrids that are intermediate to both parents in many of their characters; (3) the color and size of fruits can differ markedly when the plants are grown under various cultural and light conditions.

In evaluating firethorns for landscape use as specimen shrubs, for espaliering, or for hedges, one should consider the following factors in addition to the aesthetic qualities of their fruit and foliage:

(1) *Hardiness.* For many years *P coccinea lalandi* has been the standard for all supposedly cold-hardy firethorns. More recently other hardy varieties such as 'Kasan' and 'Royali' have been offered by the nursery trade.

(2) *Resistance to Fire blight.* This ever-threatening disease of most rosaceous plants can raise havoc with firethorns. The hybrid *P.* 'Oxford' (*P. angustifolia* x *P. crenato-serrata*) is said to be very resistant.

(3) *Lasting qualities of the fruit.* Many varieties retain their fruits (if the birds leave them alone) until Christmas time The varieties 'Kasan' and 'Victory' are reported to retain their fruits into late winter

It is not possible at this time to evaluate fully the different varieties separately for use on a country-wide basis, because test collections have not been established in the various climatic regions across the country. Information. is, however, accumulating as individuals and nurserymen try the newer varieties in their particular areas. I shall now describe some of the varieties and comment on those on which I could find specific information.

1. *Pyracantha angustifolia*
   a) Fruit color-orange-yellow to red, b) Hardiness zone-8, c) most easily distinguished species because of its tomentose leaves. Plants apparently not available in this country.
2. *Pyracantha atalantioides* (*P gibbsi, P. discolor*)
   a) Fruit-red, b) Zone 6, c) Upright growing species with large leaves and fruits which persist into late winter.
3. *Pyracantha atalantioides* 'Bakeri'
   a) Fruit-red, b) Zone 6, c) No description available, but listed as available from nurseries in the Plant Buyer's Guide.
4. *Pyracantha atalantioides belli*
   a) Fruit-red, b) Zone 8, c) Similar to *P. koidzumi,* but with large and better distributed fruits.
5. *Pyracantha atalantioides* 'Cal Poly'
   a) Fruit-red, b) Zone 8, c) Said to have showy pink flowers. Vigorous.
6. *Pyracantha coccinea*
   a) Fruit-red, b) Zone 6, c) Most widely grown species in the northern states especially its hardy form *lalandi*
7. *Pyracantha coccinea aurea*
   a) Fruit-yellow, b) Zone 6, c) Yellow fruiting form of *coccinea*
8. *Pyracantha coccinea* 'Kasan'
   a) Fruit-orange-red, b) Zone 3, c) Hardier and supposedly a heavier fruiter than *P coccinea lalandi.*
9. *Pyracantha coccinea lalandi*
   a) Fruit-orange-red, b) Zone 4, c) Most widely planted firethorn in the northern states but will probably be replaced by 'Kasan.'
10. *Pyracantha coccinea lalandi* 'Monrovia'
    a) Fruit-orange, b) Zone 5, c) Has long arching branches and glossy foliage.
11. *Pyracantha coccinea lalandi* 'Royali'
    a) Fruit-red, b) Zone 4, c) Distributed by M. G. Coplen of Rock Creek Nurseries, Rockville, Md
12. *Pyracantha coccinea lalandi* Thornless
    a) Fruit-orange, b) Zone 4, c) Thornless variety of *lalandi.*
13. *Pyracantha coccinea lindleyana*
    a) Fruit-orange, b) Zone 6, c) Seedling of *P. coccinea* with spreading habit and light green leaves Distributed by Lindley Nurseries, Greensboro, North Carolina

14. *Pyracantha coccinea pauciflora*
    a) Fruit-unknown, b) Zone 4, c) Low growing, spreading form. Sparse fruiting
15. *Pyracantha crenato-serrata* (*P yunnanensis*)
    a) Fruit-red, b) Zone 7, c) Matures its fruit later in fall than other species and retains them in good condition until early spring.
16. *Pyracantha crenato-serrata* 'Graberi'
    a) Fruit-red, b) Zone 7, c) Produces very large fruits in great clusters. Very popular in the Norfolk, Virginia area.
17 *Pyracantha crenato-serrata macrocarpa*
    a) Fruit-unknown, b) Zone unknown, c) No information available.
18. *Pyracantha crenato-serrata prostrata*
    a) Fruit-unknown, b) Zone unknown, c) No information available
19 *Pyracantha crenato-serrata* 'Rosedale'
    a) Fruit-red, b) Zone 7, c) Equally as showy as 'Graberi' with smaller but glossier fruits and in somewhat looser clusters.
20 *Pyracantha crenato-serrata yunnanensis*
    a) Fruit-unknown, b) Zone unknown, c) No information available.
21 *Pyracantha crenulata*
    a) Fruit-orange-red, b) Zone 6, c) Small-leaved species with lustrous small fruits
22. *Pyracantha crenulata* 'Crimson Tide'
    a) Fruit-red, b) Zone 6, c) No description available, but listed as available from nurseries in Plant Buyer's Guide.
23 *Pyracantha crenulata flava*
    a) Fruit-yellow, b) Zone 6, c) Bears an abundance of small glossy yellow fruits.
24. *Pyracantha crenulata kansuensis*
    a) Fruit-orange-red, b) Zone 6, c) Strong, upright growing shrub bearing an abundance of glossy orange-red fruits. Foliage small.
25. *Pyracantha crenulata rogersiana* (*P. c. aurantiaca*)
    a) Fruit-reddish-orange, b) Zone 6, c) The varieties of *Pyracantha rogersiana* of some authors are probably the same entities that are listed under the same varietal names under *Pyracantha crenulata*, e.g. *P. c. flava* is probably the same as *P. rogersiana flava*.
26. *Pyracantha crenulata rogersiana angustifolia*
    a) Fruit-unknown, b) Zone 6
27. *Pyracantha crenulata aurantiaca*
    a) Fruit-reddish-orange, b) Zone 6
28. *Pyracantha crenulata rogersiana flava*
    a) Fruit-yellow, b) Zone 6
29. *Pyracantha crenulata taliensis*
    a) Fruit-yellow, b) Zone 6, c) Produces shining yellow fruits which drop in late fall.

30. *Pyracantha Duvali*
   a) Fruit-red, b) Zone 5, c) Hybrid between *P. koidzumi* x *P. crenato-serrata.* It is said that birds will not eat the fruit.
31. *Pyracantha* 'Ingleside Crimson'
   a) Fruit-red, b) Zone unknown, c) Seedling selection. Bears profuse clusters of large red berries Distributed by Ingleside Farm Nurs , Oak Grove, Virginia.
32. *Pyracantha koidzumi* (*P formosana*)
   a) Fruit-orange-red, b) Zone 7, c) Most widely grown species in the southeastern states.
33. *Pyracantha koidzumi* 'Eddie's Coral'
   a) Fruit-unknown, b) unknown, Zone, c) No description available, but listed as available from nurseries in Plant Buyer's Guide.
34. *Pyracantha koidzumi* 'Government Red'
   a) Fruit-red, b) Zone 8, c) Fruits color in early fall One nursery catalog states that it is hardy in Zone 5.
35 *Pyracantha koidzumi* 'Low Dense'
   a) Fruit-orange-red, b) Zone unknown c) Low dense seedling form of *P. koidzumi,* practically thornless. New growth covers fruit. Killed back to ground at the Arboretum in winter of 1958.
36. *Pyracantha koidzumi* 'Pannosa'
   a) Fruit-unknown, b) Zone unknown, c) No description available, but listed as available from nurseries in Plant Buyer's Guide.
37. *Pyracantha koidzumi* 'Red Berry'
   a) Fruit-red, b) Zone unknown, c) No description available, but listed as available from nurseries in Plant Buyer's Guide
38. *Pyracantha koidzumi* 'San Jose'
   a) Fruit-red, b) Zone 7, c) Reported to bear the largest fruits—up to 5/8" in enormous clusters.
39. *Pyracantha koidzumi* 'Santa Cruz'
   a) Fruit-red, b) Zone 8, c) No description available, but listed as available from nurseries in Plant Buyer's Guide.
40 *Pyracantha koidzumi* 'Santa Cruz' prostrata
   a) Fruit-red, b) Zone 8, c) Prostrate growing habit
41 *Pyracantha koidzumi* 'Sensation'
   a) Fruit-red, b) Zone 5, c) Said to be a *coccinea* hybrid which sets an abundance of scarlet red-fruit and is compact in habit.
42. *Pyracantha koidzumi* 'Stribling'
   a) Fruit unknown, b) Zone unknown, c) No description available, but listed as available from nurseries in Plant Buyer's Guide
43. *Pyracantha koidzumi* 'Victory'
   a) Fruit-red, b) Zone 8, c) Large berried form which colors late but retains its fruits into late winter.
44. *Pyracantha koidzumi* 'Walderi'
   a) Fruit unknown, b) Zone unknown, c) No description available, but listed as available from nurseries in Plant Buyer's Guide.

45. *Pyracantha koidzumi* 'Walder' prostrata
   a) Fruit-red, b) Zone 8, c) Prostrate form which bears large red fruits in clusters.
46. *Pyracantha* 'Oxford'
   a) Fruit-orange to red, b) Zone unknown, c) Hybrid of *P. angustifolia* x *P. crenato-serrata* Said to be more resistant to fireblight.
47 *Pyracantha* 'Pride of Portsmouth'
   a) Fruit-red, b) Zone 7, c) Named by John Coleman of Portsmouth, Virginia. Bears extremely large clusters
48. *Pyracantha* 'Runyan'
   a) Fruit-orange-red, b) Zone 5, c) Probably a seedling of *P. coccinea.*

* * * * *

MODERATOR FLEMER: Thank you very much, Mr. de Vos. The floor is now open for questions

MR. JAMES WELLS (Red Bank, New Jersey): I feel constrained to point out there is one serious omission, *Pyracantha wateri.* However, that wasn't my reason for getting up here I can give a little information on some of these varieties.

Pyracantha coccinea 'Lowboy' was raised by Don McLaughlin, who is neighbor of mine in Red Bank, New Jersey and as far as I know is a seedling of *P coccinea.* It has been my observation that it is not a very steady fruiter as a young plant.

Pyracantha coccinea lalandi 'Royali' was, I believe, named by Joseph Gable. The original plant came from his garden at Stewartstown, Pennsylvania. It is supposed to be a seedling of *P. coccinea lalandi,* and I have had word from a number of people that when planted in the Midwest area alongside *P. c. lalandi,* it will stand up when *P. c. lalandi* is killed.

MR. de VOS: Thank you for those comments. If any of you know the background of some of these plants we certainly would appreciate your telling us.

PRESIDENT STEAVENSON (Elsberry, Missouri): I would like to ask if anyone knows how long it takes for firethorns to bear when grown from seed? Several years ago I grew quite a number of plants of *P. coccinea* from seedlings and put them in pots. Eventually I got them into the field where they grew for about six years without fruiting. I finally gave up in disgust and dug them out.

MEMBER: It has been our observation that some of them may bear fruit in five years while others take ten years. Some varieties are twenty years old before they bloom and bear fruit

MR. J. PETER VERMEULEN (Neshanic Station, New Jersey): A comment on 'Lowboy.' We have some of the original plants from Don McLaughlin and they have been fruiting quite heavily.

MR. DEWILDE (Shiloh, New Jersey): To comment on *Pyracantha crenulata angustifolia,* I might say that it has yellow fruit.

(*Editor's note*: Mr. Edward Scanlon, Chairman of the Awards

Committee showed a colored slide of the plaque presented to Dr. F. L. Skinner for his outstanding work in the field of plant propagation.)

MODERATOR FLEMER Thank you gentlemen, we must now continue with our program Our next speaker, to continue the subject of firethorns, is Judson P Germany, Jr., of Germany's Nursery, Fort Worth, Texas, who grows *Pyracantha* on a large scale. He will speak to you on "Propagation of Pyracanthas in the Greenhouse and Mist Bench."

Mr. Germany read his prepared paper. (Applause)

PROPAGATION OF PYRACANTHA IN THE GREENHOUSE AND MIST BENCH

JUDSON P. GERMANY, JR
Germany's Nursery
Fort Worth, Texas

INTRODUCTION

The firethorns have long been an important group of ornamental plants to commercial nurserymen in almost every section of the country. There are few plants available today which combine evergreen or semi-evergreen foliage with a showy display of white flowers in the spring, followed by a massive array of deep red or bright orange berries in the fall. While most people are attracted to firethorns because of their heavy berry production, many are discovering that they are also good subjects for training as espaliers, into tree forms and other exotic shapes. They can be used as screens, foundation plants, or in mass plantings There are dwarf forms and prostrate forms For those who appreciate variegated plants, there is at least one very interesting variegated variety

Just as the flowers and fruit of this group of plants have made them extremely popular in the past, the versatility of old varieties put to new uses and the introduction of new forms almost yearly is certain to boost their popularity to even greater heights in the years to come. Already there are available orange berried varieties which promise to extend the culture of these plants into all but the very coldest sections of the United States. The red berried varieties are still confined to the warmer sections of the country, but improved varieties are gradually moving into the northern latitudes year by year, and the time will come, no doubt, when hardy red berried varieties will be available that can be grown right alongside the orange berried kinds.

For the next few minutes I will outline the methods and describe the facilities we use at our nursery to propagate firethorns from cuttings. I believe you will find that the techniques we use are no different from those used in the average nursery for the propagation of most, common, broad-leaved evergreens.

Almost any type of propagation structure can be used for the propagation of firethorns, as they are among the easiest of plants to produce from cuttings once a few simple requirements are met and understood However, for ease of management and for almost certain results, I

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Almost any type of propagation structure can be used for the propagation of firethorns, as they are among the easiest of plants to produce from cuttings once a few simple requirements are met and understood However, for ease of management and for almost certain results, I would recommend the use of either a conventional greenhouse or one of the outdoor mist systems which have rapidly come into use in the past three or four years. With either of these two types of propagating structures, we can control the humidity with a minimum of effort, and, providing we do not allow the temperature to go to extremes, success is generally assured.

Since the management of these two types of propagation structures differ let us consider each one separately

GREENHOUSE PROPAGATION

First, the use of the greenhouse. A good tight greenhouse is essential in order to exercise humidity control, which as I have already mentioned is one of the most important factors we must consider if we intend to obtain a high percentage of rooted cuttings. The application of a shading compound on the glass will be necessary in order to keep the temperature from soaring too high and burning the foliage. Care must be exercised when the shading is applied, as too much shade reduces the light and lowers the temperature, both of which will retard the rooting process I have had the experience of having cuttings callus too heavily and fail to root, which I attributed to too much shade.

Now, let us consider the rooting medium. We have found that firethorns will root in practically any medium in common use today. In the greenhouse we have had good results with common brick sand, vermiculite, and perlite, and I have no doubt that any other medium you would care to use would work just as well. In short, we have come to the conclusion that the medium has little, if any, effect on the results, provided it satisfies the basic requirements of a rooting medium. It should be well drained and hold the cuttings firmly in an upright position. In our operation we generally use sand Naturally, we want a medium which is free from debris and fungus diseases, and therefore we change the sand each year. This would probably be unnecessary if we had steam sterilization equipment available

In North Texas we take the cutting wood from well ripened new growth anytime from about the first of July until around the first of December. Cuttings made in early part of the summer will be potted off and carried through the winter in a protected location, while cuttings made late in the season usually root slowly and are therefore left in the greenhouse until spring.

In making the cuttings, we use the smaller side growth, up to, perhaps, $\frac{3}{16}$ inch in diameter. Larger wood will root, although we like the cuttings to be as uniform as possible. Make the cuttings any convenient length without regard to terminals, nodes, or internodes. Strip or cut the thorns or side shoots up about halfway to facilitate sticking the cuttings. We stick the cuttings about a half-inch or so apart in the row with about two inches between rows Since firethorns usually root with a very high percentage, in a relatively short time, we consider the use of hormones or other root inducing substances as being unnecessary.

Care of the cuttings during the rooting period is much the same as with any other broad-leaved evergreen In the summertime the benches and walks must be sprayed frequently to maintain high humidity.

Temperatures will probably stay above 110 degrees during the day, and the cuttings will root rapidly Under conditions of high humidity and high temperature, most *Pyracanthas* will root in a matter of days. I have seen some cuttings root in as little as four days, but from two to three weeks is average. In the winter we take most of the shade off the glass in order to trap the heat of the sun, since the house is not heated artificially. The benches are watered only enough to prevent the medium from drying out.

When the majority of the cuttings are strongly rooted, they are removed from the bench and potted either into 2½ inch pots or directly into one gallon cans for overwintering. They are then placed in the shade. The soil mix we are now using is one that was developed at Texas A & M just recently, and consists of ⅓ soil, ⅓ peat, and ⅓ perlite. So far, this mix appears to be superior to anything we have used in the past. A light top dressing with cottonseed meal is applied soon after potting to get them off to a good start.

MIST SYSTEM PROPAGATION

The advantages of an outdoor mist system over a conventional greenhouse lie mainly in its relatively low initial cost and almost compete elimination of fungus disease troubles The principal disadvantage is the possibility of a power or water failure, in which case you are liable to have a bench full of cuttings burned beyond recovery.

Since we put our first mist bench into operation about four years ago, we have used it very sucessfully to root firethorns and many other varieties of ornamental plants. In fact, we no longer use the greenhouse for summer propagation, but rely on the mist system altogether. We now have two mist benches in operation, and they measure about 16 feet in length and about 5 feet in width. The spray nozzles we are using are the Florida type in one instance and the Monarch type in the other Both types have their advantages and disadvantages, but reasonably good results can be had with either kind, particularly with a subject such as *Pyracantha* which roots easily.

The benches must be constructed in such a way that maximum drainage is assured We achieved this by spacing the bottom boards 3 or 4 inches apart These wide spaces are covered with a strip of ¼ inch hardware cloth, and on top of this is placed a strip of galvanized screen wire. The hardware cloth supports the weight of the sand and the screen keeps the sand from sifting out the bottom. Both pieces of wire must be well tacked down with galvanized roofing tacks.

One element you have to cope with on the outside, but not in the greenhouse, is wind Although we have erected reed fencing and burlap windbreaks around our benches neither material has been entirely satisfactory. A more solid material such as plywood or masonite which would completely shut off the wind would be much better. The problem, here, of course, is that the wind increases the evaporation from the surface of the leaves, causing more water to be used than is necessary, and there is always the danger that it will blow the mist back from the edge of the bench and cause some of the cuttings to be burned.

It doesn't seem to make too much difference whether the mist is applied continuously or intermittently on *Pyracantha* cuttings. The first mist bench we put up was of the continuous misting type, and like most everyone else, we found that a number of plants could not tolerate so much water, plus the fact that a considerable volume of water is required to keep it in operation. This led to the purchase of an "electronic leaf" water control which we employed in our second mist set up. The theory of the "electronic leaf" would seem to make it the most ideal water control available, but we have not found it entirely satisfactory in that occasionally it allowed the water to run much longer than was necessary, or even worse, it might fail to come on when it was needed, with burned cuttings as the result. Under our hot Texas sun, it takes only about 30 minutes without water to completely ruin a bench of healthy cuttings. This can become very discouraging after the second or third time it happens.

For the past two seasons we have experimented with still a third setup using flats instead of a bench and a timer to control the water in place of the electronic leaf The timer operates on a ten minute cycle, and we allow the water to run for about ten seconds This is a little too long a cycle for most plants, including *Pyracantha,* and makes it necessary to shade the cuttings. I believe that next season we will abandon this timer in favor of one with a four or five minute cycle. This seems to be about the best compromise short of a timer with multiple settings, which is an expensive piece of equipment.

The advantages of using flats in place of benches is three-fold. First since some plants root more rapidly than others, this makes it possible to remove a batch of cuttings and replace them without disturbing the adjacent varieties. *Pyracantha* will root in perhaps one third of the time required for Burford holly, for example. The second advantage is related to the hardening off process required by some plants. Some plants when rooted under mist have to be hardened off very carefully by gradually withdrawing the water over a period of several days. Cuttings made from very tender plants are usually the ones which require this treatment. Firethorns do not require any hardening off of this nature if the cuttings are made from well ripened wood. In any event, it is a simple matter to remove a flat and place it in a special mist line for the hardening off process; whereas, if you have a bench of mixed cuttings, this would be almost impossible.

The third advantage is, perhaps, a small one, but it adds to the propagators convenience and makes the equipment more flexible. This occurs when it is necessary to make up small batches of cuttings requiring different media The use of flats makes it possible to time the operations properly and get the cuttings into the proper medium without regard to the available space, as would be the case if benches were being used.

As in greenhouse propagation, the choice of a medium does not seem to have too much effect on the rooting of firethorns so long as it is well drained. We have had excellent results with brick sand, perlite, vermiculite, and a mixture of sawdust and peat. However, we almost invariably use sand because it is cheaper.

While much more succulent wood may be used in a mist system than would be possible in a greenhouse, the cuttings made from this wood also burn much easier if anythings goes wrong with the water controls. We, therefore, still prefer well ripened cutting wood for this type of operation. Preparation of the cuttings for sticking is the same as for the greenhouse. And, again, the use of hormones or other root inducing substances is unnecessary.

When the cuttings are well rooted, they are handled in the same manner as when taken from the greenhouse. We pot them off in the soil mix I mentioned earlier, which consists of 1/3 soil, 1/3 peat, and 1/3 perlite Then we take them to the shade and topdress with cottonseed meal. After a few days in the shade, they can be moved out into the sun, or, if it is late fall, we may simply leave them in place until spring.

SUMMARY

To summarize briefly, I believe that *Pyracanthas* can be propagated with about equal success in either a conventional greenhouse or in one of the mist systems such as I have described. With either type of facility, use whatever medium you are most familiar with, as it does not seem to make too much difference when rooting firethorns. We believe that good brick sand is about as good as any. A greenhouse should be tight for humidity control, and some shading compound on the glass will be necessary in order to keep the temperature down. If you are using a mist bench, be sure that it is well drained. Be sure that your water supply and mist controls are reliable. We believe that timers are more reliable than most "electronic leaf" controls at the present time. No doubt we will see greatly improved "electronic leaf" equipment in the near future. A timer is, at best, a compromise between continuous mist and "electronic leaf" controls. The main argument against using a timer is that too much water would be applied on a very cloudy day if precautions are not taken to avoid this. Well ripened cutting wood should root in two to three weeks time under conditions of high humidity and temperature. When the cuttings are well rooted, pot them off in a well drained soil mixture, topdress with cottoneed meal or any good organic fertilizer, and keep them in the shade until top growth commences or until the following spring.

I believe that if these brief instructions are followed, anyone with a greenhouse or mist bench should be successful in the propagation of one of the nurseryman's best friends, the firethorns.

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MODERATOR FLEMER: Thank you very much, Mr. Germany. Are there any questions?

MR. JOHN B ROLLER (Scottsville, Texas): Jud, I would like to ask if you have the name of that dwarf variegated variety and also, does it fruit?

MR. GERMANY: It produces a few fruits, but not anything spectacular. I do not know the variety but I believe we may have secured that variety quite a few years ago from the Sherwood Nurseries in Corbett, Oregon. Any other questions?

MR. LOUIS SAUR (Morrow, Ohio): Have you ever tried a water filter in your electronic leaf, mist system?

MR. GERMANY: Yes, we do use a water filter Our main problem is corrosion of the electrodes. I think they will get this fault worked out in the near future.

MR JAMES WELLS: I missed your information as to the time you took your cuttings When do you start and how long do you continue?

MR. GERMANY: In our particular area we can start sometime around the first of July and continue right on until frost around the first of December, although I don't believe timing makes a lot of difference.

MODERATOR FLEMER: That is all the time we will have alloted for discussion Thanks again, Mr. Germany, for a most interesting talk.

The Agricultural Research Service of the United States Department of Agriculture is currently engaged in a most interesting project in hybridizing and breeding hardier and better forms of evergreen *Berberis* and *Mahonia*. We are fortunate in having with us, Toru Arisumi, from the Station at Worthington, Ohio, who will talk about some of the objectives and problems of the program.

Mr. Arisumi then presented his address on "Some Breeding Objectives for the Improvement of *Berberis* and *Mahonia*" (Applause)

SOME BREEDING OBJECTIVES FOR THE IMPROVEMENT OF MAHONIA AND BERBERIS

TORU ARISUMI
Ornamentals Section, Crops Research Division, Agricultural Research Service, U S Department of Agriculture

The two closely related genera of *Berberidaceae, Mahonia* and *Berberis,* comprise a large group of useful ornamental shrubs. According to Rehder (4) there are about 50 species of *Mahonia* found in North and Central America and in East and South Asia, and about 175 species of *Berberis* found mostly in East and Central Asia and South America, with a few in North America, North Africa, and Europe. Many species in these genera are susceptible to some of the rust fungi (*Puccinia graminis*) of cereals, acting as alternate hosts in the life cycles of these fungi. For this reason the cultivation and distribution of rust-susceptible barberries and mahonias are prohibited in 19 states within or near the cereal growing regions of this country Fortunately, there are about 30 species of barberries and 9 species of mahonias that are rust resistant and safe for cultivation in these states (5). This group of rust-resistant species includes many diverse and attractive types suitable for use in a breeding program.

A survey of the literature indicates the existence of many interspecific and a few intergeneric hybrids in these genera. Rehder (4) lists about 18 interspecific hybrids of *Berberis* and 2, *Mahonia* hybrids. Some of these hybrids represent crosses of quite divergent species from widely separated geographical regions. Interspecific hybrids of *Berberis* normally found in the nursery trade, such as *B stenophylla* and *B. men-*

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toiensis, show some degree of fertility. Dermen (2) reported 5 successful and 6 unsuccessful interspecific crosses from different cross combinations of 11 *Berberis* species He also tried some crosses between *Mahonia aquifolium* and 3 species of *Berberis* and obtained seeds from the cross of *Berberis heteropoda* X *Mahonia aquifolium.* He did not have any success with reciprocal crosses of *Mahonia aquifolium* and *Berberis julianae* or *Berberis sargentiana.* Later attempts at intergeneric hybridization by Jensen in Sweden resulted in the hybrids *Mahonia aquifolium* X *Berberis sargentiana* (3) and *Mahonia aquifolium* X *Berberis candidula* (6). At the present time there are at least 4 known *Mahoberberis* hybrids. All of these intergeneric *Mahoberberis* hybrids are supposed to be sterile, non-flowering forms (2) (6).

Cytological studies (2) (3) (6) also show a close relationship between these genera. The chromosomes of *Mahonia* and *Berberis* are similar in number and appearance, although there is some disagreement on the size of these chromosomes. Most of the species studied so far have 28 chromosomes, and only 4 species have been found to be tetraploids with 56 chromosomes (1).

Since interspecific and even intergeneric hybrids can be obtained in these genera, there are good possibilities of combining diverse genotypes to create new and improved forms of mahonias and barberries by breeding. Embryo-culture techniques widely used in plant breeding could be employed for the more difficult crosses. Also, colchicine treatments could be used to induce polyploidy in these species. Breeding could then be carried on at the diploid and polyploid levels. Research along these lines just mentioned is now in progress at our station in Columbus, Ohio.

Some of the more important objectives of our breeding program are listed as follows.

1. Breeding for hardiness.
2. Breeding for improved foliage and fruits of mahonias and barberries.
3. Breeding for improved dwarf forms.

The hardiest species in the group of rust-resistant barberries and mahonias are listed in Rehder's Manual (4) as being hardy in Zone 5. Included in this category are 4 species of *Mahonia,* 6 species of evergreen *Berberis,* and 4 species of deciduous *Berberis.* These species are: *Mahonia aquifolium, M. repens, M. nervosa, M. bealei,* and *Berberis buxifolia, B. stenophylla, B verruculosa, B. triancathophora, B. gagnepainii. B. julianae, B. thunbergii, B. koreana, B. gilgiana,* and *B. circumserrata.* By selecting from seedling plants of these species we hope to obtain some hardy forms for breeding Hardy forms known to be growing in colder climatic zones will also be selected for further tests and breeding. By selecting and breeding for hardier plants we hope to extend the range of these species or their hybrids beyond their present geographical limits.

The foliage of mahonias and evergreen barberries is the most important attribute of these species There is a wide variation of foliage types, not only between the different species but also within each species For example, seedlings of *Mahonia aquifolium* exhibit a wide range of leaf types that vary in size, shape, color, gloss, and ability to withstand winter conditions. The foliage of most mahonias show various degrees of injury due to wind, sun, and frost during the winter months. Some of these plants lose their foliage early in the winter, others retain them for longer periods, and some keep their foliage until spring The variability of foliage types indicates that much work could be done in selecting and breeding for improvement of foliage in this group of plants

The fruits of evergreen barberries and mahonias are not persistent, nor are they so showy as those of some of the deciduous barberries. Practically all of these have bluish or black berries which are quickly eaten by birds when they ripen or shrivel up within a short time. However, there are good indications that some plants in the species hold their fruits for longer periods than others We hope to select these Barring the occurrence of favorable mutations affecting fruit color of mahonias and evergreen barberries, the development of red-fruited forms of these species would entail a long process of breeding and selection of hybrids showing evergreen, red-fruited, and rust-resistant characters Except for some rust-susceptible mahonias, the best red-fruited forms of barberries are all deciduous A remote but interesting possibility is the use of red-fruited *Nandina domestica* for crossing with mahonias and barberries.

The third objective under consideration is that of breeding and selection for attractive dwarf forms. Because of the ever increasing need for small shrubs, breeding for dwarf mahonias and barberries is an important objective of the breeding program. These dwarfs should be compact, slow-growing types that retain most of the good qualities of the species. Some species of mahonias and barberries are actually dwarf species, but many others are fairly large shrubs that would be more useful in smaller forms.

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MODERATOR FLEMER: Thank you very much, Mr. Arisumi. Are there any questions?

MR. JOHN HILL (Dundee, Illinois): Toru, what can you tell us of the intergeneric crosses between *Berberis* and *Mahonia*, that are somehow or other finding their way into the trade? What can you tell us specifically regarding hardiness and propagation methods?

MR ARISUMI Nothing, since it was only three weeks ago that we obtained specimens

MODERATOR FLEMER. Would Roger Coggeshall please comment on the rooting qualities of these hybrids?

MR ROGER COGGESHALL (West Newbury, Mass.): They root very well taken from cuttings in the months of September and October As far as the hormone treatment is concerned, Hormodin No 2, appears to be the best. Hormodin No 3 seems to be too strong since it generally will kill the bases of the cuttings For the medium we use sand and peat mixed, half and half, by volume.

MODERATOR FLEMER: Were these hybrids fairly hardy in Boston?

MR COGGESHALL· No, they were not They didn't remain totally evergreen. As I remember the portion of the plant which was above the snow defoliated without killing the stems, and the portion below the snow remained evergreen and retained its leaves.

MODERATOR FLEMER: Thank you very much, Mr. Arisumi

Since we are running behind time I will ask Lee Enright and John Sjulin to defer their talks until this afternoon, when we have an opening in the program.

Unless there are announcements, the meeting is adjourned for lunch.

The meeting recessed at twelve o'clock, noon o

THURSDAY AFTERNOON SESSION

December 4, 1958

The meeting was called to order at one-forty o'clock by President Steavenson.

PRESIDENT STEAVENSON. The meeting will please come to order

For this afternoon the program moderator is Dr Stuart Nelson, of the Experimental Farms Service, Ottawa, Ontario, Canada, who will handle the panel on Greenhouse Propagation and Management. Dr Nelson!

Dr Nelson assumed the chair. (Applause)

MODERATOR NELSON: Thank you, President Steavenson. We have a full panel this afternoon, in addition to several papers remaining from this morning's session. There will be a short question period after each paper For those questions which cannot be handled there will be ample opportunity for you to bring them up during the Question Box period Friday evening

The first speaker on this afternoon's program is Mr. E. Stroombeek. Most of you had an occasion to see his setup yesterday on the tour. However, here is Mr. Stroombeek to describe his method of foghouse propagation in greater detail

Mr. Stroombeek presented his talk, "The Propagation of Softwood Cuttings in the Foghouse." (Applause)

THE PROPAGATION OF SOFTWOOD CUTTINGS IN THE FOGHOUSE

E. Stroombeek
Warner Nursery
Willoughby, Ohio

INTRODUCTION

When reading the title of my paper I hope you did not become confused by the word, foghouse. The only reason I used it was to distinguish between the intermittent mist system and the use of a new type of humidifier which I am going to discuss

During the last 6 years, the use of intermittent mist devices, in the field of plant propagation has become common practice. Through the years we have seen steady improvement and greater efficiency, especially in the use of outdoor mist frames However, for many nurseries, greenhouse propagation had been the established pattern of operation with the accent on fall and winter propagation The intermittent mist setup made it possible to make more efficient use of these greenhouses during the summertime. The big problem had been how to keep the humidity up and at the same time the temperature below extreme levels. Intermittent mist seemed to be the solution. We at Warner Nursery are already using an outdoor mist frame with good results, however, two, up-to-date greenhouses gave us considerable trouble when used the conventional way during the hot months of June, July and the early part of August

We checked with various people on the advisability of using an intermittent mist system in these houses, but got mixed reactions. It seemed that with certain plants like rhododendrons and holly, the saturation of the peat-sand medium which inevitably took place, was detrimental to the rooting process. This was one of the important reasons why we postponed the installation of an intermittent mist setup, since these two items make up our main greenhouse crop.

In the summer of 1957, I had the opportunity to visit my home country, Holland, and spent considerable time in Boskoop Right after the war I had served my apprenticeship at the nursery of Siem van Klaveren, one of the foremost propagators in that nursery-town. The previous year he had switched his entire propagating operation from frames to greenhouses. Mr van Klaveren had been faced with a problem similar to ours, although their temperature range is not as extreme as here in the States, ie, how to keep humidity up and air temperature down while using open benches After some experimenting he had found a solution, that struck me as quite unique, simple, but efficient. He had lined the inside of his houses with polyethylene and was using a Swiss made "Defensor" humidifier to maintain a constant, heavy fog.

This humidifier of an altogether new design was built strictly for industrial purposes and had proven itself to be effective, and quite reliable thru the post war years. I visited van Klaveren's Nursery several times during the month of August, and judging by the fine results he had with his new gadget, it seemed to be well suited for greenhouse use also. For instance, from February 1957 until November of that year he raised his total output of softwood and evergreen cuttings by 200 per cent and had to hire two extra men to keep up with his production. Now, as several of the 'Boskoopers" in the audience well know, these amazing results, achieved in Boskoop did not mean that the same could be duplicated here in the States, although it was always worth a try.

But first, let me explain about this humidifier and the way it is put to use in the greenhouse

THE DEFENSOR HUMIDIFIER UNIT

The Defensor model 3000 and the improved model, 3001 consists of a centrifugal unit with a lamellar device on top of new design, which is driven on by a high speed electric motor This apparatus is placed in a shallow pan of water. When operating, the water is sucked up thru a cone-shaped hollow attachment below the driveshaft. It is next pushed at high speed by centrifugal action thru 18 small holes which encircle the top of the cone and then it is guided by 2 revolving saucer-like disks to the atomizer grid, which is an aluminum ring with narrow slit-like openings thru which the water is forced at very high speed and then completely vaporized. Finally, the plastic propellor on top of the driveshaft will suck the vapor upwards and distribute it thru the greenhouse. The portable Defensor weighs about 18 lbs. The motor output is 1/10 H.P Voltage can either be 220 or 110 volts, 50 cycles AC. The consumption of current is about equal to that of a 75 watt lamp.

By means of an insertion collar on top of the humidifier one can regulate the fineness of the fog and the output of water. When the temperature goes up we use a somewhat coarser fog by raising the collar. By so doing there will be a very slight film of water deposited to keep the leaves moist and prevent burning.

The apparatus has to be cleaned every three to four weeks as does the water, since algae will soon develop under the hot humid conditions. Then, there is the question of the use of a humidistat. We do not feel the need for one. For one thing, when it is sunny and warm, a constant fog has to be maintained anyway, while under other circumstances, like intermittent sunshine or cloudy but bright skies, the person working in the boiler room can manipulate the timer according to the need. Of course, a humidistat could be of value if it could be rigged up to an alarm device that would be set off if the humidity dropped suddenly.

The actual measurement of the water particles is somewhere between 1-5 microns, that is 1-5 thousandth of a millimeter in diameter. This is very important, because it explains why we are dealing with a fog and its typical qualities rather than some form of mist.

In the first place, this is one of the reasons why this vapor-like fog acts like a gas and penetrates evenly through the whole area. Secondly, because the water particles are so small the fog is relatively dry in fact, during its operation in the daytime there is hardy any precipitation on the cuttings and the medium. However, the air humidity is always very high, even if the humidifiers are not operated constantly. When the temperature starts to drop at night or on cloudy days there is considerable condensation both on leaves of the cuttings and the polyethylene. The latter results in some runoff because of the pitch of the house. Most of it disappears behind the edge of the bench, although some will end up in the medium This, by the way is the only form of watering which the peat medium receives during the entire rooting process.

GREENHOUSE PREPARATION AND MANAGEMENT

The capacity of one humidifier lies between 10 to 15,000 cu. ft. of greenhouse area. We are using 2 units in a 50 by 9 ft. greenhouse and we are able to maintain a thick and even fog through the entire house at all times.

I want to stress the importance of using polyethylene lining within the house. This tight, inside cover will prevent the greenhouse from cooling off too rapidly during the night since the air space between the glass and plastic lining acts as an insulator More important, it seals in the fog. We believe it would be impossible to maintain a heavy fog without the plastic cover, because the water particles would constantly condense against the relatively cooler glass and run off through the cracks.

The greenhouse is kept fairly heavily white-washed through late spring, summer and early fall with a heavier coating along the lower edge. This will be sufficient in the early morning and late afternoon hours, during sunny days or periods of intermittent sunshine. During hot days, an additional shade is rolled out between 9 in the morning and 4 o'clock in the afternoon. Even then, the temperature will rise rapidly and often hover between 90 and 100 degrees F. During very hot days we will occasionally rinse the newly stuck softwood cuttings with a fine mist nozzle in order to cool the leaves somewhat.

FOGHOUSE PROPAGATION

Under the fog-like conditions we can create with these humidifiers, it is possible to keep practically even the softest type of cuttings in a turgid condition As a matter of fact, it happens time and again that soft cuttings are dropped beween the rows and they root just as readily without any drying or wilting. As has been demonstrated with intermittent mist, generally the softer the cutting the easier it will root. In this constant fog the cuttings do not require much moisture from the medium. Consequently, the medium can be relatively dry and, what is very important, very loose with plenty of oxygen available for the rooting process. The medium we use in our foghouse consists of 3 parts Dutch peat and 2 parts coarse perlite. The perlite is soaked with water while still in the bag and then mixed with the dry, shredded peat. This guarantees us a uniformly moist mixture, which is then dumped loosely in flats. We stick the cuttings quite close in this medium without any packing We then rinse the flats lightly with a mist nozzle before they are carried into the foghouse.

I will now give you a chronological report of our summer propagation sequence in the foghouse. We started out on April 16 by trimming the soft growth off the flats of transplanted evergreen azaleas, which have been overwintering in the greenhouse space up until this time. Without recutting, stripping or pinching we stuck these tiny cuttings, 500 to a flat. They rooted within 3 to 4 weeks, were transplanted in flats after 5 weeks and put in an outdoor frame.

On an experimental basis we did the same thing with hybrid rhododendrons on May 15th They rooted well, within 5 weeks. During the latter part of May and early June we made softwood cuttings of red maple *Prunus cistena* and Newport, Pink dogwood, *Magnolia stellata, Rhus cotinus, Cotoneaster salicifolia floccosa,* and *Ilex pernyi.* I realize that most of these species can be rooted in intermittent mist frames However, the point is that we rooted these items from very soft wood quite early when here in Northern Ohio the nights are still too cool to use the outdoor mist facility, efficiently. Besides, rooting under fog is so very rapid and profuse that the transplanted cuttings hardly suffer any transplant shock but keep right on growing vigorously. One reason for this may be the fact that there is absolutely no leaching during the rooting process

ADVANTAGES OF FOGHOUSE PROPAGATION

Some of the important advantages of the foghouse came to light when we were able to stick our first batch of rhododendron cuttings at the end of June. These by the way, were somewhat harder than the previously mentioned softwood cuttings, although still in a condition which were difficult to root under intermittent mist. These cuttings were cut, wounded, stripped to 3 leaves, and dipped in a weak solution of IBA in alcohol. They were uniformly rooted after 6 weeks and we kept repeating this operation on a limited scale after each growth period of our rhododendron stock plants. The rooted cuttings were then flatted up and kept outdoors like the evergreen azaleas. For the first time we will be able to overwinter all this material in coldframes instead of heated greenhouses. The last batch of rhododendron cuttings was made between August 24 and September 12 and we are in the process of transplanting these at the present time. Percentages and number of roots vary from good to very good. The interesting observation we have made is that the red and the more difficult to root varieties root very well when taken early in a soft condition. Another important item in September was *Cotoneaster apiculata,* which again rooted quite easily. All the softwood cuttings I have mentioned were dipped in a weak solution of IBA, in alcohol and water. In most cases the cuttings will root within 2 to 3 weeks.

The most important advantage of the foghouse is the fact that we have found a reliable and fairly easy way to effectively operate our greenhouse through the summer. We also are able to start our propagation program more than 2 months earlier than usual. We have rooted sizeable quantities of cuttings at a time when they still had a whole summer's growing season ahead of them. For example, we transplanted *Prunus cistina* and Newport cuttings into peatpots, planted them out in peat beds in early August and got 6 to 8 inches of growth by the end of September, plus a heavy root system.

Another advantage is the fact that the foghouse is easy to run. It requires just a little more care than a mist frame. We control the humidifiers with a one hour timer which can be set from continuous down to any time interval within one hour. However, we are considering the use of a different timer next year. The water level in the pan is maintained by a simple float device. This year we kept this pan filled by hand, although next year we intend to install a small central tank to feed both pans. During continuous use the Defensor unit will consume from ¾ to 1 gallon of water an hour which is low indeed compared to intermittent mist The one extra job involved in the foghouse operation is the need for practically daily shading of the house during the hot summer months.

We were surprised to find no fungus problems whatsoever, although we expected the opposite During dark cloudy weather we occasionally added some Natriphene fungicide to the water which the humidifiers spread evenly through the entire house and which seemed to be adequate for fungus control.

The one fact that we can now root hybrid rhododendron cuttings from June on, makes the Defensor worthwhile for our type of operation. We feel that this foghouse setup will make it possible for smaller nurseries with limited propagation facilities to grow more difficult-to-root material themselves. Before I mention some of the disadvantages I want to note that the foghouse is no competition to the intermittent mist facility. We will still root our large quantities of easy to root material like *Ilex, Pyracantha, Viburnum, Euonymus* and *Juniperus hetzi* in the outdoor mist. We consider the foghouse the ideal supplement to our intermittent mist setup, which enables us to make good use of our greenhouse space for rooting the more difficult to root species of plants.

DISADVANTAGES OF THE FOGHOUSE

Now let us mention some of the disadvantages of the foghouse. The main one is in the difficulty that is caused when the flats of rooted cuttings are taken out of the foghouse and have to be gradually hardened off. If this is not done properly, especially during June, July and August, the cuttings will literally burn up. At first we placed these flats in frames under heavily whitewashed sashes to keep them very cool After several days we gradually gave them more light and finally after one week we ventilated the frame. This was a slow and cumbersome process. Next time we built an intermittent mist line over this frame and ran it on a 2 minute cycle, while shades were kept on during the first several days. This method proved to be very satisfactory and we intend to use it in the future. Incidentally, the rhododendron cuttings are easy to harden off giving us no trouble from September on in outdoor beds under shade

The second disadvantage is one the foghouse has in common with the intermittent mist. In both cases we are depending heavily on mechanical devices and these might fail us at some time or other. In such a case cuttings in the foghouse would be even more vulnerable than those under mist. If power failures or obstruction of the water flow is not noticed immediately it will mean the total loss of the crop. In case of an emergency we are prepared to cover the whole greenhouse with heavy reedmats, and use mist nozzles to keep the cuttings moist Fortunately we have not had to resort to this technique as yet.

CONCLUSIONS

How reliable the Defensor will turn out to be has yet to be proven. However, judging from its record in Europe and by the fact that it is Swiss made, we are confident that it will be a worthwhile investment. We use the Defensor humidifiers from April until November, that is, during the time that sun heat is of importance in the greenhouse. Last year we used one until the middle of December, but did not notice any beneficial effects. The fog seems to keep the house too cool and the heat of the pipes makes the fog disappear immediatly after the humidifier stops.

I have told you about the use of the Defensor humidifier in respect to the rooting of cuttings, but I am sure that it has many more applications in the field of propagation. Last year we put some seed flats of rhododendron and *Hydrangea petiolaris* in the foghouse and we noticed a very quick germination, which resulted in a dense, even stand without any signs of fungus invasion.

While I was in Boskoop I was told that a nurseryman there had quick and good results when he put his summer grafts of Blue Spruce in a fog section. We intend to conduct some tests to see what can be done with grafts in this fog environment.

There is a somewhat comparable American product on the market which has been frequently advertised in the American Nurseryman magazine. I have tried to find its specifications and other details without much success.

The representative of Defensor Inc. in the U.S. is: Mr. Rene Forster, c/o Rene Forster Co Inc, 432 Fourth Ave., New York 16, N.Y.

As a final comment I feel that I should caution against too much enthusiasm for this humidifier To me it is just another good application of mist propagation, one that increases the potentialities as well as the worries of the propagator. Also I want to express my gratitude to my former employer, teacher and friend, M. Siem von Kalveren of Boskoop, Holland. Thank you.

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MODERATOR NELSON: Thank you, Mr. Stroombeek, for that most excellent description. Are there any questions to be directed to Mr. Stroombeek?

MR. ALBERT LOWENFELS (White Plains, New York): How did you know you had to shade your houses in the summer? Did you try it without shade?

MR. STROOMBEEK: I definitely did, but when I saw the first sign of burning I knew what I had to do.

MR LOWENFELS What was the temperature?

MR. STROOMBEEK: The temperature runs up to 100° F. if it is in the fog I thought that would be detrimental to the cuttings.

MR. ARIE JAN RADDER: Mr Stroombeek spoke about the American made humidifier. I have used the Walton Humidifier, made by the Walton Laboratories in New Jersey

MR. STROOMBEEK: No, I referred to the one from Standard Engineering Works in the East.

MEMBER: He is referring to the one advertised in *The American Nurseryman* for many years, by Standard Engineering Works, Pawtucket, R.I., and there are numbers of them still in operation in various greenhouses throughout the country.

MR JAMES WELLS There is a machine made by the Bahnson Company in Winston Salem which I think is very similar to this one It has a much larger capacity in that it will blow mist for at least 300 feet down the greenhouse Mr. Owens at Columbus is using that machine in a number of his houses very successfully.

What was the concentration of indolebutyric acid used to root your cuttings?

MR. STROOMBEEK: I used a weak solution, 160 micrograms to 1000 c c of 50 per cent alcohol.

MODERATOR NELSON: Are there any other questions or comments?

MR STROOMBEEK: This is Model 3001 with a thermal safety switch Of course, it is built for nursery purposes I wanted to mention this because the switch will cut in as soon as the temperature goes above 75° F, at a time that you want to have your fog very badly. If you don't specify you may get the same model without the thermonuclear switch.

MODERATOR NELSON. Thank you, Mr Stroombeek.

This next talk promises to be an interesting one I am sure that some of you got up this morning and took a look at yourself in the mirror and said, "What is it worth?" Well ,standards like those can be switched up and down, depending on the occasion. However, the standard of the red and blue of the ledger sheet is one that cannot be ignored in the industry and, therefore, it is with pleasure we have Mr. Henry A. Weller, Director of Perennial Production, from the C. W. Stuart Company, Newark, New York, to talk to us on "Propagation — Dollars and Sense." Mr. Weller.

Mr. Weller read his prepared manuscript. (Applause)

PROPAGATION – DOLLARS AND SENSE

HENRY A. WELLER
C W. Stuart & Co.
Newark, New York

In the four years that I have attended these meetings, I do not recall anyone ever stressing the actual cost of propagation. Is not being aware of the cost of propagation, and doing something about it, just as important to the nurseryman as the "know-how" of propagating?

Although propagation has been practiced since almost the beginning of time, and procedures have been basically the same, there are ways of modifying these that will result in a better plant, greater yields, and an actual decrease in cost of production.

The two words, dollars, and sense, have a direct bearing upon each other. Using common sense when producing plant material does result in a greater profit, dollar-wise. We are all vitally interested in propagation, or we wouldn't be here today, but I wonder how many of us are aware of, or know how much a given item costs us to propagate and grow. Do we know if it is profitable to keep certain items in our line?

Since I have been keeping accurate cost figures we have eliminated approximately 10 varieties of plants, simply because, no matter how we propagated these, they were not profitable to keep in our line. This idea of keeping cost on every variety grown might seem unnecessary to you, but during one season of growing *Phlox subulata,* we showed a loss of $900 00. If I had not kept accurate cost records on this specific item, we would probably have continued to grow it the same way, year after year, with the loss being absorbed by the profit of another variety Now we will either have to find a more economical way of propagating and growing *Phlox subulata* or eliminate it from our line of growing.

Let me give you a brief explanation of our cost program. All expenses incurred from the time a cutting is taken until it reaches maturity are charged to that given variety. It requires a lot of time and effort to keep these daily records straight, but it gives us a picture of where and for what we are spending money With this program we are able to determine: (1) if an item is profitable to grow, (2) the most economical method of propagation and growing, (3) the cost to grow the item, and (4) the sale price.

There are three phases of operation within our nursery where I feel we have been able to reduce cost considerably, namely: (1) storage of rooted cuttings, (2) weed control, and (3) mist propagation.

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For seven years now, we have been storing cuttings under controlled refrigeration. This enables us to hold our cuttings in perfect condition from the time they are well rooted until the time they are to be planted in the field By doing so, we are able to get two crops from the same greenhouse space that in the past produced only one This idea of storing rooted cuttings was brought to our attention by the preliminary work done at Cornell University by Dr. William Snyder We follow the procedure that when the cuttings have initiated one-half inch roots in the sand, they are fed with a water soluble plant food every two weeks to increase vitality. After sufficient rooting, the cuttings are removed from the bench, sealed in polyethylene bags and then placed in cold storage. The most important consideration during this period is that of temperature control. By maintaining a constant 34° F. we have been able to carry cuttings until such a time that they can be planted in the spring. This has been for as long a period as 4 months. The cuttings that we have successfully stored by this method include: *Teucrium chamaedrys, Buxus sempervirens, Ligustrum vicaryi, Chrysanthemum spp., Aster spp., Euonymus fortunei,* and *Euonymus fortunei vegetus.* This procedure has greatly reduced cost while increasing production and efficiency.

The practice of storing rooted cuttings under refrigeration, compared to that of putting them into cold frames, has reduced the total propagation charge by one-third, and has given us 2 crops of cuttings in the same greenhouse bench space. You can realize what this means when dealing with approximately 300,000 cuttings. I again want to stress the importance of maintaining a temperature of 34° F. On one occasion our refrigeration unit broke down and the temperature went up to 38° F for a short period of time, resulting in some rotting and loss of foliage.

The second phase of operation where we have been able to save money is in weed control. During the past ten years that I have been with Stuart's, we have been keeping records of what it costs to keep our nursery relatively free from weeds Up to 1954, we were spending approximately $30,000 annually for hand weeding and cultivation. During this period of time, we tried every conceivable method of weed control. The results were very disappointing because whatever we tried seemed to control the plants as well as, or better, than the weeds. However, with some of the new herbicides, we have been able to actually cut our labor bill by 40%, in spite of continued increases in hourly wages. This 40% reduction is based on an average of 140 acres. Sounds pretty good, doesn't it? Well, believe me, it not only sounds good, but it looks good when you add up the total costs In the nursery business, I personally think that this field has a greater potential than it has ever had before, because there are newer and better products coming out almost every day.

For our weed control program, we have been using 10% granular chloro IPC, made by the Niagara Chemical Company. We apply the CIPC with a tractor driven rotary seeder at the rate of 6 pounds actual per acre, or 60 pounds of the 10% material. When applied just after planting in the spring, we are able to control the first flush of weeds and delay hand hoeing by a month and a half

In actual figures, this is the comparison we get between chemical weeding and hand weeding. It takes 15 minutes to treat an acre of ground by using the rotary seeder After this application, it only requires an average of 48 man hours per acre to keep it free from weeds for the rest of the season This 48 hours compares with 160 man hours required to keep an acre free from weeds if not chemically treated This gives us a saving of approximately $200 00 per acre. You are probably wondering if we have had any injury to the plants by using CIPC at the 6 pounds actual per acre rate. In most instances the plants in the treated areas grew as well as those in the non-treated areas Of course, you must realize that an application above the tolerance level of the plant, will resut in injury. As far as I know, there has never been any extensive testing done to determine the tolerance level of specific plants. Through our experience with the material, we have found that 4 of the plants we grow seem to be less tolerant than the others. These include *Phlox paniculata, Iberis,, Ajuga* and *Dianthus chinensis.* By reducing the rate of application by one half, or to 3 pounds actual per acre, we were able to get a degree of weed control, without injury to the plants. I might add that, while this product is our main source of weed control, we are still not controlling all types of weeds with it. CIPC is too selective, and therefore we are continually searching and testing other products to find one that is even better. We have been working very closely with Dr. Pridham, of Cornell University, for the past few years He no doubt has more information, based on good practical experience than any other person in the field.

Mist propagation has been most influential in reducing our propagation costs With mist we have been able to get a higher percentage of cuttings to root, as well as to reduce the total number man hours and decrease losses in field transplanting. Like most nurseries, we were cautious with this new technique of propagation, so in 1953 we only rooted approximately 5,000 cuttings, using small quantities of many varieties of plants for testing We were so encouraged with the results that each year since we have increased production to the point where we are now propagating approximately 400,000 cuttings, or 30% of our annual total, under mist.

In our outdoor propagation area, we now have 1000 mist nozzles spaced every 5 feet, giving us an area of 25,000 square feet of bed space under mist. The overall area is covered with 2 inches of one-half inch gravel for drainage The beds are 5 feet in width and are edged with discarded railroad ties. The ties have already been weather proofed with creosote, and are heavy enough so that they stay in place without having to be staked We are using Florida type nozzles and have been quite satisfied with them. In order to get better water coverage and less clogging we drill the orifice to 1/16th of an inch. By increasing the size of the orifice, more water passes through, which reduces the total pressure in the line It would therefore be wise to check the pressure of your supply line before going ahead with this procedure

Each bed is controlled with an individual timer and solonoid The timers have a range from 2 minutes through one hour, and, in addition to this, have a switch which can turn the individual line off, hold it on constant mist or place the timer in control. Drying around the outside of the beds because of wind drift was a problem. It was found that wind baffles had to be erected in order to keep the water where it was needed. Of all the rooting media available we have found that terra-lite works the best for our mist operation This medium gives us good aeration and good drainage, even though we are applying relatively large quantities of water. The terra-lite also has a tendency to cling to the roots during transplanting which aids in keeping the roots moist

Some of the factors that make mist propagation ideal are as follows·

1. The flexibility of timing. In our experience, cuttings can be taken over a longer period of time with excellent results. We can take cuttings earlier in the year
2. Using flats and storage boxes that are normally put away for the summer, again is an advantage, in that the cuttings can be moved directly to the field in their growing units This means the cuttings do not have to be pulled until the last minute before they are to be planted into the ground.
3. The rooted cuttings are fed through the mist line, saving us the time and labor of hand feeding A water soluble fertilizer containing the 3 basic nutrients and trace elements is used. By doing this, we increase the growth and vitality of the cuttings so that they can be transplanted the same season that they are taken. This allows you to plant at a time when you are not as busy as you are during the spring rush. It gives you a better and larger plant at the end of the normal 2 or 3 year period of growth, and in many cases you are able to produce a saleable plant in one less year.

   The advantages of mist propagation also are numerous in many small ways. For example, with the plants we have tried, we have found that, in most cases, it does not make any difference whether the basal cut is made above or below a node. This enables the propagator to cut a handful of cuttings at one time, with a pair of pruning shears In our testing, we have not found any advantage from using hormones on cuttings rooted under mist There is no need for the constant vigilance which is required with most other methods of propagation

The plants we propagate under mist in full scale production include *Euonymus fortunei,* Winter Glory and Winter King which are two new Euonymus hybrids, *Buxus sempervirens, Mahonia aquifolium, Pachysandra, Vinca minor, Chrysanthemum vars., Plumbago larpentae, Ligustrum vicaryi,* and *Philadelphus virginalis* Others we have had under test and that have shown good results are: *Cytisus scoparius, Viburnum carlesi, Taxus cuspidata, Juniperus hetzi, Cotinus coggygria atropurpurea, Berberis atropurpurea nana, Pachistima canbyi* and *Philadelphus coronarius aureus* As far as I am concerned, mist propagation has contributed more to the nursery industry than any other development in recent years The potential is beyond comprehension

The storage of cuttings under refrigeration has decreased our handling costs, and has made our greenhouse more efficient. Our weed control program has enabled us to reduce our labor cost by 40 per cent. By rooting more of our cuttings under mist, we have been able to reduce our propagation costs This was all brought about by keeping accurate cost figures on all the phases of our operation. So don't you agree that being aware of the cost of propagation and doing something about it, is just as important to the nurseryman as the "know-how" of propagation?

* * * * *

(*Editor's note*: Mr Weller supplemented his discussion with a series of colored slides. Some of the comments and questions follow).

MR. WELLER: I mentioned the weed control program. This happens to be a good crop of chickweed which was controlled by using a fall application of CIPC at the 6 pound rate.

MR. CASE HOOGENDOORN (Newport, Rhode Island): What is the latest you apply your CIPC in the fall?

MR. WELLER. We generally try to apply it in September. It doesn't break down until you get sufficient moisture to bring about a reaction.

MR. HOOGENDOORN: What happens if you put it on in November?

MR. WELLER: You would still get control, in fact it can be done in the snow. We have had good weed control in established plantings of *Ilex verticillata* with the 3 pound rate per acre. When we get into the 6 pound rate for this plant we are getting into trouble

MR HOOGENDOORN: Do you wet the roots of the cuttings before you put them in polyethylene for storage?

MR WELLER. No, we do not. Incidentally concerning rooting of *Viburnum, Viburnum carlesi* cuttings taken on June 30, produced an excellent type of root structure

MR. WILLIAM FLEMER: How did they winter over after planting?

MR. WELLER: All right These were put in cold frames.

MODERATOR NELSON: Thank you, Mr. Weller. We have time for several more questions.

MR RALPH FISHER (Morrisville, Pa.). What is the length of your mist beds?

MR. WELLER. Approximately 150 feet.

MR. FISHER: How high is the wind baffle that surrounds them around the outside?

MR. WELLER: Approximately six feet.

MR. C. DeGROOT (Oakville, Ontario, Canada): I would like to ask what your timing is on the application of the CIPC herbicide?

MR. WELLER: It is applied right after planting in all cases

MR. HOOGENDOORN: You haven't had any bad results?

MR WELLER: As I mentioned before, with some varieties we had to reduce the concentration to circumvent injury

MR. HOOGENDOORN: I applied it last fall to beds when planted and I noticed this spring that the *Taxus* were off-color I had to bring them back with nitrogen, although I had two beds that never did come back. The chemical was applied right after they were planted.

MR. WELLER: I think it is a case of checking the tolerance of each type of plant material to learn when to apply the chemical.

DR. MAHLSTEDE: You had ten perennials you said cost too much to produce, among them, *Phlox subulata.* Who grows them, or how do you reduce growing costs?

MR. WELLER: In a case like this we have to check through our records to see where we made an error or where we have been doing something wrong. In the case of *Phlox subulata,* as you all know, it is propagated by taking divisions, and if this thing isn't done efficiently you can run into quite a number of man hours in just tearing the plants apart.

MR. RICHARD VAN HEININGEN (Deep River, Connecticut): What is the water pressure in your mist line?

MR WELLER: We are running at city pressure, which is 80 pounds. I mentioned that by the time it gets down to the end of the line it is probably down to around 65 pounds

MODERATOR NELSON: Thank you, Mr. Weller, for a very informative talk.

Now, to move right along, the next speaker needs no introduction. in the person of Mr Harvey Gray. I will now call on Harvey to speak on "Light Factors and Rooting Cuttings"

Mr. Harvey Gray, Farmingdale, New York, presented his prepared manuscript, on the effects of light on the rooting of cuttings. (Applause)

LIGHT FACTORS AND ROOTING CUTTINGS

HARVEY GRAY
State University of New York
Farmingdale, Long Island, New York

The original title suggested for this talk was "Rooting Cuttings with North Light." I asked permission to change the title so that details allied to "north light" might be considered and developed. This is a generalization of a few concepts held in the area of rooting cuttings. Such a generalization, for me, is possible through a series of demonstrational tests set up and developed over several years by students as part of their application and appreciation of the subject of plant propagation The following remarks are offered for consideration and discussion, a learning process, if you please, rather than material of unquestionable fact

We are led to believe that when all other factors are favorable, total food manufacture is in direct proportion to light intensity and duration With this thought in mind it might be wise to attempt rooting all of our cuttings in long and strong sunlight What happens to temperature in this strong and long light? It is here where we must go to an adjustment, making use of light reduction, misting or both But to bring them back with nitrogen, although I had two beds that never did come back. The chemical was applied right after they were planted.

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We are led to believe that when all other factors are favorable, total food manufacture is in direct proportion to light intensity and duration With this thought in mind it might be wise to attempt rooting all of our cuttings in long and strong sunlight What happens to temperature in this strong and long light? It is here where we must go to an adjustment, making use of light reduction, misting or both But wait, is it the high temperature that creates the problem in rooting cuttings? We have rooted a wide variety of plants with temperatures in the area of 120° F. I must hasten to add that at these high temperatures the humiity was held close to 100% with the aid of a vapor proof case

I have rushed into the subject of rooting cuttings too quickly. Let's go back to the source of the cuttings. Research and practice points to the fact that it is the food content of the cuttings at the time of insertion in the medium that effects the percentage of rooting. Cuttings taken from plants in subdued light have considerable less chance to produce vigorous rooted cuttings. The carbohydrate/protein ratio, usually referred to as the C/N ratio, is a very important control factor in rooting cuttings Cuttings from plants growing in supressed light condition fail to possess sufficient amounts of carbohydrate, and possess an excessive amount of protein to encourage rooting. Cuttings taken from plants growing in full sunight possess a good quantity of carbohydrate properly balanced with protein to produce favorable rooting At this time I am prompted to throw in another thought in regard to the C/N ratio concept Cuttings taken from plants growing in the sun, well fertilized, and well watered, unless given the opportunity to become well matured, present a problem in rooting. Again it is a case of too little carbohydrate and too much protein. Let us say, the wood is too soft

To summarize this, it might be put this way. The well chosen cutting with the proper C/N ratio is equally important, if not more important, than the number of foot candles of light permitted to fall on a cutting in the process of rooting Paraphrasing a cigarette ad, catch line, "It's what's in the cutting that counts."

Now let us return to the subject of light and the rooting of cuttings. The major problem, in summer, of strong sunlight, temperature and "evapo-transpiration" becomes a minor problem as we get into the fall and winter period when cuttings are rooted under glass. It is the summer period, from May through August, wherein lies the challenge I think that most of us would agree that it is the strong light, and the accompaning high temperature that creates the problem In order to reduce the temperature and yet not to restrict too much light is where the "North Light" principle applies.

North light implies that light that falls upon a surface makes its entry from the north sky only. Shading, on the other hand, is the reduction of direct sunlight with the aid of a wide variety of screening devices In order to obtain the maximum north light there should be no obstructions to the north such as shrubs, trees or buildings. A number of devices may be taken advantage of in creating "North Light." The north side of a grove of trees, the base of a tall wall, as well as the light deflector device made use of by Guy Nearing in his Nearing Propagation Frame, all make available the cool efficient north light for rooting cuttings.

In our instruction program at Farmingdale, many tests and demonstrations are set up to study rooting of cuttings with various light intensities Light intensity under the north light system varies within its limited range just as the direct sunlight varies over its very wide range.

Under the aluminum "deflector-reflector" as used in the Nearing Frame, the light intensity does not go much higher than 1000 foot candles, while direct sunlight may go ten to twenty times higher.

Foot candle requirement for photosynthesis varies between species of plants There is a limited amount of information on the most effective wave length of light for maximum food manufacture. It has been indicated that for most plants the rate of photosynthesis drops rapidly under a light intensity of 500 fc. With this thought in mind, we can readily see the importance of using strong cuttings with a high rooting potential when we choose to use "North Light."

With very few exceptions we successfully root more sorts of plants with "North Light," under vapor proof case conditions, than we do with full sun light under various misting systems During the 1958 summer season varieties of the following plants were rooted, making use of a vapor proof case and the principles of "North Light." *Acer palmatum, Azalea* "Knap Hill," *Cotoneaster horizontalis, Ilex opaca, Magnolia soulangeana, Prunus subhirtella, Prunus* "Kwanzan," *Pyracantha coccinea, Rhododendron* "Catawba Hybrids," and *Taxus cuspidata.*

The vapor proof case is made by putting down plastic across the bottom, up the sides and over the top of the unit, which is held in position with a turkey wire supporting device. We have found that there is no need in this chamber to use any special rooting mixtures. We just take the so-called Dutch peat as it comes out of the bale, and moisten it to the degree that when it is squeezed in the hand only a few drops of water will fall. The cuttings are then sunk into this medium with a sufficient amount of firming so as to prevent twisting after they have been positioned. All of the cutting types considered difficult to root are treated as far as wounding and rooting powders are concerned.

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(*Editor's Note*: Mr. Gray concluded his talk with a series of seven slides which summarized the points he brought out in his paper).

MODERATOR NELSON: Thank you, Mr. Gray. Are there questions?

MR. HOOGENDOORN: Under 100 per cent humidity, do you have any finishing problems?

MR. GRAY: To date we have not had any problems and I am at a loss to explain why.

MR HOOGENDOORN: What is the temperature inside your vapor proof case in the greenhouse during the winter?

MR. GRAY: As to the temperature of the bench in the winter, I might say that we attempt to regulate our heat by twisting a valve on the heating line, which is under the bench. We think we have a bottom heat temperature somewhere in the area of 68 to 72 degrees F. What the temperature in the air space above the cuttings may be, I do not have any idea.

DR. CHARLES HESS (Lafayette, Indiana). Harvey, have you made a direct comparison between the mist system and your vapor proof case system using the deflector reflector?

MR. GRAY: Indeed, I have, Charlie. I would not stand up here if I had not.

DR. HESS: Then have you made a cost analysis of the two? With the increased cost of the deflector reflector I wonder if you do not have a higher cost per cutting than you would have using a mist system alone?

MR. GRAY: No doubt you would. In this case I would not re recommend the deflector reflector, but would suggest as I did in my formal presentation, that you go to the north side of the woods and set the cases up there. Here you would need no aluminum, and you would have plenty of light reaching the cuttings. I get 1000 fc on the north side in the summer period, ample and sufficient to do a good job in rooting, bearing in mind that our cuttings are strong with a high rooting potential.

MR. WALTER GRAMPP (Red Bank, New Jersey). Using that north light setup, how long does it take to root *Acer palmatum?*

MR. GRAY. We get very nice roots showing in six weeks time, and the root system comparable to the plants on exhibit in twelve weeks.

MR. GERALD VERKADE (New London, Conn.): Is there any definite distance between the top of your plastic and the tops of your cuttings?

MR. GRAY: I don't think it makes a great deal of difference. We are checking this at the present time.

The important thing in case construction is that you do not build a circus tent and call it a vapor proof case. You have to keep the roof of your case flat You fellows who have been in this business of propagating plants for a long time know what a grafting case looks like. A vapor proof case is exactly the same thing, except you vapor proof it with plastic.

MODERATOR NELSON. Thank you very much, Harvey.

The next person on our program is John Hill, better known to all of us as Jack He is speaking on "A Practical Approach to Greenhouse and Liner Bed Sanitation" Mr. Jack Hill.

Mr. Hill discussed the subject of sanitation as it is related to the successful propagation of plants (Applause)

A PRACTICAL APPROACH TO GREENHOUSE AND LINER BED SANITATION

J B. HILL
D. Hill Nursery Company
Dundee, Illinois

Perhaps I should first define what I mean by greenhouse sanitation. Actually it is not a thing, but rather, condition. It is a condition which results from the application of cultural practices that are designed to initiate and maintain cleanliness throughout an entire plant producing facility. We feel that sanitation is a very important factor in this process of attempting to standardize. It is one of those factors which can be

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MR. GRAY: I don't think it makes a great deal of difference. We are checking this at the present time.

The important thing in case construction is that you do not build a circus tent and call it a vapor proof case. You have to keep the roof of your case flat You fellows who have been in this business of propagating plants for a long time know what a grafting case looks like. A vapor proof case is exactly the same thing, except you vapor proof it with plastic.

MODERATOR NELSON. Thank you very much, Harvey.

The next person on our program is John Hill, better known to all of us as Jack He is speaking on "A Practical Approach to Greenhouse and Liner Bed Sanitation" Mr. Jack Hill.

Mr. Hill discussed the subject of sanitation as it is related to the successful propagation of plants (Applause)

A PRACTICAL APPROACH TO GREENHOUSE AND LINER BED SANITATION

J B. Hill

D. Hill Nursery Company

Dundee, Illinois

Perhaps I should first define what I mean by greenhouse sanitation. Actually it is not a thing, but rather, condition. It is a condition which results from the application of cultural practices that are designed to initiate and maintain cleanliness throughout an entire plant producing facility. We feel that sanitation is a very important factor in this process of attempting to standardize. It is one of those factors which can be controlled, but unfortunately, is not the type of cultural practice through which you go once, and it is all done It is continuous.

The reason for practicing sanitation is simple First, it will reduce cost, and, second it may permit the production of a plant which could not be economically undertaken otherwise. This condition of cleanliness is aimed at production without interference from diseases and harmful insects Last but not least, it is aimed at producing an operation which is free from too many cull plants.

All experts on industrial relations stress the importance of neatness, orderliness and standardization, in any operation in order to achieve optimum results It is not a type of problem that you meet only once, solve it, and never experience it again. It is a type of problem that you just have to work at every day. For example, we all know how rubbish and junk tend to accumulate in corners, which, is not noticed as much after one has walked through the pile three or four days

I believe the primary point in the matter of greenhouse sanitation is a systematic cleanup. By that, I mean a specific period devoted to the collection of all plant refuse and rubbage, both inside and outside the greenhouse, under the benches, in the corners in the headhouse, and in the working area After this has been done it is then time to give a little thought to the establishment of one, strategically located rubbish pile. One must then have the firm conviction that every bit of rubbish is to be taken to that one pile, for subsequent burning or removal to a public dumping ground.

There is, of course, an endless economy to be achieved from arranging work in such a way that debries falls directly into a container, so that it can be disposed of easily. We solve that problem by making cuttings, trimming grafts and the like, by arranging to have the worker perform his duties right over a receptacle, into which the pieces will fall.

I was brought up or associated with a greenhouse operation where it was standard operating procedure to carry literally thousands of pounds of live plant material into the greenhouse every week From this quantity of plant material we made up cuttings or grafts which perhaps totaled about 20 per cent of the total mass brought into the greenhouse. The remaining 80 per cent was carefully swept into a pile and carried out in three or four days.

In our operation we have frequently seen jobs performed in such a way that it took one man, let us say, one hour to accomplish but it took two men, two hours apiece to clean up after him. We do not consider the job is finished until the working area is entirely clear and ready for the next job that comes along

In our headhouses the work benches are mainly metal. We do have one or two old wooden ones with which we are extremely careful. We cover these with copper naphthanate, in an effort to keep whatever may be in the wood inside, where it will not do any harm. We use a great deal of used newspaper, ie newspaper that is no dirtier than it gets in reading. We try to stay away from old lunch papers and similar paper. We do all the work we can on these newspapers. This facilitates the cleanup operation because they can be bundled and transported to our one, centrally located rubbish pile.

You will notice that I have not referred to any specific disease, insect, or control measure, since actually there is no way of knowing whether any are present Therefore, all the controls I am discussing are those not aimed at combating a specific, deadly disease but more at eliminating, so far as possible, the likelihood of any of the numerous agents becoming established. Any tool which is used to handle a large number of plants is much more suspect than a tool which is used to handle only a few plants Therefore, things such as wooden boxes used in the greenhouse are certainly to be watched very carefully. In our operation we have almost entirely eliminated the use of wooden boxes. For example, we use metal trays for handling all our cuttings. We have also eliminated the use of the large, square wooden box for handling propagating material. Instead we handle it all in square galvanized washtubs These tubs are nominal in cost, and of a handy size. They are easy to clean although we have good reason to believe that most fungi and bacteria would not find as happy a home on metal surfaces as they would on the wooden container Wooden containers, if used, should be painted annually or dipped in a standard strength wood preservative in order to insure its longevity and to make sure that it is not going to carry any diseases that we will later have to eliminate from our operation Of course, it is quite important to put these containers away in a clean condition They should not be put away containing earth, old roots, or other debries

Tools, in which I include such things as hand trowels, short-handled shovels, spades, and implements that are generally used in the greenhouse and propagation area, should be dipped frequently in some kind of decontamination solution. For example, a shovel might be dipped three or four times a day into a solution containing one part Chlorox to four parts of water.

As for the greenhouse itself, it is very important that it is cleaned completely By complete cleaning I mean that everything from the benches, to the gutters of the house should be scrubbed. If possible, the bars should be washed and certainly fastidious operation would require repainting the bars inside the house, if for nothing more than to eliminate the mold that often forms on them Use of a 1.50 formaldehyde solution for washing has proven to be excellent for this type of cleaning operation.

We follow a somewhat different procedure in the handling of our sand propagation benches than is generally accepted in that we do not change the sand We have some sand which has been in use now for five years We steam it at least annually, and between every crop possible. It is possible, of course, to have two benches steamed in the greenhouse while you have a crop in, say, two others. This is one of the main advantages in using steam as an overall antiseptic agent as compared to many chemical sterilants which cannot be used in a house containing growing plants. It is admitted that the medium will eventually build up with plant refuse so that the moisture capacity is higher than we like for a propagating material. However, we feel that it is safer and that there is less likelihood of diseases developing from the plant refuse which invariably comes off the cuttings and falls on the sand, than there would be in going to new sand about which we know very little. New sand is never used unless it is first steamed.

Pots, are a frequent source of contamination in the greenhouse. It is standard procedure with us to boil pots prior to use in a couple of old stock tanks that are 10 or 15 feet long, 20 inches deep and 30 inches wide. We put flats, pots and everything into the tank, hook the steam manifold in the bottom of it and attach the portable steam generator. After they have boiled, we let them soak for at least an hour in order to get as much of the salt out as possible. The boiling kills off whatever fungi and bacteria may have accumulated on that pot, and they are then put away.

In the outdoor beds used to produce banded liners we like to treat the soil either chemically or with steam. Use of chemicals such as Vapam and possibly Mylone seems to be more convenient than steaming. After the soil has been cleaned up we like to apply at least two inches of gravel so the plant bands in the trays rest on the pea gravel rather than on soil. In the past, liners which rooted out of the band and tray into the pea gravel were believed to be damaged by the lack of moisture. After a little study we had good reason to believe that much of the damage to the root tips could be traced to the lack of cleanliness or the lack of facility for maintaining it.

For several years now we have followed a procedure that we now regard as standard procedure in our operation. It is that of dipping every cutting, scion and understock which is brought into our propagating facilities into a combination dip, that we call the Triple Dip, for lack of a better name. It is comprised of Captan, Agrimycin and Terrachlor which are dissolved in ordinary water. It is a relatively inexpensive dip, and every piece of material is run through it. We are sure that this dip slows down rooting. However, since we are generally dealing with plants that are easy to propagate from cuttings, this slight reduction in speed of rooting is not serious. On the other hand, if a propagator was handling a group of plants considered difficult to root, then it might be a factor and would keep him from using this dip. We have used Ovatran in the dip, in an attempt to get rid of all mites before we ever put cuttings in the bench. We found that it often inhibited rooting more than we liked. In the process of running cuttings through this dipping solution it naturally accumulates plant debries. When this becomes excessive we do not throw the dip out but rather use it to wash down our work benches and the greenhouse floor.

In what appears to be a somewhat elaborate procedure and preoccupation with something that you often can't see, we figure that it is cheaper to take steps to prevent a disease infestation than perhaps having to fight it after it has started. You will remember in my introductory remarks that my original analysis of this sanitation procedure was to reduce production costs. Although these things I have described, sound elaborate, they are quite simple and require very little time, once they are established as routine.

A good question for me to ask in conclusion is, "How mature is your thinking in reference to things like sanitation?" We don't have to look very far back in history to find where the human race thought it was pretty well advanced, but was doing what appears now to be some pretty foolish things. For example, there was a time when surgery was just almost a warrant of death. Then it was discovered that through asepsis, surgery could be performed on the human being with pretty well, predictable results That was quite a big step. Often, this was accomplished before it was known what caused the disease or for that matter before the germs were actually seen. Thanks to Zacharias Zanser, a Dutchman and Anton Leeuwenhoek we began to see things that could not be seen with the naked eye I believe this same thing applies in the matter of greenhouse sanitation The presence of these disease organisms cannot be seeen with the naked eye until it is too late. To my way of thinking it is far easier to control them by sanitation and by preventative control measures than to attempt to fight them after they have become established. Thank you very much.

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(*Editor's Note*: Mr. Hill illustrated several of the points brought out in his paper by means of colored slides.)

MODERATOR NELSON: Thank you very much, Jack. Are there any questions you would like to ask Mr Hill?

MR. HANS NIENSTAEDT (Rhinelander, Wisconsin): Do you treat your benches in the greenhouse with Mylone?

MR. HILL: No, we have not used it in the greenhouse. We have it on hand, and it is our plan to use it for the sterilization of outdoor beds next spring.

DR. CHARLES HESS: Jack, can you tell us what is in your dip that is reducing your rooting?

MR. HILL: I believe it is the Terrachlor that is giving us the inhibiting action. We have used the Agrimycin and Captan alone on several occasions and have not experienced as much inhibition.

DR CHARLES HESS. The reason I asked is that the chrysanthemum people have found poorer rooting from cuttings which are dipped in streptomycin.

MODERATOR NELSON Thank you very much, Jack

To continue with our program I take pleasure in introducing Professor L. J. Enright, of the University of Maryland, College Park, who will speak on "Response of *Magnolia grandiflora* and Several Species of *Berberis* to Root Promoting Treatments."

Dr. Enright then presented his paper on the use of concentrated, quick dip chemical treatments for rooting cuttings of magnolia and barberry. (Applause)

RESPONSE OF MAGNOLIA GRANDIFLORA AND SEVERAL SPECIES OF BERBERIS TO ROOT PROMOTING CHEMICAL TREATMENTS

L. J. ENRIGHT
Department of Horticulture
University of Maryland
College Park, Maryland

Several workers have reported (1,2) favorable rooting responses of stem cuttings of a number of species and varieties of *Berberis* to various chemical treatments In general, the most satisfactory results were obtained with hardwood cuttings. In every case, the percentage of rooted cuttings was low and the period of time required for root initiation was lengthy. Enright (3,4,5) reported successful results in rooting a number of difficult plants with concentrated-solution-dip treatments of indolebutyric acid. This study was undertaken to determine the influence of similar treatments on the rooting response of *Berberis julianae, Berberis sargentiana, Berberis thunbergi, Berberis thunbergi atropurpurea* and *Berberis verruculosa.*

This investigation was carried out for two consecutive 12 month periods to determine the proper time for taking the cuttings, the position on the plant from which the cutting wood should be selected, the timing interval which should be used with the intermittant spray system, and the concentrations of root promoting chemicals that would be most beneficial.

It was found to be true with *Berberis* species, as it is with many other ornamentals, that cuttings rooted best which did not come from the most vigorously growing shrubs. It was also determined that those cuttings taken from the lower branches, often more shaded, rooted better than those taken from the upper branches.

The cuttings were taken from the lateral twigs of the current season's growth and cut to a length of 4 to 6 inches. All the cuttings were taken from the same parent plants for the duration of the study to avoid genetic differences in the woody material used. Although wounding was employed it was found to be of no value in producing rooting response on the barberries. In each test, 50 cuttings were used and their basal portions were dipped to a depth of 2 inches, for a period of 10 seconds, into a solution of indolebutyric acid and distilled water. The solutions were prepared by dissolving the indolebutyric acid crystals in just enough 90% ethyl alcohol to cover them. Then distilled water was added to bring the solutions to the desired volumes. The dip concentrations used were 5000 ppm, 10,000 ppm and 20,000 ppm.

A well drained greenhouse bench with an intermittant mist system was used for the propagation. This system was an in-bench installation with Florida 550B, deflection type nozzles. It was timed to spray the plants for 15 seconds during every 10 minute interval from dawn until one hour after sunset. A coarse grade of bank sand was used as the propagating medium. Soil heating cables were used to maintain the rooting medium temperature at approximately 70 degrees F. during the cold periods of the year. Whenever possible, air temperatures were maintained at a minimum of 72 degrees F during the day and 62 degrees F. at night.

In all cases, except with the *Berberis julianae,* the 5,000 ppm IBA solutions gave the best results The plants responded in this manner —

Berberis sargentiana	46 days	91%
Berberis thunbergi	17 days	100%
Berberis thunbergi atropurpurea	28 days	90%
Berberis verruculosa	31 days	96%

Cuttings taken in early spring and late fall responded with equally good rooting. Although those taken during the summer did not respond at all. A stronger, or more concentrated solution, 10,000 ppm IBA was necessary to produce roots on *Berberis julianae.* These plants did best when taken during the winter months and rooted in approximately 44 days with an average of 98% success

Magnolia grandiflora was handled in much the same manner. With this plant, however, wounding was an aid to rooting. A thin one inch slice of bark was removed from two sides of the base to expose the cambium before the cuttings were immersed in the IBA solutions The medium and mist timing were identical to that used for the barberry species.

For the College Park, Maryland area it was found that cuttings taken during the late spring or early summer produced the best rooting. It was also found that the root development was directly proportional to the concentration of the chemical solutions used The data for the month of June are a good example of this fact —

Concentration IBA	Cuttings Taken in June (% Rooted)* 1st week	2nd week	3rd week	4th week
Control (no treatment)	0	0	0	0
5,000 ppm	6	12	14	10
10,000 ppm	12	22	28	28
20,000 ppm	84	88	86	88

*Cuttings rooted in approximately 63 days

We have found that by reducing the mist interval by one half at weekly intervals, after the cuttings have rooted satisfactorily, they become sufficiently hardened for potting or outdoor planting. Our losses after transplanting have been negligible.

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5. .... 1958. Propagating several species of *Acer* by cuttings. Jour. of For, Vol. 56, No. 6.

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MODERATOR NELSON· Thank you, Professor Enright Are there questions to be directed to Professor Enright?

MR. WILLIAM FLEMER· Were any of these cuttings *Magnolia grandiflora hybrids,* or were they straight species?

DR. ENRIGHT: Straight species We had very poor results with the hybrids we tried.

MR. JAMES WELLS. Have you tried any of the strong powders in place of the concentrated dip?

DR. ENRIGHT. Not very many.

MODERATOR NELSON. Are there any more questions? If not, we thank you, Dr. Enright for a most interesting presentation.

The next speaker on our program is Mr. Hans Hess who is going to speak to us on the subject, "Copper Beeches by Grafting."

MR. HANS HESS (Wayne, New Jersey): I feel somewhat out of place talking about grafting, after having heard all these fine speakers talk about the rooting of cuttings. However, up to this point I don't believe there has been much successful work done with the rooting of copper beeches from cuttings, and therefore, we still have to resort to the old and tried method of grafting

Mr. Hans Hess presented his talk, "Copper Beeches by Grafting" (Applause)

COPPER BEECHES BY GRAFTING

C. W. M Hess, Jr

Hess Nursery

Wayne, New Jersey

It would not be proper to discuss the field of grafting without giving a little time to the preparation which precedes this mechanical operation. I will therefore start at the very beginning and speak for a few moments about the seeding of *Fagus sylvatica,* the understock for its suntanned brother. Many have had difficulty in obtaining a good stand of seedlings even though they used seed which was apparently fresh. We have found that the seed of *Fagus sylvatica* loses its viability very rapidly and consequently planting immediately after receiving the seed is of the utmost importance. The seed generally arrives from Europe after the ground is frozen solid and therefore seedbed preparation before hand is necessary. Seeding directly on the frozen ground does not effect the germination and it generally reduces the danger of rodent damage. We have, in a few instances had to remove four to six inches of snow before being able to plant the seed and obtained equally good results We have for the past few years treated our beech seed with red lead to avoid any rodent damage. The seed germinates very early, in fact it seems as though germination takes place as the frost leaves the

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In order to get maximum growth and prevent burning, the seedlings are kept under 50% shade for the entire season. A majority of the seedlings will develop to grafting caliper in one season, although with the carrot-like root system it is difficult to safely lift the seedlings and pot them before the leaves absciss. As you know, seedlings potted in a dormant condition during the fall are very slow to re-establish and therefore do not generally make a satisfactory understock We have found it satisfactory, when necessary, to pot the plants in early September with a full compliment of leaves and place them under interrupted mist for a week. By potting the plants in full leaf and using mist, rerooting is for all purposes immediate, and after three days we gradually reduce the mist until it is discontinued at the end of a week A very satisfactory root system is produced by grafting time, since the plants do not become dormant until nearly January. You have probably noticed that the European green beech will hold its leaves even though they are dormant. If you pot them early, before a frost and keep them in the greenhouse, the leaves will stay green and certainly help the rooting action

The procedure we generally try to follow is to pot the seedlings in early March into 2¼″ rose pots and grow them a full season in shaded frames. This method provides an understock with a very sound root system and insures the greatest degree of success. We bring the stocks into a cool greenhouse late in November and keep the temperature as close to 50 degree F. as possible until we are ready to graft them in late January or early February.

Before going further I must stress the importance of scion wood selection It is possible to obtain fair results with three or even four year old wood, although, for the best results and the most vigorous plant, current season's wood is by far the best. As mentioned previously, we graft our beeches late in January or early February, which period, from past experience is the most satisfactory This we feel is related to the approach of spring which encouages more rapid uniting of the scion and understock The scion at this time of year comes into growth much sooner, which we have found is important for good results.

A regular side graft has been our best method of uniting stock and scion, since it provides a maximum area of contact. The more nearly perfect the fitting of scion to stock, the better the percentage of survival after the first year. The grafts are tied with either a waxed string or rubber band, both are satisfactory. The newly made grafts are then placed in the grafting case at an angle, since the depth of the bench does not permit setting them up straight, with the unions above the peat We use both regular sash or plastic covers with equal success. It is possible, however, with plastic, to eliminate daily ventilation until it is time to harden the grafts. The sash remain closed for the first week. After this period the grafts receive a gradually increasing amount of ventilation during the morning, until they are receiving about an hours ventilation by the third week. After five to six weeks we gradually begin to harden the grafts by adding ventilation during the night. This is accomplished by placing wooden blocks of 1" x 2" first in front of the sash and later on the side. Eventually we remove the sash entirely at night Ventilation for hardening is added in the daylight hours in the seventh week until the grafts are completely hardened at the end of eight weeks. The grafts are now ready to be set up straight and to have part of the understock removed Complete removal of the understock is done when the plants are ready for shipment or for planting outdoors The grafts can be planted in a shaded bed or placed in a larger container after danger of frost has passed. They should not be planted in field rows until they are three or four years old, if you wish to have some plants left after the first year

Summer grafting has been quite successful for several nurserymen and is done during late August or early September I believe Mr. Hoogendoorn has grafted his beeches in the fall for many years. These grafts should be carried in a cool greenhouse or a frost free storage frame the first winter to prevent splitting

In summary, then, the successful grafting of Copper beech is dependent upon, a well established understock potted either while dormant in the spring or under mist in late summer, the selection of good scion wood, and finally on good grafting practices as regards well matched scion and understock, ventilation, temperature and moisture.

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MODERATOR NELSON: Thank you, Mr. Hess. Are there any questions?

PRESIDENT STEAVENSON: Hans, there is just one point that I missed. What do you do with the grafts for three or four years before they are established in the field?

MR. HESS: We recommend that they either be kept in a container of some kind or else kept in a bed where they are protected The wood of the beech is very, very brittle and of course, the scion being wrapped also is small. If it is disturbed at all it may fall off at the graft level.

MR. GERALD VERKADE (New London, Connecticut): After the grafts leave the greenhouse and are either placed in a container or bed are the losses very high?

MR. HESS: I believe the loss of beeches the first season is by far greater than for most other grafted plants This I would say is due primarily to the fact that the wood of beeches is extremely hard, and a union is never, very good I would say that you have as high as a 20 or 30 per cent loss.

MODERATOR NELSON: Thank you very much, Hans.

The next paper listed on this morning's program is entitled, "*Cotinus coggygria* by Softwood Cuttings under Mist." I understand that Mr Sjulin is not here and consequently, Mr. Gerald Pfundstein will read his paper Mr. Pfundstein!

Mr. Gerald Pfundstein read the prepared paper. (Applause)

COTINUS COGGYGRIA BY SOFTWOOD CUTTINGS UNDER MIST

John F Sjulin
Interstate Nurseries
Hamburg, Iowa

Cotinus coggygria can be successfully propagated by softwood cuttings in outdoor mist beds. At Inter-State Nurseries we have rooted fairy large quantities of the variety which we call "Royal Purple" for the last four years However, in two of those four years we suffered large losses after the cuttings had rooted. The first year we attempted to pot them shortly after they had rooted and we lost all of them. Then last year we lost about seventy-five percent of the cuttings about thirty days after they had rooted We think this was due to improper drainage caused from using the same gravel base two years in succession. This year when we rebuilt the beds, we raised them and put in fresh crushed rock. We are going into the winter with about a sixty percent stand.

Our cuttings are collected from a block of plants which are grown just for that purpose. Terminal cuttings, about eight inches in length, are taken when the stock plants have made ten to twelve inches of new growth. This is usually about the end of May in Southwestern Iowa. We make the cuttings only from new growth and prefer cuttings which are quite soft.

The cuttings are not trimmed in any special way except to remove all but four of the leaves. The cuttings are dipped in Hormodin #2 powder and stuck in the mist beds

Our mist beds are constructed on sloping ground and are built so that the bottom of the bed is level and maybe even slightly higher than the surrounding surface. Then we put in about three inches of crushed rock and top that with three inches of sand. This gives good drainage which we think is absolutely necessary for growing *Cotinus coggygria*

Our mist beds are covered with burlap on the sides and with cheesecloth on top. This covering prevents the wind from disturbing the mist pattern. The solenoid water valve is controlled by an electronic leaf. In fact, all of our outdoor beds are controlled by this one leaf. We have never used a time clock.

Cuttings start rooting in about five weeks. When about one-half are rooted we start shutting the water off for a few hours each day on that particular bed The rooted cuttings are left right in the mist beds for the rest of the summer, through fall and winter and are planted bare root directly into the field the following spring. We feel it is important that they are planted before breaking bud.

After the mist has been taken away from the rooted cuttings we put them on a regular watering and feeding program. In late fall, shades are placed on the beds and covered with a six inch layer of straw to prevent quick freezing and thawing.

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(*Editor's Note*: Mr. Sjulin's talk was reviewed by a series of colored slides which illustrated the principle features of the discussion).

MODERATOR NELSON. Is there any discussion anyone wishes to volunteer on this paper? If not, I will now call on Dr. James Kamp to present Dr Ticknors' talk entitled, "Chemical Weed Control in Nursery Beds"

DR JAMES R. KAMP (Urbana, Illinois): We are going to save some time on this paper, too, as far as questions are concerned. There is no use asking me any questions about this because I am only going to read what Dr. Ticknor has written down here. I have never seen his work, nor have I ever done any work like this

Dr. Kamp then read the prepared paper (Applause)

CHEMICAL WEED CONTROL IN NURSERY BEDS

ROBERT L. TICKNOR
University of Massachusetts
Waltham Field Station
Waltham, Massachusetts

One of the most expensive weed control jobs in the nursery is in beds where plants are grown until large enough to be planted in the field. Close spacing and the small size of the plants necessitate the use of hand labor for this job.

A number of products have come on the market in recent years to meet this problem. We at the Waltham Field Station started testing these products in 1956 for weed control efficiency and to determine how to safely use them

The two products and an untreated check plot used in 1956 were Mylone and Vapam Mylone was a 85 per cent wettable powder formulation used at a rate of ¾ pound per 100 square feet Vapam was a liquid used at a rate of one quart per 100 square feet. These materials were applied in a watering can and were thoroughly watered into the soil.

The object of these trials was to find how soon after the soil was treated on May 24th that plants could be safely set out. *Euonymus alatus, Forsythia ovata, Juniperus horizontalis, Rhododendron* "Roseum Elegans," and *Taxus media Hicks* were planted one, two, and three weeks after treatment In this experiment it was safe to plant one week following appication of Vapam but two weeks elapsed before it was safe to plant following the use of Mylone.

Both materials were effective in reducing the weed population in the bed area. Weeds from the walk areas rapidly encroached into the beds where they were not controlled. Cultivation, where soil containing weed seed may be thrown into the bed area, was not considered desirable.

During 1957, the trials were expanded to include bedding plants: *Ageratum houstonianum, Begonia semperflorens, Chrysanthemum morifolium, Coleus blumei, Hedera helix* and *Pelargonium hortorum,* as well as nursery stock: *Forsythia intermedia, Kalmia latifolia, Pieris floribunda, Pinus Thunbergi,* and *Taxus media Hicks.* Six plants of each type were set at each planting date, that is 7, 14, and 21 days after applying the soil treatments on May 8, 1958.

MODERATOR NELSON. Is there any discussion anyone wishes to volunteer on this paper? If not, I will now call on Dr. James Kamp to present Dr Ticknors' talk entitled, "Chemical Weed Control in Nursery Beds"

DR JAMES R. KAMP (Urbana, Illinois): We are going to save some time on this paper, too, as far as questions are concerned. There is no use asking me any questions about this because I am only going to read what Dr. Ticknor has written down here. I have never seen his work, nor have I ever done any work like this

Dr. Kamp then read the prepared paper (Applause)

CHEMICAL WEED CONTROL IN NURSERY BEDS

Robert L. Ticknor
University of Massachusetts
Waltham Field Station
Waltham, Massachusetts

One of the most expensive weed control jobs in the nursery is in beds where plants are grown until large enough to be planted in the field. Close spacing and the small size of the plants necessitate the use of hand labor for this job.

A number of products have come on the market in recent years to meet this problem. We at the Waltham Field Station started testing these products in 1956 for weed control efficiency and to determine how to safely use them

The two products and an untreated check plot used in 1956 were Mylone and Vapam Mylone was a 85 per cent wettable powder formulation used at a rate of ¾ pound per 100 square feet Vapam was a liquid used at a rate of one quart per 100 square feet. These materials were applied in a watering can and were thoroughly watered into the soil.

The object of these trials was to find how soon after the soil was treated on May 24th that plants could be safely set out. *Euonymus alatus, Forsythia ovata, Juniperus horizontalis, Rhododendron* "Roseum Elegans," and *Taxus media Hicks* were planted one, two, and three weeks after treatment In this experiment it was safe to plant one week following appication of Vapam but two weeks elapsed before it was safe to plant following the use of Mylone.

Both materials were effective in reducing the weed population in the bed area. Weeds from the walk areas rapidly encroached into the beds where they were not controlled. Cultivation, where soil containing weed seed may be thrown into the bed area, was not considered desirable.

During 1957, the trials were expanded to include bedding plants: *Ageratum houstonianum, Begonia semperflorens, Chrysanthemum morifolium, Coleus blumei, Hedera helix* and *Pelargonium hortorum,* as well as nursery stock: *Forsythia intermedia, Kalmia latifolia, Pieris floribunda, Pinus Thunbergi,* and *Taxus media Hicks.* Six plants of each type were set at each planting date, that is 7, 14, and 21 days after applying the soil treatments on May 8, 1958.

Materials and the rates of application on 100 square feet plots (5′ x 20′) were as follows: Allyl alcohol (Bedrench) 653 c.c., chloropicrin 3 c.c.; injections on 6″ centers; methyl bromide 1 lb., Mylone ¾ lb., Vapam 1 quart, 1.5 mil black polyethylene, and an untreated control. Allyl alcohol, Mylone, and Vapam diluted in 2 gallons of water were applied by means of a watering can followed by at least 15 gallons of water per bed. Forty-eight hours were allowed for methyl bromide to diffuse under the plastic cover. Black polyethylene strips, three feet wide, were lapped and the edges buried to make a bed five feet wide.

Walkways were treated with either dinitro at a rate of 6 pounds per acre or Diuron at a rate of 1 pound per acre. A one inch mulch of cocoa shells was applied over the herbicides to further suppress weed growth in the walkways.

The following observations and conclusions were made on the 1957 experiments:

Allyl alcohol	No observable damage to crop plants, only 30 per cent weed control and therefore not satisfactory.
Chloropicrin	Nursery stock set out 7 days after treatment was killed. Later plantings and bedding plants were not affected. Not effective for weed control.
Methyl bromide	Plant growth was good. This proved to be the most effective treatment, over 95 per cent weed control.
Mylone	No plant injury, plant growth good with approximately 85 per cent weed control.
Vapam	No plant injury, plant growth good. Approximately 85-90 per cent weed control.
Polyethylene, Black	Crop plant development was best in this treatment, probably because of the more uniform soil moisture supply. Weeds also grew lushly in the planting holes. This material doesn't seem suitable for bedding plants and small nursery stock because of the excessive labor involved in planting through the plastic film.
Control	Plant growth good but in general shorter than treated plots because of weed competition.

Our 1958 trials were set up using the most effective materials from the 1957 work, namely, methyl bromide, Mylone, and Vapam. EPTAM, a new material was used on three beds at rates of 10 and 20 pounds of active ingredient per acre. The Eptam on clay and vermiculite carriers was applied to the soil surface and rotary tilled to a depth of 5 inches. In addition to the preplant treatments, post planting treatments of sugar cane mulch, bark mulch, and granular CIPC were used in these studies. This was done because, while these chemicals control 85 per cent or more of the potential weed population, 15 per cent or less of the potential population can soon overrun the beds. The weeds that survive the chemical treatment or seeds which blow into the beds grow rapidly too.

However, this reduced weed population is much easier to bring under control than the original weed population would have been.

The beds were treated on June 6th and all plants were set out ten days later. Plants used were: *Euonymus patens, Rhododendron yedoense poukhanense, Taxus media browni, Thuja occidentalis,* and *Viburnum juddi*. The beds were 5′ wide and 20′ long and were subdivided into four, 5′ by 5′ areas for the three post planting treatments and the control area. Bark and sugar cane mulches were applied the day after planting to a depth of two inches. Granular CIPC was applied at the same time at a rate of 160 pounds per acre of a 5 percent material.

Ten days did not prove to be sufficient time for the Mylone to dissipate, since only 96 of 300 plants survived. Survival results (81 per cent) with Vapam possibly would have been better had a longer time elapsed between soil treatment and planting. These figures can be compared with 91 per cent survival in the control plots and 98 per cent in the methyl bromide plots. The post planting treatments appeared to have little influence on the survival of the crop plants. There was no loss of plants in the Eptam treated plots which had only a few representative plants in them, although the 20 pound rate appeared to generally inhibit the growth.

During the first month, little weed growth took place, except in the check plots which had to be weeded. Sugar cane mulch proved to be the most effective secondary treatment on these plots followed by CIPC and bark mulch.

By the second month the check areas of all plots except those treated with Eptam required hand weeding. The Eptam plots were completely clean at this time. Sugar cane mulch continued being the most effective post planting treatment. More of the surface of the bark plots was covered with weed growth than the CIPC plots at this time. Since there were a few large weeds instead of many small weeds, it was easier to weed the bark plots.

Three months after the soil treatments were applied the Eptam plots were still weed free. Only a small amount of weed growth had occurred in the mulched areas of the other plots following weeding. By this time any residual effect of CIPC had disappeared. It was not until four months after treatment that some weed growth, ie, henbit and chickweed, started to develop on the Eptam treated soil. This growth was still less than that on the other plots.

The following conclusions have been drawn from these studies:

(1) Eptam appears to be a very promising preplanting herbicidal material when applied to dry soil.

(2) Methyl bromide continues to be somewhat superior in herbicidal effectiveness to Mylone and Vapam. Better growth also resulted where it was used, possibly due to its shorter residual activity in the soil.

(3) Sugar cane mulch proved to be the most effective post planting treatment.

In summary, I would like to point out a few general conditions for successful use of preplanting herbicides and specific conditions peculiar to certain chemicals. Soil moisture should be at a satisfactory level for seed germination at the time of application. The soil should be prepared for planting before the chemicals are applied. Soil temperature should be 60° F. or higher for satisfactory results. Two weeks generally should elapse from the time of treatment to planting to allow the chemicals to dissipate.

Methyl bromide must be applied under a plastic cover. It can be applied to soils whose temperature is below 60° F. if the liquid is vaporized to a gas before application. Methyl bromide, of the chemicals tested has the shortest residual life in the soil

Mylone can be either rotary tilled into the soil or carried in by water. Since this chemical breaks down slowly, planting should not be done for at least two weeks.

Vapam should be applied to a soil surface which is moist and not hot, otherwise it volitilizes to form a tear gas like substance Many Vapam applications fail because insufficient water is applied immediately after application to carry it into the soil At least one inch of water should be used.

Eptam should only be applied to a soil surface which is dry otherwise it will volitilize rapidly No water seal is necessary when Eptam is rotary tilled into the soil

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MODERATOR NELSON. Thank you. Professor Kamp. Is there any discussion anyone would like to bring up at this point?

PROFESSOR J. C. McDANIEL (University of Illinois, Urbana, Illinois): I would like to make one comment on the previous paper.

It is concerned with the nomenclature on the Smoke Tree. At least as far back as the 1920 edition of Bailey's Nursery Manual the Smoke Tree has been separated from the genus *Rhus*. The correct name of this plant is *Cotinus coggygria*.

(*Editor's Note*: Dr. Chadwick was unable to attend this session and presented his paper during the Question Box Session on Friday evening, December 5, 1958. It is included at this, the regularly scheduled time for reason of continuity.)

CONTROLLING SPRING WEED GROWTH IN TAXUS BY FALL APPLICATIONS OF HERBICIDES

L. C Chadwick
Department of Horticulture
Ohio State University
Columbus, Ohio

One of the major problems in the control of weeds in commercial nurseries is the suppression or elimination of weed growth early in the spring. Cultivation is often difficult to accomplish during this season due to unfavorable soil conditions or because nurserymen are busy digging, shipping or planting stock at that time. This experiment was conducted to determine the effectiveness of some herbicides applied during the fall on the elimination or suppression of weeds the following spring If it is found that herbicides can be applied in the fall and suppress or seed germination at the time of application. The soil should be prepared for planting before the chemicals are applied. Soil temperature should be 60° F. or higher for satisfactory results. Two weeks generally should elapse from the time of treatment to planting to allow the chemicals to dissipate.

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Five herbicides, or combinations of herbicides, Simazine, Alanap 20G, a combination of SES and CMU, a combination of SES and CIPC, and CIPC were applied on November 1, 1957, to 150 square feet plots in a block of *Taxus cuspidata intermedia* Control plots were included and all treatments were replicated 10 times Buffer strips, 2 feet wide, were allotted between each treatment. The soil was mostly a Brookston silt loam and was moist at the time of the application of the herbicides. The liquid herbicides were applied with a knapsack sprayer equipped with a T-jet nozzle. The Simazine was applied at two rates, 4 and 8 pounds per acre, CIPC at 8 pounds per acre, and Alanap 20G at 25 pounds per acre In the combination treatments, SES and CMU were applied at 4 pounds and ½ pound respectively, per acre, and the combination of SES and CIPC were applied at the rate of 4 pounds of each per acre All application rates were based on commercial formulations Check and treated areas were free from weeds at the time the applications were made.

Observations of weed growth were made on several occasions during the spring months Ratings of weed growth were made for each plot on May 12 and on June 26, 1958 Ratings were based on actual weed counts and on observation of weed coverage in the different plots as compared to the control plots and the adjoining buffer strips. Control plots were given a weed prevalence rating of 10 and the other plots rated from 10 to 0, depending on the prevalence of weeds in that particular plot. Weeds most prevalent in the area included purslane, crabgrass, chickweed and pigweed. Quack grass, bindweed and Canada thistle were also prevalent in certain areas.

The data in Table I show the average rating of weed prevalence in the 10 replicated plots Ratings were made on the basis of the prevalence of weeds other than quack grass, bindweed and Canada thistle These three noxious weeds were eliminated from the ratings because they were unevenly distributed throughout the area or absent entirely from certain areas.

Table I.—Average rating of weed prevalence in control and treated plots on May 12 and June 26, 1958. Controls were given a rating of 10.

Treatment	Rating 5/12/58	Rating 6/26/58
Control	10 0	10 0
Simazine 8#/A	1 3	2 6
Simazine 4#/A	2 0	4 2
CIPC 8#/A	4 4	7 9
SES 4#/A and CIPC 4#/A	5 0	7 6
SES 4#/A and CMU ½#/A	5 4	7 6
Alanap 20G 25#/A	8 5	9 1

As the data in Table I show, Simazine at both rates gave excellent weed control even after nearly eight months from the time of application. CIPC and the combination of SES and CIPC, and SES and CMU gave satisfactory weed control through May 12th but weed growth was prevalent in plots treated with these herbicides on June 26th. Alanap

20G was generally unsatisfactory at the rate and under the conditions it was used.

In plots where quack grass, bindweed and thistle were present, Simazine (8#/A) stunted growth of bindweed and thistle slightly although quack grass was noticeably stunted and off-color. Simazine (4#/A) gave similar results although differences were not as striking. Applications of the combination of SES and CMU resulted in some stunting of quack grass but had little effect on the growth of bindweed and thistle Applications of the combination of SES and CIPC resulted in a slight stunting of quack grass with no effect on bindweed or thistle Applications of CIPC alone resulted in little or no effect on the growth of quack grass, bindweed or Canada thistle

In conclusion, on the basis of this experiment, it would appear that Simazine applied in the fall at 4 or 8 pounds per acre would result in great suppression or elimination of weed growth the following spring and early summer without injury to *Taxus*

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MODERATOR NELSON Thank you, sir.

Now that we have finished this afternoon's program I wish to thank everybody for bearing with us It has been a pleasure to act as your moderator I will now turn the meeting back to President Hugh Steavenson. Thank you very much

(President Steavenson resumed the chair.)

PRESIDENT STEAVENSON: Thank you, Dr. Nelson. You and your speakers have done a wonderful job. I never thought you would be able to adhere to the time schedule and nobody else did either.

Are there any announcements before we adjourn? If not, we do stand adjourned, as our program indicates until 9:00 a.m. sharp, tomorrow morning.

One other thing for those who have not had the opportunity to register. You will have that opportunity between eight and nine in the morning. Also, there has been some comment by a few concerning the registration fee and the inclusion of the banquet ticket. Obviously the reason why the registration fee has been made a package deal, is to encourage as large attendance as possible through the entire meeting. I might say also that the registration fees will hardly cover the cost of the meeting. So if you can't possibly make the banquet, you can be glad in your heart that you are making a contribution toward our deficit.

MR WILLIAM FLEMER I would like to make another plea for nominations for the Plant Propagators Award. We received only 10 cards from the mailing this year Certainly there must be more whom should be considered

PRESIDENT STEAVENSON: Bill, if I may say so, the Awards Committee did meet and have considered a number of nominations. Our purpose here is simply to supplement the nominations already made by further invitation to the group for additional nominations which might have been overlooked. I did want to make that explanation, Bill. There has been consideration for over a 12-month period concerning a nominee.

We now stand adjourned until 9:00 a.m. tomorrow morning.

The meeting recessed at four-fifty o'clock.

FRIDAY MORNING SESSION

December 5, 1958

The meeting was called to order at nine-five o'clock by President Steavenson.

PRESIDENT STEAVENSON: The meeting will please come to order. We are anxious to do right by our Vice President and Program Chairman this morning and get started approximately on time. We have a very interestting topic for discussion this morning, to be supervised by our long-time member and friend, Ray Halward, of the Royal Botanical Gardens, Hamilton, Ontario The panel discussion is on the propagation of *Prunus.* Ray Halward.

Mr. Ray Halward assumed the chair

MODERATOR HALWARD: Thank you, Hugh. We are going to have a very interesting session this morning on the genus, *Prunus,* one which hasn't been too widely covered at previous meetings and one of our most important groups of ornamentals.

Our first speaker this morning, Richard Hampton, gained his formal education at Iowa State College. He is now serving at the Irrigation Experiment Station at Prosser, Washington. He is to talk today on "Propagation of Virus-Free Stone Fruit Varieties and Understocks."

Dr. Hampton presented his paper on the propagation of virus-free stone fruits (Applause)

PROPAGATION OF VIRUS-FREE STONE FRUIT VARIETIES AND UNDERSTOCKS

RICHARD O. HAMPTON
Irrigation Experiment Station
Prosser, Washington

INTRODUCTION

Investigation of stone-fruit virus diseases began in the early 1880's with the work of Edwin F Smith with peach-yellows Only five stone-fruit virus diseases, all affecting peach, had been described prior to 1930. Milestones in the development of the present knowledge include the discoveries that certain peach viruses could be eliminated from budwood by heat treatment (7,9), that certain virus diseases which are masked in sweet cherry could be detected by use of index hosts (6, 11) and that some viruses are seed transmitted (1, 2, 3) Much work must yet be done in the following phases of research with these viruses. host ranges, symptomology, in-host behavior, means of natural transmission, their chemical composition and their control by heat treatment, host resistance and chemotherapy.

In the United States, approximately fifty stone-fruit virus diseases have been described. Since the complete host range of many of these viruses is not known, the number affecting each *Prunus* species has not been established. Some are found in specific areas, e g. albino of cherry in the vicinity of Medford, Oregon, while others are found in more general areas of the United States, e.g. phony peach in the Southeast, peach yellows and little peach in the Northeast and peach rosette in the South. Necrotic ringspot has been reported widely in the United States as well as other countries. The terminology of known viruses is not yet universally standardized and differences of stone-fruit virus strains and in host varieties in the various continents interfere with such standardization.

The effects of various stone-fruit viruses on growth and/or yield of clones of *P. cerasus* and *P. avium* have been measured by workers in Missouri (14, 15, 16), Oregon (12, 13), Pennsylvania (10) and Wisconsin (17) as well as in England (18). The seriousness of their effects have varied from slight to intense among viruses and among host species and clones used in the investigations.

Occasionally some virus-host combinations may result in death of the host in 1-3 years e.g. virus gummosis in apricot, Lambert mottle in Lambert cherry, albino in sweet cherry and necrotic ring spot in the Shirofungen variety of *P. serrulata* Other virus-host combinations may result in definite and characteristic symptoms with perhaps reduced yield and vigor but without direct death of the host, e. g. twisted leaf in Bing cherry, mottle leaf in Bing and Royal Ann, rugose mosaic, rasp leaf and rusty mottle in most sweet cherry varieties, and apricot ring pox in certain apricot varieties. Certain virus-host combinations may result in few obvious symptoms but may be demonstrated to reduce vigor and/or yield, e. g. necrotic ring spot in most varieties of sweet cherry and Montmorency sour cherry and sour cherry yellows, sour cherry bark splitter and sour cherry mid-leaf necrosis in Montmorency (13).

The detection of "masked" viruses is accomplished primarily by the use of virus-sensitive "index" plants. For instance, necrotic ring spot may be detected by placing the juice of macerated leaves from a suspect tree into cucumber or by placing buds from a suspect tree onto trees of Montmorency sour cherry, Shirofugen, or seedlings of *P tomentosa,* since these plants react to this virus.

Natural tree-to-tree spread of stone-fruit viruses has been observed and recorded (19). This could account for virus spread in scion and seed-source blocks All stone fruit viruses are bud and graft transmitted. The necrotic ring spot virus is transmitted through the seeds of Mazzard (2) and peach (3), while both ring spot and sour cherry yellows are transmitted through the seeds of Mahaleb and Montmorency (1) These points should stress the importance of propagation from approved, indexed scion and understock sources.

REGISTRATION OF SCION AND SEED-SOURCE TREES AND NURSERY STOCK CERTIFICATION

Stone fruit certification programs have been or are being established in California, Michigan, Minnesota, New York, Oregon, Washington and other states. This certification will be based on trueness to variety and freedom from known virus diseases. The basic approaches in obtaining these objectives are similar in many cases and ultimately must involve establishment of blocks of registered scion- and seed- source trees which are maintained under a program of systematic indexing for viruses. Once blocks of supposedly virus-free trees are established, it is necessary to continue indexing procedures and to remove those trees which are later found to be infected. Outlines for certification and scion-source utilization are shown in Figures 1 and 2.

Figure 1.—General outline for nursery stock certification.

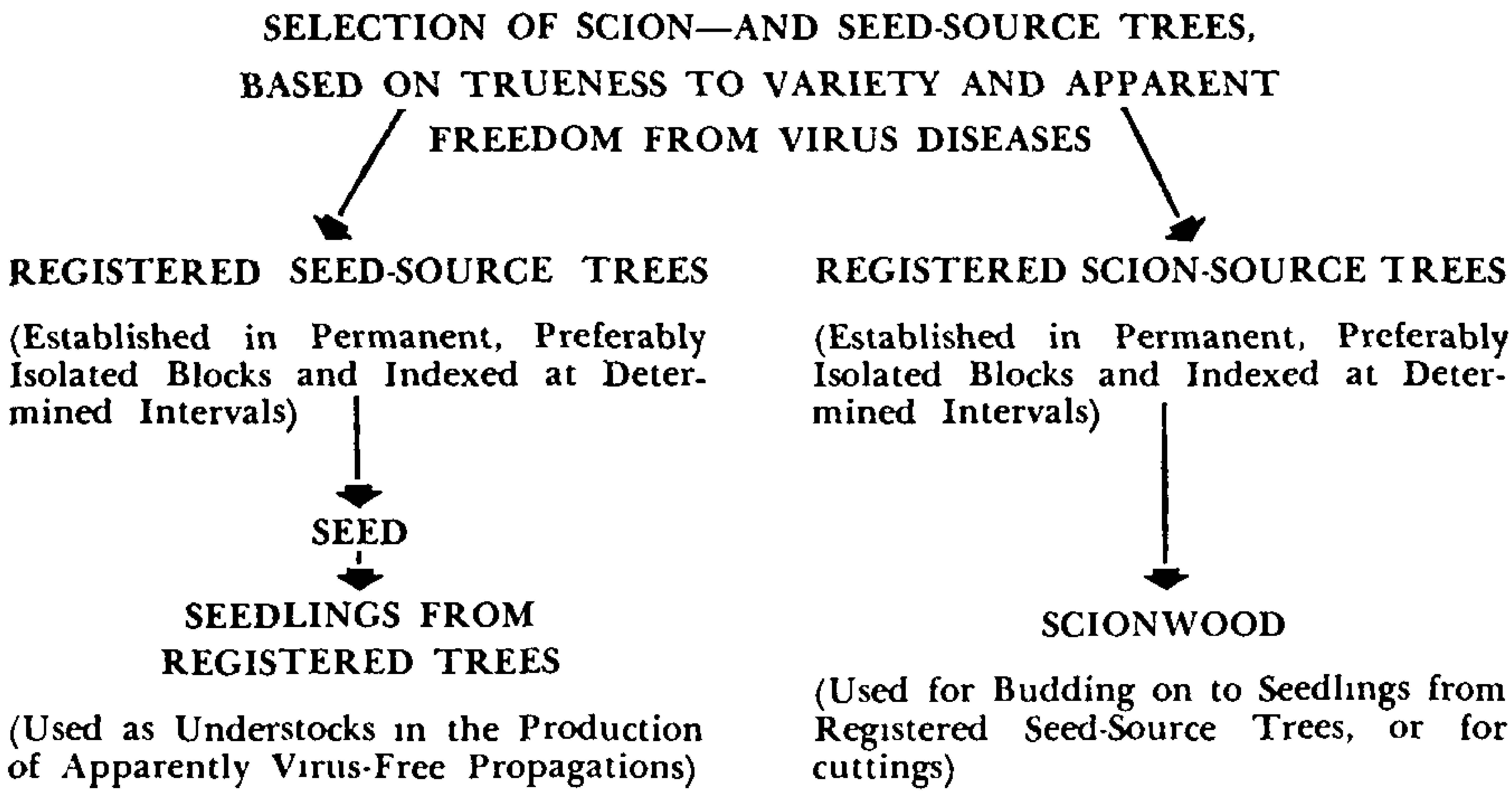
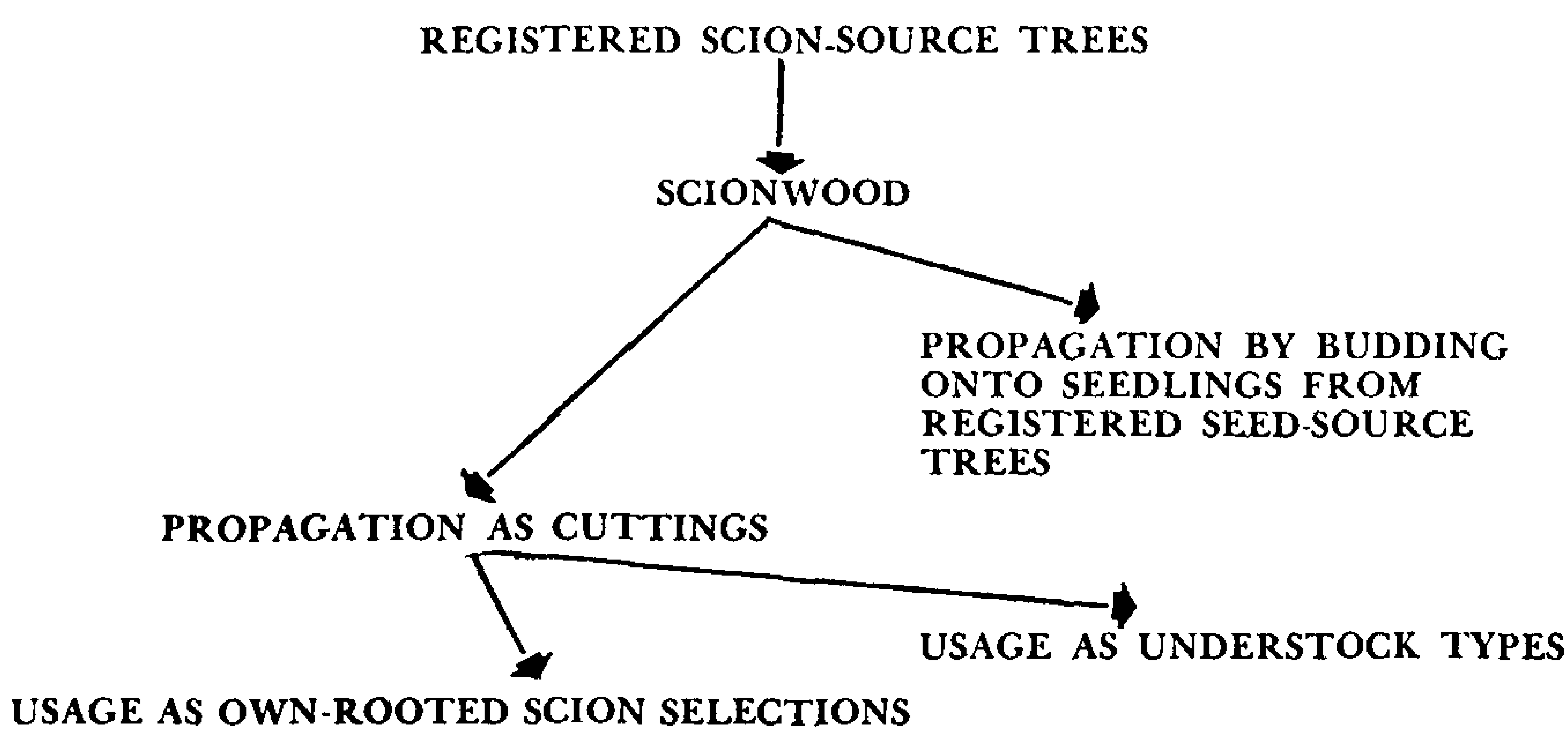


Figure 2.—Utilization of registered scion-source trees.



Sprays to control possible insect vectors of stone fruit viruses in established blocks are being considered.

Two major difficulties are apparent. In the first place, the establishment and maintenance of large blocks of seed source trees is expensive. Secondly, the task of indexing and evaluating both seed-source and scion-source trees by certifying agencies, on a state-wide basis, becomes very great. Close cooperation between nurseries and certifying agencies is essential in surmounting such difficulties.

UTILIZATION OF REGISTERED SCION AND SEED-SOURCE TREES

Once virus-free trees are established, production of virus-free seeds and seedlings and propagation of virus-free clones becomes possible. Where propagation is by budding, virus-freedom is highly important in both the understock and the scion. *Prunus* species and varieties which lend themselves to propagation by cuttings enable the propagator to eliminate the use of the understock, and consequently virus freedom in the clone is of prime importance.

CONSIDERATIONS FOR PROPAGATION BY CUTTINGS

Unfortunately, under most conditions propagation survival is lower as either soft- or hardwood cuttings than as budded seedlings, and also the quantity of budwood required is greater. It is not uncommon to achieve 100% rooting in softwood cuttings from certain clones of *P. mahaleb*. However, unless carry-over conditions are unusually well controlled, field establishment of a high percentage of these propagations becomes difficult The principle obstacle in producing finished cuttings of those species in which rooting can be induced has proven to be survival following rooting Permitting softwood cuttings to go into dormancy normally, without transplanting until completion of dormancy, seems to result in better survival

Optimum conditions for rooted cuttings during dormancy appear to be the following: 1) temperatures between 35 and 40° F. to reduce respiration, and relative humidity above 80% to reduce water loss, 2) moisture percentage in the rooting medium which is high enough to prevent drying out of roots and low enough to prevent rotting by bacteria and fungi. Transferral immediately after rooting appears to damage newly formed roots and increase probability for damage by these organisms. Moreover, the possibility of such damage increases when the plants are dormant as opposed to actively growing.

One promising approach involves the manipulation of cuttings so that rooting can be induced immediately following dormancy and so that root branching and differentiation can precede the following dormant period This has been accomplished at East Malling in England (4, 5, 8) by taking cuttings in September before leaf fall, treating with root inducing hormone and planting in cold frames. Callus formation occurs prior to dormancy. Root formation and development occurs the following spring and summer Then in the succeeding fall when the propagations go into dormancy, root development and branching is well grounded. Plants of this type are better suited to handling and transplanting, with less root injury and less damage by micro-organisms during dormancy. Mariana, *Prunus cerasifera gigantea*, in California and St. Julian, variety of *P. cerasifera*, in Oregon and British Columbia, are commercially propagated as cuttings by methods partially based on this principle.

PURPOSES AND LIMITATIONS OF PROPAGATION BY CUTTINGS

Purposes of propagation by cuttings fall into two general categories: 1) clonal maintenance and 2) quantity clonal increase. Fulfillment of the former is usually quite successful, except in the very difficult-to-root *Prunus* species and varieties, since low survival is not especially disrupting. However, in the case of the latter purpose, in which large numbers of finished rooted propagations are required, high percentage survival becomes important. It is here that exacting procedures and controls are often necessary. For the average nurseryman, propagation by cuttings of any random species and variety of *Prunus* for the purpose of quantity increase may not be practical, at least until relatively inexpensive and successful measures have come into use. The most feasible method of propagation of the majority of *Prunus* species and varieties seems to be budding of selected and indexed scion sources on seedlings from apparently virus-free seed source trees. However, in research studies involving uniform understocks and self-rooted scion selections, and in large-scale nursery operations, a premium is placed on high percentage survival in large numbers of rooted cuttings. Results obtained in these realms may eventually lead to methods suited to general commercial practices.

DISCUSSION AND SUMMARY

At least fifty stone fruit virus diseases have been described in the United States. All these viruses are graft and bud transmitted and some are known to be seed transmitted. Perhaps the most important control measure is avoidance of the use of virus infected scions and understocks in the nursery. Propagation of clones by cuttings offers the advantages of clonal increase of understocks and of eliminating scion-rootstock incompatability Virus transmission to scions through seedlings originating from contaminated seed-source trees is also avoided. At the same time this method offers the disadvantage of requiring special, well controlled and more expensive production measures.

Except for a few extremely-difficult-to-root *Prunus* species which require precise and expensive manipulation, at least small percentages of finished clonal propagations from cuttings can be produced. The standard budding procedure, supported by the use of scions and understocks free of known viruses, appears at present to constitute the most practical means of stone-fruit-variety propagation.

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MODERATOR HALWARD: I think we will dispense with the question and answer period. If we have any time at the end of the program we will work them in at that time.

Our next speaker this morning will discuss the "Propagation of *Prunus* Species and Varieties." This topic will be presented by Mr. W. A Cumming of the Experimental Station, Morden, Manitoba, where he has been for some three years. Previously he worked at the Plant Protection Division of the Federal Government and has done some work with Dr. Skinner. I now give you Mr. Cumming.

Mr. Cumming presented his talk an "Propagation of *Prunus* Species and Varieties" (Applause)

PROPAGATION OF PRUNUS SPECIES AND VARIETIES

W. A. CUMMING
Ornamentals Section
Canada Experimental Farm
Morden, Manitoba, Canada

Studies on the propagation of *Prunus* at the Canada Experimental Farm, Morden, Manitoba, have been concerned with methods for the multiplication of both the fruit and ornamental varieties of this genus and specifically for varieties which have been introduced or are being developed by breeding programs, for use on the Canadian Prairies. The lack of knowledge on methods for the propagation of some of the introductions, hybrids and selections has seriously hampered their commercial production and final acceptance by the gardening public.

The background of the *Prunus* varieties with which we are working is, for the most part, quite different from that of those which are grown in the more favored areas of this continent We have problems in common with the States which are situated in the Northern Great Plains area, only ours on the Canadian Prairies are slightly more accentuated. Some of you who know Morden, I expect are ready to challenge that statement By virtue of the fact that Morden is situated at the base of the eastern escarpment of the Pembina Hills, which form part of the first Prairie Steppe, the climate of the surrounding area is atypical of the Canadian Prairies in general. We can grow many plants which do not thrive elsewhere in the Prairie Provinces However, our field of service in horticultural research is the Canadian Prairies and it is to this larger area that I refer.

Last winter, tables, showing the results obtained from the various combinations of rootstock and scion variety used in budding and grafting of *Prunus* at the Morden Farm, were prepared. These tables are a composite of all experiments conducted on the graftage of *Prunus* from 1934 to 1956 inclusive. Since these figures encompass experiments on techniques as well as compatability studies, they are lower than those which can be normally expected. They are, however, indicative of the success with which various combinations of rootstock and scion variety can be made.

A summary of the results on some of the more important rootstocks for plums and sandcherry — plum hybrids has been published in the Proceedings of the Fourteenth Annual Meeting of the Western Canadian Society for Horticulture.

Open pollinated seedlings of *P nigra* and *P. americana* varieties along with seedlings of *P. Besseyi* have been used almost exclusively as hardy rootstocks for both plums and sandcherry-plum hybrids. The figures indicate that there is no significant difference in results obtained between the species *P nigra* and *P americana* but that there is a very significant difference in the results obtained with varieties within these two species Seedlings of Assiniboine, which is a *P nigra* variety, when used as a stock, gave an average stand of 56 percent while a 55 percent stand resulted from the use of the *P. americana* variety, Wastesa. Seedlings of the variety Zekanta (*P. americana*) gave a 44 percent stand, Cheney (*P. nigra*) a 31 percent stand, and so on down to Olson (*P.*

nigra) which yielded an average stand of 17 percent Seedlings of Pembina and Cree which are both *P nigra* hybrids with Japanese (*P salicina*) blood gave 51 percent and 45 percent average stands, respectively. These figures indicate that more care should be exercised in the selection of varieties from which seed is obtained for the production of seedling rootstocks. I can foresee that the time may come when it will pay commercial propagators to obtain seed for seedling rootstock production from a known variety, which has proven itself superior for this purpose.

Seedlings of *P Besseyi* commonly known as the sandcherry have been used extensively as a rootstock for both plums and the sandcherry-plum hybrids. In our trials, however, their use resulted in only a 23 percent average stand Other serious objections to the use of this species as a rootstock include its prolific suckering habit and the poor anchorage afforded by its root system.

The propagation of hardy apricot varieties has presented us with problems. Apricots on plum and sandcherry rootstocks form an incompatable union which very soon breaks apart

Apricot seedling rootstocks, widely used elsewhere, have not proven reliable under our climatic conditions. They suffer severe injury from prolonged spells of wet, cool weather, which we frequently encounter. Seedlings of *P. mandschurica* have given us slightly better average stands than have seedlings of *P. sibirica*. Very poor stands have resulted from the use of seedlings of the hardy *P. armeniaca* of Russian origin.

We have been investigating the use of an intermediate stock to overcome the incompatabilities between the plum rootstock and the apricot Two hybrids are presently under test for this purpose The variety Yuksa, a hybrid between sandcherry and European apricot, is a contribution from the work of the late Dr. N. E. Hansen of South Dakota and M-800 which is a Morden hybrid between sandcherry and the Siberian apricot. Both of these hybrids appear to be quite compatable with either plum or apricot.

The normal procedure for the introduction of an intermediate between rootstock and scion variety is to bud the intermediate one season and the scion variety in the second year By budding in the spring, the operation can sometimes be completed in one season. We have been experimenting with the double-shield bud technique combined with spring budding to further reduce the time and labor which it takes to produce an apricot tree.

In the autumn of 1955, Dr D. V. Fisher who is Head of the Pomology Section of the Summerland Experimental Farm, visited Morden on his return from an extensive European tour Among other things discussed, he told us of a method being used by Mr R. J. Garner of the East Malling Station in England, of budding intermediate and scion variety in one operation This technique was being used to bridge an incompatability between Quince 'A' stock and Bartlett pear. Apparently this method has been employed by European gardeners for many years, and has been one of those secrets of the trade which has been passed along from generation to generation.. The procedure is very ably described in detail by Drs. Mahlstede and Haber in their most excellent book, "Plant Propagation."

We first used the double shield bud or Nicoheren technique in the Spring of 1956 and secured a 55 percent stand, which made well branched 3 foot young trees by the fall of the same season. Seedlings of *P. americana* were used as a rootstock, Yuska as the intermediate and several varieties and selections of hardy apricots as scion varieties.

Another approach which we are preparing to explore is the use of these sandcherry-apricot hybrids as clonal stocks They can be propagated by layering quite readily as demonstrated by preliminary tests undertaken at Morden.

Early attempts, to find a hardy sour cherry that would grow and produce fruit on the Canadian Prairies, centered around the hardy Russian varieties of *P cerasus* such as Shubianko, Vladimir, Bessarabian and Koslov. None of these have proven satisfactory Horticulturists have now shifted their attention to the dwarf bush cherry, *P. fruticosa* and to a lesser extent to the Nanking cherry, *P tomentosa* as being the most promising sources of hardiness for a cherry which can be grown on the prairies.

Seed of *P. fruticosa* first came to us from the Tcheliabinsk Fruit Breeding Station in the Ural mountain region of western Asia, in February 1938. Seedlings of this species have been widely distributed and we now know that it can be grown successfully in most regions of Prairie Canada Selections have been made for fruit size and quality both at Morden and at Ottawa. Distribution and testing of these selections has, however, been hampered by difficulties encountered in their propagation. Seedlings of *P japonica* gave only mediocre results when used as a stock for these selections. Plants which were established on this stock made poor growth and it is suspected that the few which did not eventually succumb, had become established on their own roots.

A new, rather complex hybrid, *P. dropmoreana* holds the most promise of being a suitable hardy rootstock for the *P. fruticosa* selections as well as the standard varieties of sour cherry *P dropmoreana* is a product of Manitoba's renowned plant breeder Dr. Frank L. Skinner. It's parentage is (Koslov-Morello x *P. pennsylvanica*) x *P. maacki*. Plants which have been established on this stock are vigorous and the union is excellent. We have been a little disappointed in the stands which we have secured in our limited tests with this new stock. Our lack of success has been attributed to the fact that the stock is a vigorous grower with an exceptionally thin bark which opens up around the newly placed bud before a proper union can be achieved. There has also been some breaking over of the tops in heavy winds at the point where the top of the "T" cut is made We suspect that our date of budding, late July and early August, may be too early in the season.

In discussing this matter with Mr. Les Sjulin, of Inter-State Nurseries, Hamburg, Iowa, a year ago, he suggested that we try budding later in the season. Inter-State have also been doing considerable experimenting with this stock.

Beginning on August 23, 1957 and at weekly intervals thereafter, until September 20, 1957, buds of one of our *P. fruticosa* selections were placed on *P. dropmoreana*. Examination of these buds in the early winter revealed that those placed during the first half of September appeared to have made an excellent union with no opening of the bark on the stock Unfortunately we had a winter with no snow accompanied by severe soil drifting conditions which resulted in a very poor stand of all our *Prunus* buds.

Most of the Nanking cherry which are grown are produced from seed. For the few varieties and selections, which we have, seedling plum roostocks have proven the most suitable

Rootstocks for ornamental *Prunus* have received much less attention than those for fruit of this group *P. tomentosa* seedlings have proven to be the most satisfactory rootstocks, under our conditions, for *P. triloba multiplex* and *P* 'Prairie Almond.' The latter is a Morden introduction resulting from a cross between *P. pedunculata* and *P. triloba multiplex*.

P. padus seedlings are used for Shubert chokecherry, a purple leafed sport of *P. virginiana*. Seedlings of *P. virginiana* are sometimes used as a stock but should be avoided because of its objectionable suckering habit.

Plum seedlings are used as rootstocks for Muckle plum (*P nigra* x *P. tenella*), Cistena sandcherry (*P pissardi* x *P. Besseyi*) and Manitou (*P. tenella* x *P. persica*).

For the last 10 to 12 years growers have complained concerning the poor stands they have been getting in their *Prunus* budding and grafting operations Summer budding in late July and early August and bench grafting in February have been the most common methods of propagation A few growers have reported good results from spring budding, that is budding shortly after growth commences in the spring. Dormant budwood, collected earlier and held under refrigeration is used A three year comparison of these methods gave us the following figures at Morden:

Spring budding — 61 percent stand
Summer budding — 41 percent stand
Bench grafting — 21 percent stand

It has been frequently observed that although summer-placed buds seem to be in excellent condition when they go into the winter, many of them fail to grow the next summer. The winter of 1957-58 was particularly severe and only 2 3 percent of the buds placed in the summer of 1957 resulted in plants. The same varieties were rebudded on the same rootstocks in the spring of 1958 and resulted in a 64 percent stand In most seasons the spring placed buds result in plants that are ready to lift in the fall of the same season. One of the serious drawbacks with spring budding is that the plants keep on growing late into the fall. The result being that we often encounter rather severe "kill back" during the first winter out-doors. Cellar storage circumvents this problem.

The feasibility of the production of "own root" plants by means of layering is also being investigated. As a group, the sandcherry-plum hybrids have responded quite well to this method of propagation. In the Spring of 1956 we harvested 1,480 well rooted layers from a row of 65 mother plants. Seven varieties were included in the row, five sandcherry-plum hybrids and two straight sandcherry selections. This is an average of 23 new plants from each mother plant. The same mother plants yielded an average of 36 rooted layers in the Spring of 1958. Under our conditions we can only harvest a crop of layers in alternate years One season is required to produce the whips for layering the following spring. If a yearly supply of plants is required, two sets of mother plants are maintained. With favorable growing conditions the young plants secured by layering, will make marketable size in one season. It would appear that layering is an alternate method of producing sandcherry-plum hybrids that is economically feasible. We are extending our layering tests to include other species and hybrids of *Prunus*.

To avoid the possibility of mixtures occuring, as the result of the growth of rootstocks in our layering experiments, we use only plants which have been previously established on their own roots. The most successful technique, that has been employed at Morden to secure plants on their own roots, is by means of an inverse root graft. The method is the same as is used in normal bench grafting except that the scion is inserted in the distal end of the root instead of the apical end, or the inverse to normal procedure, hence the name The restriction, which results from the reversal of the rootstock piece, stimulates the development of roots on the scion just above the graft union The rootstock does not grow to any extent and can be readily removed when the plants are lifted This method has given us a consistently higher percentage of own root plants than any other technique which we have used. A *modified lateral graft sometimes referred to as a nurse graft* has also been tried This is a graft in which the scion is attached to the side of the root at about the midway point. This method gave us approximately the same percentage of own root plants as the normal method

Comparisons of the three methods over a three year period gave us the following percentages of "own root" plants. inverse 15 8 percent. nurse 6.5 percent and normal 6.1 percent

An extension of the production of *Prunus* varieties on their "own roots" is the testing of those which are easily propagated. as clonal stocks Earlier in this paper I briefly mentioned the possibility of using sandcherry-apricot hybrids as clonal stocks for apricots Varieties like Mansan which is an upright growing sandcherry-plum hybrid may have possibilities. Results of earlier experiments on topworking this variety indicate that it is compatable over a wide range. Last spring it yielded 520 rooted layers from 10 mother plants. These young plants were lined out for budding along with a number of other varieties which are now under test as clonal stocks.

Some of the *Prunus* can be propagated quite readily from root cuttings. Most of our work in this field has been confined to *P. fruticosa* because we were particularly interested in finding alternative methods of increasing our selections of this species, so that they could be sent out for wider adaptation trials At first we attempted to use roots dug from around the original plants of the selections, and results were far from encouraging. In a publication from the East Malling Station, concerning the propagation of clonal rootstocks, they reported very marked improvement in the production of plants when the roots were taken from one or two year old trees as compared to those taken from older trees We can now report that roots taken from one year old plants have given us much more encouraging results

Our procedure is to dig the young plants in the fall and cut the roots up into 3 or 4 inch lengths. These root pieces are packed into boxes with slightly damp peat moss and placed in storage at a temperature of from 34° F. to 38° F. If they are to be started in the greenhouse in February, the boxes containing the roots are held at room temperature for a week to ten days before the actual planting. This warming up period is sufficient to start adventitious buds to form and makes it possible to discard those which show no signs of development. From our experience we would recommend that cuttings which have been started in the greenhouse should be kept actively growing until danger of outside frost has passed, at which time they can be transplanted into outdoor frames. We have not tried planting the stored root cuttings directly out-doors in the spring, but I see no reason why it should not be satisfactory. In limited tests fall planting under our conditions was a practical failure. Other species with which we have had measure of success, in propagating them from root cuttings, include varieties of *P nigra* and *P salicina* (Manchurian), and *P dropmoreana*.

We have encountered difficulties in the propagation of *Prunus* from softwood cuttings but apparently we are not alone in this respect. The following remarks are only suggestions, for we realize that our program has been limited and much more research is necessary. Among the varieties which will root fairly readily are Dura, Sapa and Opata (Sandcherry x plum), *P. Cistena* (*P pissardi* x *P. besseyi*), Muckle (*P. nigra* x *P tenella*), Drilea (*P. tomentosa*) and selections of *P tenella*. Intermediate in their rooting response were Prairie Almond (*P. pedunculata* x *P. triloba*), *P triloba multiplex*, Coronation (*P. cerasus*), *P. maacki* and selections of *P. fruticosa* Varieties of *P. nigra* which have been so far tested refused to root. Treating the cuttings with a hormone such as I.A.A or I.B.A (1/1000) has proven helpful in inducing root formation. As a carrier we use Bentonite, a locally produced inert clay product Lateral growths with a heel attached have given us better results than terminal growths. Untrimmed cuttings or at the most a very minimum of trimming also resulted in better rooting. The main difficulty with softwood cuttings of *Prunus* is, of course, in getting them transplanted and re-established after rooting has taken place. Except for very special and valuable stock, the practice of potting up the cuttings and carrying them on in a greenhouse is economically unsound under our conditions.

In our search for a way around these difficulties a number of exploratory techniques have been tried. One of the best of these is to leave the plants undisturbed in the frame in which they were propagated for the winter and the following summer. This of course implies the use of outdoor propagating frames and their loss as such for one season. If a sterile medium is used for propagation, the application of fertilizers is also necessary Another fairly satisfactory method is to leave the cuttings in the outside propagating frames overwinter and transplant them the following spring, when growth is well started again, into frames which can be shaded for the first few weeks Following this procedure releases the propagating frames for use again in the same season.

Where permanent structures are used for propagating and in areas where successive crops are possible, these methods cannot be put into practice. In such cases a third method is suggested. Cuttings are taken as early as possible in the season. When rooting is well underway the cuttings are carefully transplanted into well protected frames, where every precaution is taken to keep them "growing on" vigorously. The young plants are left in these frames over winter and throughout the next growing season. The success of this method depends on providing a long growing period in the first season, hence the emphasis on taking the cuttings early Frames in which plants are being overwintered should be well protected with a coarse mulch. Heaving with the attendant breaking of tender young roots often causes serious losses when winter protection is inadequate

As a general rule, under our climatic conditions, seed of *Prunus* should be sown as soon after harvest as possible. It should not be allowed to dry out anymore than is necessary to make it easily handled For those species which require a long after ripening period, mulching in the late fall extends the time in which the soil temperatures remain at the proper level Wide boards are useful for this purpose

Drying out seems to be particularly injurious to seeds of *Prunus fruticosa* which lose surprisingly large amounts of water when allowed to dry. Mr. C. R. Ure, who heads the Fruit Crop Section at the Morden Farm, in studying the relationship of seed weight to whole fruit weight, found that there was a loss in weight between freshly cleaned pits and dried pits of from 24 to 41 percent. This may at least partially explain why we have obtained such markedly superior germination from seed which is never allowed to dry out. There would also appear to be a delayed dormancy factor involved in seed of *P fruticosa.* We have some evidence that this is more pronounced in selections which ripen their fruit early than it is in later ripening selections Our studies on seed of this species are being continued

Dried seeds of plum, apricot and sandcherry, when soaked in water 2 days at room temperature, stratified in moist sand for about 120 days at a tmperature between 34° and 38° F, and sown in the early spring have given us reasonably good stands.

An accelerating interest, by workers in the more favored regions of this continent and even in Europe, in the hardy species and hybrids with which we have been working, has been quite apparent within the last few years Interest is not usually concerned with the fruit produced by these varieties, but rather in their use as hardy rootstocks, intermediate stocks, or as new germ plasm for their breeding program.

We are always happy to be of service to fellow horticulturists and in a small way reciprocate the many courtesies which have been extended to us.

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MODERATOR HALWARD: Thank you very much, Bill This paper completes the program on *Prunus* this morning.

Our next paper is concerned with the propagation of the flowering cherries from cuttings. Mr. David Paterson, Longwood Gardens, Kennett Square, Pennsylvania will discuss this subject for us.

Mr. Paterson read his prepared address on "Flowering Cherries from Cuttings" (Applause)

FLOWERING CHERRIES FROM CUTTINGS

David B. Paterson
Longwood Gardens
Kennett Square, Pennsylvania

When we first decided to try to grow flowering cherries from cuttings, we knew that at least a few nurseries were already doing this with some success Our aim was to try to find a method of rooting and growing these plants, one of which would fit in with our conditions and our procedures.

Naturally, this work was started with some preconceived ideas as to what the major problems and the best means of solving them would be. Our first consideration involved the type of cutting and the best time for taking them For some reason or other it was assumed that the problem of timing would be similar to that of Pink dogwood, and the Japanese red maples. From what we had heard and read of these, and from a little experience with Pink dogwood cuttings, we felt sure that the answer would be to take soft tip cuttings in June and place them under mist.

This problem was solved in a rather unique way Since 1957 was the first year of the existence of the Nursery Department at Longwood Gardens, our propagating house was not completed until late July. We decided to go ahead anyway, and on August 1st, we took and stuck 50 cuttings each of the following 3 varieties or species: *Prunus serrulata "Kwanzan," P. yedoensis,* and *P. Sargentii.* The stock plants were all 3 years old or less.

Since our timing had of necessity been changed, we also decided to modify the type of cutting In addition to the tips which were quite soft at this time, we also took a quantity of cuttings from below the tips. The tip cuttings were treated with Hormodin #2 and the harder ones with #3. All cuttings were 6 to 8 inches long from current season's wood and were heavily wounded One half of each variety were inserted in sand and the other half in a mixture of 50-50 sand and peat They were all under intermittant mist controlled by a Watco Timer set to come on for approximately 8 seconds every 3 minutes from 7 AM to 8 PM After a week this was reduced to once every 6 minutes.

The initial results were very encouraging. In four weeks something like 90 percent of all varieties were heavily rooted and on September 1st were potted into 3 inch pots. They were placed on a bench where they received intermittant mist (once every 6 minutes) during the hottest part of the day for one week and were then placed on an open bench in the greenhouse where they were given shade and syringed according to the weather The mortality the first three weeks or so was quite high, but it was noted that by far the highest mortality was in the tip cuttings, in fact, very few of the tip cuttings lived and very few of the others died

The next factor to be dealt with was over-wintering Again we likened the problem to that of the dogwoods, feeling that they would have to make some new growth before they would be able to go through the first winter. We tried supplemental lighting (both lengthening of the day and interrupting the night). There was no response, not even any noticeable swelling of the buds, and the plants were placed in a deep coldframe in late fall with some misgivings. However, when they were removed from the frames in the spring, it was found that survival had been surprisingly good and a little better than 75 plants were planted in beds in early June. These plants are now on the average 3 to 4 feet in height.

While we do not consider 50 percent survival from cutting bench to field a good average, it was at least encouraging. We therefore decided to try again this year applying what we hoped we had learned to better our rooting and survival percentages.

In addition to the young stock plants mentioned earlier, we have at Longwood, some very old specimens, many of which were injured quite severly in a snow storm last March These of course had been pruned heavily and had produced a quantity of water sprouts. Some of these water sprouts were used as cutting wood. The varieties were Shiro-Fugen and Beni-Higan

On July 27th of this year, cuttings of the varieties used the previous year plus cuttings from these older trees were stuck in plain sharp sand, since no appreciable benefits were noted from using the sand-peat mixture. Although results from tip cuttings had been poor, it was decided to try a few as a test in case last year's results were not conclusive These were even less successful this year, since most of them rotted and died in the bench

Following the suggestion by Mr Wells in his talk here last year on the "Propagation of Hollies," hormone treatment varied with the condition of the wood at the discretion of the operator. Three strengths were used, i.e. Hormodin #2, #3, and 2 percent IBA. Again a heavy wound on both sides of cuttings was used

The cuttings again rooted rapidly and heavily and were potted up at the end of four weeks. It was noted that the heaviest cuttings gave the best results, in fact, cuttings 1½ pencil thickness and up at the base rooted extremely well.

After potting, the plants were hardened off using the same methods as last year and after a week or so of this occasional misting were placed in a deep coldframe and shaded heavily the first week or so. At the present time they look quite good and if over-wintering is as successful as last year we should have some nice flowering cherries to plant out in the spring

For those who like statistics, data from the notes on one variety which are fairly typical of the results obtained from all varieties are included in Table 1

Table 1.—Rooting of PRUNUS SERRULATA, Shiro-fugen*

	No	Hormone**	No Potted	Percentage
	20	#2	16	80%
	25	#3	23	92%
	25	2% IBA	25	100%
Total	70		64	91%

* Data does not include results with tip cuttings

** *Strength of hormone correlated to hardness of wood*

I realize that these tests have been on a small scale, but I hope that they will be of some help to some of the members. By the same token, if anyone has any suggestions as to how our methods could be improved, I would be very happy to hear them and try them.

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MODERATOR HALWARD: We now have time for a short question period here. Has anyone any questions to ask Richard Hampton, Bill Cumming or David Paterson? If there are no questions, we will continue with the second half of our program this morning, which comes under the heading of "Hardwood Cuttings."

Our first speaker is Mr. Phillip Worth, Kankakee Nursery Company, Kankakee, Illinois, who will discuss "Growing Fall Stock Hardwood Cuttings." Mr Worth

MR PHILLIP W. WORTH (Kankakee Nursery Company, Kankakee, Illinois): This is nothing that can be called a new procedure or new method, but possibly some of the techniques that we have used may be of interest to you. There is nothing at all technical about the way we propagate plants from hardwood cuttings

As a matter of fact, it could all be summed up in four words, that is, we *take* them, we *saw* them, we *stick* them and we *dig* them

GROWING FALL STOCK HARDWOOD CUTTINGS

PHILLIP W. WORTH
Kankakee Nursery Company
Kankakee, Illinois

The history of our procedure started as a result of the poor stands we had been getting by taking the cuttings and storing them over winter. We knew we had a soil that was, you might say, a natural rooting medium, being very sandy, light and well drained. About three years ago we stuck possibly around 10,000 cuttings of the more or less easily rooted common shrubs in the fall. This was done at a time when in our operation we had approximately two or three weeks in between additional evergreen diggings and before we were able to start digging deciduous material In these two weeks we would usually have five or ten men standing around doing only fill-in jobs. We were very elated with our results this first year but still were a little pessimistic because we realized that the excellent results we obtained may happen this time and maybe never again However, we again had very good results.

The next year we went into it a little more extensively, sticking three or four times as many cuttings, and again we had very good results. For us it is a labor saver There is no need for costly storage We take the cuttings, process them, and they go directly into the field. We were losing many of our cuttings handled overwinter because of the lack of mechanical refrigeration.

We generally take all one-year-old wood which is produced on mother block or cutting block plants reserved for this purpose. Although only experimental, we have tried applying a water soluble fertilizer to these stock plants in an effort to condition the cuttings for root-

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The next year we went into it a little more extensively, sticking three or four times as many cuttings, and again we had very good results. For us it is a labor saver There is no need for costly storage We take the cuttings, process them, and they go directly into the field. We were losing many of our cuttings handled overwinter because of the lack of mechanical refrigeration.

We generally take all one-year-old wood which is produced on mother block or cutting block plants reserved for this purpose. Although only experimental, we have tried applying a water soluble fertilizer to these stock plants in an effort to condition the cuttings for rooting. Incidentally, the majority of the time we leave the leaves right on the cuttings when they are made up on the band saw. We make the cuttings eight inches long for fall sticking, and only seven inches for those planted in the spring. One thing we have tried this year is taking these cuttings, particularly the lengthy ones, tying them in bundles and packing them in peat, in boxes, wetting them down and more or less sweating the leaves off before planting.

In planting we plant about $1\frac{1}{2}$ inches apart in the row and have been doubling the rows around six inches with each set around 42-inches apart. We realize that we are losing a lot of space. However, the reason we have not done it differently was because the equipment we have is set up to take care of these wide rows and we didn't want to go to the expense of buying new equipment until we were sure that this was going to be a real practical thing. Actually, we are still experimenting. However, we do intend later on to put the cuttings in single rows on probably 18-inch centers. In planting, the cuttings are put about seven inches in the ground and covered by throwing dirt up with the cultivator.

We are also going to try leaving about an inch uncovered to see if it doesn't work just as well as burying them.

Some of the results we have obtained by this method of propagation are as follows: *Chaenomeles lagenaria rubra*, 65 percent, *Physocarpus opulifolius nanus*, 90 percent, *Spiraea bumalda* Anthony Waterer, 86 percent, *Spiraea thunbergii*, 23 percent, *Spiraea zabeliana*, 96 percent, and *Syringa rothomagensis*, 48 percent. Other plants we propagate include *Deutzia spp.*, *Hydrangea A.G.* and *P.G.*, *Ligustrum spp.*, *Philadelphus coronarius*, *Philadelphus virginalis*, *Prunus cistena*, *Prunus glandulosa*, and *Viburnum tomentosum*.

*   *   *   *   *

MR. HOOGENDOORN: Have you tried any of the weigelas' or forsythias' in the fall from hardwoods?

MR. WORTH: No, we haven't tried weigela but we have been getting some excellent results with forsythia in the spring.

MR. MERTON CONGDON (North Collins, New York): Can you be just a little more specific about the dates when you take the cuttings from the stock plants?

MR. WORTH: Yes. In a normal year we start between the 15th of September, and probably finish around the tenth of October.

MR. FLEMER: How did you uncover the cuttings that were covered over in the fall?

MR. WORTH: We didn't. As you probably noticed, we used a tiller to prepare the bed and so naturally the soil was fluffed up. By the end of the winter, after the rains and snows, the ridge was packed and over an inch or an inch and a half of the cutting was exposed.

MR. MARTIN VAN HOF: How close to the tip of the cane do you come in making your cuttings?

MR. WORTH: We try to make all of our cuttings about the size of a lead pencil. To do this sometimes we have to go all the way to the tip of the cane.

MR. VAN HOF: In the latter part of September the wood is still green, doesn't it bend when you stick it in the ground?

MR. WORTH: Oh, no, they are not that soft.

MR. VERMULEN. Do you have any trouble with the cuttings heaving out of the ground during the winter?

MR WORTH: This is a good question. They might heave out as much as one half of their length. We hire some schoolboys to put them back. They can put 100,000 cuttings back in the ground in a day.

MR HOOGENDOORN Did you ever try putting on a mulch after you get them stuck?

MR. WORTH· No. I have thought a lot about it.

MR. LOUIS SAUR: Have you tried making your cuttings and putting them in different kinds of soil, other than the sandy loam you described?

MR. WORTH: No, I have never tried it on any different type of soil.

MODERATOR HALWARD: Thank you, Mr Worth

The next speaker on the program needs no introduction. Those of you who were on the tour the other day saw him and what he has been and is doing The next paper is on "*Magnolia* and *Viburnum* from Hardwood Cuttings," by J Ravestein.

Mr Ravestein then presented his talk on the "Rooting of *Magnolia* and *Viburnum* from Hardwood Cuttings." (Applause)

ROOTING OF MAGNOLIA AND VIBURNUM FROM HARDWOOD CUTTINGS

J. Ravestein
Gerard K. Klyn
Mentor, Ohio

We collect our magnoia cuttings from old plants which we have been using for a number of years to produce layers. We take the current season's growth which shoots up in the middle of our plant. The length of these cuttings doesn't matter and we cut them nearly any size. The longer these cuttings are the better, since through the years we have run our tests it has been shown that the stronger and longer the cuttings are, the better the percentage of survival you have, that is, if you have any at all.

The wood for our viburnum cuttings is taken from plants which have been budded the previous year. One such plant is *Viburnum carlesi*. Here also we prefer the longer cuttings. If I may go off the subject for a moment I would like to note that we have also in our tests the Japanese maples, Purple beeches, and the Cutleaf red maple.

We take our wood as soon as the dormant stage sets in, that is, in our part of the country, around the beginning of November In some years we have to take the terminal leaves off. After cutting they are brought into the greenhouse where we have an average temperature of around 70° F. We keep them in the greenhouse for about two days before they are made up. As I stated before, our cuttings are quite

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I don't know what your reaction will be after I am thru talking about this procedure, but our tests are run different than any that I know of. Some may think that our way is old fashioned and maybe it is, but it seems to be the only way we get results. I hope that there are some of you here who have run similar tests so that we might compare notes later. At the warmest place in the greenhouse we reserve enough space to contain the anticipated number of cuttings we have taken for this experiment. As you all know, there are places in heat controlled houses that are warmer than others. We take out of the bench whatever rooting medium we have previously used and start by putting about 2 to 2½ inches of peatmoss in the bottom of the bench. This peatmoss is then moistened. On top of the peatmoss we place a thin layer of clean sphagnum moss which is also moistened. Our cuttings are then placed on top of this and by placing, I mean we lay them side by side making sure that the cuttings do not touch one another. On top of the cuttings we place a heavier layer of sphagnum moss which in turn is covered with peatmoss to a depth even with the top of the bench. We make certain that nothing is stored or placed upon this portion of the bench until we have completed this part of the experiment Once we made the mistake of placing some flats on top of this and the results were nil. We also make sure that no water is sprayed on them, since we feel that the moisture is high enough without adding any more. After about 3 weeks we plant our rooted cuttings. At this time we find that almost every one of them will show some sign of root formation and some will have roots one-half inch or longer. It is here that our trouble begins. We know that by having these cuttings for a length of time in the dark and at the same time very moist and warm that they should be handled with utmost care. Consequently they are handled very carefully, being planted in a mixture of peatmoss and sand in the best location of the bench space available where we will not disturb them until planting time arrives. Three years ago we had a perfect stand, but since then our results have been very poor.

Now you may ask why don't we do this process later in the season than November? We have tried this process at later dates and have come to the conclusion that the later you start, the faster the buds develop on your cutting. Because of this, root action is retarded to the point where your stand suffers at the beginning instead of dying later on. We all know that when a cutting starts growing on the top before root formation has started, the chances for a good percentage of survival is very small. In other experiments we have tried storing cuttings taken at various times in cold storage. The length of storage was also varied. Cold storage cuttings do not give as good a percentage of liveability as when they are used as previously described. From this description you see that we have tried in every way that we can think of to obtain a satisfactory stand By a satisfactory stand I mean at least a 80% or 90% take

Field results are not conclusive, although after being planted out for one year there was no noticeable top growth but the root system showed considerable increase, thereby giving a good foundation for future development of the plant

I hope I have been able to offer information that will be of some benefit to all, because there is nothing more rewarding than starting out with an experiment and through trial and error come up with satisfactory results I wish to thank you all for the attention given and I am looking forward to answering any questions you may have during the discussion period

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MODERATOR HALWARD. We have time for a few brief questions.

MR. WALTER GRAMPP: Have you tried anything other than 2 per cent IBA?

MR. RAVESTEIN Yes

MR. SAUR: Do you think you get more root growth by having a long cutting than you would from a shorter cutting?

MR. RAVESTEIN. Definitely The bigger your cutting, the better rooting you have I don't believe in small cuttings.

MODERATOR HALWARD· That will be all the questions on hardwood cuttings. I believe Mr. Cumming has slides that he brought with him, and we have had some requests to show these slides. We will work them in now, before our last speaker of the morning.

Editor's Note: Mr W A. Cumming showed and discussed a number of colored slides which brought out particular features of his foregoing talk.

MODERATOR HALWARD. We are right on schedule, fortunately, and the last speaker of the morning is Mr. Hans Nienstaedt, Lake States Forest Experiment Station, Rhinelander, Wisconsin. He received his education at the Royal College of Agriculture at Copenhagen and at Yale University I present Hans Nienstaedt who will talk on "Fall Grafting of Spruce and Other Conifers."

Mr. Nienstaedt then presented his address on "Fall Grafting of Spruce and Other Conifers." (Applause)

FALL GRAFTING OF SPRUCE AND OTHER CONIFERS

HANS NIENSTAEDT
Lake States Forest Experiment Station
Rhinelander, Wisconsin

We in forestry are novices in the field of propagation, while you have been at the game for centuries. We have had to look at the experience gained in horticulture for the fundamentals to use in the propagation of our plant material. However, since our work schedule, our plant material, and our objectives often differ from yours, our approach to problems have sometimes followed new directions and have to obtain a satisfactory stand By a satisfactory stand I mean at least a 80% or 90% take

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Mark Holst of the Petawawa Forest Experiment Station in Ontario was, I believe, the first tree breeder on this side of the Atlantic to suggest fall grafting. His initial results and the earlier results reported by Stefansson (4) in Sweden were not very successful and prompted me to try to develop a more satisfactory technique. In the following, I shall discuss the results of my experiments and newer successful experiments by Mark Holst with spruce, I will also mention some additional information on pine.

EXPERIMENTAL APPROACH

The assumption was that grafting success primarily is a function of the speed and effectiveness of union formation and that these in turn depend on the amount of cambial activity of the root stock and scion at the time of grafting and immediately thereafter. Therefore, the experiments attempted to control this activity through photoperiodic treatments and chilling.

With most trees long photoperiods of 16 hours or more extend the growth period while short photoperiods of about 13 hours or less result in the early cessation of growth. White spruce and Norway spruce are typical in this respect as indicated by earlier experiments in which cambial activity was maintained at least until late September on long-day but stopped very soon after the plants had been exposed to short-day conditions.

The root stocks used in the experiment were 2-year-old seedlings of white and Norway spruces. The stocks were unusually large, the largest seedlings in a group of several hundred thousand Normally we would use 2-1 or 2-2 transplants. The plants were potted in the spring of 1956 in 4-inch pots in a 50-50 mixture of leaf mold and a light sandy loam, and were set in the field under partial shade.

Rootstock treatments were begun on June 27, when the plants were moved to a lightproof shed. The treatments were.

L (for long day) 20-hour photoperiods 6/27 to 9/11. Active at time of grafting.

F (for field conditions) Remained in field until September 11. Dormant at time of grafting Chilling required for resumptoin of growth

C (for chilling) 13-hour photoperiods 6/27 - 7/12; chilling at 41°F. 7/12 - 9/11. Dormant at time of grafting, ready to resume growth.

S (for short day) 13-hour photoperiods 6/27 - 9/11. Dormant at time of grafting. Chilling required for resumption of growth.

The extended photoperiod beyond 13 hours was of low intensity from 25-watt incandescent light bulbs. Throughout the treatments the stock plants were carefully watered to maintain them in the best possible growing condition.

The scions were collected September 10. They were all from the current year's growth, were cut about 3 inches long, and were taken in the lower crown of approximately 30-year-old white spruce trees. The plants were grafted on September 11-14, 1956, using the veneer graft with the graft union placed 3 to 6 inches above the soil line, but below the crown of the seedlings. The grafts were waxed with Trowbridge's grafting wax and placed on the open bench The greenhouse was not readily controlled; temperature was set at a 65-68° minimum, but often reached into the high 80's on warm sunny days with corresponding relative humidities as low as 30 per cent.

After grafting, the plants were again exposed to different environments of photoperiod and chilling, which were expected to influence the growth activity of the scion and rootstock and therefore the formation of the union. These treatments were.

l (for long day) 20-hour photoperiods.

cn (for chilling and normal daylight) 13-hour photoperiods 9/12 - 10/31; chilling at 41°F. 10/31 - 4/1; then normal greenhouse conditions.

cs (for chilling and short day) 13-hour photoperiods 10/15 - 10/31; chilling at 41°F. 10/31 - 1/2; then short day in greenhouse.

cl (for chilling and long day) as cs except long day in greenhouse.

s (for short day) Unaltered short day in the greenhouse.

The rootstock was first cut back on October 31, when the leader and a few of the first side branches were removed Not until the scions had completed one season's growth were the stocks completely cut back.

EXPERIMENTAL RESULTS

Survival. The result of the experiment clearly indicates that grafting of white spruce in September is feasible; 76.5 percent of the original 340 grafts survived on July 29, 1957, almost 11 months after grafting. In 22 of the treatment combinations (comprising 220 of the original grafts) survival was 80 per cent or better. Very similar results have been reported by Holst **et al** (2) in Canada; they have obtained average survival percentages ranging from 72 to 95 per cent in grafts of white spruce scions on Norway spruce rootstocks and of Norway spruce scions on white spruce stock.

Only in 4 of the 34[1] treatment combinations was survival much influenced by the treatments, and then only when white spruce was involved. In treatments **L**-s the sudden change from long— to short-day undoubtedly is a considerable shock to the plant and affects union formation; in **cn** the plants were not exposed to light (as they were in the other chilling treatments) and the white spruce rootstocks lost all their needles shortly after they were moved back to the greenhouse. This undoubtedly accounts for the low survival

The rootstock behaved as expected in response to the treatments before grafting. At the time of grafting, some were active (**L**), some were dormant (**F**), and remained dormant and some were dormant but resumed growth shortly after they were grafted (**C**). However, since survival showed no characteristic response pattern depending on treatments, (with only the few exceptions already mentioned) the conclusions must be that rootstock activity during the first 6 weeks of grafting had little or no effect on survival. Continued dormancy, on the other hand, is not desirable. This is not clearly evident in the data on survival after

[1]The 4 rootstock and 5 graft treatments for 2 species suggest a total of 40 treatment combinations However, no **cn**, **cs**, or **cl** graft treatments were applied to rootstocks given the short-day (**s**) treatment

1 year (3); however, the majority of the grafts that were not chilled and failed to break dormancy during the first year eventually died. Holst et al (2) also recommend chilling after grafting to obtain the highest possible survival.

Growth The dormant scions will only resume growth if they are exposed to cold or long-day conditions. Of the chilled grafts surviving (treatments **cs**, **cn**, and **cl**), 96 per cent had grown at the end of the experiment. Seventy-three per cent of the nonchilled grafts on long-day (treatment **l**) had shown activity, but only 4 per cent put out new shoots on short-day (treatment s)

The plants on long-day which had no chilling showed the first signs of flushing in the middle of March, 6 months after grafting, while the chilled plants began to show signs of activity 3 weeks after they were removed from the chilling conditions to the greenhouse.

Not only is chilling required for the maximum number of the plants to become active, it is essential if maximum growth is to be obtained Chilled grafts growing on long-day (treatment **cl**) had an average leader growth of 6 60 centimeters (2 6 inches)—almost twice the amount (3 62 centimeters or 1 4 inches) obtained with nonchilled scions on long-day (treatment **l**). Chilled scions on short-day (treatment **cs**) grew 5 46 centimeters (2 1 inches) or 17 per cent less than chilled scions under long-day (treatment **cl**).

Choice of Roostock: Mark Holst recommends that only Norway spruce be used for grafting during the late fall since white spruce suffers greatly by being kept in the warm greenhouse over winter without chilling; the following summer growth is reduced and the foliage has a poor color.

Although the tests showed distinct differences in the chilling requirements of the two species, (basically similar to those reported by Holst (1), there was no clear-cut effect of rootstock species on either survival or growth of the scions except in the unchilled scions on long-day (treatment **l**), and here white spruce rather than Norway spruce gave the best results. Thus, only 56 per cent of the surviving grafts on Norway spruce rootstocks showed active growth while 89 per cent grew when white spruce rootstocks were used.

Scheduling Fall Grafting of Spruce: Only well-established rootstocks potted the previous spring should be used. No special treatment of the plants is necessary aside from regular care to keep them in the very best condition.

The fact that rootstock activity apparently has very little effect on graft survival indicates that it should be possible to extend grafting over a considerable period during the fall It is not surprising, therefore, that Holst has reported successful grafting from August through the month of November He did report some decrease in survival as the season progressed.

After grafting, about 6 weeks are needed in the greenhouse to allow some degree of union formation. Thereafter, some provision must be made for chilling the plants to insure normal flushing. Where the grafts have been made early in the fall and in mild climates, this can be done in cold frames outside. Where the conditions are too severe to permit direct removal to the cold frames, indoor cold-storage facilities can be used. The schedule I have used in that case can be summarized as follows: Grafting approximately by September 15, followed by 4 weeks at long-day (20-hour photoperiod), then 2 weeks of short-day, and finally chilling The plants can either be left in cold storage or they can be taken out after about 8 weeks (perhaps shorter) and returned to the greenhouse, where they will break dormancy in about 3 weeks. By repeating this cycle, it is actually possible to have the plants complete one period of growth in the course of the winter and be ready for renewed growth by late May Present experiments indicate that the chilling period may be cut to between 4 and 6 weeks, which should permit at least two flushes of growth during the winter season.

GRAFTING OTHER SPRUCE SPECIES

Holst has made a great many grafts of Norway spruce with a high survival percentage. Besides white spruce we have grafted nine species with suvival percentages as listed below.

Species	*Percent survival after one year*
Picea koraiensis	72
P. abies acrocona	63
P bicolor	16
P. orientalis	28
P. jezoensis V. 11	73
P. jezoensis V. 10	50
P. montigena	25
P. omorika V 17	80
P. omorika V. 16	10
P. koyamai	16
P. asperata	Final survival not determined

White spruce rootstocks were used for all these grafts. The scions used for the grafts of *P. bicolor* and *orientalis* had been in the mail for several days before they were grafted; this very likely accounts for the low survival The low survival of the *P montigena* grafts probably was due to the low vigor of the scions which came from a suppressed tree of low vigor. The low survival of *P. koyamai* is as yet unexplained; more grafts will be needed to show whether this species actually is poorly adapted for fall grafting.

GRAFTING OF OTHER CONIFERS

To my knowledge, the work which has been done with other conifers such as the pines is very limited.

Dr. C. Heimburger of the Southern Research Station at Maple, Ontario, had "very encouraging"[2] results with field grafting of white pine from the middle of September until the middle of October. Veneer grafts are used on the side of this or last year's leader of trees 2 to 4 feet tall. They are tied with a rubber band (not budding strips) and

[2]Personal communication on file at the Northern Institute of Forest Genetics, Rhinelander, Wisconsin

covered with friction tape. The graft is enclosed in a plastic bag which in turn is protected with a kraft paper bag. The bags are supported by the cut stub of the leader above the graft. They will partly disintegrate during the winter and can be removed in one operation the following spring

The method is suited for grafting in already-established plantations, but does not give the type of tree desirable for landscaping. However, the results are encouraging, and modified techniques suitable for horticulture undoubtedly can be designed.

Holst at Petawawa has found the grafting of red pine *Pinus resinosa*, and Scotch pine, *Pinus sylvestris* more difficult than the grafting of spruces He emphasizes two factors in particular: (1) Grafting in late fall in November and early December gives better results than grafting in October, (2) The grafts should be over-wintered in the greenhouse For example, in one experiment 150 grafts were made on October 8 and placed in the greenhouse on the open bench, 20 survived. The same year, 112 grafts were made December 3 and kept in closed air in the greenhouse until February 28, 85 (76 8 percent) survived. In another experiment (2) red pine was grafted on Scotch pine in the middle of October. Half of the grafts were set out in cold frames to be chilled on November 21, the rest were kept in the greenhouse The following June, 42 per cent of the chilled and 69 per cent of the non-chilled grafts survived.

When the plants are brought out on the open bench, the stock should only be trimmed, not until a couple of months later should it be completely cut back.

SUMMARY

Experiments at the Northern Institute of Forest Genetics and in Canada indicate that grafting of spruce during the fall months, September to December, is feasible. To obtain maximum survival and growth, the grafts must be chilled During the early fall and in milder climates this can be done in cold frames outside; otherwise cold storage at about 40° F for about 8 weeks is quite satisfactory. A detailed grafting schedule for spruce is discussed.

Fall field grafting of white pine is satisfactory, and techniques now in use in Canada probably could be modified to fit the needs of horticulture.

Red pine and Scotch pine apparently give the best results if grafted in the late fall, ie., November and early December. They should be over-wintered in closed air in the greenhouse to insure maximum survival.

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MR. JAMES WELLS· Mr. Nienstaedt, I am sure everybody else in the room, together with myself, is busy trying to adapt what you have said to the economical production of spruce.

I have a hypothetical question. If we all rushed home and grafted some spruce we can presume that the union should be complete in, say, six to eight weeks. On a short day and normal conditions in the greenhouse, this brings us to about the middle or end of January. Now, if we put them outside under cool conditions, which would normally exist at that time, do you think that we would get better development of the scion? Do you follow me?

* * * * *

MR NIENSTAEDT· Let me just get this straight You have your plant on a short day without any chilling in the greenhouse Then your question is, "Should you move them out to get normal development the following spring, or should you not?"

You would definitely have to chill them if you wanted normal development next spring. As in all cases here, except two plants in 96 I had not chilled and kept on a short day, they never developed a shoot until the following July.

MR. WELLS: But the development of the apical shoot is of prime importance in the development of a symmetrical tree, and one of the arguments for fall grafting, which the Dutch pursue Following this procedure the development of the apical part in the spring is normal, whereas if you graft at the end of February and March, you do not get the normal development of the apical part. Therefore, I thought that if we were to set back our grafting time to say next week, we would enable the plants to unite, and then they could be chilled prior to spring when we would get normal growth.

MR NIENSTAEDT· That is right. Maybe I didn't get your schedule quite right. Did you say grafting on September 15?

MR WELLS No, I said *grafting* on December 15

MR. NIENSTAEDT: Oh, by December 15 you probably would have had enough chilling, I would think, to get normal development.

MR. RICHARD H. FILLMORE (Durham, N.C): Did I understand that long day, at least in part, will substitute for chilling and bring about normal resumption of growth of the plant part?

MR. NIENSTAEDT. The general response that you get if you use the long'day is that it does compensate in part for the lack of chilling. However, again to repeat, whereas 96 per cent of the plants that had been chilled came through, only 72 per cent of the scions on long day and no chilling came through

DR. CHARLES HESS On your plants that received only partial chilling, do you find that the lateral buds tend to break?

MR. NIENSTAEDT: I would say yes You do get, with partial chilling, very irregular bud development. In addition, you get the same kind of irregular response on the rootstock on long day without chilling

DR. CHARLES HESS. The reason I brought this up is because with our pink dogwood we found the last bud to break under deficient chilling requirements was the terminal. This may substantiate the point you brought up, Jim, that poor development of the terminal bud on the spruces by late grafting would be due to improper chilling

One important thing I think you brought out, however, is that when your scions have already received sufficient chilling, when they were taken in February, they could carry on normally. In other words, they won't require any further chilling. Or do they have to receive this chilling after grafting?

MR. NIENSTAEDT. I don't think it makes much difference. In terms of physiology, it shouldn't. But I think perhaps interference with the scion at the time of grafting in February is sufficient to interefere with normal development of the bud Apparently I got less interference by doing it in the fall and then chilling. That apparently is the type of response you have.

MEMBER· We know very little about spruce, of course, in the South, but I wonder if the chillings after the union is made would apply to juniper grafts. We seem to get good union and when I think they are on their way we lose them

MR. NIENSTAEDT: I must admit ignorance on the question. I do not know how juniper responds. You can't make a general statement about these things because sometimes they do not need chilling and sometimes they do not respond So I wouldn't want to commit myself.

MODERATOR HALWARD: Thank you, Hans. May I also thank the other speakers this morning for their detailed preparation, their fine delivery and the cooperation they have given the Moderator

PRESIDENT STEAVENSON Ray, you did a fine job. You are exactly on the minute.

We all stand adjourned until one-thirty o'clock.

The meeting recessed at twelve o'clock

FRIDAY AFTERNOON SESSION

December 5, 1958

The meeting was called to order at one-forty o'clock by President Steavenson.

PRESIDENT STEAVENSON. Will you please take your seats, and we will get our afternoon program underway.

Roy Nordine said you asked for plant materials, and this afternoon you are going to get it. He has certainly lined up an outstanding symposium on noteworthy woody ornamentals. Our moderator for the afternoon program is Mr. A. R. Buckley, Dominion Arboretum, Ottawa, Canada. Mr. Buckley.

MODERATOR BUCKLEY: Mr. Chairman and Fellow Members of the Propagators' Society. This afternoon pleases me very greatly indeed, because we are having a series of talks on new and noteworthy plants. This signifies to me that the propagator is not only interested in the propagation of plants but he is also interested in acquiring new plants. I am sure that a great many of our institutions, both commercial and otherwise, owe a great deal of their plant selection to the work of the propagators themselves

I hope that the result from this afternoon's talks will leave everybody free to ask for materials which they think might prove desirable in our own establishments. I am sure people are always willing to cooperate since everyone likes to see different plants distributed throughout the country so we see less monotony and more variety.

If any of you would come to my office you would see a great untidy desk. For a year I have had this pamphlet on my desk and I never dreamed I would be introducing one of the men responsible for this work. However, it now gives me a great deal of pleasure to introduce to you the head of the Horticultural Department of Ida Cason Callaway Gardens, whom I am sure you all know, if you don't you certainly will get to know him. Dr Fred Galle.

Dr Fred Galle presented his paper entitled, "Plants at the Ida Cason Callaway Gardens." (Applause)

(*Editor's Note* Dr. Galle integrated his discussion with a set of well chosen, colored slides, which unfortunately cannot be included in the Proceedings)

PLANTS AT THE IDA CASON CALLAWAY GARDENS

F. C. Galle

Ida Cason Callaway Gardens

Chipley, Georgia

This is one of the newest gardens in the United States and one of the largest The Gardens were initially started in 1947 and were formally opened in the Spring of 1952. At present, they comprise 2,500 acres with over 300 acres in water in ten lakes, ten miles of scenic drives throughout the area, and three miles of walking trails.

The main plant collections are native plants of the Southern Appalachian region, however, there are on the walking trails, collections of

American hollies. Collections have also been started of the Flowering crabapples, *Camellia sasanguas, Magnolia species,* and Hybrid rhododendrons.

The area of the Garden is normally considered in Zone 7, although, there are many plants that are normally considered to be for Zone 8 and 9, which can be grown in protected locations in the Gardens and, equally as well, many of the plants from colder regions of the country that are very satisfactory in this location.

There is one main function of the Gardens, which should be explained to all nurserymen (and I believe that this same condition exists with all other gardens and arboretums throughout the country,) in that we are a "service organization" for the nursery industry in as much as we are displaying plants and testing and evaluating plants for our own areas. These plants are on public display at all times so that often we can be called a "silent salesman" For example, during the past year, we had nearly 400 thousand people visit the Gardens and, of course, from these, there were many requests regarding the purchase of plants, where the various plants can be obtained and how they can best be used in their own landscape.

The Ida Cason Callaway Gardens is a non-profit organization We do maintain our own greenhouse and nursery in order to propagate and raise many of the native plants that we are dealing with since they are not available in the trade and the volume of material that we are planting out in this area makes it impossible to purchase all our materials. For the last several years, we have averaged over ten thousand plants permanently placed in the Gardens, plus four to five thousand annual bedding plants that are normally used

With slides, I will show you the main groups of plants that we are working with and will start with the native azaleas, including the Piedmont azalea, which is the most abundant It is very similar to the species, *Rhododendron nudiflorum,* which is hardy further North. Another outstanding plant in our section is *Rhododendron speciosum* which is in the same alliance with *R calendulaceum;* however, it flowers four to five weeks earlier than *R calendulaceum* and there are numerous intergrades of this species and *R canescens* and also *R. arborescens,* which can be found in the wild. We are working on increasing one of the rarest of the native rhododendrons, which we have in our section, ie *R prunifolium,* an orange to red flowering rhododendron, which normally starts flowering with us around the first of July and flowers spasmodically through August and September. We have some interesting hybrid seedlings now, resulting from crosses between *R. prunifolium* and *R arborescens,* and other earlier hybrids resulting from *R calendulaceum* and other species We have found that the propagation of the native azaleas is extremely difficult and, since a large volume of plants needed, basic propagation is by means of seed. We have had some success with root cutting of some species and there are several species, such as *R arborescens,* which can be rooted from cuttings We have also a collection of the Kurume and Indica azaleas and are working with the late flowering ornamental azaleas, such as many of the Glenn Dale and Beltsville hybrids, as well as the Chugai hybrids.

We have also, established a hybrid rhododendron trail, for we were of the opinion that hybrid rhododendrons could be grown in this warm climate and we have found that most of the difficulties do not result from the high summer temperatures, but rather from the fluctuating winter temperatures We have had our best success with the old Waterer hybrids, which are commonly used on the East Coast There also are some of the West Coast varieties, such as Mars, Pink Pearl, Vulcan, and others that are doing very satisfactorily

On our holly trails, of which there are three, one is reserved for Oriental species, one for American species and one for English species Our holly collection consists now of over 300 species and varieties and we are continually looking for new and better selections. Many of you I think are still of the opinion that yellow holly will not sell All I have to say is if you show it to enough people you can't keep it. I think most of you have never seen good yellow fruited hollies, so we are basing it on the fact that holly should have red berries. Why should it have red berries? This is difficult to answer. We just have associated red berries and holly as being synonymous, although yellow fruited forms will show up oftentimes better than the red fruited forms. In poor light, poor locations you can always see the fruit on a yellow holly, but can you say that of a red fruit?

We have a non-fruiting dwarf type of *Ilex vomitoria,* the Yaupon. It does have a few berries, but it is not noted for fruit, but rather for its gray-green foliage. Those plants have not been sheared at all although they are about six years old

We have a white-fruited form of *Ilex glabra,* which was found in Florida There has been another strain or genotype found in New Jersey I don't know that it has a great deal of possibility but at least there is a mythical white flower.

Another holly is *Ilex cassine myrtifolia,* which comes from South Georgia and Florida, is difficult to move, but is an interesting species in itself. It has yellow fruits with a little blush.

Then a group of hollies that are becoming quite popular in the South are the Foster selections Mrs Foster, of Bessemer, Alabama, made some five selections, among them Foster No 2 It is a narrow leaf, opaque type, although it is a *I. cassine* hybrid It has leaves like *Ilex opaca,* except that they are small, and it has the fruiting characteristics of the *Ilex cassine.* It is a very common plant in our section and works out very well. I might add that we have some Foster hybrids up in Ohio I don't know how hardy they really are, although I would take a guess that the Foster hybrids might do well at least up to Cincinnati.

Ilex decidua is one of the deciduous types of hollies. Unfortunately, it does not fruit at an early age but will retain its fruit even when the leaves come on in the spring Birds do not feed on it readily as they do on many of the other species. It is a desirable cut material type and does prove to be hardy up in many areas

Ilex chinensis now called *Ilex purpurea oldhami* has nearly a smooth serrate leaf and looks like an evergreen pear tree, with red berries. It is a little more difficult to propagate than some of the other hollies although it still is a desirable plant

Camellia sasanquas, the fall blooming camellias, are very satisfactory in our area and more so than the *Camellia japonica* species. We have now a collection of over 50 varieties which are used on the trail in conjunction with our Oriental hollies to give early fall color. There are many satisfactory plants within this group, from the singles to the semi-doubles to anemone types

Another group of plants we are interested in belongs to the genus *Lagerstroemia* There are a number of varieties including the lavender form. A good light pink one is called Near East, Watermellon Red is another These also make good small trees.

We have also started working with the dogwood genus, including a native form of *Cornus florida.* We don't know too much about it, but it is not a double. We are trying to see what we can do by grafting this plant It is not a thing that you are going to grow a great deal of but it is very interesting.

After the series of color slides on plants, a few slides were shown of equipment used at the Gardens One slide showed a coldframe constructed of Transite with Corrulux used as a substitute for glass. Another showed a homemade compost shredder, operated on the power-take-off of a tractor, a leaf suction machine for the collection of mulch and a series of pictures of a steam cleaning jenny, which has been converted for use of sterilizing soils, with a quick pipe coupling which has been adapted for this operation.

Invitation is extended to all plantsmen to visit the Gardens. We will be happy to exchange ideas and information with you and to aid in testing your plants in our particular area, if you are so interested.

* * * * *

MODERATOR BUCKLEY: Thank you very much, Fred. We have time for perhaps three or four questions if anybody would like to ask them from the floor.

MR. N. C. FARR (Northeast, Pennsylvania). I wanted to ask you if *Ilex pedunculosa* is among the plants you have at the Gardens, and if so, how it is doing?

DR. GALLE: It is one of the plants that we have but it is also one of the poorer plants We are unable to get it to grow as it does in other areas. We have only one plant now out of about 15 tries, and it is just holding on.

MR. JAMES WELLS (Red Bank, New Jersey): I want to ask Fred what is the longest distance you can carry your steam in your sterilizing operation?

DR GALLE: The generator is portable and we can shoot the steam over 100 feet to the bed by using galvanized pipe. Flexible hose is best but it is extremly expensive, so we use galvanized pipe and bend a short piece of hose to get into the bed where you want it.

MR. FRANCIS de VOS (National Arboretum, Washington, D.C.): Someone asked about the hardiness of the Foster hybrid. I saw some at Warner's Nursery on the tour Apparently it has been there for a couple of years. It does extremely well at the National Arboretum. This is rather strange and a little unusual, because *Ilex cassine* is not too hardy in Washington, but apparently *Ilex opaca* is a hardier form.

MODERATOR BUCKLEY: Our next speaker is a very charming and courageous young lady. Courageous because it rather reminds me of a lady driver. You know if you are a lady driver you really have to be good to avoid criticism from the men, and I am sure Miss Mary Milton is good in her work. I am going to call on her now to come up and address you. She is, by the way, propagator for the Morris Arboretum, in Philadelphia, Pennsylvania.

MISS MARY MILTON (Morris Arboretum, Philadelphia, Pa.): It is a pleasure for me to be here, and to discuss with you some of the plant materials we have growing at the Arboretum. If no one has any objections I would like to discuss these ornamentals from slides. May I have the first slide, please.

(*Editor's Note*: Miss Milton commented on each of these as follows.)

This tree is *Abies holophylla*, the needle fir. Although it gets quite tall, perhaps it could be used for small gardens. It has been planted at the Arboretum for ten or twelve years.

The Trident maple, *Acer Buergerianum*, is not too common. We have it planted in one of our Japanese gardens. It is quite a lovely thing, and has been planted there for some 40 or 45 years. It will be hardy in perhaps Philadedlphia as its northern limits.

The Henry maple, *Acer Henryi*, would be hardy to about Boston, I would say. It grows about 30 feet high and our specimen has multiple trunks.

The next tree I have selected is *Acer macrophyllum* or the Oregon Maple. Although it comes from the western part of the United States, I think perhaps Philadelphia would be about its southern limits. The leaves are very large and trimmed with brilliant orange in the fall.

Actinidia arguta or the Bower actinidia has edible fruit which is quite a delicacy, I understand, in Japan. It has rather inconspicuous flowers in June. It is a good plant for banks, and the report is that it will stand conditions which many vines won't.

Cedrela sinensis or the Chinese cedrela belongs to the Magnolia family, and grows to a height of about 60 feet. It has been used as a street tree in Philadelphia. I might add that the bees use this tree quite a lot, although it takes a long time to flower, perhaps as long as twenty years.

The Harlequin Glorybower or *Clerodendron tricotomum* might be considered a weed further south than Philadelphia since it suckers quite badly and the foliage itself is rather coarse. The flowers are quite nice and the plant has bright blue fruit.

Cotoneaster salicifolia floccosa or the Willowleaf Cotoneaster looks much like a firethorn although it isn't. It is a Zone V plant and is a heavy red, fruited ornamental.

Davidia involucrata or the Dove tree takes some time to flower, and even then it flowers rather erratically. It comes from China and grows about 16 feet high. Philadelphia may be the northern limit for this plant.

Ehretia thyrsiflora will grow about 30 or 40 feet and is hardy in Zone 5 or Zone 6. It has large white flowers borne in panicles in mid-July.

This next tree has attracted quite a lot of interest in the Philadelphia area. As you may or may not know, we have a bee garden, and Mr. Slocum, who is the curator, has done quite a bit of work in trying to find trees which attract bees He has found that this tree, *Evodia Daniellii*, is quite an outstanding tree for this use. It grows well and flowers quite late in the summer. *Evodia hupehensis* is not considered as good a tree as *Evodia Daniellii*.

Eucommia ulmoides or the Hardy rubber tree is interesting because it is about the only rubber tree that grows this far north The rubber it yields isn't enough to be worth while commercially.

The Franklinia tree, *Franklinia altamaha* is hardy to around Zone 5. It belongs to the tea family and will get about 30 feet high The foliage is rather sparse. It blooms late in the season and begins to bloom in August and very often goes to the first of October. It has an excellent flowering habit.

Halesia monticola or the Mountain Silverbell is outstanding in that there are not too many insects attacking its foliage

Kalopanax pictus belongs to the same family that ivy does and is quite unusual when it is young. It has little spurlike thorns that come out all over the tree As I understand, it is quite disease and insect resistant.

Laburnocytisus adamsii, a hybrd, is a cross between *Cytisus* and *Laburnum*. I rather like the shape of the plant since it is a bit unusual, although I understand it is not too popular. It is more of a curiosity than anything else.

We have several plants of *Mahonia Bealii* planted in one of our Japanese gardens I don't think it is my favorite plant growing in the Philadelphia area, because it is almost always subject to some winter damage and it is very stiff and formal

Metasequoia glyptostroboides or the Dawn Redwood, has been planted in several locations at the Arboretum. One is near the street. We also have some planted on rather dry banks and they seem to have done equally well in both locations. The growth on the *Metasequoia* has been phenomenal I have seen it grow from 3-½ to 4 feet in one season Unfortunately they are deciduous

Osmarea Burkwoodi is a hybrid, a cross between *Phillyrea decora* and *Siphonosmanthus delavayi*. It is evergreen in our area and is quite fragrant.

The Lace Bark pine or *Pinus Bungeana* is hardy in Zone 4. It is a truly lovely pine and has exfoliating bark Unfortunately not too many nurseries carry this ornamental We have many requests for the tree, and it is quite hard to find anyone who carries it It has multiple trunks I might mention also that it has some kind of disease or insect in the bark which is giving us some trouble

We have had quite a few requests for scions of *Pinus griffithii zebrina* or the Himalayan Zebrina pine. It is lovely, with little bands of gold on the leaves having in addition all the soft texture of the Himalayan Pine.

Quercus macrocarpa 'Deamii' is a fastigiate form of the Mossy Cap oak It came from Mr Deam in Northern Indiana.

Symplocus paniculata or the Asiatic sweetleaf, belongs to the rose family. The fruit is very bright and quite a delicacy for the birds, although it doesn't last long.

Xanthosceras sorbifolia, the Shinyleaf yellowhorn flowers quite late in May. I understand it is hard to transplant.

Mr. Fred Burton of Cedarville, near Philadelphia, has an amazing collection of dwarf plants One of these is *Picea abies microsperma,* the Dwarf spruce. The annual growth is supposed to be about one or two inches.

I couldn't find any authority for *Tsuga* "Jervis," the Jervis hemlock. It is reported to be 25 years old and is only about eight inches tall. I do not know the species Another one of the most interesting dwarfs Mr. Burton has growing is the Golden weeping cedar, *Cedrus deodara pendula aurea* It is the only one I have ever seen. This plant is only about 18 inches high

(*Editor's Note.* Miss Milton completed her discussion by showing a number of scenes and landscapes of the Arboretum.)

MODERATOR BUCKLELY. Thank you very much I am sure you appreciate the fact now that many of these lady gardeners do know their stuff. We have two minutes for questions.

MR. JAMES WELLS: Miss Milton, can you give us anything on the propagation of *Pinus Bungeana?*

MISS MILTON: The Zebrina pine, you understand, is grafted on the species of Himalayan pine *Pinus Bungeana* is grown almost entirely from seed. There are a number of nurseries I know that carry them.

MR. WILLIAM FLEMER: Jim, I believe the Arboretum may graft *Pinus Bungeana* on *Pinus strobus.* We have some plants that have been grafted that way and they have done very nicely.

MR. C. W HESS: We have grafted *P Bungeana* on either White pine or Scotch pine, and they do very well

MR. NORDINE: Don't get the idea you can graft White pine on Scotch pine All pines are of two general types, the five-needle pine and the two or three needle pine and they are not compatible one on the other. When you graft, put the five needle pine on the five needle pine, and the two and three needle pine on the two and three needle pines.

MODERATOR BUCKLEY. If there are no more questions Dr Hodge, our next speaker, is going to speak to us on the plant introduction program that I understand is going to be carried out at Longwood Gardens. Dr Hodge is in charge of this new program. Dr. Hodge. (Applause)

COOPERATIVE PLANT EXPLORATION

Walter H. Hodge
Longwood Gardens
Kennett Square, Pennsylvania

Longwood Gardens was the private country estate of Mr. Pierre S. du Pont until his death in 1954. At that time it came under the care of the Longwood Foundation, Inc., a non-profit philanthropic foundation, and today is beginning to become in some ways more like certain old-line arboreta and botanical gardens though it will always remain primarily a display garden.

When long-range plans and goals for the future of Longwood Gardens were being formulated, we wondered how the Gardens could initiate a plant introduction program which would benefit its own displays as well as ornamental horticulture elsewhere in the United States. The result was a cooperative program of plant exploration in which the parties concerned were Longwood Gardens and the U S. Department of Agriculture. It seemed logical that, since the Federal Government through its New Crops Branch (USDA) already had the 'know-how,' the staff and facilities for plant exploration, Longwood should work cooperatively with it. Longwood Gardens would transfer sufficient funds each year to maintain a trained man in the field as a plant explorer but the actual field work would be supervised and conducted by the USDA.

To give you some background of the plant introduction activities of the United States Department of Agriculture, the cooperating agency, I might briefly describe a bit of its organization and work. Plant exploration and introduction activities are centered in the New Crops Research Branch of the Agricultural Research Service with headquarters at Beltsville, Maryland The work of the Branch includes that of a Plant Introduction Section and a Crop Development Section. The Plant Introduction Section conducts all work involving the procurement or international exchange of plant material, its inspection and inventory. The Crop Development Section, on the other hand, conducts all work on the screening, maintenance, and development of plant material after it has been introduced.

There are four federal Plant Introduction Stations, located at Coconut Grove, Florida; Chico, California; Glenn Dale, Maryland; and Savannah, Georgia. These are primary centers for handling new plant introductions. In the course of making exhaustive tests on certain categories of material, large collections are built up and held for long periods. The Introduction Stations, therefore, constitute important reservoirs for plant germ-plasm which are thus made available, often over a long period, for breeding programs throughout the country.

In addition to these four federally operated stations there are four state-federal cooperative plant introduction stations located in each of the primary geographical regions of the country — Geneva, New York; Experiment, Georgia; Ames, Iowa and Pullman, Washington. Plant introductions to be tested under this program go directly from the Inspection House to a coordinator at one (or more) of these regional stations. It is quite obvious that, because of geographical locations, certain regions are better fitted to handle the increase and testing of specific crop items. At the end of each year, detailed seed or plant lists are assembled by each coordinator for distribution to all state experiment stations in his region. These lists indicate the materials which are available through these regional plant introduction stations. The existence of test locations such as these federal and state-federal introduction stations was, of course, one of the reasons for considering cooperative plant introduction with the federal government

Since 1946 four cooperative explorations have been conducted under the Longwood Gardens — USDA program. The first was to southern Japan. The warmer parts of Japan were selected because it was felt there had been a great deal of effort made in the past to collect for the colder areas of the United States Practically no attempt had been made to help the South, the Southeast, the Southwest or the Pacific Northwest. Therefore, our first explorations have been aimed to aid those areas.

The Japan exploration was conducted in 1956 by Dr John L Creech, USDA Horticulturist. Southern Japan is an area well supplied with broad-leaf evergreens Many of the plants he collected should be of interest to comparable areas in this country

Besides visting wild areas for native plants, explorers also visit gardens, experiment stations and flower shows Since Longwood maintains a fine display collection of chrysanthemums, we were particularly interested in any new types of these plants from Japan Dr. Creech therefore visited chrysanthemum shows where over 200 clones were found and subsequently introduced Some of them are quite unusual and have already entered into Longwood's Fall chrysanthemum displays.

The second Longwood-sponsored exploration investigated the ornamental horticultural centers of southern Europe where are to be found many plants which are little known in this country Dr. F. G. Meyer, USDA botanist, was selected to conduct this work His travels in 1957 covered Portugal, Spain, southern France and Great Britain.

The third exploration, conducted in 1958 by Dr. Llewelyn Williams, USDA botanist, focused on southern Brazil, an area rich in showy sub-tropical flowering trees, some of which are frost-tolerant. Such species should be very useful for Florida, Southern California, Hawaii and Puerto Rico Longwood hopes to be able to grow representatives of such plants in her conservatories as dwarfed tub specimens.

A fourth cooperative exploration began in September, 1958. As a matter of fact, I had the pleasure of helping initiate this exploration in Australia which was undertaken by Mr George H Spalding, a horticulturist on loan to the USDA by the Los Angeles State and County Arboretum. Since I participated, if briefly, in this work, I would like to comment on this exploration, using it as a means of showing you how such sorties are organized and carried out.

Australia was considered important for a number of reasons. In the first place, little if any organized plant exploration has been done by Americans in this area. The reason for this is obvious. Australia is an English-speaking country. Australians are wonderful cooperators and they have sent hundreds of living plant materials to this country as contributions to our plant introduction program. However, as all of you know, this is not always the best way to conduct plant exploration. You don't always know actually the range of materials unless you see them in person. Sometimes what others feel are not worth much, may be just the thing you are looking for

If you put a map of Australia over the United States it would just about cover our land area. To cover an area the size of the United States in a period of four to six months is impossible and, therefore, an exploration of this type should be considered no more than a reconnaissance. It has, however, pin-pointed areas which may bear revisitations in the future

Australia is largely arid and most of the exploration was done on the eastern, southern and western margins where more adequate rainfall supports a richer flora than that to be found in the interior of the continent. Rainfall maps are of much importance to plant explorers. The rainfall pattern of Winter rains and dry Summers — Mediterranean climates — is typical of much of the Australian area explored. In this country, southern California has a similar rainfall pattern and plants introduced should do best, therefore, in that state The other type of map important to a plant explorer is the temperature map. South of the Equator, July is the coldest month, so one must look to see what the limiting temperatures are in that month Australia's climate is a warm one Few areas have freezing temperatures which means that Australian introductions in general cannot be expected to be cold- tolerant.

Just a few words about Australian plants. The "down under" continent is unsurpassed, except perhaps by South Africa, for the wealth of its showy and unusual plants. Particularly noteworthy is the concentration of showy herbaceous and woody materials to be found in the state of Western Australia. Australia is most famous for the concentration of species in the two genera, *Acacia* and *Eucalyptus*. The acacias ("wattles" in Australia) number over 300 species In this country we think of them usually as trees There exists, however, a great variety of habit in the genus and the lesser known shrubby forms are especially showy. It is to be hoped that the introduction of some of the latter will add variety to the acacia species currently being grown in this country as ornamentals. With over 500 species, *Eucalyptus,* is equally intriguing. A number of the eucalyptus of Western Australia are very showy in flower. What appealed to me, however, was the beauty of the trunks. particularly in the *Eucalyptus* group known as "gums" Here the bark exfoliates somewhat like that of our paper birch or sycamore, leaving varying shades of contrasting color Examples are barks that gray and white, yellow and green, or even pink and white. I would recommend that selection of eucalyptus for introductions as ornamentals be based not only on the more usual tree or shrub characteristics, but also on this unusual one of attractive bark coloration patterns as well.

In conclusion, I might suggest at this point that anyone particularly interested in the introduction of new plant materials of a special sort and difficult of introduction privately should contact the New Crops Research Branch. Certain of these requests might be able to be handled in conjunction with planned explorations under this cooperative program Recommendations should be directed to the Plant Introduction Section, New Crops Research Branch, Plant Industry Station, Beltsville, Maryland. Consideration can then be given by those concerned with planning these explorations Additional explorations are already being scheduled. One to West Europe will be conducted in 1959, one to northern Japan in 1960, while a Madagascar exploration is tentatively planned for 1961. If you have particular ornamental items of interest from these areas, requests should be directed to the address just mentioned.

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MODERATOR BUCKLEY: I have been most inspired. I had no idea how far the United States was going in introducing new plant materials. The problem is going to be, of course, getting these plants established in other countries.

Now we have a moment or two for questions from the floor.

MR. DAVID LEACH (Brooksville, Pennsylvania): I would like to know if you found any rhododendrons growing in the Auckland area?

DR. HODGE: We didn't get to Auckland. We hope to arrange a plant exploration to New Zealand for I understand the rhododendrons in this area are beautiful to behold I would say one of the things we were particularly looking for were some of the select rhododendrons which have been in special collections, such as the Javanese rhododendrons. These would be of no use outdoors except in the tropics, although there were some native ones in Northern Australia. Some forms of these will be selected through cooperation with some of the botanical gardens in Brisbane.

MR HOOGENDOORN: Two years ago in July when I went to the Canadian Rockies I noticed what I thought were rhododendrons in bloom Do you know what variety this might be?

DR. HODGE: I have no idea, but I think maybe Francis de Vos might be able to help.

MR. de VOS: It could very well have been *Rhododendron albiflorum* It is a very unusual species

MODERATOR BUCKLEY: I purposely left my talk until the last so we can get this session over on time I don't intend to be too elaborate about my own paper.

Moderator Buckley then presented his paper on the "Dominion Arboretum" and "Noteworthy Woody Ornamentals." (Applause)

THE DOMINION ARBORETUM

A. R. Buckley
Dominion Arboretum and Botanic Garden
Ottawa, Canada

In 1886 when plans were being made to establish the Central Experimental Farm at Ottawa, a piece of land 65 acres in extent was set aside for the development of an Arboretum and Botanic Garden. It was felt that such a garden would play a very important part in agri-handled in conjunction with planned explorations under this cooperative program. Recommendations should be directed to the Plant Introduction Section, New Crops Research Branch, Plant Industry Station, Beltsville, Maryland. Consideration can then be given by those concerned with planning these explorations. Additional explorations are already being scheduled. One to West Europe will be conducted in 1959, one to northern Japan in 1960, while a Madagascar exploration is tentatively planned for 1961. If you have particular ornamental items of interest from these areas, requests should be directed to the address just mentioned.

* * * * *

MODERATOR BUCKLEY: I have been most inspired. I had no idea how far the United States was going in introducing new plant materials. The problem is going to be, of course, getting these plants established in other countries.

Now we have a moment or two for questions from the floor.

MR. DAVID LEACH (Brooksville, Pennsylvania): I would like to know if you found any rhododendrons growing in the Auckland area?

DR. HODGE: We didn't get to Auckland. We hope to arrange a plant exploration to New Zealand for I understand the rhododendrons in this area are beautiful to behold. I would say one of the things we were particularly looking for were some of the select rhododendrons which have been in special collections, such as the Javanese rhododendrons. These would be of no use outdoors except in the tropics, although there were some native ones in Northern Australia. Some forms of these will be selected through cooperation with some of the botanical gardens in Brisbane.

MR HOOGENDOORN: Two years ago in July when I went to the Canadian Rockies I noticed what I thought were rhododendrons in bloom. Do you know what variety this might be?

DR. HODGE: I have no idea, but I think maybe Francis de Vos might be able to help.

MR. de VOS: It could very well have been *Rhododendron albiflorum*. It is a very unusual species.

MODERATOR BUCKLEY: I purposely left my talk until the last so we can get this session over on time. I don't intend to be too elaborate about my own paper.

Moderator Buckley then presented his paper on the "Dominion Arboretum" and "Noteworthy Woody Ornamentals." (Applause)

THE DOMINION ARBORETUM

A. R. BUCKLEY
Dominion Arboretum and Botanic Garden
Ottawa, Canada

In 1886 when plans were being made to establish the Central Experimental Farm at Ottawa, a piece of land 65 acres in extent was set aside for the development of an Arboretum and Botanic Garden. It was felt that such a garden would play a very important part in agriculture and all its branches by the introduction of plants from all parts of the world, in order to test their hardiness and usefulness, as well as to exhibit to the general public a representative collection of exotic and native plants

Work started on the garden in 1887 under the direction of Dr. James Fletcher, botanist and entomologist of the Dominion Experimental Farms who, two years later, planted the first trees and shrubs. During the initial year of planting, about 200 species were set out, two specimens of each, placed in their individual generic groups Quite a number of these first trees are still to be seen in the Arboretum in good state of health. Among these were the Black Walnut (*Juglans nigra*) Siebold's Walnut (*Juglans sieboldiana*), White Ash (*Fraxinus americana*) Maidenhair Tree (*Ginkgo biloba*) and some splendid stately oaks.

In 1898 the Arboretum and Botanic Garden was placed in charge of Dr. W. T. Macoun, later appointed as Dominion Horticulturist and Curator of the Arboretum Under Dr Macoun and with the Assistance of the director of Experimental Farms, Dr. W. T. Saunders the Arboretum made good headway.

It was during this period in the year 1899, that one of the most outstanding contributions from the Arboretum was forthcoming This was the publication of a catalogue of trees and shrubs tested in the Arboretum up to that time with notations as to their hardiness and suitability for this climate

This list contained names of 3,071 species of trees and shrubs. Of these 1,465 were proven hardy, the rest either tender or half hardy, some had not been planted long enough to determine their hardiness

During these early days institutions such as the Royal Botanic Gardens, Kew and the Arnold Arboretum, made most valuable contributions of seeds and plants Large collections were also secured from nurseries such as Spaeth in Germany and Ellwanger and Barry in the United States

After the death of Dr W T Macoun the Arboretum was transferred to the Division of Botany and placed under the Chief of this Division who was then Dr H. T. Gussow, the Dominion Botanist. Steady progress was made in increasing the collections and many early plant introductions were made through the medium of the Arboretum At that time special attention was given to securing trees and shrubs suitable for western Canada Thousands of Siberian Pea trees (*Caragana arborescens*) grown as windbreaks and hedges in the west have had their origin in seeds from the plants in the Dominion Arboretum. In 1911 seeds of the plants of the Arboretum were collected and a seed exchange initiated with foreign institutions

In 1938 the Dominion Department of Agriculture was re-organized and the Division of Botany and Plant Pathology (including the Dominion Arboretum) was transferred from the Experimental Farm Branch to the newly created Science Service, a branch of the Department of which Dr. J. M. Swaine was director.

The Dominion Arboretum was originally located to the south of Ottawa between the Prince of Wales Highway (Route 16) and the

Rideau Canal. It is still bounded by these two points but is now almost in the centre of the city

The climate at Ottawa is a particularly tough one for trees and shrubs, although not as tough as some of the Prairie Provinces. For example, the average temperature for January is 12 degrees F. with a record low of 35 degrees below in 1935. The average July temperature is 68 6 degrees F. with an all time high of 102 degrees F. Annual rainfall is 34 89 and the annual average snowfall is 80 5 inches The average January temperature of 12 degrees F. is similar to that of Moscow U.S.S.R.

The worst winter on record corresponds to the worst winter of many places in North America, that of 1933-34. In Ottawa that year not much snow had fallen and the temperatures remained at 20-30 below for a consistently long period. At that time a major part of the Apple Orchard at the Experimental Farm was killed and the *Malus-Pyrus-Sorbus* collection at the Arboretum almost wiped out. It is remarkable, however, that so many trees survived, since younger trees of many of the species would never withstand such temperatures It would seem that individual trees build up a resistance against severe cold temperatures and the older they get the more resistant they become — to a point. Some trees during this period were killed back to ground level, however, and sent up new twigs that developed into trunks

Work for the first forty years of the Arboretum's existence was centered mainly upon the plantings of new species and varieties and taking notes on hardiness, these included several thousand species and varieties of herbaceous perennials as well as tree and shrubs. In 1938 a complete re-assessment was given the entire planting, and a mapping program carried out The whole Arboretum was divided in 200 ft squares and all the plants correctly mapped in the squares The old system of enumeration was abandoned and a new system which showed at a glance the year of planting, origin and reference of each plant, was introduced

It soon became apparent that if any publication was to be forthcoming a thorough taxonomic survey would have to be made for it was perfectly obvious that many plants were wrongly labelled. Even today this work is not finished although completion is very near at hand as far as the older trees are concerned.

Embossed labels have now replaced the old zinc type — 2 identification labels are placed on every plant and each specimen correctly identified is given a display label approximately 5 x 3 inches on which is engraved the name, common name, location and accession number Labelling is still quite a problem as it is in most public places.

Today the Arboretum collection serves as a source of supply for correctly named material for research in forestry, forest tree breeding and many phases of horticulture. Programs of research include hardiness investigations, propagation, ground covers, mulches and cultivation problems.

The Arboretum also offers to the general public a retreat from the whirl of city life Large swards of lawn, a thousand large shady trees, lovely panoramas of the Ottawa valley from its lookouts, await those who are in search of a place in which to rest or picnic

Last year through the sponsorship of a local newspaper Hi Fi was introduced to the Arboretum. Four large units, each containing six loudspeakers were hidden in the trees and on Sunday afternoons a program of music descended upon the throngs who sat on the grass, branches, or on their own lawn chairs brought for the purpose. This program was so popular that it will most likely be continued.

The value of some such gimmick to Arboretums in general, is perhaps inestimable, but there is no doubt in my mind that we were almost swamped with phone calls about trees and shrubs every Monday morning by visitors who would never have otherwise stepped out of their cars.

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(*Editor's* Note. Mr Buckley distributed a descriptive list of select trees and shrubs growing at the Dominion Arboretum.)

MODERATOR BUCKLEY: Are there any questions?

MR. JAMES WELLS: I am interested in *Daphne houtteana.* I have the plant, which I obtained from Canada. I would like to know its origin.

MODERATOR BUCKLEY: It was developed at a nursery in British Columbia. I have forgotten the natural habitat, but I can tell you later since I have it in my notes.

MR. WELLS: Is it hardy?

MODERATOR BUCKLEY: It has about the same hardiness as *Daphne odora.*

MR. K. B FISHER: I would like to ask how long you have had *Daphne burkwoodi* in Ottawa?

MODERATOR BUCKLEY: I would say not more than three or four years.

If there are no further questions, I will turn the meeting over to Hugh. Mr. President.

PRESIDENT STEAVENSON: Thank you, Mr. Buckley, for that very excellent disseration and for your fine panel. As you all know we have our question box program scheduled for this evening at eight o'clock.

Are there any announcements before we adjourn? If not, we will stand adjourned until eight o'clock.

(The meeting recessed at four-fifty o'clock.)

PLANT PROPAGATION QUESTION BOX

FRIDAY EVENING SESSION

December 5, 1958

The Plant Propagation Question Box Session of the Eighth Annual Meeting convened at 8:00 P.M Dr. Sidney Waxman, University of Connecticut presiding.

The transcript of this session of the annual meeting is not recorded in these Proceedings.

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SATURDAY MORNING SESSION

December 6, 1958

The meeting was called to order at nine-ten o'clock by President Steavenson.

PRESIDENT STEAVENSON. We are honored and privileged to have with us this morning as our panel moderator Mr. Albert G. Johnson, of the Department of Horticulture, University of Minnesota. Mr. Johnson is engaged in ornamental plant breeding at the new Minnesota Landscape Arboretum. Mr. Johnson.

MODERATOR JOHNSON: It is my privilege and honor to act as moderator at this session

Our first speaker, as you all know, is Dr. Karl Sax. I first became aware of Dr. Sax's name when I was in school. It was in a bibliography I was preparing on the subject of genetics. Later when I became interested in conifers, I saw his name in the bibliographies of articles on the morphology of these plants. Then I heard of him as an eminent horticulturist in connection with the work conducted at the Arboretum in Montreal He is president of the Genetics Society of America, and Professor of Forestry How many fields a man can be versed in I don't know, but apparently Dr. Sax has no limit Dr Karl Sax.

Dr. Karl Sax presented his prepared address on "Breeding Ornamental Trees and Shrubs" (Applause)

BREEDING ORNAMENTAL TREES AND SHRUBS

KARL SAX
Arnold Arboretum
Harvard University
Jamaica Plain, Massachusetts

In some respects the breeding of ornamental trees and shrubs is easier than breeding crop plants. Woody plants can be propagated by cuttings or by grafting so that it is not necessary to produce homozygous segregates which will breed true from seeds For the same reason, it is not necessary to produce a fertile hybrid, if fruit is no ornamental asset.

Some knowledge of genetics and cytology can be helpful. The plant breeder should have some knowledge of the breeding behavior of heterozygous and homozygous varieties, the inheritance of dominant and recessive characters and the cytological basis of hybrid sterility. In past years plant breeders wasted considerable time and effort in crossing commercial double forms of carnations to get new types, not realizing that these types are hybrids between worthless "bullhead" doubles and single flowered forms As a result they obtained only fifty per cent commercial doubles, whereas if they had crossed "bullheads" with singles they would have obtained 100 per cent commercial doubles

Often, however, the "shotgun" technique is adequate, especially if one is crossing horticultural varieties which are of hybrid origin Crosses are made and large populations are grown from which the desired types can be selected for vegetative propagation. In most cases we are looking for small segregates which bloom at an early age, so that the hybrid segregates do not need excessive space or time in the test plots

In most breeding systems it is desirable to control cross pollination. The first step is the prevention of pollination by insects, or by the wind, so that only the pollen from the desired male parent will function in the production of the hybrid. The anthers of the tree or shrub selected to be the female parent must be removed before the pollen is shed in order to avoid self-pollination Even when the species is self-sterile, the flowers should be emasculated and the petals removed before the flower opens to avoid insect pollination. In many genera the petals and anthers can be removed together by inserting the thumb nail below the sepals and pulling or breaking off the sepals, petals and the anthers in a single operation. Plants with conspicuous flowers are usually insect pollinated, and if the petals are removed the insects do not carry pollen to the stigma.

Flowers which are wind pollinated, such as the poplars, willows and conifers, must be protected from foreign pollen. This can be done by enclosing the female flowers with paper bags before the pollen from the male flowers is shed and removing the bags only long enough to pollinate with the desired pollen. This method has two disadvantages In the Arnold Arboretum the paper bags are vulnerable to small boys, especially those on hunting expeditions with BB guns. In the case of conifers, the removal of the bag to permit artificial pollination exposes the female cone to air borne pollen This can be avoided by injecting the pollen through a hole in the bag, but this method has disadvantages. A method developed by the foresters avoids some of these troubles. The female clones are enclosed in a polyethylene or paper bag a few weeks before normal pollination time. The heat within the bag hastens cone development so that it is receptive before the air is filled with pollen The male cones are forced in the same way so that pollen can be collected to dust on the female cones when they are receptive

Pollen can be collected from dehiscing anthers in the field early in the morning, but it is better to collect flowers about to open, spread them on a sheet of paper, or float them in a shallow pan of water, and collect the pollen the next morning Branches with flower buds about to open can also be brought indoors and will provide pollen the following day. The pollen can be collected in small vials and applied with a small camel's hair brush, or the opening anther can be picked up with a pair of forceps and used to brush the pollen on the stigma.

Often it is necessary to store pollen if the blooming times of the parental species or varieties do not overlap The pollen of many species can be stored for long periods of time by placing it in a vial in a desiccator in a refrigerator. The vial itself can be made into a desiccator by putting some calcium chloride in the base of the vial and covering it with a disc of porous paper The pollen can be placed on top of the paper plug properly sealed, the vials kept under refrigeration will preserve the pollen of some species for as long as a year

Trees which mature their seeds rapidly can be crossed in the greenhouse by using flowering branches. Branches of poplars, willows, elms and some of the maples, when cut off just before the flowers open, and the stems kept in fresh water, will produce mature seeds when crossed in the greenhouse.

Often the trees and shrubs which bloom early in the spring set a poor crop of seeds due to injury by the cold weather We have had much better results in producing plum X peach hybrids when dwarf plants are planted in tubs and moved into a cool greenhouse at flowering time. The peaches and plums are dwarfed by budding them on *Prunus tomentosa* so that they can be more easily grown in tubs in the greenhouse.

Crosses between distant species or genera can sometimes be induced by use of a fruit setting hormone. Brock, working at the John Innes Horticultural Institute in England, was able to cross pears with apples by treating the cut calyx of the female flower with a fruit setting hormone, thus preventing the abscission of the flower before fertilization and embryo development occurred

In some cases fertilization may occur in species hybrids, but the embryo does not develop to maturity. In such cases embryo culture will save these embryos. Embryo culture in plant breeding was first used by Laibach in Germany and more refined techniques, using nutrient agar and auxins, have been used in this country.

In peach hybrids, the late Dr Blake of New Jersey used to extract the seed and culture it before it became dormant, thus getting a seedling the year the cross was made. A similar technique has been used in the breeding of roses in California by Lammerts. Taylor uses vermiculite for growing nectarine hybrids, and in the long season of California they become large enough to bud on a standard rootstock the same summer, thus speeding up the breeding program. Sphagnum is a good medium for growing the mature naked seed since it is a natural antibiotic and reduces danger of fungus infection.

A wide species hybrid may produce a viable embryo, but the young seedling may die at an early age or grow very slowly. This behavior was found by Brock in apple X pear hybrids, but when the hybrid was budded on either apple or pear it made better growth. We have had similar experiences with our plum X peach hybrids About 100 hybrids have been obtained during the past four years, but only three have survived on their own roots One of these was budded on *P. tomentosa* four years ago and on *P persica* three years ago. In 1958 the original hybrid was less than a foot tall and very feeble at the age of four years. On *P. tomentosa* it was about 3 feet tall after three years, and on peach it was nearly 5 feet tall and reasonably vigorous at the age of two years after budding. Apparently some of the weak hybrids can be saved if propagated on suitable rootstocks.

This technique has also been used with lilac hybrids. The "Chinese" lilac, *Syringa chinensis*, is a hybrid between *S laciniata* from China and *S vulgaris* from the Balkans The cross is easily made and the hybrids make good growth the first year. In subsequent years they begin to die and after five or six years almost all are dead. Some of these weak hybrids can be saved by grafting them on *S. vulgaris* seedlings or on cuttings of established clones of *S chinensis.*

In some cases it is much more efficient to let the insects do the hybridizing. We have in the Arnold Arboretum a single specimen of *Syringa laciniata* surrounded by varieties of the common lilac *S vulgaris* Since the lilacs are largely self-sterile, most of the seeds set by *S laciniata* produce hybrid seedlings

About ten years ago we produced a hybrid plum involving *P. besseyi.* It is a very hardy plum with larger and better fruits than those of *P besseyi.* It was grown in a collection of other plums including *P. domestica, P. incana,* and other species The hybrid produced open pollinated segregates, among which were several with the vigor and leaf characters of the *P domestica* variety. Since the *besseyi* hybrid is a diploid and the Stanley is a hexaploid the hybrid should be a tetraploid, and preliminary somatic chromosome counts confirm this assumption. Hybrids between diploid and hexaploid plums have been made by artificial pollination in both England and Canada, but it is easier to let the bees do the work

Induced polyploidy is a useful tool in producing new types of horticultural plants. Tetraploid plants usually have larger and more deeply colored flowers than do diploids The chromosome number of diploids can be doubled by soaking the seeds in 0 1 per cent colchicine solution for a day or two, by treating the growing point of the seedling with the solution for several days or smearing the young seedling with a 0.5 per cent colchicine solution in lanolin paste The tetraploids may be of immediate horticultural value, such as the tetraploid snapdragons, but often their greatest value is in the production of triploids by crossing them with diploids

A tetraploid *Forsythia* was produced at the Arnold Arboretum nearly 20 years ago by treating a seedling of *F. intermedia* with colchicine. It has large, deep yellow flowers It was awarded the Lindley medal of the Royal Horticultural Society, but has not been very popular in this country because of its rather stiff growth habit. It was crossed with the diploid to produce triploids Of the several dozen progeny one was named Beatrix Farrand, in honor of America's leading woman landscape gardener. This triploid variety has very large flowers and vigorous vegetative growth. Another segregate is of more compact growth and with deep, orange-yellow flowers turned out to be a tetraploid This was unexpected since forsythia's are self-sterile. Perhaps polyploidy restored self-fertility and the tetraploid parent was accidentally self-pollinated.

The use of facultative apomicts permits the production of hybrids which breed true from seed. This feature is not important in horticultural plants which can be propagated vegetatively by cuttings or grafts, but it could be of great importance in developing "clonal" varieties of rootstocks which could be grown from seed and thus avoid the possibility of virus infection from infected rootstocks Apomixis is common in apples, hawthorns, cotoneasters and other *Pomoideae.* We have been using the facultatively apomictic *Malus sargenti* and the variety *rosea* in our breeding work This species and its variety normally produce 90 per cent or more of maternals, but hybrids can be obtained. The variety *rosea* is probably a spontaneous hybrid between the tetraploid *M sargenti* and a neighboring diploid, since it is a triploid.

Hybrids of *Malus sargenti* include a variety named "Mary Potter," one of Professor Sargent's daughters It is similar to *M. sargenti rosea,* but more vigorous Another hybrid, 33340, is a cross between *M. sargenti rosea* and *M. astracanica.* It has the growth habit of the mother plant, although larger, and has large, flat, pink flowers which are fragrant, but unfortunately the fruits are not attractive. This hybrid is triploid and tends to breed true from seed, indicating that facultative apomixis is dominant Some of the progeny are tetraploids, indicating that the unreduced egg cell may be pollinated by pollen from neighboring diploids. The tetraploids resemble the mother plant, but bloom a few days earlier and have larger flowers.

It is often desirable to obtain ornamental plants which bloom later in the spring in order to avoid early frosts. The Star Magnolia is a lovely plant with us, but too often the flowers are injured by cold weather. Crossed with a late flowering species, such as *Magnolia virginiana,* it should be possible to get segregates in the second generation which would have the *M. stellata* type of flower and growth habit and yet bloom several weeks later. Miss Renshaw, at the Arnold Arboretum, has been working on this combination for several years.

In order to combine the desired characters of two parental varieties it is often necessary to grow large numbers of segregates. If the hybrids require many years to come into flower and fruit, a breeding project can consume a lot of time and money. In order to speed up flowering of hybrid seedlings and to conserve space, many plant breeders graft the young seedlings into mature bearing trees. When they flower and fruit, the desired ones can be propagated and the others cut out and discarded

If mature plants are not available as nurse trees, the seedlings must be grown to the flowering and fruiting stage We grow the young seedlings in the nursery for a year or two and then transplant them four or five feet apart in rows ten feet apart. In more recent years we have tried to select the desired type in the nursery row, since we were primarily interested in small ornamental trees which bloom early. By culling out the very vigorous trees it is possible to keep them in the nursery with rows four feet apart, and the trees spaced two feet apart, for three or four years Scoring the stems of the larger trees can check growth considerably, but it does not hasten the time of flowering.

Certain varieties or species are superior to others as breeding stocks. Among the apples *Malus spectabilis* is the maternal parent of such outstanding varieties as 'Katherine' produced at Rochester Park, 'Blanche Ames' produced at the Arnold Arboretum, and probably 'Dorothea,' a spontaneous seedling found in the Arnold Arboretum by Dr. Wyman. Among the flowering cherries *P. subhirtella* has produced a number of interesting segregates, including the beautiful, small 'Hally Jolivette' cherry with its semi-double flowers and long period of bloom.

Conifer seedlings occasionally produce dwarf segregates of ornamental value. An outstanding example is *Picea glauca conica* In 1904 Professor J G. Jack of the Arnold Arboretum collected what he thought were seedlings of *P. albertiana* in Banff, Canada and sent them to the Arboretum One of them proved to be the juvenile dwarf which does not produce cones, but is easily propagated by cuttings. Some of the dwarf conifers, such as the dwarf *Pinus sylvestris*, produce cones and the seedlings are dwarfs. Nurserymen who grow large numbers of conifer seedlings should save the dwarfs and test them for their value as ornamentals

Mutations are the primary source of variation in plants and animals, but mutations are rare Mutations can be greatly increased by subjecting plants or animals to X-rays or other ionizing radiation. In the case of trees or shrubs the dormant scions can be irradiated with X-ray or neutron sources, which can not be transported to the field, and then grafted onto plants in the nursery or orchard. Granhall in Sweden, and Bishop in Canada have produced fruit color mutations in apples by such methods. We have a number of ornamental trees and shrubs growing in the "gamma field" at Brookhaven, but as yet no obvious mutations have appeared

Mutations can also be induced by treating the plant with radioactive isotopes. Solutions of radioactive phosphorus, P^{32}, are the best because it has a half life of only 14 days and emits short range radiation so that it can be handled in experimental work without excessive danger. It can be fed into a hole bored into the trunk of the tree or fed into a branch by slipping a corsage holder full of a P^{32} solution over the cut end of a young branch This work is also in the preliminary stage.

At best the production of new hybrid trees and shrubs requires many years Few seedlings will flower in less than three or four years and many will require five to ten years The selected types then have to be propagated by cuttings or grafts for further testing for size, growth habit, hardiness and adaptability This will require another five to ten years After the new variety is turned over to the nurseryman, it will require several years to build up stock for distribution. Thus it may take from ten to twenty years from the time the hybrid is made until it is available to the public The breeder of ornamental trees and shrubs should start his career early and live to a ripe old age.

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MODERATOR JOHNSON. I am sure Dr. Sax, after this most interesting talk, would be glad to answer questions. We have a few minutes, if there are questions on some of this material.

MR HANS HESS. Dr Sax, how has the tree "Hally Jolivette" been propagated, by budding, grafting or cuttings?

DR. SAX: We have propagated it very easily by softwood cuttings There is nothing to it You get almost 100 per cent take. You do have to be a little careful the first winter. It probably would be better to keep them overwinter the first year in a protective cold frame or pit. They will flower very early, sometimes when only two years old, from cuttings and almost invariably when three years old.

This would be the perfect plant to grow in containers. You can grow it in a rather small can and sell it in flower and double your price.

MR. J. C. McDANIEL (University of Illinois, Urbana, Ill.): Do many of these peach-plum hybrids have showy flowers? The only ones I have seen lost their buds before they opened.

DR. SAX. Ours have not flowered yet but I suspect that will be the case We have had crosses of *Prunus incana* and *P besseyi*, with nice vigorous plants and flowers, but no fruit The buds abort prior to flowering When you double the chromosomes you destroy some of the fertility If we can just get some of the *P. besseyi* blood into some of the peaches we would like that in the northern states

MR C. DeGROOT Dr Sax might be interested to know that we have had profuse flowering of the Arnold Dwarf forysthia.

DR. SAX. I suspect if we take our propagating wood from flowering shrubs they will flower earlier for us also. This is the old story of seedlings. They are very slow in coming into flower, but once they reach the adult stage they will come into flower very much quicker when vegetatively propagated

MR. JAMES WELLS: We are trying "Hally Jolivette" grafts. We find it flowers on the rooted cuttings and keeps on flowering from there on. It also grows beautifully in the can and has a splendid fall color.

What I want to ask you, Dr Sax, is what is the natural length of flowering time of this plant at Arnold Arboretum?

DR SAX: It depends on the season, but in most seasons it is good for at least ten days. Of course, it is usually fairly cool with us. This can be contrasted to *Prunus sargenti*, which is good for about two days.

MODERATOR JOHNSON. Our next speaker is one who needs no introduction to the majority of you. She has dealt with seed germination and seed germination problems for the past forty years at Boyce Thompson Institute Dr Lela Barton, Boyce Thompson Institute, Yonkers, New York

Dr. Barton presented her paper entitled, "Germination and Seedling Production of Species of *Viburnum*." (Applause)

GERMINATION AND SEEDLING PRODUCTION OF SPECIES OF VIBURNUM

LELA V. BARTON
Boyce Thompson Institute
Yonkers, New York

Seedling production of the genus *Viburnum* has long been a problem. It has been discussed in the literature without any definite and satisfactory answer. Giersbach (2) summarized the work done up to 1937. As early as 1894, Jack reported "about seeds with a hard bony

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Boyce Thompson Institute
Yonkers, New York

Seedling production of the genus *Viburnum* has long been a problem. It has been discussed in the literature without any definite and satisfactory answer. Giersbach (2) summarized the work done up to 1937. As early as 1894, Jack reported "about seeds with a hard bony covering," which might commonly be expected to grow in the second rather than in the first year, especially if not planted until spring. He mentioned *Viburnum* as one of these. Many of the reported germination tests of *Viburnum* seeds consisted simply in planting the seeds in soil out-of-doors at various times and recording the time of emergence of the seedlings. For the most part no planned experiments were conducted to determine the effect of various factors on germination.

Davis in 1926 (1) observed two stages of germination of the high-bush cranberry The first was the growth of the radicle at a temperature of 68° F. or higher, the second the development of the cotyledons, still covered by the seed coat at a cold temperature of 40 to 50° F., during which time the root system enlarged After the cold period, seedlings developed normally in a warm greenhouse More extensive detailed tests conducted by Giersbach and published in 1937 (2) indicated that there were indeed two stages of germination, though the vital process of the second stage had to do with the breaking of the dormancy of the epicotyl rather than the development of the cotyledons. Much, if not all of the difficulty experienced in seedling production in this genus may be traced to the existence of these two stages of germination: the first stage, that of root production, the second stage, that of green shoot production. Once this is recognized and the requirements for completion of each stage known, seedlings may be produced at will, though a rather long period of time is necessary for most species.

The work of Gierbach (2) which was conducted at Boyce Thompson Institute for Plant Research will be presented in detail The species studied were *Viburnum acerifolium* L., *V dentatum* L., *V. dilatatum* Thunb., *V lentago* L., *V nudum* L., *V. opulus* L., *V prunifolium* L., *V pubescens* Pursh., *V rufidulum* Raf., and *V. scabrellum* (T.&G.) Chapm The fruit of *Viburnum* is a one-seeded drupe with soft pulp and a thin stone. For the germination and seedling production tests the stones, referred to in this paper as seeds, for convenience, were freed from the pulp immediately after harvest Experiments as conducted may be divided into germination tests where root production was recorded and seedling production in soil where shoot production was recorded. As all *Viburnum* species studied showed a similar trend in behavior, *V. acerifolium* will be described thoroughly as a type, while the other species will be discussed in a general way, except where deviations from the pattern of *V. acerifolium* are shown. Constant and daily alternating temperatures were used. In the case of the latter, the cultures were left at the higher temperatures for 8 hours and at the lower temperatures 16 hours each day

GERMINATION (ROOT PRODUCTION)

Cleaned seeds of the ten different species were mixed with moist granulated peat moss and placed at constant temperatures of 33°, 41°, 50°, 59°, 68°, 77°, and 86° F. and daily alternating temperatures of 50°, to 86° F., 59° to 86° F., and 68° to 86° F. Different *Viburnum* species vary in germination rate and in range of effective temperatures (Table I.)

Table 1.—Effective treatment for producing plants from *VIBURNUM* seeds

Species	Requirement for root production Temp. (°F.)	Time (mos.)	Pretreatment for shoot production Temp. (°F.)	Time (mos.)
V. acerifolium		12-17	41,50	2 -3
V. dentatum		12-17	"	0.5-1
V. dilatatum	68	7-9	"	3 -4
V. prunifolium	50 to 86*	7-9	"	1.5-2
V. pubescens	68 to 86*	12-17	"	2 -4
V. rufidulum		12-17	"	2 -4
V. lentago	59,68,77	5	"	3 -4
V. opulus	50 to 86*	2	"	1.5-2
	68 to 86*			
V. nudum	Entire range	1-2	no dormancy	
V. scabrellum	41-86	1-2	no dormancy	

* Daily alternation.

The most satisfactory temperatures for growing the roots of all species have been found to be constant 68° F. and a daily alternation of 68° to 86° F. These are the temperatures which permit the most rapid growth of the very small embryo to the full length of the seed, a process which precedes the appearance of the young root. This is clearly demonstrated in figure 1 in which the development of the embryos of *V. acerifolium* after five months in moist granulated peat moss at various tem-

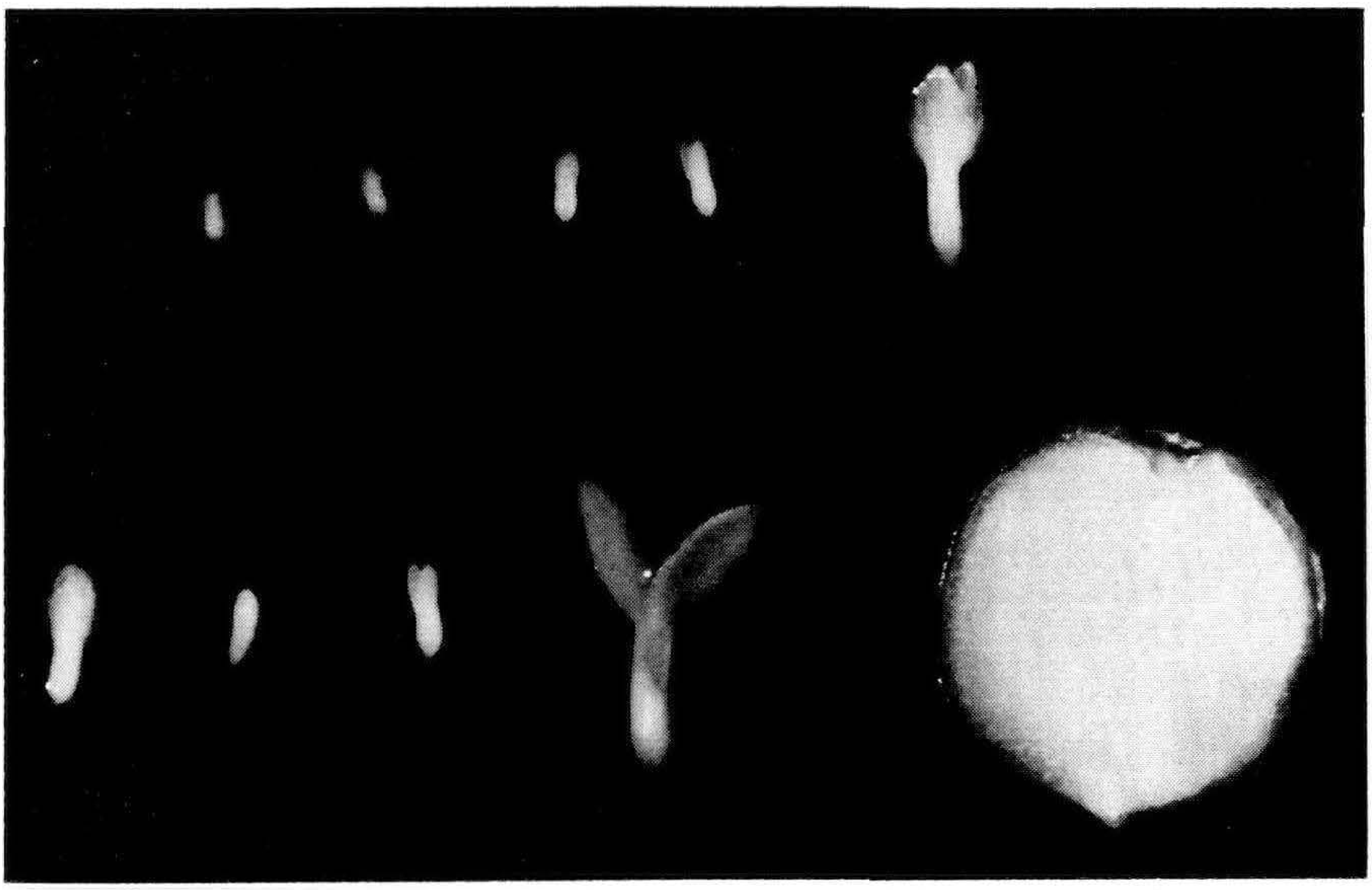

Figure 1. Embryos of V. acerifolium, excised after five months in peat at various temperatures. Left to right: (Upper row) dry seed, 41°, 50°, 59°, 68°, F.; (lower row) 77°, 86°, 50°, to 86°, 68° to 86° F., cross section through seed.

peratures is shown. Actual root production in this species occurred over a period of six to seventeen months. About the same amount of time was required for seeds of *V. rufidulum* and *V. dentatum*. In *V. prunifolium* and *V. dilatatum*, germination to form roots was completed in seven to nine months; in *V. lentago*, five months were required; and in *V. opulus*, two months at optimum temperatures. Seeds of the southern forms of *V. nudum* and *V. scabrellum*, on the other hand, germinated during the first month at the most favorable temperatures, and tolerated the whole range of temperatures from 41° to 86° F. These last two species also failed to exhibit the epicotyl dormancy to be noted below and shown by the other species studied, thus completing the seedling production process in one phase instead of two.

SEEDLING PRODUCTION

When germinated seeds with the roots developing satisfactorily are kept in a greenhouse, the green shoots fail to come through the coil.

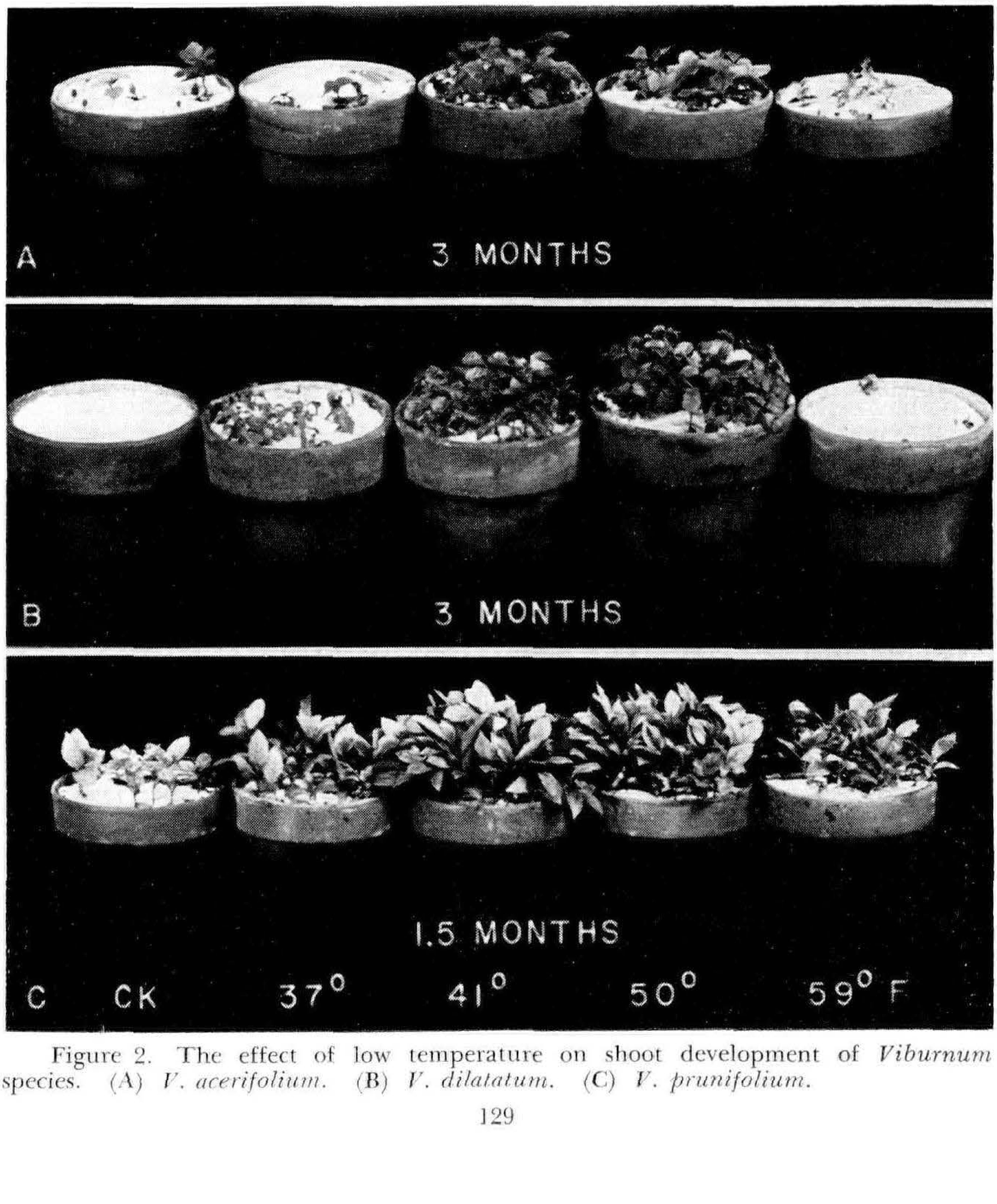

Figure 2. The effect of low temperature on shoot development of *Viburnum* species. (A) *V. acerifolium*. (B) *V. dilatatum*. (C) *V. prunifolium*.

The roots will continue to grow until the food supply in the seed is exhausted, after which they will die unless they have had a period at low temperature to after-ripen the bud that forms the shoot. Thus we have the second phase of the seedling production process for these forms. For the initiation of this phase a temperature in the range of 41° to 50° F. for a period of two to four months, depending upon the species is required (Table I). This type of germination response has been designed as epicotyl dormancy and is characteristic of the seeds of the tree peony and of certain, so-called, two-year lilies.

Experiments at Controlled Temperatures. To determine the optimum length of time at low temperatures and also the optimum low temperature needed to overcome the epicotyl dormancy typical for most species of *Viburnum*, seeds of *V. acerifolium*, *V. dentatum*, *V. dilatatum*, *V. prunifolium*, and *V. opulus*, pregerminated in peat at 68° to 86° F daily alternation, were planted in pots and kept in rooms of 37°, 41°, 50°, and 59° F as well as in a greenhouse of about 70° F. Series of pots were transferred from the various rooms to the greenhouse every half month, and subsequent appearance of green shoots above ground was noted. The general appearance of seedlings of three different species is shown in figure 2. It will be seen that the best response in all cases was to pretreatment at 41° and 50° F. The seeds of *V. prunifolium* were the least dormant of these three species as shown by the growth of some green shoots in the greenhouse without any pretreatment (fig. 2C, control). Germinated seeds of *V. dentatum* produced up to 41 per cent seedlings in the greenhouse without any cold pretreatment, but such seedlings were always poorly developed. Actual germination percentages obtained are shown in Table II for *V. acerifolium*.

It will be seen that the optimum cold treatment for seedlings of this species was two and one-half months at 41° F. with 61 per cent shoot development and four months at 50° F. with 81 percent. Shoot development was very poor in the pots held at 37° or 59° F for pretreatment, and only two shoots appeared above ground in the greenhouse controls (no pretreatment).

The two southern species, *V. nudum* and *V. scabrellum*, did not show any epicotyl dormancy. When seeds of these species were planted in flats and kept at a high temperature seedlings came up in one to one and one-half months. When seeds were sown in flats in greenhouses of various temperatures, seedlings grew somewhat more slowly in the cooler houses. At temperatures above 70° F and when flats were alternated between 61° and 80° F. seedlings damped off easily.

The high percentages obtained throughout the epicotyl dormancy tests were due to the fact that only germinated seeds were used.

Plantings Out-of-doors. We have seen the seeds of *Viburnum* germinate to form roots at temperatures that correspond roughly to those of spring and summer in many localities. Since a period at low temperature needs to follow this root production before seedlings appear above ground, it would seem logical to sow the seeds out-of-doors in the spring. Roots will be produced before the summer is over and then the epicotyl will after-ripen the following winter and seedlings will ap-

Table 2.—Effect of pre-treament of germinated seeds of *Viburnum acerifolium* at various low temperatures on shoot production in the greenhouse. Crop 1932

Pre-treatment		Per cent shoot production after months in the greenhouse (about 70° F.)					
Temp. °F	Months	0.5	1	1.5	2	2.5	3
	1	0	0	0	5	6	9(7)*
	1.5	0	3	4	7	9(5)	
37	2	1	3	4	4		
	2.5	3	4	7			
	3	1	2	4			
	4	16					
	1	0	1	4	11	12	
	1.5	0	12	35	42	46	
41	2	0	29	49			
	2.5	13	61	61			
	3	6	49	51			
	4	51					
	1	0	9	23	30	35(20)	
	1.5	0	9	27	33(7)		
50	2	1	13	31	31(2)		
	2.5	3	25	36	40		
	3	34	60	67(6)			
	4	77	81(2)				
	1	0	2	9	13	19	
	1.5	0	7	13	13		
59	2	5	9	17	19		
	2.5	4	7	8			
	3	7	13				
	4	13					
None		0	0	0	1	1	2(2)

* Numbers in parenthesis indicate seedlings above soil but with seed coats attached

pear above ground the spring after planting. This has been tried and found effective. Some of the results are shown in Table III and figure 3.

Table 3.—Effect of planting *Viburnum* seeds at various times during the year and wintering in a board-covered cold frame.

Species	Per cent seedling production in spring from seeds planted preceding					
	Apr. 1	May 1	June 1	July 1	Aug. 15	Sept. 15
V. acerifolium	40	55	17	15	—	0
V. dentatum	31	32	30	26	—	0
V. dilatatum	79	88	79	54	—	0
V. prunifolium	10	26	0	1	0	0
V. opulus	60	64	76	87	1	0

It will be seen that seeds of *V. acerifolium* produced up to 40 and 55 per cent seedlings after one winter when planted in April or May at

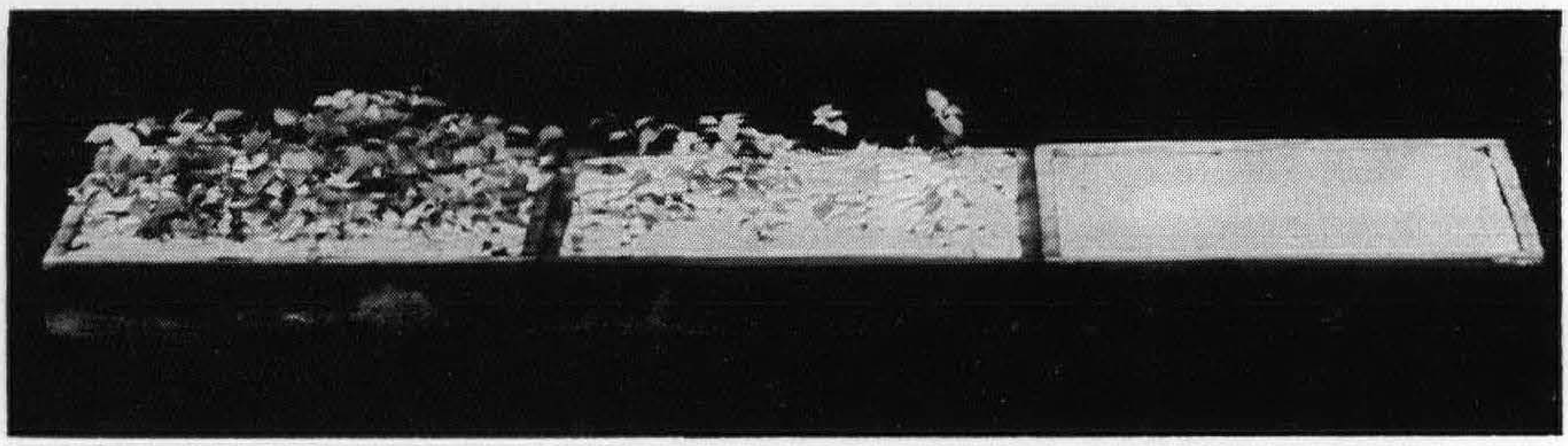

Figure 3. V. *acerifolium*. The effect of various planting times on seedling production the following spring. Left to right: Planted April 1st, June 1st, September 15th.

Yonkers, N.Y. Seedling production decreased rapidly for plantings made in June and later, with none at all for the plantings in September.

The effective length of exposure to warm temperature followed by a cold period varied for the different species. The response of *V. prunifolium* to high temperature was somewhat similar to that of *V. acerifolium* with 26 per cent seedling production for the May planting, and only occasional seedlings for any later plantings. Seeds of *V. dentatum, V. dilatatum,* and *V. opulus* sown as late as July gave 26, 54, and 87 per cent seedling production, respectively, the following spring. Seeds sown in August or September, however, gave good seedling production only after being in the ground for two winters. In other words, late summer or fall planting is too late to give the seeds the necessary amount of warm weather for root production, so the first winter the seeds remain ungerminated. With the advent of warm weather the next year, the roots germinate and develop and the following winter after-ripens the epicotyl. Low temperature is ineffective if given before the roots have formed. Flats kept at 70° F. for the duration of the experiment where seed received no low temperature for breaking epicotyl dormancy, contained a few weak seedlings.

It has been reported that seeds of *V. lantana* and *V. lentago* planted in early October in Ohio produced seedlings to the extent of 84 and 73 per cent respectively by the following July (5).

DISCUSSION

To summarize, then, it may be said that the *Viburnum* species described above, except southern forms, require a constant temperature of 68° F. or a daily alternating temperature of 68° to 86° F. for root production followed by a low temperature pretreatment for shoot production. Except for southern forms, seeds sown in flats in the fall and placed in cold frames produce seedlings only after the second winter. Spring plantings, however, give a good crop of seedlings after one winter. All of these effects have been confirmed by germination tests in moist granulated peat moss and seedling production tests in soil at controlled temperatures. Leweling (4) used this method effectively for *V. Carlesii.* He placed the seeds in moist sand at 65°-71° F. for 60 days; 40° F. for 60 days; then 70°-90° F. for seedling production.

The fact that germination to form roots extends over such a long period indicates that some treatment should be effective in bringing about more prompt and more complete germination Giersbach (2) was not able to accomplish this by giving temperature pretreatments or by removal of the hard coats. However, Knowles and Zalik (3) found coat removal effective for seeds of *V trilobum* Marsh. They reported dormancy in both seeds and seedlings of this species. Dormancy of seeds placed at 68° F, expressed by slow growth in some seeds and by failure to germinate in others, was associated by these authors with the presence of a water-soluble inhibitor, coupled with a need for an appropriate temperature treatment. An increase of 19 per cent germination followed removal of the endocarp which contained the inhibitor, but highest germination was obtained by endocarp removal accompanied by alternating temperature treatments (36° to 68° F., or 41° to 68° F). Smith (6) in a recent publication also found that the waxy coat of recently harvested seeds of *Viburnum lantana* and the entire integument of fresh seeds of *V. lentago* exerted slight inhibitory effects on germination. He believed the cause of this effect may have been impermeability to gaseous exchange or to the presence of an inhibitor. Epicotyl dormancy was broken in *V. trilobum* in the light following exposure in the dark to either 41° or 68° F. (3). This is contrary to the results presented above which indicate that lower temperatures are required for the after-ripening of the epicotyl Knowles and Zalik (3) concluded, further, that epicotyl growth of *V. trilobum* was governed mainly by the cotyledons. Dark treatment of seedlings for two weeks at 41° or 68° F followed by removal of the cotyledons 14 days after transfer to the light resulted in 100 per cent epicotyl growth within 10 days. Intact seedlings with the same treatment failed to develop epicotyls. No data were given for the effect of cotyledon removal following longer temperature pretreatment periords. Also, *V. trilobum* seedlings were grown in vermiculite for short periods, which gave no evidence of further vigorous development.

One of the effects of longer periods at low temperature may be to remove an inhibitor from the cotyledons. However, cotyledon removal would not be feasible for large scale production of seedlings since it would involve tedious manipulation and the young seedlings would be deprived of their original food supply It, perhaps, should be noted that Vacha and Harvey (7) stated in 1927 that ethylene or propylene 1:500 for 8 days in three doses gave good germination of dormant seeds of highbush cranberry. Species and details of the experimental procedures were not given, and no other reports on this subject have appeared in the literature

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MR. MARTIN VAN HOF. Did I understand that the seed that was gathered in 1958 was sown immediately?

DR. BARTON. Yes, it was sown as fresh seed. It was stored dry until April without stratification.

MODERATOR JOHNSON· I am sure that Dr Barton would answer any questions you might have on this subject

DR. CHARLES HESS: In what publication did Knowles and Zalik publish?

DR. BARTON. Their article was published in the *Canadian Journal of Botany,* Volume 36, 1958.

MR. VAN HOF: Have you tried soaking the seeds in gibberellic acid in order to speed up germination?

DR. BARTON: We have had no luck. We tried Arnold crab apple seed also, because there was an indication that it might work on natural dwarfs. When you spray seedlings you eliminate the dwarf condition by causing internode elongation. We thought therefore, that we could soak the seeds and partially overcome dwarfism but it didn't work.

MR HOOGENDOORN: Have you ever tried to break the dormancy of *Sciadopitys verticillata?*

DR BARTON: Yes, we have. This was done a number of years ago and I don't remember the details. We tried low temperature at the time, as I recall, and we didn't do well with it. We obtained maybe 20 or 30 per cent germination, after low temperature treatment for two months in 41° F

MR. COGGESHALL. I have two questions. First, am I assuming correctly that you people at Boyce Thompson Institute do not consider it necessary or practical to clean the seed prior to sowing?

Second, have you done anything along the lines of collecting viburnum seeds green, before the formation of a hard seed coat?

DR. BARTON: We always clean the seed before sowing. The only trouble with cleaning them after you store them is the pulp dries and you are apt to injure the seeds trying to get them clean.

As to the second question, we have not tried collecting any immature seeds of viburnum to see if they would be non-dormant. We tried that for a lot of other seeds, because this has been reported in the literature from time to time We have never found that you could clean immature seeds and get non-dormant seeds The immature seeds, if they are too immature, rot before you can germinate them, and if they are older, they are dormant This has been our experience We took apples one time at the beginning of the formation of the embryo thinking we could get at this dormancy factor but we found about the same thing there

MR MARTIN VAN HOF: I think this question which I have in mind was asked, but maybe I came a little bit late. Some of the seeds, of course, which are gathered, soaked, cleaned and stored, sprout

DR BARTON: I think that is almost universally true of any seeds that show any type of dormancy You have all these variations in dormancy in the individual seeds.

One of the biggest advantages in after-ripening in breaking dormancy is to get all of your seeds germinating at the same time This is true in many forms that will germinate without low temperature, pines, for example. There are some pines where you get a seedling without low temperature, but if you pretreat them, even a short period, depending on the pine, you get a uniform stand

DR SIDNEY WAXMAN (University of Connecticut, Storrs, Conn.): We did some experiments with *Sciadopitys* three years ago. They will germinate under normal conditions in about 100 days. We tried various treatments, including photoperiod and misting. The result was that when they are under mist they will not germinate on long days but will germinate on short days or in total darkness In darkness they germinate at 65 degrees when treated with thiourea. It takes about 35 days to germinate on short days under mist. If we treat with chemicals and then place the seeds in the dark they will germinate in 30 to 35 days

DR. CHARLES HESS: What type of dormancy does the *Ilex* seed have?

DR BARTON: I wish you people would ask me easy ones. *Ilex* is one of those that in the early days we did a great deal of work on at Boyce Thompson, and we have never done anything that gives any better germination than fall planting. The next spring you get seedlings and the next spring more seedlings, and the next spring probably still more seedlings, it is quite sporadic.

American holly is the plant that we worked on principally, and it has a very undeveloped embryo, just a mass of undifferentiated cells.

Dr. Peter Nelson, of the Brooklyn Botanical Garden once did a lot of work on excising the embryos of holly seed. He never published it. I asked him awhile ago why he hadn't published it, and he said he had not found out much of anything.

DR. L C. CHADWICK (Ohio State University, Columbus Ohio): We appreciate the importance of the changes of temperature from the warm temperature of 68 degrees to break the seed coat to 41 degrees to overcome the epicotyl dormancy I am wondering if you have any information, whether or not you can make that switch from the warm temperature to the cold previous to the protrusion of the root radicals through the seed coat: in other words, make the change while it is still in the seed

DR. BARTON: It will not work for these particular forms that show epicotyl dormancy You must have the root growing first, before you can get any effect of the low temperature to the shoot This we have worked out morphologically. The differentiation of the tissues takes place for the epicotyl only after the root is growing.

Gibberellic acid has the same effect. It will not have any effect until the embryo gets to that stage.

MODERATOR JOHNSON: I think we had better go on. Thank you, Dr. Barton, for a most interesting talk and discussion

Our next speaker, I am sure, needs no introduction. Dr. Baumgartner is known to all of you for his work as a consultant to the nursery industry. Dr. Baumgartner

Dr. Baumgartner read his prepared paper entitled, "Basic Factors in Good Water and Soil Management for Balanced Plant Growth." (Applause)

BASIC FACTORS IN GOOD WATER AND SOIL MANAGEMENT FOR BALANCED PLANT GROWTH

L. L. Baumgartner
Baumlanda Horticultural Research Laboratory
Croton Falls, New York

When our program chairman asked for a discussion of this subject we were well aware of the fact that it is a broad title and that books have been written on each of its three phases Therefore, if this presentation should be acceptable to you, it will probably represent a greater contribution to the art of organization and condensation rather than a contribution to scientific discipline Our primary objective is to re-examine the handling of water and plant foods in the light of operational problems in nursery management. Some of my statements based on my experience will undoubtedly be contrary to your experiences and I hope that this may provide the basis for further discussion. This subject often appears overly-complicated and possibly mysterious because of the many special circumstances and exceptions which make many facts appear to be contrary to each other. I am certain that this will appear very elementary to some of you and I beg your indulgence as I attempt to develop a subject without including the many exceptions and special circumstances. This is prepared for the non-professional.

WATER

Sources of Water: One of the most controversial subjects revolves around the belief that rain water is better for plant growth than irrigation water. In New England there have been reports that the use of irrigation water actually harmed nursery crops, while in Arizona similar crops could never have been raised without irrigation. Now what might the answer be?

The divinity of water from heaven has not been generally accepted but if it comes often enough it is certainly satisfactory Rain water generally falls in small droplets and continues for an extended period of time. It not only producers a beneficial cooling of the air surrounding the plants but soil can better absorb water that is applied slowly. Rain does entrap some nitrogen and sulfur from the air and carries it to the soil.

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In industrial and metropolitan areas rain can often supply the total sulfur requirements of a plant but only an infinitesimal amount of the required nitrogen The greatest advantage of rain is its low cost. Where soil is cultivated or otherwise in good tilth, rain water does seem to penetrate better than water from irrigation systems.

The disadvantages of depending on rain as our sole supply of water are that, 1) it occurs in an unpredictable pattern, 2) it is often unrelated to the growth habits of the plant varieties being grown, and 3) it may occur in either excessive or inadequate quantities For example, the growing season along a sea coast may be longer than that of the interior only because adequate rain is available during each month of the summer season.

To quote a farmer from New Mexico whose viewpoint is rather extreme, "the greatest advantage of rain is that it produces a reservoir of available water for irrigation " This may be extreme, but when one remembers that a plant contains more than 90% of its weight as water, we can see quite clearly that it is important to have water readily available.

The second source of water is from irrigation facilities. This can be a method of sub-irrigation where water is brought to the roots by periodically saturating the soil with water from ditches, or by impounding nearby water to create a high water table. The more common methods employed, however, are overhead watering devices or hand watering from water tanks equipped with water hoses

The advantages of irrigation are, 1) water can be applied when needed, 2) water can be applied in required quantities, and 3) irrigation systems can be used to apply fertilizers, nematocides, insecticides, etc.

The disadvantages of irrigation are, 1) soil structure can be injured if water is applied too rapidly and constantly in excess — irrigation should not be hurried, 2) some (but few), water sources may be harmful to plant growth. The most frequently experienced difficulty occurs when highly alkaline water is used to irrigate plants growing in soil mixtures containing a high quantity of peat moss. The calcium seems to be entrapped in the peat moss with the result that the pH of the mix becomes alkaline and ericaceous plants become chlorotic, and 3) irrigation water is too often used too late as a method of "saving" plants rather than growing plants

How is Water Used by Plants?: Before explaining the advantages of using adequate quantities of water or the dangers of misuse of water it is well that we quickly list the various ways that plants use it. The order in which these uses are listed has no significance.

1. Water can be used to cool plants. Where shading is not practical the use of a mist system is quite a good method of maintaining a cooler atmosphere around plants There is also some evidence that a moist soil maintains a lower and more beneficial temperature in the root zone. This still requires proof but many nurserymen feel that dry soil becomes too hot for good root development for shallow-rooted plants The work of O F. Curtis (1936) provides strong evidence that water passing through plants has no beneficial value. He points out

that there is no difference in growth between plants transpiring at a rapid rate as compared to plants transpiring at a slower rate

2. Water is an essential part of the soil organic matter, for without water the soil micro-organisms cannot be active, and without this microbial activity there can be no conversion of raw fertilizers to usable plant foods.

3. After raw plant foods are converted to usable plant foods, it is necessary to have more water available to dissolve them and transport them to the root zone, into the roots and up the stem to the leaves for further processing into sugars, starches, amino acids, etc.

4. Water performs one additional function which might be considered its most important one. Photosynthesis, or the manufacture of food, is accomplished in the cell sap which is predominantly water Like so many chemical reactions in nature, the manufacture of sugars, etc. is done in a water medium.

What Happens When — — — ?

1 —there is too little water. In extreme cases the plant, of course, dies, but before this happens it will go into a state of wilt Wilting is a protective mechanism that occurs in plants to conserve moisture Plants can be revived from this state by supplying water, but with many varieties of plants the wilting may have induced dormancy and further growth of the plant is finished for the season This is a well-known occurrence in the florist industry but more needs to be known about it in our industry. It has been commonly observed in *Taxus*. With a little skill, it is also possible to adjust wet and dry periods to induce heavier flower bud formation. I have been successful in accomplishing this with dogwood but there must be many other plants that might be equally susceptible. I suspect that flowering in *Pyracantha* might be subject to this influence.

2. —there is too much available water There are many horticulturists who feel that it is more detrimental to plants to use too much water as compared to too little. Many of you have undoubtedly experienced the unusually heavy top growth that can be obtained by using large quantities of water You may also have noticed that roots are more extensive when growing in dry soil. I do not know how to capitalize on this at the moment, but these responses do occur.

The most important danger from over-watering is that of stopping all growth. We call it "interference with soil aeration," but here is what happens. Respiration of plant roots is an essential process and consists of an exchange of oxygen and carbon dioxide. This gas exchange can only occur in a porous soil, thus, if the soil is saturated with water this exchange cannot occur and the roots cannot perform their function of procuring water When soil saturation occurs frequently or for long periods, the plant stops growing and dies. Oxygen is essential for rooting plants and also for root development of established plants.

There is a relationship between excessively wet soil and a high incidence of root-rotting diseases In many instances this is true but it is a complicated subject that can be better discussed at another time

SOIL

What is Soil?: Soil has many definitions such as 1) an earth shell of weathered rocks, 2) the upper six inches of the earth's crust, etc. but for our purpose I propose a more meaningful definition. Soil is a plant food or fertilizer and may occur on the earth's surface or in a plant container holding a special soil mix It is true that soil serves as an anchor for plants, but if it did not also feed plants we would not be interested in it

What is Soil Made of?: The most elementary example of soil consists of weathered rocks, which in turn are made up of many chemical elements *including* most of the essential plant food elements These are phosphorus, potassium, magnesium, calcium, manganese, copper, zinc, cobalt, boron, strontium, sulfur and sometimes nitrogen. Freezing and thawing, of course, break large rocks to small rocks but the food elements are not available to higher plants until the dissolving acids from organic matter (consisting of dead and living plants and animals) react chemically with the rocks to release the plant food elements The only other materials a plant requires are oxygen and carbon dioxide which it obtains from the air. and water.

Gentlemen, this is the way that the tremendous reserve of plant food was produced in virgin soil. This warehouse of food has eventually become depleted (as of now) and it is essential to replenish it, but how are we going to do it — by scattering more rocks over the field? You are saying "no," but, is that true? What are you doing when you spread a bag of 10-10-10 or 5-10-5? Where did it come from? The potash is nothing more than rock mined from relatively pure veins of potash rock that occurs naturally in our mountains; the phosphorus (super or triple super) is just rock that accumulated in high concentrations in certain parts of the United States A number of you used to buy and spread ordinary rock phosphate until more economical triple and superphosphate became available, but superphosphate is only rock phosphate that has been chemically weathered to hasten its availability. In manufacturing we use strong acids such as hydrochloric and nitric acid but in the soil the micro-organisms use weak and slow-acting carbonic acid. Some forms of nitrogen come from rock mined in Chile or elsewhere In fact, right here at home we are mining concentrated forms of calcium and calcium-magnesium under the name of limestone Therefore a bag of fertilizer may contain nothing more than ground-up rocks, obtained elsewhere. With this background you will agree with me that our whole fertilizer industry consists of digging and shipping rock from one part of the world to another and spreading it where we want plants to grow There is nothing dangerous in a bag of chemical fertilizer — the danger is in mishandling it

The second component of soil is organic matter which is a term that includes all living and dead plants and animals, and materials that were derived from plants or animals. This would generally include all carbonaceous material such as peat, humus, coal, oil and organic chemicals responsible for producing soil structure In short, organic matter is that dynamic chemical plant that manufactures plant food, warehouses it and releases it in forms and quantities suitable for plant growth and welfare.

Many forms of organic matter, for example manure or compost, are "predigested plant foods" and can in themselves sustain plant life, but generally the best growth for the biggest variety of plants is obtained from a combination of organic matter and rocks (chemical fertilizers).

What is the Function of Rocks?. I have used the term "rocks" rather freely for the purpose of emphasizing the fact that basically soil consists of two major constituents, i.e, 1) particles of inorganic materials in the form of inanimate rocks, and 2) particles of organic materials derived from plants and animals The term "rock" indicates something large, and therefore, I now wish to modify this term to include coarse stone, fine stone, coarse sand, fine sand, silt and specialty sands such as expanded shale, perlite and vermiculite.

Rocks have these principle functions: 1) These materials can in themselves, or when combined with organic matter, provide suitable anchorage for plants. 2) As mentioned earlier, they serve as a source of plant foods. 3) Their physical soil conditioning action, which as a third use, may be equally important as the food source Few plants can live long in 100% organic matter, but when the organic matter is made porous with sand or similar material, plants will thrive.

What is the Function of Organic Matter?: I have just mentioned that rocks contribute a physical soil conditioning effect on organic matter, and we now can reverse this story and state that organic matter, especially if it is coarse, will produce a physical soil conditioning effect on mineral materal especially if it contains high quantities of silt and clay. It makes tight compact soils more porous and keeps the very fine soil particles from forming a water-repellent crust on the surface of the soil Unfortunately, as the organic matter decomposes, the soil again becomes compact.

Organic matter performs another soil conditioning activity called chemical soil conditioning which is even more important than the physical conditioning just stated Living organisms and residues of dead organisms produce a series of "long-named" chemical materials that literally bind fine soil particles together to form coarse soil aggregates. As these aggregates grow larger, the soil becomes more porous, and thus develops better tilth. You can readily see this difference if you compare some virgin soil near the edge of an old cemetey with the soil of a nearby field which has been cultivated. This is the type of soil conditioning that one should attempt to obtain when using cover crops for soil building

A third and very important function of organic matter is that of increasing the water-holding capacity of the soil mixture. This is accomplished in two ways: first by absorbing water as a sponge might, and second, by providing an increase of particle surface to hold more capillary water This last feature is extremely important because this is the only kind of water that plants can pick up

Its fourth important function is that of providing a living medium for micro-organisms, so that they can accomplish their task of contributing to soil building and plant food conversion.

At this point, in the interest of soil management, we might inject reference to the controversial subject of the function of earthworms. There are some who hold that earthworms build soil, and others who contend that earthworms do not inhabit a given soil until after it has developed a good tilth I take no part in this controversy, but I find that the presence of earthworms and other similar large soil animals is not beneficial to growing shallow-rooted plants or bedding plants, because their presence encourages moles and small rodents. Moles, especially, cause considerable unnecessary damage by lifting newly planted plants and creating tunnels under established plants. Earthworms in containers produce a cementing action of the soil to the container sides, thereby creating a problem in removing the plants I am of the opinion that it is desirable to use an insecticide to keep earthworms and insects at a low level.

SOIL MANAGEMENT

By the above introduction to our subject of soil management I have tried to take apart the various important component factors of water and soil and discuss them separately. Now to put it all back together again is an easy task It can be readily summarized by stating that the objective for soil management or soil preparation is to produce a loose textured material that has fertilizing power It is accomplished by using mineral materials from rocks as a source of food elements, organic material (representing a chemical operation) to release and convert these elements and water as a medium in which the operation can take place and as a vehicle to carry the end products about in the soil and in the plants

The task of the nurseryman is to recognize the interrelationship of these three factors and keep them in a degree of balance

BALANCED PLANT NUTRITION

Assuming that balancing available plant food, organic matter and water are the important components of balanced plant nutrition, the logical question is, "what is an example of a balanced plant diet?" I am forced to say that this seemingly logical question cannot yet be answered, but the following are examples of how plant "diets" can be, and are being, unbalanced.

The present common practice is to feed in excess of assumed minimum requirements, but this has often caused trouble when certain food elements were not completely used in a given period of time or a season and they soon accumulate in toxic quantities Probably the most commonly caused trouble is that of producing soft growth on semi-hardy plants which later became injured from early frosts.

The amount of a plant food or fertilizer that a given block of plants will require is subject to a number of variables, which under most situations are subject to control. Let us examine some possibilities

Probably the greatest violation of controlling a variable is practiced in acidity control. It is not uncommon to adjust the pH of the soil with sulfur or lime to fit a particular type of plant material. Here is a simple example of what commonly happens. a given strip of soil 100 feet wide is planted to azaleas and rhododendrons and the soil is treated with sulfur to make it acid. Three years later all the plants except a few rows are sold. The soil is cultivated and lime is added to make it sweet The important and very difficult question is how much lime is necessary to alter the current pH level plus counteracting any residual sulfur that will in turn counteract the lime. Two years later the remaining rhododendrons and most of the two year-planted "sweet-soil" plants are sold The nurserymen must now adjust the pH of a small sulfured strip, a sulfer-lime strip and any soil adjacent to the original 100 feet strip In other words, he has to adjust three different pH levels Now who is able to bring this mixed-up area back to a uniform pH with one treatment and what operator can afford the time to make a variety of different applications of lime or sulfur on such small areas?

This thing called pH has nothing to do with plants except to help release a different "diet" of food elements from the soil. For example, a sour soil releases more iron and manganese if they are present. In the other extreme, a very sweet soil releases much less iron and manganese but a higher proportion of other food elements. Now for a practical operational procedure, isn't it better to keep a compromise pH level and feed the extra food requirements that would be expected to be in short supply? After all, changing the soil pH cannot encourage the release of food elements that might not be there in the first place!

Another questionable practice is that of starving plants to force early dormancy This practice is effective but does it not reduce the profit that might be produced from a given area? It is generally conceded that root development and caliper increase continue late into fall or early winter — our experience confirms this Now if a plant is starved in mid- or late-summer as forest trees are, where will the food be obtained to produce the additional late growth? Would it not be more profitable to employ a heavier feeding program and take precautions to see that there is not an excess of nitrogen in late season, or in other words, to maintain a "balance" of major elements?

Another common source of trouble occurs when high levels of fertilizer are maintained without consideration to water availability. One case, as an example, occured in 1957. Nurseryman "A" borrowed a fertilizer program from nurseryman "B" who also had a good water supply. The program was a relatively heavy one, but also fairly well-balanced. A severe drought occurred in late June, July and August. The plants in nursery "A" stopped growing, but in nursery "B" where systematic watering was practiced, the plants added considerable new growth. September was a very wet month and the plants in nursery "A" broke bud and started growing vigorously, but most new growth was seriously frozen back by an unanticipated freeze on September 21st. The September growth in nursery "B" was quite small and very little damage occurred.

I am not prepared to prove the reasons for these two different responses We have considerable experience to demonstrate that high fertility programs return the greatest profits, but that these programs will not be productive if not balanced with an adequate and regular water supply.

Many other examples can be given, but these were selected to demonstrate that water, soil and plant food are interrelated and none of them should be used without giving careful consideration to the others.

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DR. CHARLES HESS. I think you have taken a very difficult subject and have generalized many cases to a point where I feel your explanations are of questionable use and sometimes questionable accuracy. I would like to see you take these theoretical approaches and work out a practical use for them In other words suggest a soil mixture which will have the proper drainage and a fertilization program which will provide the proper nutrients.

DR BAUMGARTNER It might be very well. In the last eight years I have been working on a production basis with nursery superintendents and people who do not understand, because of their interest and their efforts, in an altogether different direction It is a matter of transplanting the significance of some of our important technical material to rule-of-thumb or common language. It is a most difficult thing to do.

MODERATOR JOHNSON: Thank you It was a stimulating talk that should create some arguments, but I think we had better defer them until after the lunch period, since we are now exactly on time.

Another subject connected with the soil problem, a subject dear to the hearts of many of us in the Midwest and adjoining parts of Canada, is iron chlorosis. Dr Brown is with the U.S D.A. Agricultural Research Service at Beltsville, and he will address us on this problem of iron chlorosis.

Dr John C. Brown presented his address on "Genotype of Rootstock as a Factor in Plant Nutrition with Emphasis on Iron Chlorosis." (Applause)

GENOTYPE OF ROOTSTOCK AS A FACTOR IN PLANT NUTRITION WITH EMPHASIS ON IRON CHLOROSIS

JOHN C. BROWN
Soil and Water Conservation Research Division
U S Department of Agriculture
Beltsville, Maryland

Chlorosis is a general term which denotes a yellowing in plants, a condition related to a large number of abnormalities. The more specific term, iron chlorosis, refers to a "chlorosis" which can be alleviated by providing the plant with suitable iron compounds. This disorder is particularly prevalent on calcareous soils where it is difficult to keep iron in forms which are available for all plant growth. It may occur on neutral or slightly acid soils, especially where so-called acid-loving plants such as azaleas, rhododendrons, and blueberries are grown. Growth medium, fertilizer, organic matter, and water are all contributing factors to this yellowing or iron deficiency (1). Soil and/or plant treatment for control is often difficult, but can be achieved by the care-

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Several thousand observations of chlorosis have been made in the southern Great Plains area on 183 species and varieties of plants (3) These observations include a wide variety of ornamental trees, shrubs, vines, and perennials, along with fruits and fields of sorghum, buffalo and blue grama grass Thorne and Wann (5) tested the susceptibility of 32 different species of shrubs and 10 different species of trees to iron chlorosis and found a great deal of variability between species. The fact that plant species differ in their susceptibility to iron chlorosis (1) indicates that in addition to an external medium effect there must also be an internal plant difference affecting the absorption and transloca-tion of iron. As iron supply becomes limiting, competitors with iron in the absorption process become more important as possible causes of iron chlorosis

Absorption of other elements is known to be dependent upon plant species or variety. Pope (4) found that when Utah 10B celery, a variety susceptible to a magnesium deficiency, is crossed with Summer pascal, a non-susceptible variety, F2 plants are obtained in the ratio of 3 non-susceptible to 1 susceptible The susceptible variety is a less efficient absorber of magnesium than the nonsusceptible variety.

Grafting or budding chlorosis-susceptible varieties on chlorosis-resistant rootstock is one of the methods of treatment suggested to prevent and to control iron chlorosis Grafting labrusca grape varieties on vinifera grape rootstock has been particularly successful as a method of correcting iron chlorosis in American grapes (6). Many European (vinifera) varieties exhibit a high degree of resistance to iron chlorosis. When labrusca rootstock, chlorosis-susceptible variety, were used in southwestern Europe to combat phylloxera, an insect pest, numerous crops failures resulted because of iron chlorosis.

PI-54619-5-1 soybean (PI), susceptible to chlorosis, are inefficient and Hawkeye soybean (HA), nonsusceptible to chlorosis, are efficient in their ability to absorb and translocate iron from a given nutrient medium. PI soybeans develop an iron chlorosis on most naturally calcareous soils and on solution cultures containing less than 5 ppm inorganic iron Iron chlorosis has been induced in PI soybeans by increasing the phosphorus and copper concentration of a given nutrient culture. In contrast, HA soybeans were nonchlorotic when grown under each of the above conditions. Both the HA soybean and the vinifera grape may be called efficient absorbers of iron.

Approach grafts have shown that the rootstock of the PI and HA soybeans are regulatory to the absorption and translocation of iron from a growth medium (2) Grown on a growth medium of limited iron supply, PI-top on PI-root was chlorotic, HA-top on HA-root was non-chlorotic, PI-top on HA-root was nonchlorotic, and HA-root develop chlorosis. The HA-rootstock absorbed and translocated more iron to the tops of the plant than PI-rootstock. This difference in iron absorption is genetically controlled (7) and a knowledge of the mechanism involved is believed to be fundamental to an understanding of iron absorption by plants.

Iron was inactivated internally in PI soybeans by the combined effects of phosphorus and calcium in nutrient culture, which was separated from the plant's source of iron by the use of a split-root technique. In contrast, iron was absorbed and remained mobile in HA soybeans under the same conditions of growth and element concentration Thus, genotype of rootstock is an important controlling factor in the absorption and utilization of iron from a growth medium.

Mineral nutrition, as affected by genotype of rootstock, is a subject worthy of more attention. It should be of particular significance to the plant propagators if they are to grow and develop plants adaptive to the varied growth media which are experienced in disseminating their product to the field.

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MODERATOR JOHNSON: Thank you. Dr. Brown By my watch we have one minute for possibly one or two questions.

MR JACK HILL (D. Hill Nursery Company, Dundee, Illinois): Would it be possible to construct imperical rules regarding these nutritional difficulties, or would it be necessary to run down and analyze each plant or each species, before general rules could be laid down?

DR. BROWN: My reaction to that question is that I believe that a nurseryman should be aware of where his material is going, or specifically the type of the soil his customer has. If you are selling in the Midwest, i.e, Oklahoma, Kansas, and on west, you should be very concerned as to whether or not your species is susceptible to this chlorosis.

MR HILL: How can you tell or predict this?

DR. BROWN: That is a thing that has to be worked out I think in growing plants, as far as the growth medium is concerned, I would not recommend the use of high phosphate levels. It has been our experience that high phosphate does not help the growth too much. You have to have some, but you don't need a lot of phosphorus in the growth medium. You do need calcium. I noticed one comment about using ground rocks as a propagation medium I think one must be very careful in using ground rock for propagating plants, because it has been our experience that in some areas you get a batch which will not root anything Analysis of these showed a very high molybdenum content. If you have good sand and are getting good results I would stick to the sand, because I believe you should not use just anything as a growing medium, particularly ground rock.

MR W. A. CUMMING (Morden, Manitoba) What are the possibilities in apples, for instance, in getting genotypes of rootstocks that will tolerate these conditions you have described?

DR. BROWN: I think there is very great promise in this area I think that we are generally looking for something that is disease resistant and we forget the importance of nutrition in selecting genotypes

MODERATOR JOHNSON: I think we had better wind it up. I want to thank all the speakers of their cooperation in keeping within the allotted time and for their excellent papers The meeting is recessed until 1:30 P.M this afternoon.

The session adjourned at twelve-five o'clock.

SATURDAY AFTERNOON SESSION

December 6, 1958

The meeting was called to order at one forty-five oclock by President Steavenson.

PRESIDENT STEAVENSON. Here is a wire just received from Louis Vanderbrook, who was our President of last year.

"Dear Hugh, please convey to the members my sincere appreciation of the beautiful flowers sent me They certainly brighten my hospital room and help to alleviate the pain I hope this will be the biggest and best meeting in the history of our organization. God bless you all"

I know Louis will be gratified to learn that as a matter of fact it is the biggest and I trust the best. Registration is well up over 200.

This afternoon we have as our moderator none other than Mayor Zophar P. Warner. Some of you may not know that he has been mayor of one of the outlying metropolises until his success as a nurseryman caused him to shelf his duties. He is now a full-time propagator.

So with this introduction, I am most pleased to give you our friend and fellow grower, Zophar P Warner. (Applause)

MODERATOR WARNER: As you all know, a politician has to be a good speaker, and I had a very short tenure in office. When I get through with this panel, you will see why I was wise enough not to keep on with my political affiliations

My duties here this afternoon are principally to make sure that we are through by three-thirty, and with that in mind I am not going to make a very lengthy introductory statement. I don't think we will have time for question periods after the speakers The most worthwhile questions can come at the end of the program, providing we have any time

Without further comment we are going to start right off, with Professor F. L. S O'Rourke, Michigan State University. Professor O'Rourke.

Professor F. L S O'Rourke presented his paper entitled, "Efficient Propagation with Hardwood Cuttings in England." (Applause)

EFFICIENT PROPAGATION WITH HARDWOOD CUTTINGS IN ENGLAND

F. L S. O'Rourke

Department of Horticulture

Michigan State University

East Lansing, Michigan

The hardwood cutting method of propagation is relatively convenient and inexpensive and whenever reasonably good results are obtained by the use of hardwood cuttings, that method is usually preferred to layering, grafting, or the other more cumbersome types of propagation. Several discoveries recently made by Mr. R. J. Garner and Dr. E. S. J Hatcher at the East Malling Research Station in Kent, England, may lead the way to a much more extensive use of hardwood cuttings for propagation in the future. These investigators have studied the propagative factors affecting hardwood cuttings from three aspects, (1) the source plant and the condition of the cutting wood before taking, (2) the care and handling after collection, (3) the environment under which the cuttings are rooted.

An analysis of the factors affecting the source plant from which the cuttings are taken shows the extreme importance of this consideration It includes a study of the particular clone involved, its genetic constitution, state of nutrition, carbohydrate reserve, degree of lignification, period of establishment in the soil, chronological age, and the particular degree of juvenility, senility, the vegetative or reproductive condition of the plant or portions thereof from which the cutting wood is taken. Equally important is the consideration of the age, size, position on plant, and date and manner of collection of the cutting wood.

The East Malling experiments with various apple selections show that cuttings taken from a clone budded on a vigorous rootstock root and survived to a greater degree than those taken from the same clone budded on weaker rootstocks Other tests report that the rooting of cuttings taken from hedges that are kept in a vegetative condition by close pruning is superior to those taken from nursery plants or from the upper portions of layered stems in the stool blocks It is also indicated that cuttings taken relatively early in the fall (October) survive to a higher degree than those collected in the late fall or during the winter.

A rather difficult-to-root apple selection known as Crab C has been used as the test plant in these experiments Scions of Crab C were grafted on a number of rootstocks and when grown, hardwood cutting material was taken for comparison. The results are shown in the following table:

Table I.—Per cent rooting of hardwood cuttings of the apple clone Crab C taken from different plants grafted upon several rootstocks.

Rootstock	Vigor of rootstock	Per cent rooted
M IX	Weak	21
M II	Medium	35
M VII	Medium	37
M XVI	Vigorous	59
M Crab C	Fairly vigorous	40

Malling XVI, a vigorous rootstock, thus imparted to the wood of the scion variety the propagative ability to root nearly three times as well as wood from the same clone grafted on the weak rootstock Malling IX.

Hedges of various own-rooted clones of apple and plum had been established as windbreaks at East Malling. These hedges, about 7 feet high by 30 inches wide, were kept in a *vegetative* condition by close clipping and the removal of the flowering wood. Hardwood cuttings taken from these hedges were found to root to a much greater degree than cuttings taken from plants growing in the nursery. The differences are shown in Table 2

Table 2.—Per cent rooting of Malling Crab C apple cuttings.

	From nursery plants	From hedge plants
Basal cuttings (12″ base of 1-year shoot)	0	45
Second cuttings (Next 12″ above basal cutting)	6	42

As yet, no data are available as to cuttings taken from hedges formed of the selected clone grafted on the most vigorous rootstocks. The possibilities in combining these two discoveries to grow "source plants" are immense and may make the stool-bed layer method obsolete for the great majority of clones now being propagated by that means. While the East Malling experiments have been concerned solely with fruit plants, the same principles may well apply to woody plants used for other purposes.

The East Malling investigations concerned with the care and handling of hardwood cuttings after collection include studies pertaining to the length and diameter of the cutting, wounding, callusing, rate and manner of application of synthetic growth regulators, temperature conditions, storage, and date and method of planting. The results of the many experiments may be briefly summarized as follows:

a — The concentrated solution method, also known as the "quick dip" method, at a rate of 2½ milligrams of indolebutyric acid to 1 milliliter of 50 per cent alcohol is effective for most hardwood cuttings.

b — The most effective size of cutting is about 12 inches in length with a diameter between 6 and 10 millimeters

c — Rooting and survival are greater when the cuttings are taken in October and stored over winter with the bases plunged in a peat-sand medium heated to 45° F. Frames equipped with electric heating cables and insulated with bales of straw have been used successfully.

The importance of treating with IBA (indolebutyric acid) and storing at 45° F. over winter is shown in the following table:

Table 3.—Per cent rooting of M Crab C apple cuttings stored and field planted.

Treatment	Position	Cuttings taken and stored			Cuttings taken and planted in fall
		Oct	Nov	Dec	
None	Basal	0	0	3	13
None	Second	0	0	0	0
IBA	Basal	87	31	37	23
IBA	Second	81	68	22	2

Studies in relation to the factors of the environment of the cutting while in the process of rooting are also being carried out at East Malling, particularly in regard to the most favorable moisture and air content of the soil, and the most favorable temperature to induce rooting. The result will be reported when more data are available

The East Malling investigators have opened several new avenues for further research The influence of vigor-inducing rootstocks and the use of vegetative wood from hedges should be considered in relation to accepted theories of physiological juvenility The propagative power of hardwood stem tissue has definitely been increased by these methods The interrelationship of time of collection, growth regulator treatment, and controlled-temperature storage is significant. The application of these principles and methods with proper modifications to other plant species should advance the progress and knowledge of plant propagation quite materially.

Acknowledgement:

The writer extends his thanks and appreciation to Mr R J. Garner and Dr. E S J. Hatcher of the East Malling Research Station for their kindly cooperation and the unreserved contributions of their research data.

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MODERATOR WARNER The next man on our program is Mr. March of the National Arboretum in Washington, D.C. He will discuss the hardy eucalypti

Mr. Sylvester G March read his prepared address on "Hardy Eucalypts." (Applause)

HARDY EUCALYPTS

SYLVESTER G. MARCH
Propagator
U S. National Arboretum
Washington, D.C.

The mention of eucalyptus to most people brings to mind thoughts of the Koala bear and Australia Uniquely, the genus *Eucalyptus,* with its 500 species, is native only to Australia, Tasmania, and neighboring islands.

In addition to eucalyptus leaves being an essential part of the diet of the Koala, eucalypts play an important role in the economy of Australia Its wood is used for paper pulp, fibreboard, commercial lumber, firewood and charcoal. From its bark comes tannin and from its leaves, essential oils. These essential oils are used in disinfectants, perfumes and medicines.

At the turn of the century a good deal of effort was expended to establish plantations of this rapid-growing tree in California, New Mexico, Arizona, and Florida, but land proved to be of greater value for farming and therefore most of the eucalypt plantations have disappeared. Today, in California the eucalypt is best known as an ornamental tree for street planting. So intensively have they been planted there, that most Californians believe them to be indigenous. There is a story told about a soldier from California stationed in Australia during World War II in which he remarked, "Say, you got some of our eucalpts here!"

In its native habitat the genus is distributed widely over areas of greatly varying climatic conditions. The regions that interest us most

The East Malling investigators have opened several new avenues for further research. The influence of vigor-inducing rootstocks and the use of vegetative wood from hedges should be considered in relation to accepted theories of physiological juvenility. The propagative power of hardwood stem tissue has definitely been increased by these methods. The interrelationship of time of collection, growth regulator treatment, and controlled-temperature storage is significant. The application of these principles and methods with proper modifications to other plant species should advance the progress and knowledge of plant propagation quite materially.

Acknowledgement:

The writer extends his thanks and appreciation to Mr. R. J. Garner and Dr. E. S. J. Hatcher of the East Malling Research Station for their kindly cooperation and the unreserved contributions of their research data.

* * * * *

MODERATOR WARNER: The next man on our program is Mr. March of the National Arboretum in Washington, D.C. He will discuss the hardy eucalypti.

Mr. Sylvester G. March read his prepared address on "Hardy Eucalypts." (Applause)

HARDY EUCALYPTS

SYLVESTER G. MARCH
Propagator
U. S. National Arboretum
Washington, D.C.

The mention of eucalyptus to most people brings to mind thoughts of the Koala bear and Australia. Uniquely, the genus *Eucalyptus*, with its 500 species, is native only to Australia, Tasmania, and neighboring islands.

In addition to eucalyptus leaves being an essential part of the diet of the Koala, eucalypts play an important role in the economy of Australia. Its wood is used for paper pulp, fibreboard, commercial lumber, firewood and charcoal. From its bark comes tannin and from its leaves, essential oils. These essential oils are used in disinfectants, perfumes and medicines.

At the turn of the century a good deal of effort was expended to establish plantations of this rapid-growing tree in California, New Mexico, Arizona, and Florida, but land proved to be of greater value for farming and therefore most of the eucalypt plantations have disappeared. Today, in California the eucalypt is best known as an ornamental tree for street planting. So intensively have they been planted there, that most Californians believe them to be indigenous. There is a story told about a soldier from California stationed in Australia during World War II in which he remarked, "Say, you got some of our eucalpts here!"

In its native habitat the genus is distributed widely over areas of greatly varying climatic conditions. The regions that interest us most are the colder areas of New South Wales and Victoria on Australia's southeast coast, and the southerly adjacent island of Tasmania. The Blue Mountains in New South Wales and the Australian Alps in Victoria reach elevations of 3,500 to 7,300 ft. It is in this mountainous region where those species of eucalypts which are relatively cold-tolerant can be found The weather records of the Kosciusko Meteorological Station in New South Wales, which is midway between Sydney and Melbourne, indicate an annual average of 157 days with frost, and that a minimum temperature of 5° F. had been recorded

Tasmania, which is only some 150 miles to the south of New South Wales, belongs to the same Great Dividing Range System of the continent and has elevations to 5,200 ft The Waratah Station in Tasmania has recorded a minimum of 4° F. and an average of 44 days of frost per year.

Two and a half years ago, seeds of several species of *Eucalyptus* were sent to the National Arboretum in Washington, D.C., by the Forestry and Timber Bureau in Canberra, Australia. Some of the seeds that were sent came from trees growing in the coldest regions of Australia and Tasmania The plants raised from this seed were planted out in the fall of 1957, and received no protection during last year's severe winter, in which a low of 3° F was recorded at the National Arboretum It is of course much too early to evaluate what the ornamental usefulness and cold tolerance of eucalypts will be It is interesting, however, to note the initial response of the eight species which have shown varying degrees of cold-resistance at the National Arboretum.

E. niphophila, which has handsome blue-gray foliage, withstood our low temperature of 3° F. without any dieback or foliage burn This species has withstood temperatures of 10° F at the U S. Plant Introduction Station at Glenn Dale, Maryland, located some 12 miles from the National Arboretum.

A closely allied species of *E niphophila* is *E. pauciflora* In its native habitat of New South Wales, Queensland, and Tasmania, *E. pauciflora* is found growing on cool mountain sites and in subalpine areas which have frosts in winter and moderate snowfall, cool summers and moderate and regular rainfall. At the Arboretum, this species also withstood our low 3° F, without any inury.

The species that surprised us most was *E camaldulensis* Last fall three six-foot plants were set out Reports we had from Norfolk, Virginia, indicated the species to be hardy there, so our hopes for survival at the Arboretum were high. Much to our disappointment, the plants were killed to the ground Somewhat discouraged, the dead tops were lopped off at ground level. Later in the spring, much to our surprise, several shoots broke from below ground level and now range from 6 to 8 ft. in height.

This experience brought to mind the idea that in colder regions, some of the species might be treated as herbaceous plants. It must be quite humiliating for the lofty *Eucalyptus,* with some of its species reaching heights of 300 feet in Australia, to condescend to being treated as an herbaceous plant.

Perhaps the most attractive species is *E. gunnii*. In its juvenile state the very attractive leaves are extremely glaucous and interestingly arranged on the stem. At the Arboretum, in two contrasting situations, *E. gunnii* behaved quite differently. The foliage on plants protected by a building showed some evidence of winter burn, but did not suffer from any dieback. In another situation, without any protection, it behaved herbaceously like *E. camaldulensis.* It too broke from below ground level and made good growth of about 6 ft. this season.

Several other species which have given indications of cold-tolerance at the Arboretum are *E. aggregata, E. largifloreus, E. rubida,* and *E. stellulata.*

Presently, the accepted method for propagating eucalypts is by seed. Of the species mentioned, *E. niphophila* and *E. pauciflora* require moist stratification for 60 days at 40° F for best germination. Germination time for most species is between six and 18 days. By early spring sowing and over-wintering the plants the first winter in a cool greenhouse, they will be ready for planting out the following spring. After our experience last winter with species that behaved herbaceously, it would be well to give these plants some protection the first two winters in an effort to build up a hardy woody stem. Such protection for two winters might make the difference between the plants acting herbaceously or shrub-to-tree-like thereafter.

In the event cold-resistant selections are made from existing species or new hybrids, a commercially feasible method of asexual propagation will have to be devised. Athough our first attempts to root *Eucalyptus* from cuttings have been unsuccessful, we will continue our efforts. Grafting has been tried with *E. niphophila* at the Arboretum and has proven successful. On the West Coast, air-layering, grafting and inarching have been used in the propagation of desirable varieties.

A great deal needs to be done in the way of exploration for *Eucalyptus* and other ornamentals of which we desire more hardy forms. Unfortunately, in the past, effort has not been made by plant collectors to obtain plant material from the colder regions of the plant's natural distribution range. The National Arboretum, as part of its research program, is keenly interested in the furthering of exploration in this country and abroad for new ornamentals and hardier forms of those already in cultivation.

As research on this genus is in the early stages at the Arboretum it will be several years before testing can be undertaken by other Botanic Gardens and before plant distribution will follow.

* * * * *

MODERATOR WARNER: Thank you, Mr. March. I am sure that in the future we are going to benefit from the publication of these minutes, because these talks are obviously so full of information that only by digesting the minutes published next year will we get the full value of them.

The next man we have needs no introduction to the members who are here. He was my near neighbor until he moved out to Iowa, Dr. John Mahlstede.

DR. MAHLSTEDE. This discussion entitled, "Graft Failures in Apple Stions," might more specifically be designated as "The Effect of Sanitation on the Stands of Apple Grafts."

It is quite apparent that the theme of many of our presentations here at these meetings has been centered around sanitation.

It has been referred to directly during the current sessions by Jack Hill who emphasized the need for cleanliness in and around our propagating facilities. The removal of wastes, debries, and general decontamination procedures have been highlighted as being very important factors contributing to the success of any one particular propagation sequence.

Dr. Richard Hampton, in his excellent presentation on *Prunus* viruses and their relationship to propagation techniques also referred to the need for sanitation and clean scionwood Carnation growers in Colorado have done essentially the same thing in producing disease free cuttings, a process conducted through the culturing and isolation of disease-free stock plants.

Sanitation has also come to light more or less sub rosa; Bill Flemer referred to it in pointing up the nematode problem. Harvey Gray has mentioned it in his cesspool reference, Fred Galle has referred to it in connection with soil sterilization to eliminate weeds and pathogens in transplant beds

When one becomes older he has a tendency to reminisce. On this subject of sanitation I think back to my Professor, Teacher and friend, Steve O'Rourke, who on the first day in his propagation course passed out a one sheet dissertation on sanitation Here he pointed out one fact, i.e , the propagation house is like a maternity ward, keep it clean.

All in all the reasons for these precautions are the elimination of failures and the increase of propagation efficiency.

Dr. J. P. Mahlstede presented his prepared address entitled, "Graft Failures in Apple Stions" (Applause)

GRAFT FAILURES IN APPLE STIONS*

J. P. Mahlstede
Department of Horticulture
Iowa State College
Ames, Iowa

INTRODUCTION

Ever since man first began grafting plants there have been failures. In some years a nurseryman might have unusual success and have a 80 or 90 per cent take Other years, with the same understock and the same scion variety, handled under what the propagator considered identical conditions, stands of 50 or 60 per cent might be realized.

The essential aspects of understock culture of the common red cedar have received particular attention in recent years, since this material is the most commonly used stock for junipers and has given the most trouble to propagators of evergreens. Frequent transplanting to promote the formation of a fiberous root system, and a good sanitation program are considered requisite to an acceptable, commercial stand

* Journal Paper No J—3569 of the Iowa Agricultural and Home Economics Experiment Station, Ames Iowa Project No 1214.

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Melhus and Maney (1921), working on the control of crown gall in apple grafts, suggested the feasibility of dipping the grafts in a bordeaux mixture of an 8-8-50 composition. It is quite apparent that sanitation is quite important to successful propagation, regardless of the technique of reproduction employed In 1953, Louis Vanderbrook outlined his program for rooting hardwood cuttings of deciduous shrubs before the Plant Propagators Society One of the salient features of this discussion was the step he referred to as the most critical operation, namely the placement of the 3½ inch cuttings on a screen and their subjection to a water spray under considerable pressure Before placing the cuttings in the rooting medium it was noted that the basal end was immersed in a sulphur, fungicide dust

To leave the question of sanitation for a moment, it would be well to briefly review some of the other theories of causes for graft failures of apple, since this material has received the greatest attention in the past.

In 1929, R H Roberts of the Wisconsin station noted that in apple grafts made from material having different diameters, the position of the top bud was important to successful grafting. The theory here was that the top bud should be directly above the matched tongues of the graft, since it starts growing most readily, and therefore should be in a direct vertical line with the point of callus union. Here it was suggested that the sap rises readily, but its lateral distribution is quite slow If the top bud is not matched on different diameter scion and root combinations then, this may be one factor contributing to some of the losses.

Some propagators believed that only the whole root graft should be used, while others preferred the long root, short scion, or still others the long scion, short root. One year the whole root graft would give the best stands, in other years the short root, long scion would give better results, and so forth It has since been fairly well established that the long scion, short root method is about as effective as the whole root method, and, of course, is more economical of propagating stock.

Crown gall in apples became an important consideration for nurseries at the turn of the century. Von Schrenk and Hedgcock (1906) suggested that the excessive callusing of apple grafts at the point of union might be due to an infection by fungi or bacteria. A year later Smith and Tonsend (1907) established that crown gall was caused by a bacterium *Agrobacterium tumefaciens.* Von Schrenk, et al suggested the use of cloth and wax to keep whatever was causing the damage from entering the union. Based on this research the cloth nursery tape currently being used today for grafting was developed Again, sanitation has been emphasized as being highly important.

Tukey and Brase (1945) suggest that in certain apple scion-stock combinations, failures or uncongenialities could be attributed to somatic variations, viruses, or physiological disturbances which were carried through the grafting operation. Other failures may also be due to poor mechanics, such as the mismatching of cambium layers, insufficient pressure at the point of union, and excessive gumming All things considered, there may be another reason why grafts might fail, a cause which might explain, in part, the variation from year to year, and from season to season.

Because of the losses that are incurred in bench grafted apples between the time they are grafted until they become established in the field, an experiment was designed to investigate the possibility of the influence of the included bud and its microflora on the stands of grafts Since it had already been established by Keener (1950), that many fungal spores and hyphae could be contained in and on bud scales, it appeared that poor union and complete failure of grafts might be the result of fungi invading the graft union during the hot or cold callusing sequence, or even after the grafts had been placed in the field. This invasion might be favored by wrapping the union with tape or polyethylene sheeting, thus creating a microenvironment quite favorable to the development of certain fungi and bacteria Furthermore, in mismatched unions or grafts having roots and scions of different diameters, larger cavities would be left in the vicinity of the graft union because of the difficulty in taping The type of growing season before scionwood collection, the incidence of disease organisms during and after bud development, storage environment and the method of handling scionwood and grafts are a few of the more important factors which will ultimately determine the success of any grafting operation, in any given year.

METHODS AND MATERIALS

The results are based on an experiment conducted with apples. using dormant scionwood of the variety Red Delicious, containing three buds, and 4 inch piece roots of Washington grown seedlings. Scions collected for the check or control treatments came from a scion block which had been very carefully sprayed at regular intervals during the course of the growing season. Scionwood for all the remaining treatments came from trees which received no fungicidal or bacterial sprays during the progress of the season. Treatments for comparison included the following:

	Scion Source	Scion Treatment	Stock Treatment
1	Sprayed scion block	None	None
2	Sprayed scion block	10 min soak in 1% $KMnO_4$ plus Captan dust after drying	None
3	Non-sprayed scion block	None	None
4	Non-sprayed scion block	$KMnO_4$ soak plus Captain dust	None
5	Non-sprayed scion block	$KMnO_4$ soak plus Captain	$KMnO_4$ soak plus Captan dust
6.	Non-sprayed scion block	None	$KMnO_4$ soak plus Captan dust
7	Non-sprayed scion block	Disbud graft bud No fungicide	None
8	Non-sprayed scion block	Disbud graft bud $KMnO_4$ soak plus Captan dust	$KMnO_4$ soak plus Captain

The common whip graft was used to combine the stock and scion components. All unions were taped with cloth grafting tape. Immediately after grafting, five replications, containing 20 grafts per treatment were individually packed in moist sphagnum moss, wrapped in polyethylene sheeting, and hot callused for 10 days at a temperature of 65° F The grafts were then held for a period of 4 weeks at a temperature of 40° F and subsequently field planted on May 15, 1956. Records on field stands were then taken at two week intervals during the growing season

RESULTS AND CONCLUSIONS

From Figure 1 it is quite apparent that scionwood that was sampled from scion blocks which received a regular disease and insect spray

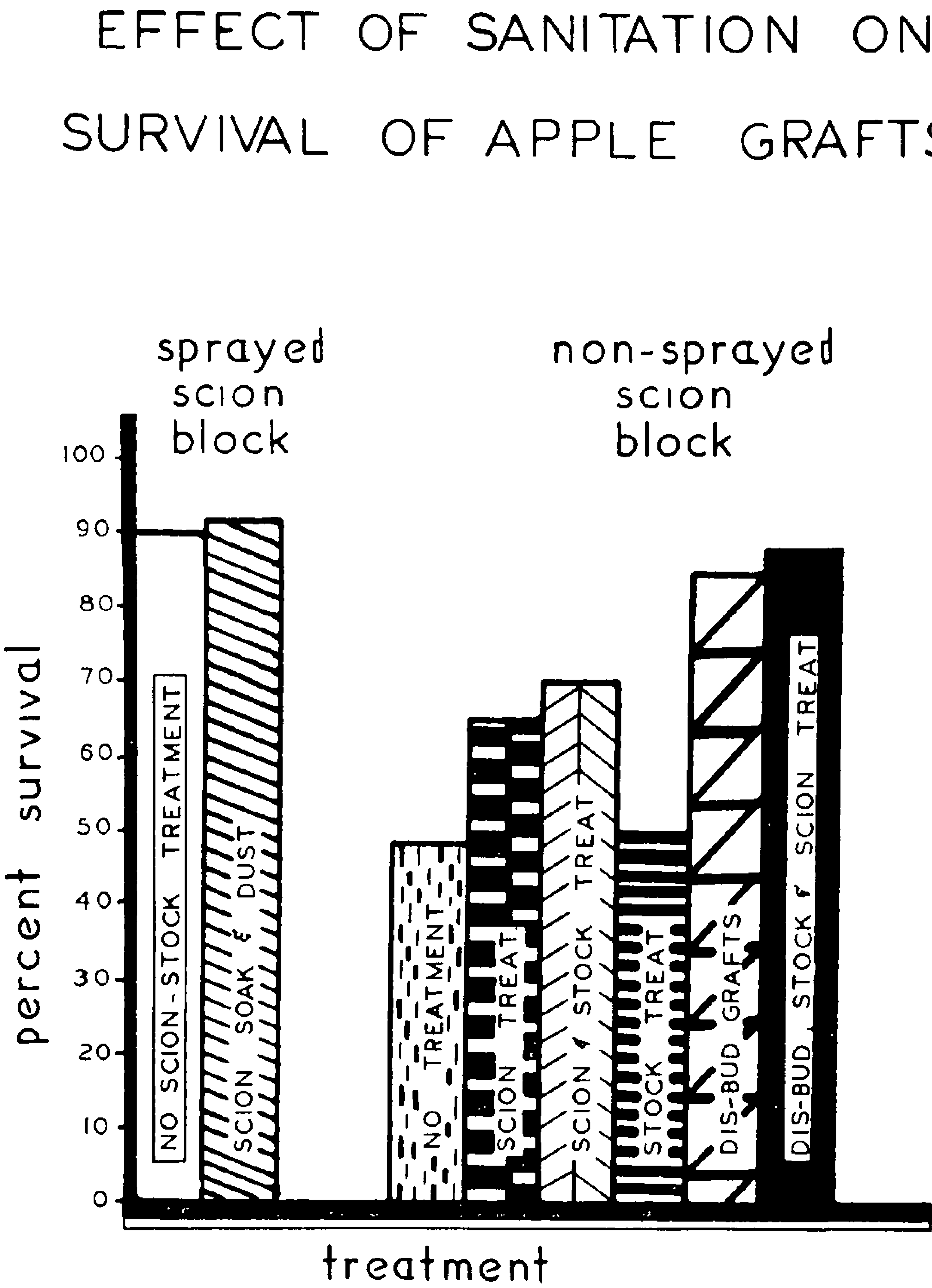

Figure 1. Effect of sanitation on the survival of apple grafts. Note the high survival percentages of grafts made from scions collected from regularly sprayed scion blocks and from non-sprayed scions having the graft bud removed.

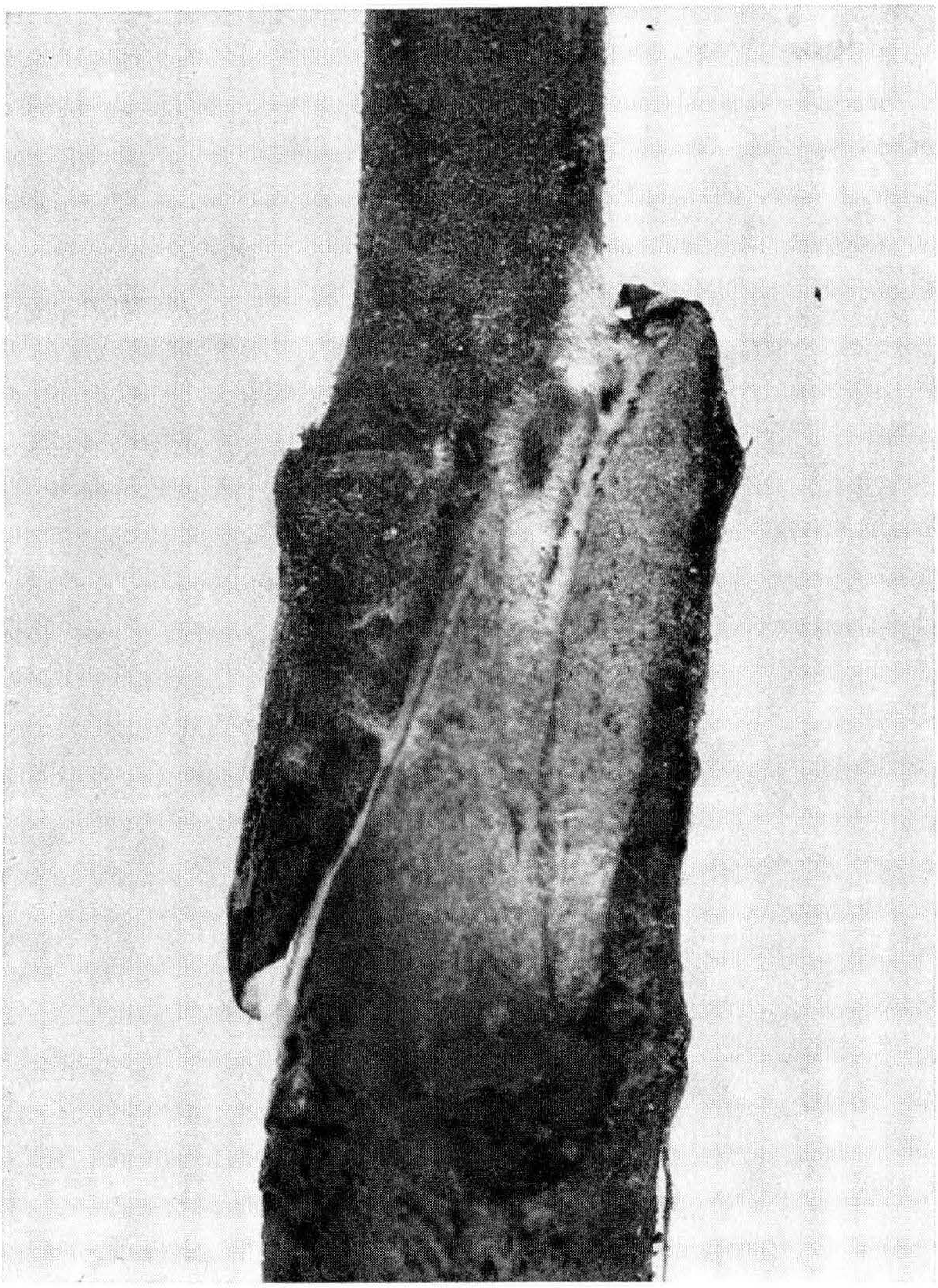

Figure 2. Closeup of a graft union with the grafting tape removed and a portion of the understock cut away to show fungus activity in the graft interfaces.

sequence during the season gave the highest survival percentages. Soaking the scions in a potassium permanganate solution followed by a fungicide dust treatment did little to improve the stands of grafts which made use of "clean" scionwood. The fact that removal of the graft bud, or bud which would normally fall on or close to the lip near the union resulted in stands nearly as good as those which made use of scionwood sampled from a regularly sprayed scion block, suggests that the included bud may have considerable influence in determining field stands Microscopic examination of graft unions of combinations which periodically failed during the course of the growing season showed that, nearly always failures were accompanied by either fungal or bacterial activity. Naturally some of the grafts which failed, failed because of poor fits, insufficient pressure at the point of union, and/or some other reason which was not readily apparent.

The fact that treatment of scionwood which was collected from unsprayed scion blocks gave higher stands than those which were not treated, further points to the fact that sanitation is quite important in apple grafting Naturally, roots being the underground portions of the plant harbored relatively few organisms which caused graft failures This was evidenced by the very little increased survival in treatment 6 which made use of treated roots, compared to the control (treatment 3).

The results of this experiment further emphasize the need for a carefully planned sanitation program by propagators using this technique to propagate apples.

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MODERATOR WARNER: Thank you, Dr. Mahlstede. The next gentleman on our program is Mr. J. C. McDaniel, of the University of Illinois.

Mr. J. C. McDaniel presented his paper on "Procedures to Increase Take in Budding and Top-Grafting" (Applause)

MR. McDANIEL: I have in the back of the room a few copies of a leaflet from the University of Illinois on "Plastics Useful in Tree Budding." Also available from the University is a leaflet describing the plate bud technique of budding

PROCEDURES TO INCREASE TAKE IN BUDDING AND TOP-GRAFTING

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Despite the recent advances in cutting propagation procedures, there are some species of fruits, nuts and woody ornamentals where grafting and budding are the only practical means for multiplying clones, and others in which for various reasons budding and grafting will supplement cutting propagation My talk is based on work with nut trees and several fruits growing in the open. Several variations from the usual procedure, particularly in summer budding, have shown promise as means of getting more uniform take, with difficult materials or in seasons when ordinary budding practices have not been very successful Three that I wish to emphasize are (1) plate budding as a substitute for "T" budding, (2) plastic bud covers and (3) protective fungicide treatments for nursery-budded or topworked woody plants.

SOME ALTERNATIVES TO "T" BUDDING

The ordinary "T" or shield bud is standard nursery practice for summer propagation of roses, fruit trees of the rose family and many ornamental clones of hardwood species in other families, such as honeylocusts, elms and Norway maples. It works very well for a wide range of easily handled materials. But there are other budding methods that appear more generally effective with some species, and even with roses and common fruits. This is particularly true when growing conditions are not at optimum, due to season, degree of cambial activity, poor maturity of budwood, thickness of the stock bark, or unfavorable weather following budding. The inverted "T", which is standard for citrus tree propagation in Florida nurseries, seems always to work as well as the upright "T" for deciduous plants in the midwest, and often is better. The traditional reason assigned for this is better drainage around the bud This is of some importance, but I believe a major reason is the fact that the stock will form more abundant callus tissue above a horizontal incision than it will below it. The inserted bud therefore has a better chance to unite quickly, if there is an uninterrupted vascular connection between the surrounding stock bark and the active foliage and growing points of the upper stock.

A still more efficient connection between the bud and the upper stock bark is secured with a chip bud or a plate bud For most deciduous materials, except vines, I prefer the plate bud method developed by J F. Jones in Missouri about 1896, which is also called "dry budding" by some Canadian authors. It could be called a reduced chip bud, or a minimum graft Jones made the cuts on the budstick similar to the standard chip bud, except that it was removed with a thinner slice of wood under the eye of the bud. The cut on the stock doesn't extend deeper than the cambium layer, by preference, and all cutting is done with a grafting knife. The bud piece, when placed on the stock, has its sliced bark in contact with live bark of the stock throughout most of its inner face. Callus tissue growing either from the cambium proper, or from the upper stock's inner bark tissues will be in position to give a prompt union with tissues of the bud piece. Jones, who developed this as a method for fall budding of cherries when the bark would not slip, left a lower bark flap on the stock. Some fruit and nut propagators now prefer to eliminate this flap Another variation, used by some with walnuts, pecans and other species tending to have "humped" buds, is to simply slice off a stock bud and a little surrounding bark, replacing this with one cut similarly from the budstick. The latter technique seems to be confined to early spring use.

I have compared, on the same topworked stock, "T" buds, inverted "T" buds and plate buds. With both persimmon and pear trees used in this direct comparison, the advantage usually lies with the plate bud, not only in giving a higher percentage of takes, but in giving a more vigorous initial scion growth from buds that have taken Another advantage, in the case of topworking, is that the plate bud can be set wherever wanted, in branches up to four or five years old, where the bark would be too thick to accomodate a "T" bud. I have used such older limbs for plate budding with mountainash, persimmon, pawpaw, cherry and apple, and in establishing pear and quince on old stocks of *Aronia melanocarpa*

Some species seem poorly adapted to either "T" budding or plate budding methods, at least in late spring or early summer when their bark slips very readily The walnut family is adapted to ring or patch budding in warm weather, provided we can use relatively small buds surrounded with thick bark (Dormant buds from older wood can be used for pecan and black walnut.) Chestnuts, probably in common with oaks and others of that family, are morphologically ill-adapted to budding. These, along with hackberries and some persimmons that have proved difficult to bud, can be propagated in both spring and summer by "girdle grafts," in which thin scions are bridged over a section of larger diameter stock where a ring of bark has been removed or inverted It is a fairly tedious but very effective method If patch buds or girdle grafts are used in hot weather, a sheet of plastic is better than wax for covering

PLASTIC BUD ENCLOSURES

Various plastic materials have been tried as bud and graft enclosures and bud ties during the past twelve years. Among the first were polyvinyl films, used by workers at the University of Miami in successfully budding mango on young seedling stocks In a 1957 publication from New South Wales, a clear elastic polyvinyl strip has been recommended as superior to the usual natural rubber propagating strip in tying buds of pecan, citrus and common pome and stone fruit nursery stock The latest arrival in America, which I have not yet tried, is the Speed-Easy Bud Tie distributed by the Conard-Pyle Co. It is a patented device invented in West Germany, which European nurserymen know as "Fleischhauer's O. S V." Now available in two sizes, it combines a rectangular translucent elastic film, to be stretched over an inserted bud, and a U shaped wire pin for fastening on the opposite side of the stock plant. Besides providing a labor saving method of bud tying wth a protective and moisture retaining shield, it is claimed for this film that it disintegrates in the sun. The bud grows right through it, and labor is saved again, as it does not require a follow-up for removal like ordinary ties, whether raffia, string, rubber strips, or the more durable types of plastic films.

The ordinary plastic bag variety of polyethylene has already been used widely by American amateurs and some professional propagators, as a substitute for grafting wax in the topworking of fruit and nut trees. In southern localities or in hot weather, the plastic bag is combined with aluminum foil wrapping to shade the base of the graft, which is usually a bark graft in the case of nut trees L. D. Romberg, of the U.S Pecan Field Station in Brownwood, Texas, published two methods for plastic application on grafts One was a complete enclosure of scion and the cut-back stock area just below the scion or scions. The alternate method exposed the scion's top bud through a slit in a corner of the tied-on bag Both methods are being used in the midwest with chestnuts, pecans, walnuts and fruit trees, including persimmon. O. S. Gray, an Arlington, Texas nurseryman who pioneered with plastic bags for grafting, now prefers to have the top bud outside the bag, but coated with shellac. With partial shading and polyethylene bag enclosures, it is possible to topwork graft with leafy green shoot scions in the summer or late spring. I have grafted in this manner, pome fruits, persimmon, mulberry, hickory and baldcypress, but was not successful in limited trials with peach grafts.

Polyethylene wraps or shields, in my experience, have given the best results of any material tried for the enclosure of summer buds of pecan, walnut and other difficult hardwood species, particularly when combined with the use of protective fungicides. A plastic ribbon can be used in place of the usual rubber budding strip on materials that are not too soft. More generally, a polyethylene patch is used in connection with a string or rubber tie. Although the clear type of plastic is satisfactory,I had more rapid and profuse callus formation last summer when walnut patch buds were covered with a black polyethylene film.

PROTECTIVE FUNGICIDE TREATMENTS

A number of midwestern nut propagators for several years have reported better takes of buds and grafts protected with the fungicide, ferbam I had nearly as good results on pecan, walnut and other materials this year where zineb was used, and a combination of ferbam and zineb seemed as good as ferbam alone, on polyethylene wrapped buds. Thiram has shown less benefit in increasing bud take, and captan, in earlier trials, sompletely inhibited bud unions on several nut and fruit species. In the 1958 tests, the fungicides were applied according to the method of August M. Gorenz, which he published in U. S. D. A. Circular 913 in 1953. Ferbam and other fungicides he tested as protectants in *Hevea* rubbertree budding were made up with 20% of the commercial wettable powder preparation in water (200 grams to a liter). The stick of budwood is wiped with a cloth moistened with the fungicidal preparation and allowed to dry before buds are removed. The budding area on the stock is similarly wiped before its bark is lifted to insert a bud. The films of fungicide remain to protect the bud and surrounding area against different fungus spores which might germinate to cause infection in the wounded tissues. Gorenz suggested and observations with nut scions confirm, that budwood which is to be shipped should first have a fungicide treatment. The same thing is true with scions or budwood to be stored before use.

In some of my earlier trials, the dry wettable ferbam powder was lightly dusted on cut bud pieces, and some correspondents report good grafting results where scions are shaped, then dipped in ferbam powder before grafting, but probably more uniform results will be obtained with the concentrated mixture in water

Part of the benefit from ferbam and zineb applications on buds may derive from a stimulative effect on callus formation resulting from use of these chemicals. Both are dithiocarbamate compounds, and contain nitrogen which is at least slowly available as a plant nutrient. Where ferbam is sprayed on fruit trees it has been noted that leaves take on a greener appearance. A similar stimulative effect has been noted with cuttings of some herbaceous plant materials that had ferbam applied to their cut ends.

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MODERATOR WARNER. Thank you very much.

The next speaker is Mr. Zimmerman of Rutgers University, New Brunswick, New Jersey. I understand you are doing work under a fellowship Is that correct?

MR RICHARD ZIMMERMAN (Rutgers University, New Brunswick, New Jersey): Yes, and I would like to express my appreciation to the Metropolitan Nurserymen and the New Jersey Nurserymen's Association for sponsoring the work I have been able to do at Rutgers. This is the first chance I have had to come back to Ohio, which is my home state.

Mr. Zimmerman read his prepared paper entitled "Effects of Liquid Fertilizers on Rooting of Cuttings." (Applause)

EFFECTS OF LIQUID FERTILIZERS ON ROOTING OF CUTTINGS

RICHARD H. ZIMMERMAN
Department of Horticulture
Rutgers University
New Brunswick, New Jersey

In the past twenty years, there have been scattered reports of the treatment of cuttings with various types of ferilizers in an effort to improve rooting. These attempts have covered a wide variety of plants, numerous types of fertilizers and several methods of application. In many of the trials, root and/or shoot growth was stimulated by the addition of fertilizer but in almost all cases, the cuttings also had to be treated with a chemical root-inducing compound for the effects to be noticeable.

A series of experiments was conducted with cuttings of several species of woody ornamental plants to determine the effect of fertilizer applications during the rooting period on the rooting, root growth and shoot growth of the cuttings.

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A series of experiments was conducted with cuttings of several species of woody ornamental plants to determine the effect of fertilizer applications during the rooting period on the rooting, root growth and shoot growth of the cuttings.

It was found that soaking greenwood cuttings of California Privet (*Ligustrum ovalifolium*) for 24 hours in a liquid fertilizer had no effect on rooting or root growth and a very slight effect on shoot growth. After the cuttings were inserted in the rooting medium, fertilizer was applied to groups of cuttings at two-day, four-day and six-day intervals. The fertilizer used had an analysis of 15-35-25 and it was used at one teaspoon per gallon, a gallon being enough to treat 250 cuttings. In comparison to cuttings receiving no fertilizer, the cuttings treated at the four-day interval had the greatest increase in growth at the end of 39 days in the bench No increase in rooting percentage was found although root and shoot growth were increased at least 25 per cent. Cuttings receiving no fertilizer produced no lateral shoot growth while 25 per cent of the cuttings treated at four-day intervals had an average of 5 shoots per cutting.

The rooted cuttings were planted in flats and measured six weeks later during the first week of October. Differences in terminal shoot growth were not changed but there were striking changes in the number and distribution of lateral shoots. Lateral shoots had developed on most of the cuttings which had received no fertilizer and to a lesser extent on the cuttings treated with fertilizer. The plants which received no fertilizer were shorter but had more lateral shoots than the plants which had received fertilizer at the four-day intervals.

The following spring, the plants were set out in the field but no differences in overall shoot growth were found after one growing season in the field.

Cuttings of Japanese Yew (*Taxus cuspidata*) were treated with different concentrations of a commercial water soluble fertilizer with the analysis of 23-21-17 This was used at the rates of one-half, one and two teaspoons per gallon with one gallon treating 350 cuttings. Applications were made weekly. The two higher rates increased root growth by 50 per cent in comparison to untreated cuttings.

The time of application of fertilizer in the rooting period was also studied. Fertilizer was applied to the cuttings before roots had formed, after roots had formed and both before and after roots had formed. There was also a group of unfertilized cuttings as a control Hardwood cuttings of *Taxus cuspidata* and *Pyracantha coccinea* were used in one experiment while softwood cuttings of *Pyracantha, Viburnum Sieboldii, Spiraea Bumalda* Anthony Waterer, *Corylus Avellana* and *Cornus mas* were propagated under intermittent mist in the other. The commercial 23-21-17, water soluble fertilizer was used at the rate of one teaspoon per gallon per 400 cuttings The hardwood cuttings were treated weekly and the softwood cuttings every three days.

With cuttings of *Taxus,* it was found that fertilizer applied after roots had formed was more effective in stimulating root growth than fertilizer before roots formed The fertilizer applied after roots formed resulted in a 25 per cent increase in rooting percentage and root growth.

Both hardwood and softwood cuttings of *Pyracantha* showed a greater response to fertilizer applied before the roots had formed. As much as a 50 per cent increase in root growth was found for both the hardwood and softwood cuttings.

The cuttings of *Cornus* and *Corylus* rooted very poorly and no differences were found between the different treatments. The cuttings of *Spiraea* and *Viburnum* rooted very well but again no differences were found.

From the work completed to date, it appears that the effectiveness of fertilizer applications varies with the time of application, the method of application, the amount of fertilizer and the plant species.

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MODERATOR WARNER: Thank you, Mr Zimmerman.

Our next speaker is Frank Turner, who I am sure needs no introduction When we were talking a while ago, he was very conscious of this rule that we have in the Propagators' Society that we should not withhold information from fellow members. He is so conscientious about that, he told me he was telling things he didn't even know.

Mr. Frank Turner, Berryhill Nursery Company, Springfield, Ohio, presented his paper. (Applause)

FORM VARIATIONS IN TAXUS AS RELATED TO THE SOURCE OF THE CUTTING ON THE STOCK PLANT

Frank Turner
Berryhill Nursery Company
Springfield, Ohio

Thank you for the privilege of appearing before you to call some of these observations to your attention To clarify the title, "Form Variations in *Taxus* as Related to the Source of the Cutting on the Stock Plant," I will say that we are referring to the location or level from which the cutting is taken from the stock plant as it in turn is related to the subsequent development of the mature specimen My remarks are made in order to stimulate thinking about observable differences that could be attributed to taking cutting pieces from various plants and from the "same" plant in different locations, whether that be done by design or habit

On several occasions at these meetings we have been reminded of the influence of position on the plant and the influence of the age and variety of plant on the rooting of yew cuttings These reports have been confined almost universally to the speed, percentage, and quality of rooting. In some reports the plant subjects have been of types usually considered quite difficult to root. We have seldom, if ever, had reports on the subsequent development of these rooted cuttings. In saying this, I mean to imply that there seems to be little information on the capability of these experimentally rooted cuttings to efficiently make plants of good quality and desirable structure.

If you grant that this situation is true regarding variations in plants in general, I believe that I can point out some observable variations in *Taxus* varieties which may be due to the type of cutting and the location on the plant from which it was taken

Some of the reasons why a grower selects a particular type of plant and type of cutting for propagation have good reason. He often be-

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Some of the reasons why a grower selects a particular type of plant and type of cutting for propagation have good reason. He often believes, and rightly so, that cuttings from the lower third of a tree root best. On the other hand, with certain varieties, he is also endeavoring to select a lead shoot, or the nearest thing available to it that he can get. He often takes the lower wood to overcome a slightly disavantageous time (early) to start his propagation of *Taxus*. There are also other reasons such as habit and conviction tending to fix his pattern for selecting cuttings

I believe we are just beginning to discover slight variations in our supposedly even run crops of yews These can often be desirable changes and the key to desirable improvements These same characteristics may also explain why a grower might believe that he has developed a superior selection in a given variety In truth he has done this, not by choosing superior plants but rather by choosing superior cuttings. Some variations that can be found are as follows:

Taxus browni is found in both near globe and near upright forms.

Taxus capitata has individual specimens that will always produce an upright tree with a central leader, regardless of where on the tree the cutting is taken.

Taxus columnaris, on the other hand, produces a flat spreading tree when lower side branch cuttings are taken. It yields an upright tree when lead shoots are taken as cuttings

Taxus media hicksi often develops a poor lower structure (unless overly severe shearing is practiced) This difficulty relates to the persistent taking of top cuttings.

Taxus kelseyi is a plant that will take many forms

I know these are common examples that most of us accept quite readily. Because they are so commonplace, I doubt that we expect to develop specific techniques for securing the exact development of and extra performance from even the less than ten varieties that constitute what we might call our major crops in the *Taxus* species.

In consideration of the time available and for the sake of simplicity I have produced examples that could have only remotely developed as a result of a mutation or reversion to the adult or juvenile stage. I believe that if we give consideration to known practical results we will end up with some workable explanations For example, it is a known fact that we get change from overworking stock plants That is true for *Taxus* and even more so for some other plant species It is apparently possible with some clones of our standard *Taxus* plants to induce practically a physiological change in growth type (from lateral branch growth to apical dominance) by mechanical manipulation such as staking and tying.

It may well be that at this time we do not see how processes similar to these can be applied to *Taxus,* although they have been applied to other plant families. For instance, we know how to change a rose from a bush to a vine If that is true, how far can we go with *Taxus?*

The fact that there are modifications brought about by taking different types of cuttings from *Taxus* stock plants, does not necessarily mean that they are always good variations. Each one has to be checked. If you have two variations coming from the same parent plant, they have to be checked against each other. If they are under consideration as a crop, you should have them planted side by side in the field in order to make a final satisfactory commercial appraisal Here, we have some more or less basic rules to guide us For example, plants of *Taxus* grown from extreme lead shoots are almost universally poor developers of bottom structure While I haven't referred to it previously there must be some explanation as to why some types develop sparse root structure while others develop heavy root systems.

In conclusion, may I say that we are dealing with something that we do not as yet have rules for naming. We have a thing here, that has caused us innumerable difficulties in identification.

I believe that we have a good opportunity to strike pay-dirt if we persevere diligently in our efforts to observe, analyze, test and try, some of the variations of which I speak

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MODERATOR WARNER: Thank you, Mr. Turner. We are right on schedule and therefore will delay any questions until the end of the panel.

Mr. Harvey Gray from Farmingdale, New York, is our next speaker Mr. Gray.

MR. HARVEY GRAY (Long Island Agricultural and Technical Institute, Farmingdale, New York): This paper is an extract from a class project at the State Institute at Farmingdale in a course on Nursery Management It really is the class' work and not mine, although I asked them to set it up and run it.

Mr Gray then presented his paper on "*Tsuga canadensis* from Cuttings." (Applause)

TSUGA CANADENSIS FROM CUTTINGS

HARVEY GRAY
State University of New York
Farmingdale, New York

Rooting *Tsuga canadensis* cuttings has always presented a challenge to the plant propagator A test on the rooting of this plant was devised and put into operation on December 15, 1957. A total of 1518 cuttings was involved in the test. The cuttings were made from the previous season's growth, taken from five year old vigorous nursery plants. The ten inch cuttings were wounded with a spiral type cut and subjected to various synthetic hormone treatments. Indolebutyric acid diluted in talc and in alcohol at .8% and 2% concentration, making four different treatments, was used.

The following rooting media used straight or in mixtures as indicated in the table were: medium sand from a local sand pit, sphagnum peat and two grades of styrofoam, irregular pea size pieces and coarse dust. All media were placed in flats and moistened to an even consistency. The cuttings were inserted and the flats were placed in a polyethylene vapor proof case. All of our polyethylene cases are made vapor proof by completely enclosing and sealing. To accomplish this, sideration as a crop, you should have them planted side by side in the field in order to make a final satisfactory commercial appraisal Here, we have some more or less basic rules to guide us For example, plants of *Taxus* grown from extreme lead shoots are almost universally poor developers of bottom structure While I haven't referred to it previously there must be some explanation as to why some types develop sparse root structure while others develop heavy root systems.

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On March 14, 1958, three months later, the cuttings were removed from the various media and the results were recorded With these tests it appears that the quick liquid dip treatment is better than the powder treatment. Not only did the liquid dip treatment produce more rooted cuttings but also the root systems were more extensive. There is an indication in the data presented that a concentration less than 20,000 ppm and more than 8,000 ppm might produce better results.

There is another area of interest which developed out of this test which needs checking. Many of the well rooted cuttings failed to make satisfactory growth during the following growing season. At the start of the test, the four plants on display were very much like the unrooted cuttings. After recording the results of the tests, all rooted cuttings, regardless of treatment, were put into one lot for growing on during the 1958 season. Now at the end of the season we note that about ⅓ of the plants developed in a normal manner. The other ⅔ failed to make normal growth. Growth from the buds was inhibited to a greater or lesser degree. This might be caused by the synthetic hormone treatments and needs verification and correction.

Table I.—Influence of the medium and hormone treatment on the rooting of Tsuga cuttings.

Medium	Hormone Treatment			
	QLD* 20,000 ppm	QLD 8,000 ppm	Powder 20,000 ppm	Powder 8,000 ppm
Sand	14.5**	20.8	0.0	4.1
½ sand, ½ peat	24.9	41.5	20.8	22.9
⅔ sand, ⅓ fine styrofoam	43.7	46.3	20.8	18.7
⅔ sand, ⅓ pea styrofoam	42.5	12.7	40.7	12.1
⅓ sand, ⅓ peat, ⅓ fine styrofoam	74.9	62.5	45.8	45.8
⅓ sand, ⅓ peat, ⅓ pea styrofoam	47.9	46.6	25.0	35.4
Peat	31.6	34.0	4.2	4.0
⅔ peat, ⅓ pea styrofoam	51.1	66.9	29.1	20.8
⅔ peat, ⅓ fine styrofoam	59.5	65.2	21.8	24.4

* QLD — Quick liquid dip
** Percent rooted

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MODERATOR WARNER: Thank you, Mr. Gray. We still have three more people to appear on the program. The next gentleman to appear will be Mr. Martin Van Hof.

Mr. Van Hof read his prepared paper on "Rooting Under Plastic." (Applause)

ROOTING UNDER PLASTIC

MARTIN VAN HOF
Rhode Island Nurseries
Newport, Rhode Island

We at the Rhode Island Nurseries have been propagating our softwoods under polyethylene for the last three years and previous to that for two years, on a somewhat experimental basis.

I would like to start by trying to tell you how our propagating beds are prepared Each bed is six feet wide and up to 100 feet long, of course the length does not matter. We use 8 or 10 inch boards for the sides of the bed. Of course, a 1″ x 2″ furring raised to about 10 inches is much cheaper and will do practically as well.

It is important to thoroughly prepare the soil in your bed. I prefer a Rotohoe to a tiller as the mechanical hoe will not pulverize the soil as much as the tiller will, which means less compaction after watering. Of course, a digging fork and a strong back will do a good job also. Next, the bed is raked as level as possible and the soil is pressed down with a wooden tamper or a roller At night the prepared bed is covered with tar paper or discarded plastic to protect it against rain or digging by animals.

Soft cuttings six to ten inches long, depending on the variety, are inserted into the soil We probably use a different method than most people, the men doing the sticking sit on a plank placed across the frame and use a footboard. A pointed steel dibble about one quarter inch thick and eight inches long is used to make the hole for the cutting and to tighten it at the base with a slanting movement. When a four foot section of the bed has been completed, the cuttings are watered in, although one might call it flooding, and are then given temporary protection from wilting by a four by six foot shade covered with burlap which is kept damp. When four of these sections (16 ft) have been filled, we begin covering that much of the bed with plastic.

A shallow trench is dug just outside the ends and sides of the bed and the shades with the burlap are removed. Next four 2 x 2 pieces of lumber, two feet long are spaced four feet apart in the center of the bed and are driven eight inches into the soil A 1 x 2 inch furring 16 feet long is then nailed on top of these supports forming a ridgepole for the plastic through the center of the bed. This 16 inch high center has proved to be the best height for providing the correct humidity in our locality. All sharp corners are padded to prevent tearing of the plastic, which is unrolled over the structure. One side of the plastic is laid in the trench, covered with soil, and tamped down by foot. Next the plastic is pulled tight across the frame and fastened with soil in the other trench. Since plastic traps heat, specially constructed 7 foot shades with laths one quarter inch apart are used. The extra foot of the 7 foot shade allows enough additional length so that the shades protrude 6 inches beyond the edges of the bed We use either wooden runners or "T" shaped iron stakes on which to place our shades. They are high enough so they are 2 inches above the ridgepole. The overhang of the shades also provides shade for those cuttings near the edges of the bed This procedure continues until the frame is filled.

The plastic used in covering these cuttings is 4 mils in thickness and comes in rolls of 100 feet long and 10½ feet wide. It is used only one year.

Through experience one learns to group the cuttings of these varieties that root in the same length of time. If this is impossible because of small numbers of certain varieties, the bed can be sectioned off by bringing the plastic down into the soil to form a wall, thereby separating the varieties which take different lengths of time to root. If one propagates a large number of varieties, be sure to keep the slow rooting and fast rooting varieties separate. For instance, *Magnolia* and some of the *Viburnum* varieties just would not be practical to stick with fast rooting *Deutzia, Weigela* and *Hydrangea* varieties.

Once the frames are closed, the plastic covers should not be removed for at least two and one half to three weeks. If at the end of this time, it is discovered that the tops of the cuttings are dry, you can be sure that they were not watered sufficiently when originally inserted. After the cuttings begin to root, I recommend that you give them air by opening part of the flap on one side of the plastic covering and letting it hang down. This allows the air to circulate without drying the cuttings too much although it starts the hardening off process. After two or three days the plastic is rolled up on this side and tucked between the lath shade and its supporting runners or stakes. At this time additional watering is necessary. I should caution you that fungus might set in at this particular stage of development if they do not get sufficient air in the bed

The plastic is removed entirely after about one week or ten days The shades are kept on for another two weeks and then gradually removed when the cuttings are really hardened off. I, for myself, believe propagation under plastic is cheaper than under glass in cold frames or mist. Of course, sashes are not used anymore but just for comparison, what a terrific drudgery it used to be to root softwood cuttings.

I can highly recommend winter propagation in a plastic house built to the University of Kentucky specifications, especially for anyone with little capital. An outside layer of 4 mil. and an inside layer of 1½ mil. plastic with a two inch air space between is advisable. A sufficient number of ventilators should be included to control the heat in the early Spring. Even on a bright January day, temperatures in a house of this type may rise to 95 degrees, which, of course, would force excessive top growth.

Heating can be done in a house of 52 x 12 feet with a two pot kerosene space heater, which gives about 80,000 B T.U 's and would keep the house at 70 degrees when the outside temperature is zero. With a heater like that the temperature should be kept high in order to keep the sand at 60 degrees *Taxus, Juniperus, Ilex, Thuja,* and *Chamaecyparis* cuttings are grown successfully plus the seed of *Pieris, Azalea,* and *Rhododendron.*

A word of caution is in order, since special care should be taken to keep the rooting medium moist. Sand tends to dry out quite rapidly near the sides of the plastic.

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MODERATOR WARNER: Thank you, Martin. We have next Mr. Robert Eshleman, Jr. of Bloomsburg, Pennsylvania, to talk on "Planting Through Plastics." Mr. Eshleman.

Mr. Eshleman read his prepared paper on the use of plastics for rooting hardwood cuttings, and for growing potted plants. (Applause)

PLANTING THROUGH PLASTICS

ROBERT J. ESHLEMAN
Eshleman's Nursery
Bloomsburg, Pennsylvania

This system works well for me when I need only 500 to 1000 plants of a variety of flowering shrub, produced quickly, with little labor or expense.

The principle of using plastic to plant through is much like any other mulch but with many features that are far superior to the average material used for mulching By plastic I am referring to sheets .002 to .004 inches in thickness and preferably black in color.

The plastic is waterproof except where it is punctured to insert the cutting or plant. Rain enters at these points and spreads under the plastic. It cannot leave except through the foliage of the plant The plastic maintains a uniform soil moisture content even through dry spells. This makes the perfect environment for rooting hardwood cuttings.

The plastic acts as a greenhouse to help retain heat in the soil. This is very beneficial for root growth in the early spring.

The plastic makes an effective weed control barrier, and if black plastic is used, many weed seeds will fail to sprout at all. This enables one to plant out small cuttings that would ordinarily be engulfed by weeds or which would require a great deal of labor to keep clean

The plastic keeps the rain from packing the soil surface so that good aeration is maintained and cultivation is unnecessary. The plants hold the plastic down so that the mulch stays in place.

In order to give you some idea of how we use this technique in our operation I will describe the general procedure in detail. Prepare the beds for planting in the usual manner for the type of plant being raised, adding all soil amendments and rotovating them in. Do this preparation the fall before, if possible, to be able to make earlier spring plantings.

Spread the plastic over the bed and anchor the edges with soil until the bed is planted. The width of plastic is optional and would depend on the width of bed use. If shading is to be used, 4½ foot plastic on a 4 foot bed works well. For hardwood cuttings of flowering shrubs shading is not ordinarily used which allows you to make the beds much wider.

I have tried this system of planting through plastic with two types of plants, i.e., hardwood cuttings (*Weigela rosea, Forsythia spectabilis, Spiraea prunifolia,* etc.) and with potted plants (*Pyracantha coccinea lalandi, Cotoneaster divaricata,* etc)

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PLANTING THROUGH PLASTICS

Robert J. Eshleman
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This system works well for me when I need only 500 to 1000 plants of a variety of flowering shrub, produced quickly, with little labor or expense.

The principle of using plastic to plant through is much like any other mulch but with many features that are far superior to the average material used for mulching By plastic I am referring to sheets .002 to .004 inches in thickness and preferably black in color.

The plastic is waterproof except where it is punctured to insert the cutting or plant. Rain enters at these points and spreads under the plastic. It cannot leave except through the foliage of the plant The plastic maintains a uniform soil moisture content even through dry spells. This makes the perfect environment for rooting hardwood cuttings.

The plastic acts as a greenhouse to help retain heat in the soil. This is very beneficial for root growth in the early spring.

The plastic makes an effective weed control barrier, and if black plastic is used, many weed seeds will fail to sprout at all. This enables one to plant out small cuttings that would ordinarily be engulfed by weeds or which would require a great deal of labor to keep clean

The plastic keeps the rain from packing the soil surface so that good aeration is maintained and cultivation is unnecessary. The plants hold the plastic down so that the mulch stays in place.

In order to give you some idea of how we use this technique in our operation I will describe the general procedure in detail. Prepare the beds for planting in the usual manner for the type of plant being raised, adding all soil amendments and rotovating them in. Do this preparation the fall before, if possible, to be able to make earlier spring plantings.

Spread the plastic over the bed and anchor the edges with soil until the bed is planted. The width of plastic is optional and would depend on the width of bed use. If shading is to be used, 4½ foot plastic on a 4 foot bed works well. For hardwood cuttings of flowering shrubs shading is not ordinarily used which allows you to make the beds much wider.

I have tried this system of planting through plastic with two types of plants, i.e, hardwood cuttings (*Weigela rosea, Forsythia spectabilis, Spiraea prunifolia*, etc.) and with potted plants (*Pyracantha coccinea lalandi, Cotoneaster divaricata*, etc)

Hardwood cuttings are prepared in the usual manner in January or February and buried in sand in bundles until planting time in March or April. Holes are made through the plastic the diameter of the stick and to a depth of 6 or 7", or to a point where one inch of cutting appears above the plastic The cutting should fit snugly in the hole. It helps to use soil with few to no stones in it. The spacing of the holes depends upon how long the shrubs are to remain and how fast they grow If the plants are moved in one year, 6 inches usually is sufficient spacing, although if left two years, 12 - 18" is required. The growth made is almost equal to that under irrigation because of the uniform moisture supply. The plants are all uniform in size and can be spaced closer than in ordinary field planting because there are no weeds to compete with and no cultivating is necessary For most hardwood cuttings, one year in the bed is sufficient They can be sold or lined out in the field for continued growth

When pot plants are put out, a digger similar to a bulb planter can be used. A circle of plastic and a volume of soil equal to the pot ball are removed and the plant is dropped and firmed in.

This system really simplifies transplanting of small plants without the need of sterilizing the soil to remove weed seeds or adding mulch later to retain moisture.

I have used plastic also out in the field in three-foot rows around established evergreen plants. This was put down after the plants had been planted. It didn't work nearly so well because I only stripped the plastic about 12 inches on each side of the row and the weeds between that had to be removed by cultivation. If you could afford to cover the whole planting surface with plastic in order to eliminate cultivation it would probably work well

Something else I could remark on would be the type of plastic we used. Clear polyethylene film was pretty well broken down by fall although it stil covered the surface sufficiently to keep the weeds down. The following spring it did not interfere with digging. When I used black plastic, it remained quite tough through two years, and might offer some interference with removing the plants after the first year

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MODERATOR WARNER Thank you for your very interesting talk.

We are now up to the last item on the program. We have a paper on "Rooting Deciduous Azaleas from Cuttings," by Warren Baldsiefen, who was unable to be here, but Mr. Leach has consented to read this paper.

Mr. David Leach read the paper prepared by Mr. Warren Baldsiefen, Rochelle Park, New Jersey. (Applause)

DECIDUOUS AZALEAS FROM CUTTINGS

WARREN BALDSIEFEN
Rochelle Park, New Jersey

If the limited use of deciduous azaleas in the landscape is ever to be overcome, it can only be brought about with handsome, healthy, long-lived plants, and these can only be developed from rooted cuttings Seedlings are no substitute for named clones, grafting produces a short-lived plant and one which lives for only the briefest span in fringe areas where growing conditions are somewhat or totally adverse to the requirements of the plants, layering in any form is slow to provide plants in quantity. In addition, layered plants in too many cases develop long naked stalks while attached to the stool plant, which later make ungainly specimens.

Outlined herein is the method used at Rochelle Park, New Jersey which has performed with consistent success these many years. Each step is described in full and in the exact sequence it occurs.

The rooting takes place in a modified Nearing frame. As many of you know this frame is an outdoor Wardian type enclosure the approximate size of two hotbed sashes placed end to end, partitioned in the middle forming two separate units, with a superstructure overhead excluding all direct rays of the sun. Blueprints for its construction and details for its operation can be obtained from Mr. David Leach or myself.

Into each of the two units in a frame are emptied and levelled, three bushels of shredded commercial peat moss. On top of this is added two bushels of shredded commercial peat moss thoroughly mixed with two bushels of washed coarse masonry sand. This too is carefully levelled Thinly spread over this is ¼ inch of coarse masonry sand which prevents the peat moss from floating with watering. Into this medium the cuttings are set They are spaced approximately 2½ inches apart in the row and the rows are approximately 1½ inches wide allowing about 3-400 cuttings per unit. Cuttings are never crowded so that leaves overlap to any extent. In rooting, carbohydrates plus nitrogenous substances are required, which are synthesized in the leaf. Hormones alone are not the answer It is necessary therefore, on inserting the cuttings, that they be so arranged that each leaf receives the maximum amount of light

In Rochelle Park, deciduous azalea cuttings are taken beginning the latter part of May and extending through the middle of June, depending on the season, and the age and location of the stock plants. The cuttings on stock plants growing in full sun mature before those grown in semi-shade. The exception are those cuttings which break at the base of the current season's flowers. Precise timing in taking the cuttings, heretofore directly linked with success or failure, does not appear to be vital and cuttings may be taken from the same plant at intervals of a week or more with good results The stem growth of a deciduous azalea is a continuous elongation which does not ripen simultaneously along its entire length. The new stem of a deciduous azalea is strigose. As the wood of the stem matures, beginning at its point of origin, and advancing toward the growing tip, the bristles gradually vanish and give way first to a light colored smooth bark, which later transforms to a woody, rough brown bark.

In preparing a cutting it is essential not to use the woody or smooth part of the stem. The later in the season the cutting is made the more decisive this fact becomes Cuttings are usually 4 inches long, slightly larger or smaller bearing no influence on rooting, with usually three leaves-trimmed, if they are too large. Trimming leaves is reputed to weaken cuttings but I have never noticed any ill effects from the practice Two inches or less of the cutting are inserted in the medium so that the bottom leaf barely rests on the sand. If cuttings are placed deeper in the medium the base of the cutting will protrude down into the soggy peat, at times causing it to rot

On all cuttings the terminal bud or growing tip is pinched off and I cannot stress too strongly the critical significance of this step for I consider it of vital importance in the overall success of rooting and subsequent growth the following spring. It is established fact that indoleacetic acid is synthesized in the growing tip and upper leaves and then transported to other parts of the plant. Indoleacetic acid being an aid to rooting, it would appear that removing this apical bud, and upper leaf or two when succulent, would have an inimical effect on rooting. But this is not true. It does not impair rooting, but to the contrary it augments the process, unreasonable as it may seem Of equal significance is the almost immediate expansion of the axillary buds, clearly visible within a week or 10 days after removal of the terminal. A spur-like shoot or shoots is often produced at these leaf axils in the rooting beds. But whether or not shoots are produced, these swollen axillary buds are the points of origin from which growth commences the following spring.

Before inserting in the rooting medium, all cuttings are soaked for about 15 hours, exact timing having no noticeable effect on rooting, in 3-indolebutyric acid, 75 ppm with the exception of the yellow flowered azaleas which are treated with a 50 ppm solution. For some reason the yellows are more sensitive to treatment and may burn in the 75 ppm solution if the wood is slightly immature for cuttings The cuttings are not wounded as would be the case in preparing large leaved rhododendron cuttings. Half inch wire mesh is placed over pyrex glass trays filled with solution, and into this the cuttings are set No special enclosure or other conditions are provided for the soaking of the cuttings. Trays are placed indoors or out in a semi-shaded location. On being removed from the trays the cuttings are immediately wrapped in either wet burlap or polyethylene to prevent drying, and then as soon as possible set in the rooting frames The cuttings are set in holes made with a template. Cuttings are watered in, not tamped. The rooting medium is drenched until a layer of water $\frac{1}{4}$ to $\frac{1}{2}$ inch deep momentarily covers the sand The glass is then fitted tightly over the cuttings and left undisturbed until the next watering in about a week There is ample water if, on inspecting the frames in the morning, water has condensed on the undersurface of the glass. Water once each week the first month whether or not there is apparent need In draining off through the medium the water draws down a fresh supply of oxygen essential in rooting. Depending on the amount of sunshine and condition of the cuttings, many cuttings will strike roots after 4 weeks. By the beginning of August virtually all will be rooted. At this time watering is withheld and the plants are removed from the rooting frame between the latter part of August and the beginning of September. It is best to wait until the evenings become cool, before transplanting the cuttings. No effort is made to force growth on the cuttings at this time. Such an attempted alteration of the innate cycle of the little plants and the disruption of the normal metabolic processes taking place at this time in preparation for dormancy, is most unwise. Over aeons of time, these plants have adapted themselves to their environment. One of the requisites for survival was to cease growing in late summer and make the necessary physiological adjustments for winter. And it is a discreet plantsman who shows respect for the laws of nature. The method herein described does not require any late-season forcing or other unnatural conditions, to insure the start of growth the following spring. This, of course, is the most important aspect of propagating deciduous azaleas. The greatest problem has always been to induce the cuttings to start into growth the following spring after they have been rooted The procedure described in this paper eliminates this problem

Cuttings are transplanted from the rooting bins into 14 x 20 x 4″ cedar flats, 24 cuttings per flat. The flatting medium consists of 2 parts shredded commercial peat moss, 1 part sifted or shredded top soil, and ½ part Michigan peat moss In this mixture a strong root system has its genesis and the cuttings develop into young plants able to withstand a winter outdoors. The medium is friable so that it will not remain soggy after drenching rains, as would be the case if the percentage of soil equalled or exceeded that of the peat Also the physical structure, chemical and mineral composition of the mixture are similar to that in the planting beds into which the cuttings are to be later moved in the spring, so that the shock of moving will be reduced to a minimum. Many propagators use 100% commercial peat moss as a flatting or potting medium for newly rooted cuttings, but I consider such treatment not to be in keeping with the best interests of the plants. Biologically, nutritionally, and minerally it is a poor medium for roots. Although large root masses form these roots often fail to leave the peat upon transplanting into soil. In addition the peat ball remains intact for many years, holding excessive moisture during periods of prolonged rainfall.

After being flatted the cuttings are placed in a double lined cinder-block frame running north and south. The frame used at Rochelle Park is about 50 ft. long and 12 ft. wide with a ridge pole about 1 foot higher than the sides This rise allows ample drainage after the glass is set in place, yet the incline is so slight that the sun's rays in early morning reflect off the glass with a minimum warming of the frame. The object of having two rows of cinder block is for insulation so that temperature fluctuation during the winter is held to a minimum. The height of the frame is determined by the four courses of 8 inch blocks set up without mortar. The dirt floor of the frame on which the flats are set, is ground level. While it would appear to be advantageous to use a deep pit for overwintering, our present location makes this impossible.

Once set in the overwintering frame in late August or early September, the plants are shaded with lath admitting about 50% sunlight. At this time no glass is used. In early October the lath shading is temporarily removed, glass is placed over the cuttings and the shading replaced Each sash is propped open a few inches at this time The purpose of the glass being to keep off the autumn rains, allowing the soil sufficient time to dry and become aerated before freezing weather sets in. Any excessive active absorption of water at this time of the year, when drastic temperature fluctuations are common, followed by a freeze, could cause the bark of the little plants to split. The soil therefore, is permitted to dry to a point where the leaves of the cuttings actually flag for want of water. When this condition exists the plants are sprinkled only lightly so the leaves again regain their normal position and appearance.

The beginning of November the glass is closed tightly on the frame and left undisturbed until the end of the year, at which time the lath shading is again temporarily removed and a sisal-craft paper covering is placed over the glass. The lath shading is then replaced to hold down the sisal-craft. The paper covering prevents the direct rays of the sun from entering the frame and causing wide temperature changes during the open days of winter. It remains in place until mid-March Such a covering does not place the inside of the frame in total darkness Cracks in the cinder blocks, and glass imperfectly seated allow enough light to enter that the inside of the frame has the appearance of dull twilight.

In mid-March before the sun and warmer weather warm the inside of the frame the sisal-craft paper is removed and the glass is again ventilated This ventilation prevents overheating and stimulation that might occur during successive clear days the latter part of March The beginning of April, as the weather permits, the glass is removed, and the plants are bedded out, mulched and shaded. Bedding out this early in the season produces a substantially larger root system by fall and a second growth (the same year) two to three times larger than would be the case if the bedding were postponed until late April or early May. In climates warmer than that of Rochelle Park bedding-out can begin at a much earlier date, weather permitting.

The first season the little plants do not receive any commercial fertilizer, yet many attain a height of a foot or more. These are generally cut back in fall or the following spring to insure a sturdy well ramified plant. The second season growth is made under lath but the young plants are transplanted into the sun in the fall of the second year or before growth begins the following spring.

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MODERATOR WARNER: Thank you, Mr Leach. I am glad that this paper has been presented.

I noticed we are running exactly a half hour behind, which isn't too bad, considering the number of speakers. On the other hand, I do not think it will allow us any time for questions.

Without further ado, I will turn the meeting back to President Hugh. We hope that this probably minor dissatisfaction and enthusiasm for asking questions can be carried over into another year

PRESIDENT STEAVENSON: Thank you very much, Zo, for that masterful job. I can understand why you were elected mayor. I can't understand why they let you go.

I think we can now proceed with our business meeting with dispatch.

The meeting recessed to reconvene in the Annual Business Meeting (See page 11).

EIGHTH ANNUAL BANQUET

The Past President, Mr Hugh Steavenson, and the newly elected President, Mr Roy M. Nordine, presided at the annual banquet

Highlighting the banquet was the presentation of a Life Membership and Plaque to Dr F L Skinner, Dropmore, Manitoba, Canada, for his outstanding work in the field of plant propagation

Following a period of entertainment, Dr. Seymour Shapiro, Brookhaven National Laboratory, Upton, Long Island, New York presented a graphic discussion of Radio-active Materials, Bud Regeneration and Root Growth

(*Editor's Note*)· For further reading attention is called to Dr. Shapiro's article appearing in *The Physiology of Forest Trees,* 1958, edited by K. V. Thimann. pages 445-465 Roland Press Company, New York.

The Eighth Annual Meeting of the Plant Propagators Society adjourned sine die at 10 00 P.M.